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December 2017

Owl Creek Watershed, Level I Study

FINAL REPORT

PREPARED FOR:
WYOMING WATER DEVELOPMENT COMMISSION
CHEYENNE, WY

PREPARED BY:
LOWHAM WALSH
LANDER, WY

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Owl Creek Watershed
Level I Study
Final Report

Prepared for:

Wyoming Water Development Commission
6920 Yellowtail Road
Cheyenne, WY 82002

Prepared by:

Lowham Walsh Engineering & Environmental
205 S. 3rd Street
Lander, WY 82520

December 2017

Owl Creek Watershed

Level I Study

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Owl Creek Watershed, Level I Study

Final Report

Lowham Walsh Project No. 1209490

WWDC Contract No.

December 2017

I hereby certify that Sections 3.7, 3.8, 3.9, 4, 6 and Appendices G & I of this report were prepared by me or under my direct supervision, and that I am a duly Licensed Professional Engineer under the laws of the State of Wyoming.

Frank Grimes
Wyoming PE 2892

I hereby certify that Sections 3.3, 3.4, 3.5, and 3.6 of this report were prepared by me or under my direct supervision, and that I am a duly Licensed Professional Geologist under the laws of the State of Wyoming.

Kyle Smith
Wyoming PG 3970

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TABLE OF CONTENTS

List of Tables

List of Figures

List of Acronyms and Abbreviations

AC	Alternating Current (commercial electrical power)
ACEP	Agricultural Conservation Easement Program
ac-ft.	acre-feet
ALE	Agricultural Land Easements
AMA	Agricultural Management Assistance
AMPs	Allotment Management Plans
amsl	above mean sea level
AOI	Areas of Influence
bgs	below ground surface
BHP	Brake horse power
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BMP	Best Management Practices
CCAA	Candidate Conservation Agreement with Assurances
CCI	Construction Cost Index
cfs	cubic foot per second
CIG	Conservation Innovation Grants
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
CWSRF	Clean Water State Revolving Fund
DU	Ducks Unlimited, Inc.
DWSRF	Drinking Water State Revolving Fund
ECP	Emergency Conservation Program
EPA	U.S. Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ESA	Endangered Species Act
ESDs	Ecological Site Descriptions
EWP	Emergency Watershed Protection
FSA	Farm Service Agency
FTO	Farm Turn Out
ft.	feet
GIS	geographic information system
GLCI	Grazing Lands Conservation Initiative
gpm	Gallons per minute
GPS	global positioning system
HDPE	High Density Polyethylene
HFRP	Healthy Forests Reserve Program
HP	Horse Power
HSCD	Hot Springs Conservation District
HSU	hydrostratigraphic unit
HU	hydrologic unit
HUC	hydrologic unit code
in.	inches
ISTO	Irrigation Storage Improvements
ISYS	Irrigation System Improvements

LMP	Land Management Plan
LPPC	Lucerne Pumping Plant and Canal Co.
LW	Lowham Walsh LLC
LWGs	Local Sage-Grouse Working Groups
MARSH	Matching Aid to Restore States Habitat
MBTA	Migratory Bird Treaty Act
Mgal/d	million gallons per day
MOU	Memorandum of Understanding
NAWCA	North American Wetlands Conservation Act
NEPA	National Environmental Policy Act
NFOC	North Fork Owl Creek
NFWF	National Fish and Wildlife Foundation
NHD	National Hydrography Dataset
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NREX	Natural Resource and Energy Explorer
OCID	Owl Creek Irrigation District
OSLI	Wyoming Office of State Lands and Investments
OWI	Other Watershed Improvements
POD	Point of Diversion
PMC	Plant Materials Center
PSI	Pounds per square inch
PVC	Polyvinylchloride
RCPP	Regional Conservation Partnership Program
ROW	rights-of-way
SCS	Stream Channel Stabilization Projects
SERP	State Environmental Review Process
SGCN	Species of Greatest Conservation Need
SGI	Sage Grouse Initiative
SGI	Sage-Grouse Initiative
SHPO	State Historic Preservation Office
sq.	square
SWPP	Small Water Project Program
TMDL	Total Maximum Daily Load
URI	Upland Range Improvements
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USGS	United States Geological Survey
VFD	Variable Frequency Drive
WACD	Wyoming Association of Conservation Districts
WaterSMART	Sustain and Manage America's Resources for Tomorrow Program
WBD	Watershed Boundary Dataset
WBLC	Wyoming Board of Land Commissioners

WCFSP	Water Conservation Field Services Program
WDEQ	Wyoming Department of Environmental Quality
WFPO	Watershed Protection and Flood Prevention Operations
WGFD	Wyoming Game and Fish Department
WGS	Wyoming Geological Survey
WLCI	Wyoming Landscape Conservation Initiative
WMA	Weed Management Area
WOGCC	Wyoming Oil and Gas Conservation Commission (WOGCC)
WQ	Water Quality
WQD	Water Quality Division
WRDS	Water Resources Data System
WRE	Wetlands Reserve Easements
WRIR	Wind River Indian Reservation
WSEO	Wyoming State Engineer's Office
WSFR	Wildlife and Sport Fish Restoration Program
WSGCF	Wyoming Sage-Grouse Conservation Fund
WSP	Watershed Surveys and Planning
WWDC	Wyoming Water Development Commission
WDO	Wyoming Water Development Office
WWDP	Wyoming Water Development Program
WWNRT	Wyoming Wildlife and Natural Resource Trust
WYDOT	Wyoming Department of Transportation
WyGISC	Wyoming Geographic Information Center

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OWL CREEK WATERSHED STUDY AND MANAGEMENT PLAN

1 INTRODUCTION TO THE OWL CREEK WATERSHED STUDY

The Hot Springs Conservation District (HSCD) submitted a request to the Wyoming Water Development Commission (WWDC) in 2015 for funding to complete a watershed study to evaluate current watershed hydrology, water availability, water supply, and water storage systems in the Owl Creek and neighboring Coal Draw and Sand Draw Watersheds. The WWDC selected Lowham Walsh Engineering and Environmental Services, LLC (LW) to complete this study.

The District was interested in enhancing natural watershed processes and repairing or developing water supplies, irrigation conveyance systems, and upland livestock and wildlife water sources. HSCD is seeking information that enables a better understanding of natural resources within the study area. They require a plan that outlines potential management strategies based on a full evaluation of water development opportunities, specifically focusing on approaches that enhance watershed function.

The Owl Creek Watershed study area is located in north-central Wyoming within the Upper Bighorn River Basin Watershed on the eastern slope of the Continental Divide. Waters entering the Owl Creek Watershed begin collecting at the peaks of the southern Absaroka and Owl Creek Mountains and flow into the Bighorn River, then the Yellowstone, Missouri, and Mississippi Rivers, eventually reaching the Gulf of Mexico. The Owl Creek study area drains a 937-square mile area within the Wind/Bighorn River Basin (**Figure 1.1-1**). The watershed is bounded to the south by the Owl Creek Mountains, to the west by the Absaroka Mountains, and to the north by a low plateau that separates Owl Creek from Cottonwood Creek. Owl Creek generally flows from west to east, joining the Bighorn River just south of the community of Lucerne. The highest elevation in the watershed is 12,523 feet (ft.) at the summit of Washakie Needles, while the lowest elevation is approximately 4,275 ft. in the irrigated agricultural fields north, and downstream of, the area of Lucerne.

The study area also includes land within Coal Draw and Sand Draw. It includes uplands located to the north of Owl Creek and to the east of Owl Creek, on the east side of the Bighorn River in the area of Cedar Mountain. It includes uplands around Kirby Creek but does not include Kirby Creek. It also includes the irrigated lands along the Bighorn River adjacent to the area of Lucerne, Tiedown Flats, and Winchester including the upper reaches of the Upper Hanover Canal. To the south of Owl Creek, the study area includes drainages flowing north and east off the crest of the Owl Creek Mountains, with Red Canyon Creek being the largest. This sub watershed surrounds Nostrum Mountain on three sides and flows directly into the Bighorn River south of Thermopolis. The study area includes other small, short, ephemeral watersheds that drain directly to the Bighorn River in Bighorn Canyon and are located on the north side of the Owl Creek crest.

In addition to an overview of the natural and human resources found within the study area, the report focuses on potential improvements to, and water conservation on, irrigated lands served by Owl Creek and its tributaries, and irrigated areas served by the Lucerne Ditch and the Kirby Ditch. Because there is little or no irrigation outside of these areas, and no projects were identified by landowners in the Red Canyon Creek, Sand Draw, or Coal Draw Watersheds, these area are only briefly developed in the following report.

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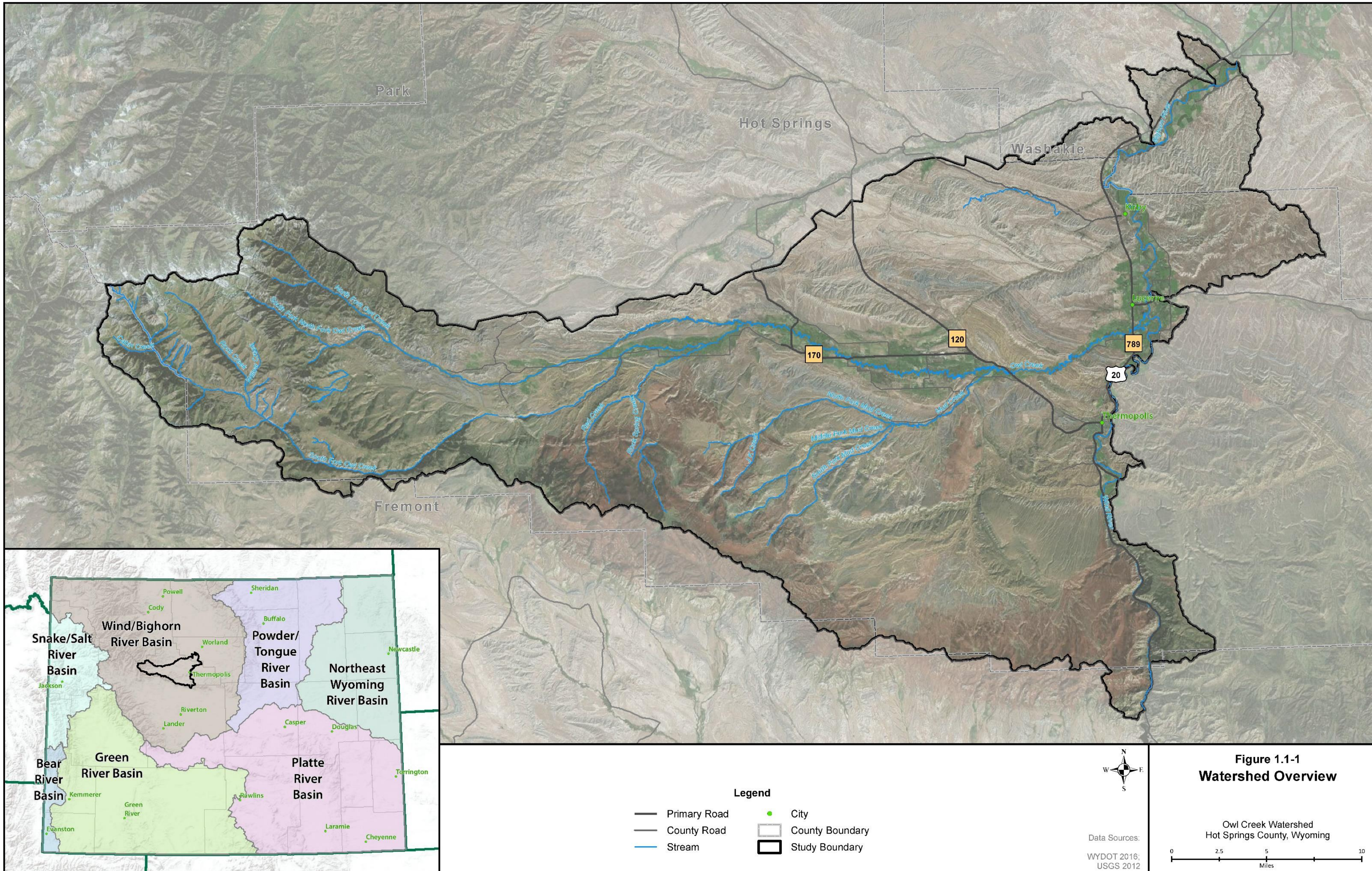

Figure 1.1-1
Watershed Overview

U:\Projects_2015\OwlCreekWatershed\Map\Mxd\Report\Fig_1_1-1_WatershedOverview.mxd 5/17/2017

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1.1 How to Use this Document

Sections 1 through 3 of this document serve as a Watershed Study that discusses the physical characteristics of the project area such as hydrology, biology, the current irrigation infrastructure, and population and land use. Sections 4 through 9 of this document serve as a Rehabilitation and Management Plan that presents proposed watershed improvement projects identified during the study, estimated costs for these projects, and potential funding and permitting sources. Section 10 provides a summary of the findings and recommendations of this document. Sections 11 and 12 and Appendices support earlier chapters.

Section 4 describes each project that was identified during the study based on project type. No landowner names are given. In general, projects are numbered from upstream to downstream. A brief project description is provided for each project identified. Within each project description is summary information that reference specific sections of the report with more specific information. Also included is the estimated cost to construct the project, potential funding sources that may be used for that project type, whether the project is a new project or is a rehabilitation of an existing structure or system, what potential issues were identified with each project that may need to be addressed before the project can move forward, such as habitat for protected plant species, and appropriate Net Effect Diagrams (NEDs) that can be used in permit applications. NEDs are helpful because they provide a summary of potential project benefits, which may be required for certain funding applications.

1.2 Project Overview

A watershed is a region of land that drains into a common waterway, such as a wetland, lake, or river system. Water falling as precipitation or reaching the surface from underground springs or seeps is channeled along slopes into soils and drainages. Because watersheds encompass both the terrestrial and aquatic landscape, the health of a watershed can affect many aspects of the ecosystem such as water holding capacity, ground water recharge, infiltration of rainwater, and water quality and quantity. As early as 1878, the explorer and geographer John Wesley Powell made the case for managing the arid western lands of the U.S. by watershed boundaries rather than general land areas, realizing that watersheds made sensible water management units (Powell 1879).

The State of Wyoming recognizes the benefits of basin planning efforts on the basis of watershed areas that do not necessarily adhere to political boundaries such as counties or states. This began in the 1930s as a result of the dust bowl era with the formation of special agricultural districts across the country whose boundaries were based on watersheds (WDO 2009). The relationship between stream systems, landscape function, and human health and communities was recognized over time. Landowners, community leaders, and scientists now understand that the health of the local landscape is integral to successful watershed management.

The WWDC, working with a local community sponsor, in this case, the HSCD, funds and supports the development of watershed studies that provide a comprehensive evaluation, analysis, and description of the resources (physical and biological) within the watershed. There are three prominent issues that are important considerations in a watershed information review and study.

The first issue is surface water storage. Water storage allows a community to address seasonal and annual shortages of water supply; augment late season stream flows to benefit riparian habitat, fisheries and wildlife; address flood impacts; and improve water quality and steam channel stability (WDO 2009).

The second issue is the evaluation of irrigation infrastructure and flow information that can be used to foster system rehabilitation and water conservation. This often focuses on ways to improve water use measurement and delivery. Improvements to on-farm irrigation water use can address annual or seasonal shortages of water supply or irrigation water delivery issues (WDO 2009).

The third issue is the enhancement and distribution of upland water resources for livestock and wildlife. This allows adjustments to grazing management and can lead to range resource improvement and improved storage of water within the soil resource. Benefits to the watershed, through plant community invigoration, and reduction of erosion and stream channel stabilization, can be achieved from water development projects being strategically implemented over the watershed (WDO 2009).

Other issues and opportunities, such as making beneficial use of produced water from oil and gas facilities and removal of high water demand invasive species, can also be important (WDO 2009).

The Owl Creek Watershed Study is one of several watershed planning studies completed on behalf of the WWDC and the Wyoming Water Development Office (WDO). Watershed investigations either completed or in the process of being completed include the following:

- Prairie Dog Creek Watershed Study
- Clear Creek Watershed Study
- Popo Agie River Watershed Study
- Kirby Creek Watershed Study
- Cottonwood Creek/Grass Creek Watershed Study
- Shell Valley Watershed Study
- Sweetwater River Watershed Study
- Thunder Basin Watershed Study
- Buffalo Creek Watershed Study
- Little Snake River Watershed Study
- Middle North Platte River Watershed Study
- Upper Green River Watershed Study
- Badwater/Poison Creek Watershed Study
- Snake River Watershed Study
- Medicine Bow River Watershed Study
- Upper Laramie River Watershed Study
- Middle North Platte – Glendo Watershed Study
- Bear River Watershed Study
- Upper North Platte River Watershed Study

As a direct result of these WWDC efforts, and with participation from local, state, and federal partners, numerous follow-up studies have been initiated and multiple projects have been constructed.

1.3 Project Need and Purpose

Water scarcity is a continual challenge within the Owl Creek Watershed, with annual surface water shortages in all hydrologic conditions and at most diversion points (WWDC 2003). Shortages for allocated surface water are estimated to range from 17% in wet years to 34% in dry years within the watershed (WWDC 2003). In addition, interviews with landowners and field observations by the LW team documented problems with irrigation systems on Owl Creek, Lucerne Canal, and the Kirby Ditch, including seepage or siltation, and diversion structures and flow measuring devices in poor or non-working condition. The team identified stock and irrigation reservoirs that no longer hold water and observed areas of upland rangeland that support palatable forage but are far from reliable water sources. There is significant opportunity for improved water storage, distribution, and use within the study area.

The purpose of this watershed study is to evaluate existing biological, water, and human-built systems located within the study area, and provide HSCD with recommendations that have potential to enhance watershed health and increase water availability for irrigation and livestock/wildlife use. This includes management opportunities and improvements that can be made to water conveyance, storage, and livestock management systems that would affect one or more landowners.

This report uses information compiled from published documents and web resources as well as interviews with federal, state, and local agencies, and people living or working within the study area. The report includes proposed improvements and management practices and their estimated costs, and lists potential funding sources from federal, state, and local entities that may be available for each project type[1].

1.4 Project Goals

The primary goal of the Owl Creek Watershed Level I Study is to comprehensively assess watershed conditions and needs in a report that will aid the local sponsor group and their partners to pursue projects and practice implementation strategies that may enhance the function of the Owl Creek watershed. This study encompasses the following secondary project goals:

1) Gather and summarize existing information describing the physical and biological conditions of the Owl Creek watershed, including land and water use, geomorphology, hydrology, and ecology
2) Engage the public in the planning process by providing information about the study and soliciting local knowledge about and the interest in updated management practices and project improvements.
3) Provide a qualitative and quantitative overview of benefits resulting from the implementation of best management practices and watershed improvements. Identify the needs and opportunities

[1] There are 3 levels of studies funding by the WWDC. Level I studies provide reconnaissance and analyses. Level II studies consist of two phases that serve first to address project feasibility and then, if the project is determined feasible, to review alternatives and refine the project design for a Level III funding request. Level III projects are construction projects. See Section 7 for further information.

to improve land and water management practices for irrigation, water distribution and storage, water quality, and ecosystem health.

5) Prepare preliminary concept designs and cost estimates for practical, economical improvement projects. Provide a framework to prioritize projects.

6) Provide an overview of permits and regulatory frameworks that may affect the implementation of projects.

7) Provide information on potential funding sources.

2 DATA COLLECTION AND MANAGEMENT

2.1 Project Meetings, Open Houses, and Interviews

The success of watershed studies is largely determined by the involvement of the local stakeholders. The input and participation of the residents of Hot Springs County played an essential role in the Owl Creek Level I Watershed Study. To increase public outreach and involvement, public meetings were organized by LW and included informal presentations conducted by LW team members followed by an open house where people could discuss project ideas with the LW team. In general, the objectives of the meetings were to:

- Introduce the consultant, cooperating agencies, and landowners to each other;
- Discuss the scope of the watershed study and any information or tools available to help interested parties understand and become involved with the study;
- Identify concerns and answer questions about the area's water and land resources; and
- Obtain stakeholder project ideas and request participation in the study effort.

Project meetings were held in Thermopolis, Wyoming, on the following dates:

- August 23, 2016
- October 12, 2016
- February 13, 2017
- March 9, 2017
- March 29, 2017
- October 24, 2017

2.1.1 Project Meetings and Open Houses – Synopsis

At the first three meetings, LW representatives were available to discuss the study one-on-one with landowners/stakeholders and to initiate development of watershed plan alternatives. Information summarizing the status of the project and the next steps to be accomplished were also presented. The project geographic information system (GIS) (outlined in **Section 2.3**) was demonstrated when appropriate to bring landowners up-to-date on the information that would ultimately be incorporated within it. After the formal introduction and project update, LW shifted to a "workshop" setting where landowners and other individuals could discuss project ideas with LW staff, mark proposed project locations in the GIS, and set up appointments to visit the proposed project site or discuss their ideas further.

The two March meetings were strictly workshops. Landowners were interviewed in the meeting room rather than conducting "on the ground" field-based meetings. GIS mapping was available to help locate and evaluate project location.

The October 24 meeting presented project findings and provided people with the opportunity to look through the draft report to review their projects. Attendees were reminded that all comments must be received by November 3.

2.1.2 Landowner Interviews

On-site landowner interviews generally occurred soon after the public meetings. Field efforts focused on inventory of irrigation systems, irrigation storage, upland range improvements, and stream channel conditions. An inventory of all projects identified are presented in **Section 4.3** under the categories listed below with each project being given a unique number within its category, such as 001, 002, 003, etc. The five project categories are:

- Irrigation System Improvements – ISYS
- Irrigation Storage Projects – ISTO
- Stream Channel Stabilization Projects – SCS
- Upland Range Improvements – URI
- Other Watershed Improvements – OWI

Projects identified during the workshop meetings are denoted with a “w” before the project identifier.

Field meetings with landowners were scheduled at landowners’ residences and properties where discussions focused on land and water resource concerns and issues specific to the landowners’ operations. Usually, the landowner gave a tour of the property for the LW field team. During these property visits, initial planning and conceptual project designs were discussed. These informal interviews provided valuable insight to the overall condition and assessment of the watershed.

Interviews conducted prior to January 2017 were completed on-site. Due to the high level of public interest in the study and the existing inventory of different types of projects, interviews conducted after January 2017 were conducted in the community meeting room of the Big Horn Federal Bank in Thermopolis.

2.2 Digital library

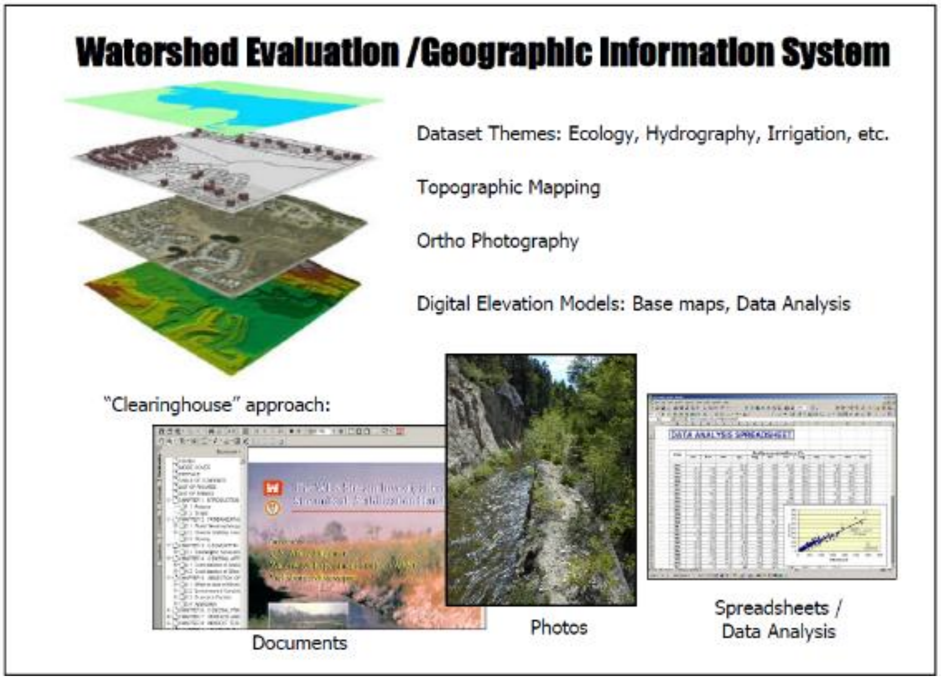
The Digital Library is a collection of documents, plats, maps, figures, spreadsheets, etc., pertaining to the study. Documents reviewed during the completion of this study were scanned and included in the Digital Library to the extent possible. Copyright-protected documents were not included in the Library; however, the cover page and publication information are included. Documents published by public agencies were included where feasible. The Digital Library consists of a spreadsheet listing the available documents and links to each; it can be searched or sorted depending upon the user’s needs. Individual document files can be directly accessed via the Digital Library through the project report, which will be stored on WWDC Water Resources Data System (WRDS), accessible at library.wrds.uwyo.edu, under “Online Documents.” Documents included in the Digital Library were obtained from the agencies listed in **Table 2.2-1**, among others.

Table 2.2-1 Reference Sources Used in Report	
Wyoming Geological Association Guidebook	Owl Creek Master Plan, Level I, Final Report
Upper North Platte Watershed Study Level I, Final Report	Association of Petroleum Geologists Bulletin
Wyoming Game and Fish Department	U.S. Census Bureau
Bureau of Land Management	U.S. Department of Agriculture
Wyoming State Geological Survey	Natural Resources Conservation Service
Interagency Ecological Site Handbook for Rangelands	Western Regional Climate Center
United States Fish and Wildlife Service	Wyoming Interagency Spatial Database and Online Management System
U.S. Army Corp of Engineers	Wyoming Department of Environmental Quality
Environmental Systems Research Institute	Wyoming Department of Transportation
University of Wyoming	Wyoming Oil and Gas Conservation Commission
Hot Springs County Planning and Zoning Commission	Wyoming State Historic Preservation Office
Canadian Geotechnical Journal	Wyoming Water Development Commission
U.S. Geological Survey	Wyoming Weed and Pest Council
Geological Society of America Bulletin	
Natural Resource and Energy Explorer	

2.3 Geographic Information System (GIS)

A Geographic Information System (GIS) file geodatabase contains data collected from various government agencies, past WWDC projects in the Owl Creek Study Area, and all field data collected as part of this study. A GIS can be thought of as a powerful three-dimensional mapping tool that can be used to evaluate and compare spatial data about a wide range of topics. Numerous maps can be “stacked” to overlay information; each map, or “theme”, incorporates data, or “attributes” pertaining to the theme. For example, a theme showing the location of irrigation ditches could also include numerical data regarding landowners served by the ditch or acreage irrigated by the ditch, and the various documents prepared or collected during the course of the watershed study. A model of GIS is included in **Figure 2.3-1**.

The GIS information in this study was reviewed, along with data collected during inventory efforts and other resources, to evaluate natural resource conditions and assist in the planning and cost estimating of projects proposed in **Section 4**. **Table 2.3-1** below presents a comprehensive list of datasets, feature classes within each dataset, a brief description of each dataset, and notation of any hyperlink access to external databases, spreadsheets, documents, subject websites, or photographs. Datasets represent a collection of related feature datasets of a specific category. The distinct datasets represent thematic collections by feature type and also encapsulate collections of previous WWDC studies in the area, including this study. The information generated through this study can be found in three of the datasets (Analysis, Field, and Proposed Projects). All datasets developed by LW include FGDC compliant metadata. Third party source metadata is either included or, where absent, includes a “credit” statement detailing the data source.



Source: Anderson Consulting 2015.

Figure 2.3-1 Example of Owl Creek Watershed Study GIS structure.

Data collection was either field delineated or remotely gathered during the course of this study by using a gps enabled iPad. For all features that were field delineated, data were collected using an Arrow 100 unit coupled with the iPad to ensure sub-meter accuracy in accordance with Task 9 of the original scope of services defined by WWDC.

All map figures presented in this report reference the geodatabase. Each figure has been provided as an ".mxd" ArcGIS project file to WWDC for future investigations and development. GIS software (ArcMap 10.x) is required to view and utilize the data. However, free 'shareware' data viewers (ArcGIS Explorer: http://www.esri.com/software/arcgis/explorer) are available which enable the user limited capabilities to view and query the data.

It is important to note that data presented in the project GIS and within this report are subject to change with time as agencies responsible for these data frequently update their databases. The user is encouraged to obtain the most current data available to meet the needs of future endeavors utilizing the project GIS.

Table 2.3-1 Comprehensive List of Datasets		
Analysis	NWI_HUC10_Identity	National Hydrography dataset by HUC10
Analysis	OwlCr3_County_Intersect	Analysis of county acreage within OC project boundary
Base	Cities_WY	Wyoming cities (point)
Base	Mask	Regional mask of OC project boundary
Base	WRIR_Full	Wind River Indian Reservation (complete)
boundary	OwlCreek3_16FinalJMP	OC project boundary
boundary	states	US States
boundary	WRIR	Wind River Indian Reservation (clipped to OC project boundary)
boundary	WY_county	Wyoming counties
boundary	WY_town	Wyoming town limits
cadastral	first	PLSS sections
cadastral	Fremont_parcels	Fremont County parcels
cadastral	HotSprings_parcels	Hot Springs County parcels
cadastral	ladesc	PLSS quarter-quarter sections (40 acres)
cadastral	SMA	Wyoming surface land ownership
cadastral	Township	PLSS townships
cadastral	Washakie_parcels	Washakie County parcels
Cultural	BridgerTrail	Historic Bridger Trail route
Ecology	AvgAnnualPrecip	Average annual precipitation
Ecology	NWS_AnnualRainfall_contours	National Weather Service Annual rainfall contours (inches)
Ecology	NWS_ObsStations	National Weather Service Observation Stations
Ecology	ULT_AOI	Utes Ladies' Tresses Area of Potential Impact
Field	Ditch	Irrigation Ditch
Field	ErosionPt	Erosion Feature
Field	Irr_Problem	Failing or Inadequate Irrigation Feature
Field	IrrPt	Irrigation Feature Point of Interest
Field	Misc_Obs	Miscellaneous Observation
Field	Misc_Photos	Miscellaneous Phone Point
Field	Pipeline	Proposed Pipeline Feature
Field	Rosgen_pt	Delineated Rosgen Point

Table 2.3-1 Comprehensive List of Datasets		
Field	Water_pt	Water Feature of Interest
Field	Weed_pt	Noxious Weed Area Identified
geology	bedgeol_2010	Bedrock geology
geology	surfgeo_2003	Surficial geology
geology	USGS_earthquake_1900_20161111	USGS earthquakes 1900 - 2016
hydrography	BoysenRes	Boysen Reservoir (outside OC project boundary)
hydrography	HU10	HUC 10 level boundaries relevant to OC project boundary
hydrography	HU12	HUC 12 level boundaries relevant to OC project boundary
hydrography	HU2	HUC 2 level boundary relevant to OC project boundary
hydrography	HU4	HUC 4 level boundary relevant to OC project boundary
hydrography	HU8	HUC 8 level boundary relevant to OC project boundary
hydrography	NHD_Flowline	National Hydrography dataset within OC project boundary
hydrography	NHD_Perennial2	National Hydrography dataset Perennial streams only
hydrography	NHD_Point	National Hydrography dataset point data
hydrography	NHD_Rosgen_ned10	National Hydrography dataset point data for Rosgen Analysis
hydrography	NHD_Waterbody	National Hydrography dataset waterbodies
hydrography	NWI_Wetlands	National Wetlands Inventory within OC project boundary
hydrography	PFC_EVAL_Completed	Source BLM RAIDS database
hydrography	Watershed_HUC8	HUC8 boundaries in Wyoming
hydrography	Watershed_WWDC	WWDC Regional Watershed boundaries
hydrography	WSGS_WY_Springs	Springs (Wyoming State Geological Survey)
industry	BLM_Community_Pits	Gravel pits? (Mahoney_20161129 - no information provided)
industry	BLM_Pits_AuthorizedArea	Gravel pits? (Mahoney_20161129 - no information provided)
industry	BLM_Pits_DisturbedArea	Gravel pits? (Mahoney_20161129 - no information provided)
industry	LgActiveMine_WBRB_select	Active large mines in the Wind/Bighorn River Basin permitted by the Wyoming Department of Environmental Quality's Land Quality Division.
industry	PitsQuarries_WBRB	This data set contains and shows the map reader mines, pits, quarries, mills, plants, and occurrences of industrial minerals and construction materials in the Wyoming Wind/Bighorn River Basin area.
industry	WDEQ_Mine_Permits	Mines permitted with Wyoming Department of Environmental Quality

Table 2.3-1 Comprehensive List of Datasets		
industry	WOGCC_PA_20161101	Wells (plugged and abandoned [P&A]) - WOGCC
industry	WOGCC_WH_20161101	Wells (other than P&A) - WOGCC
industry	WyoBen_Mine_OC_PT0321	Permit boundary for non-coal mine PT0321 in Wyoming.
irrigation	Irr_Lands	Irrigated lands (WBH Basin Plan 2002)
irrigation	Irr_Lands_crop_analysis	Cropped Lands (WBH Basin Plan Update 2010)
irrigation	SEO_POD	Points of Diversion (State Engineer's Office)
irrigation	SEO_WaterRights	State Engineer's Office water rights
irrigation	wbhpod	Points of Diversion (WBH Basin Plan 2002)
KirbyID_Cons_2010	KirbyDitch_PressureProfile	Kirby Ditch - Kirby Irrigation District Study data 2010
KirbyID_Cons_2010	KirbyFeatures_pt	Kirby irrigation features - Kirby Irrigation District Study data 2010
KirbyID_Cons_2010	KirbyID_bnd	Kirby Irrigation District boundary - Kirby Irrigation District Study data 2010
KirbyID_Cons_2010	KirbyIrrLands	Kirby Irrigation District irrigated lands - Kirby Irrigation District Study data 2010
landuse	GrazingAllotOperator	BLM grazing allotments by operator
landuse	GrazingAllotPasture	BLM grazing allotments by by pasture
landuse	USFS_SNF_rmu_subunit	Shoshone National Forest subunits
landuse	USFS_SNF_rmu_unit	Shoshone National Forest units
landuse	WeedMgmtAreas	Areas where organized efforts by private, local city and county, state, and federal individuals have been made to eradicate or control invasive and/or non-native weed species in the Bureau of Land Management, Bighorn Basin, Worland Field Office, Wyoming
landuse	wfo_InvasiveNonNativePlants	Invasive, non-native weed species (exotic brome, Downy and Japanese) acres found in Bureau of Land Management, Worland Field Office, Wyoming.
OC_Cons_2006	DevelopedAreas	Developed Areas, Owl Creek Conservation District 2006 Study
OC_Cons_2006	Homes	Homes, Owl Creek Conservation District 2006 Study
OC_Cons_2006	Lucerne_WaterSewerDist_bnd	Lucerne WaterSewerDist_bnd, Owl Creek Conservation District 2006 Study
OC_Cons_2006	OC_ID_bnd	OC_ID_bnd, Owl Creek Conservation District 2006 Study
OC_Cons_2006	OC_ID_Buffers	OC_ID_Buffers, Owl Creek Conservation District 2006 Study

Table 2.3-1 Comprehensive List of Datasets		
OC_Cons_2006	Parcel_ExcludeOut	Parcel_ExcludeOut, Owl Creek Conservation District 2006 Study
OC_Cons_2006	Pipeline_TreatedWater	Pipeline_TreatedWater, Owl Creek Conservation District 2006 Study
OC_Cons_2006	Pumps	Pumps, Owl Creek Conservation District 2006 Study
OC_Cons_2006	Tanks	Tanks, Owl Creek Conservation District 2006 Study
OC_Cons_2006	UndevelopedAreas	UndevelopedAreas, Owl Creek Conservation District 2006 Study
OC_Cons_2006	Zoning_Thermopolis	Zoning_Thermopolis, Owl Creek Conservation District 2006 Study
OC_ID_Storage_2008	PropAccessRd_SEH	PropAccessRd_SEH, Owl Creek Irrigation District Storage 2008 Study
OC_ID_Storage_2008	PropAnchorIsolationDikes_SEH	PropAnchorIsolationDikes_SEH, Owl Creek Irrigation District Storage 2008 Study
OC_ID_Storage_2008	PropCanals_SEH	PropCanals_SEH, Owl Creek Irrigation District Storage 2008 Study
OC_ID_Storage_2008	PropReservoirs_SEH	PropReservoirs_SEH, Owl Creek Irrigation District Storage 2008 Study
OC_ID_Storage_2008	PropSpillways_SEH	PropSpillways_SEH, Owl Creek Irrigation District Storage 2008 Study
OC_MP_2004	DiversionStructures_pt	DiversionStructures_pt, Owl Creek Master Plan 2004 Study
OC_MP_2004	LateralDir_arrow	LateralDir_arrow, Owl Creek Master Plan 2004 Study
OC_MP_2004	LucerneFeatures_pt	LucerneFeatures_pt, Owl Creek Master Plan 2004 Study
OC_MP_2004	LucerneStructures_pt	LucerneStructures_pt, Owl Creek Master Plan 2004 Study
OC_MP_2004	ProposedDiversions_pl	ProposedDiversions_pl, Owl Creek Master Plan 2004 Study
OC_MP_2004	ProposedReservoirs_2004	ProposedReservoirs_2004, Owl Creek Master Plan 2004 Study
OC_MP_2004	RecordingStn_pt	RecordingStn_pt, Owl Creek Master Plan 2004 Study
OC_MP_2004	TrialDiversions_pt	TrialDiversions_pt, Owl Creek Master Plan 2004 Study
Proposed_Projects	MapGrid	Data driven pages extent file for proposed project figures
Proposed_Projects	MapGrid2	Data driven pages extent file for proposed project figures
Proposed_Projects	Project_Labels	label placement (point) feature class for proposed project figures
Proposed_Projects	Project_Linear	Proposed project linear features
Proposed_Projects	Project_Points	Proposed project point features
Proposed_Projects	Project_Reservoir	Proposed project reservoir boundaries
Proposed_Projects	Prop_Projects	Proposed project general placement points
Proposed_Projects	Prop_Projects_Workshop	Proposed project general placement points (workshop developed)
soils	gsmsoil_mu_a_wy_clip	STATSGO2 general soils layer within OC project boundary
soils	soilmu_wy043	Washakie County SSURGO soils

Table 2.3-1 Comprehensive List of Datasets		
soils	soilmu_wy647	Wind River Indian Reservoir SSURGO soils
soils	soilmu_wy656	Shoshone National Forest SSURGO soils
transportation	railroads	general railroads layer (ESRI) within OC project boundary
transportation	USA_Roads	general roads layer (ESRI) within OC project boundary
transportation	WY_MiscRoads	WYDOT miscellaneous roads
transportation	WYDOT_County_Roads	WYDOT county roads
transportation	WYDOT_Highways	WYDOT highways
utilities	TransmissionLines	Transmission lines in the OC project boundary
water	BLM_developed_springs	BLM developed springs
water	BLM_guzzelers	BLM guzzelers
water	BLM_pipelines	BLM pipelines
water	BLM_reservoirs	BLM reservoirs
water	BLM_wells	BLM wells
water	DEQ_303d_Streams	Wyoming DEQ 303d streams
water	DEQ_MonitorStn	Wyoming DEQ monitoring stations
water	HSC_catchment_guzzler	Hot Springs County guzzlers
water	HSC_pipelines	Hot Springs County pipelines
water	HSC_reservoirs	Hot Springs County reservoirs
water	HSC_springs	Hot Springs County springs
water	HSC_water_storage	Hot Springs County water storage facilities
water	HSC_wells	Hot Springs County wells
water	SEO_Streamgages	State Engineer's Office stream gages
water	SEO_Wells	State Engineer's Office wells
water	Site9_DeepAquifer	Deep Aquifer site
water	USBR_Streamgages	US Bureau of Reclamation (USBR) stream gages
water	USGS_Streamgages	USGS stream gages
water	WBH_FutureWaterUse	Future water use opportunity sites (WBH Basin Plan 2002)
water	WQ_Monitor	water quality monitor stations (WBH Basin Plan 2002)
water	WYPDES_Outfalls	WYPDES outfalls (WBH Basin Plan 2002)

Table 2.3-1 Comprehensive List of Datasets		
wildlife	Aquatic_CrucialHabitat	location of habitat priority areas in Wyoming developed as part of the Wyoming Game and Fish Department Strategic Habitat Plan (SHP, revised January 2015).
wildlife	BighornSheep_CrucialRange	big game crucial range
wildlife	Combined_CrucialHabitat	combined aquatic and terrestrial crucial habitat layers
wildlife	CrucialStreamCorridors	Crucial stream/river corridors for aquatic species (WGF 2007)
wildlife	Elk_CrucialRange	big game crucial range
wildlife	Moose_CrucialRange	big game crucial range
wildlife	MuleDeer_CrucialRange	big game crucial range
wildlife	Pronghorn_CrucialRange	big game crucial range
wildlife	SG_Corev4_20150729	Sage-Grouse (sg) Core Areas as defined by the Governor's Sage Grouse Implementation Team (SGIT) on 3.17.08 in Lander, WY.
wildlife	SWAP2010_AquaticConservationAreas	Aquatic conservation areas were developed for each of the 6 basins defined and described in Wyoming's 2010 SWAP.
wildlife	Terrestrial_CrucialHabitat	Location of habitat priority areas in Wyoming developed as part of the Wyoming Game and Fish Department Strategic Habitat Plan (SHP, revised January 2015).
wildlife	WGF_XYPassageStructures	Locations of known diversion or dam structures on Owl Creek, from Wyoming Game and Fish Department, received 3/31/2017.
wildlife	YellowstoneCutthroat_KnownRange	Yellowstone Cutthroat Trout (Oncorhynchus clarkii bouvieri) current known range in Wyoming developed for Wyoming's State Wildlife Action Plan (SWAP) 2010.

3 WATERSHED DESCRIPTION AND INVENTORY

This section provides an overview of the existing conditions of human and natural resources found in the Owl Creek watershed, including demographics, land use, climactic, topographic, geologic, edaphic (soil), and vegetative conditions. These factors form the general structure for the watershed.

3.1 Demographics and Land Use

3.1.1 Land Ownership

There are approximately 599,703 acres and portions of three counties within the Owl Creek watershed study area (**Figure 3.1.1-1**). The surface lands within the study area are owned or managed by a variety of entities. The Wind River Indian Reservation (WRIR) manages the largest share of land (approximately 37% of the study area), federal agencies (primarily the Bureau of Land Management [BLM]) manage approximately 33%, privately owned lands makes up approximately 26%, the state of Wyoming owns approximately 3%, and the remaining land (less than 1%) is owned by city or county governments (BLM 2016) (**Table 3.1.1-1**).

Table 3.1.1-1 Acreage of Land by Surface Landowner within the Owl Creek Watershed Study Area

Landowner		Acres	Percentage of Total Acres
Wind River Indian Reservation		222,996	37.18
Federal Agencies			
	Bureau of Land Management	180,110	30.03
	U. S. Forest Service	17,843	2.98
	Bureau of Reclamation	0.34	0.00
Private		156,237	26.05
State of Wyoming		19,575	3.27
Water		1,866	0.31
Local Government		1,076	0.18
Total		599,703	100

Source: BLM 2016 Metadata, GIS landownership layer

Generally, surface and sub-surface (mineral) rights are held by the same land owner/manager. Mineral rights include minerals such as clay and gypsum, coal, or oil. However, some lands are “split estate,” that is, surface is owned by one entity while the mineral rights are owned by the federal government or another entity. According to Wyoming Environmental Quality Act § 3-11-406(b)(x), on split estate lands, the entity with mineral rights must get written consent from the surface landowner before a mining and reclamation plan can be approved. The Wyoming Department of Environmental Quality (WDEQ), Land Quality Division, oversees the permitting process.

3.1.2 Population

The study area falls primarily within Hot Springs County (covering approximately 47% of the county), extending into the northern edge of Fremont County (less than 3 miles at the furthest reach), and approximately 7.5 miles into the southern edge of Washakie County along the Bighorn River corridor (**Figure 3.1.2-1**). The estimated human population within the study area is 4,487 (U.S. Census Bureau 2015), with the highest densities along the Hwy 20/789 corridor, particularly in the towns of Thermopolis, Lucerne, and Kirby.

3.1.3 Transportation

Within the study area, there are approximately 205 miles of arterial and collector roads with paved or maintained gravel surfaces (approximately 113 miles of paved highways, and approximately 92 miles of county roads). An additional 2,091 miles of smaller local roads, primarily unmaintained gravel or two-tracks, complete the road network within the study area. Highway 20/789 runs north along the eastern boundary of the watershed, and County Roads 120 and 170 run northwest between Thermopolis and Meeteetse WYDOT 2016) (**Figure 3.1.2-1**).

In addition to roadways, there are approximately 40 miles of rail line operated by the Burlington Northern Railroad (ESRI 2008). The rail line follows the Bighorn River corridor through the study area (**Figure 3.1.2-1**).

3.1.4 Agricultural Land Use

Acreage in Agriculture

The primary land use within the Owl Creek watershed is agricultural. Approximately 95% of agricultural land within the watershed is used for rangeland/pastureland and livestock production. The other 4% of agricultural land is cropland. Approximately 80% of the irrigated cropland in this area is used to cultivate grass and alfalfa used in hay, which is used to feed area livestock. The remaining irrigated acreage is planted primarily in barley, sugar beets, and dry beans (USDA 2016).

Due to the physical characteristics of the Owl Creek drainage basin, existing irrigated lands do not extend far from the source of water supply, subsequently distribution ditches are relatively long. Based on available information sources including the Wyoming State Engineers Office (WSEO), Owl Creek Irrigation District personnel, and the 2004 Owl Creek Master Plan (Nelson Engineering 2004), there are 56 diversions for irrigation ditches within the Owl creek Drainage. There is one diversion point off the Bighorn River below the confluence of that river and Owl Creek that serves irrigators on the Lucerne Pumping Plant and Canal Company and the Cyclone Ditch. The Kirby Ditch also diverts from the Bighorn River and is within the watershed study area. **Figures 3.1.4-1 through 3.1.4-3** are maps of study area showing diversion and irrigation ditch locations.

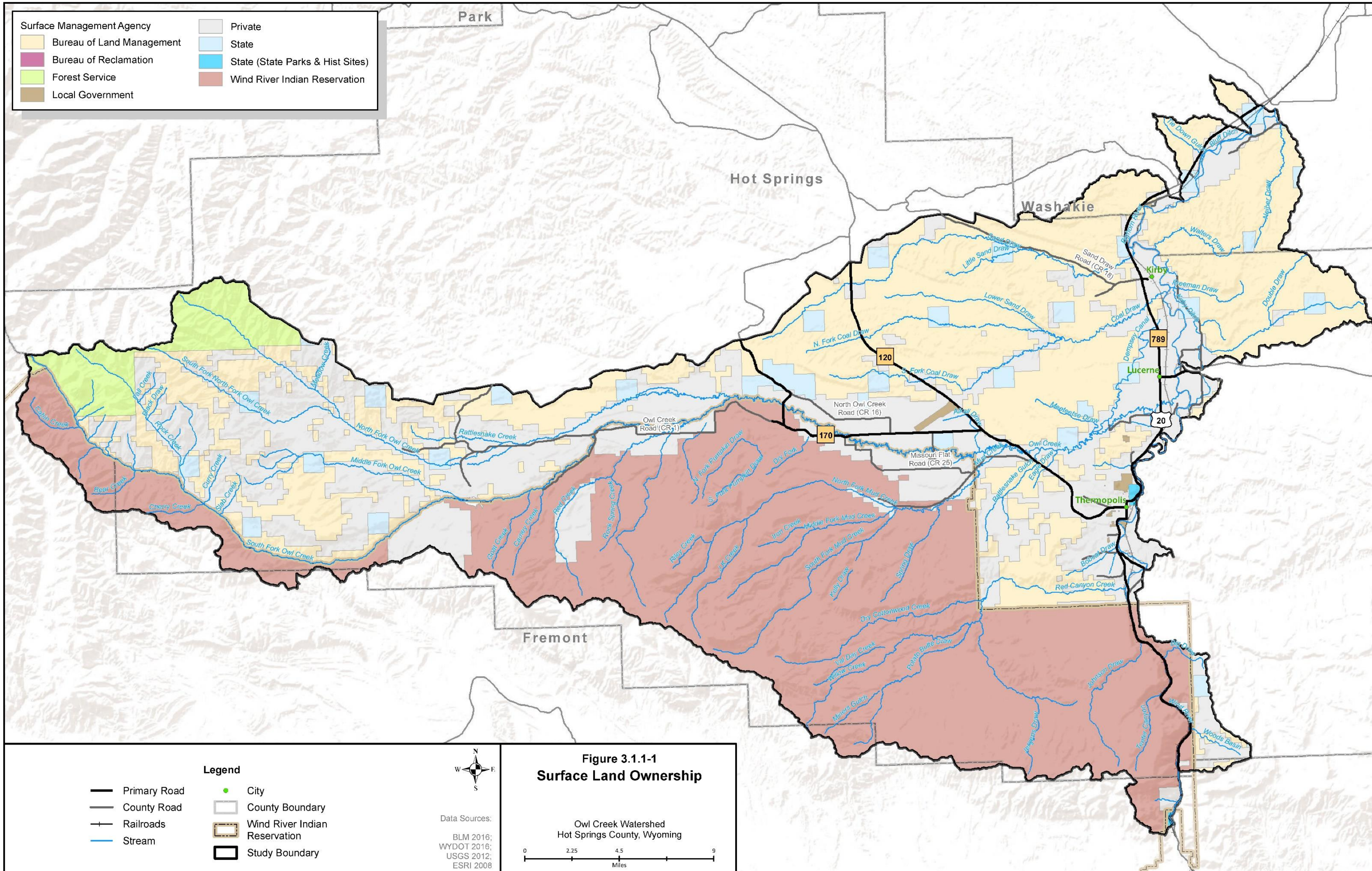


Figure 3.1.1-1
Surface Land Ownership

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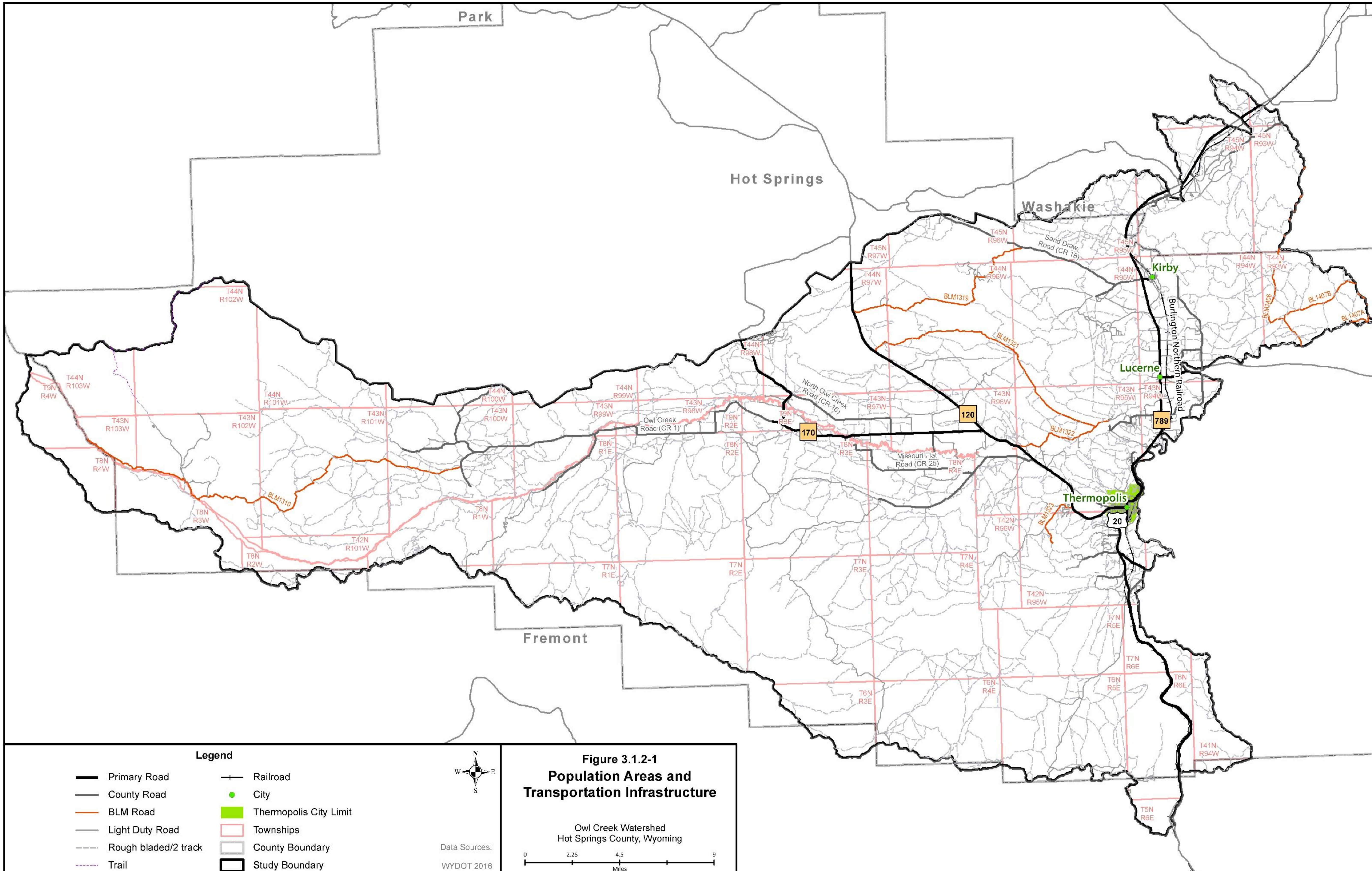

Figure 3.1.2-1
Population Areas and Transportation Infrastructure

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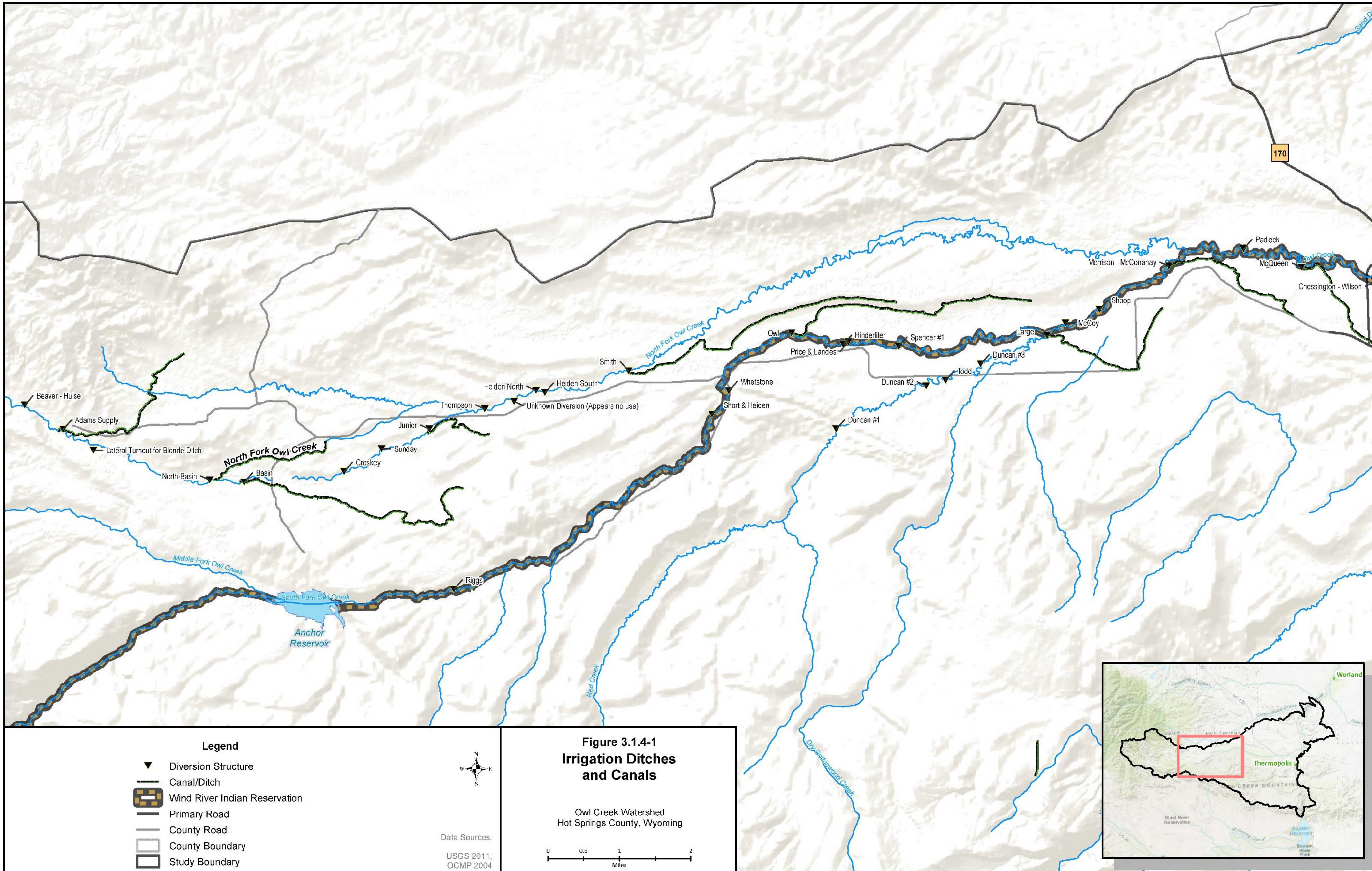

Figure 3.1.4-1
Irrigation Ditches and Canals

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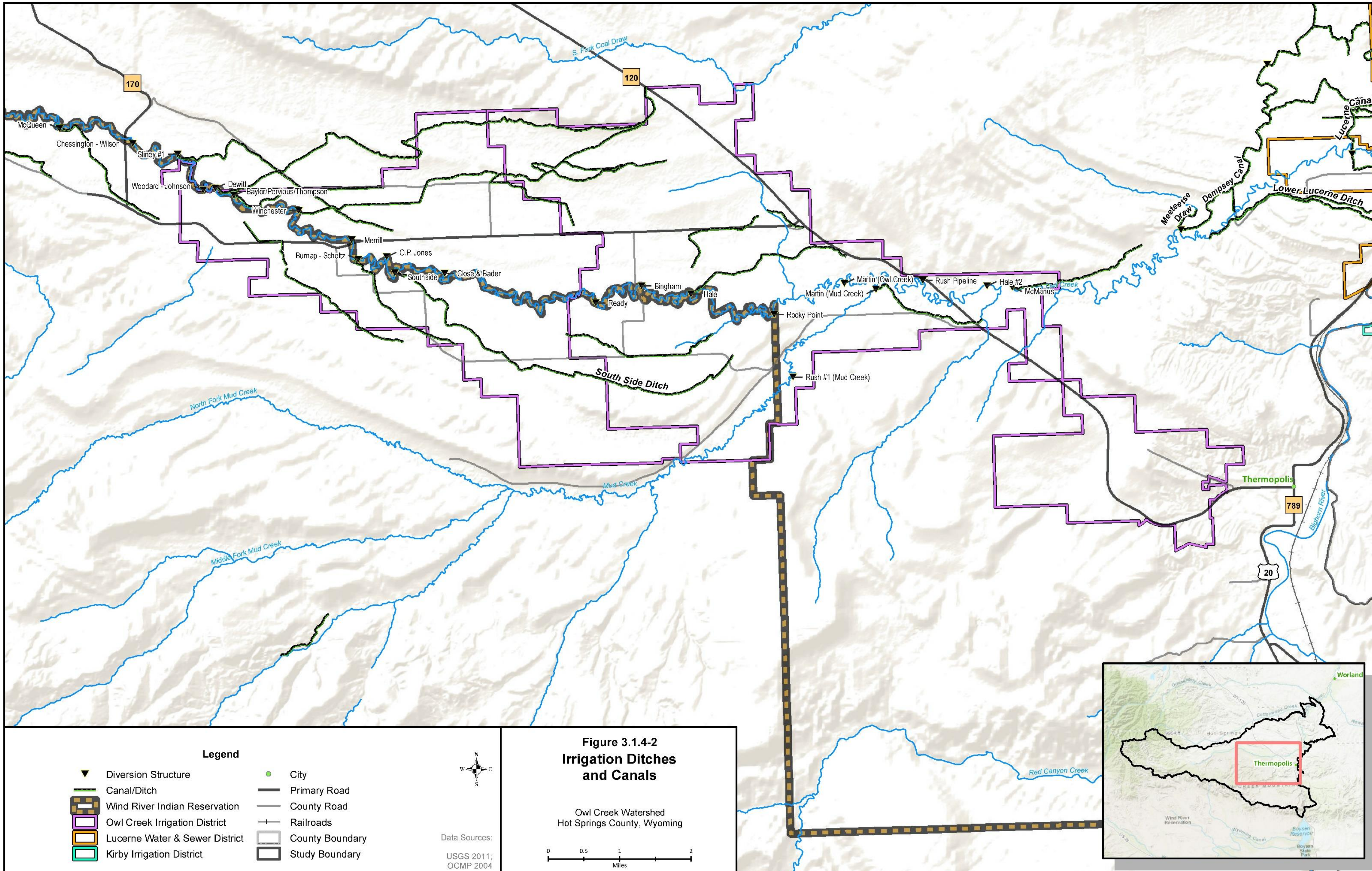

Figure 3.1.4-2
Irrigation Ditches and Canals

Owl Creek Watershed
Hot Springs County, Wyoming

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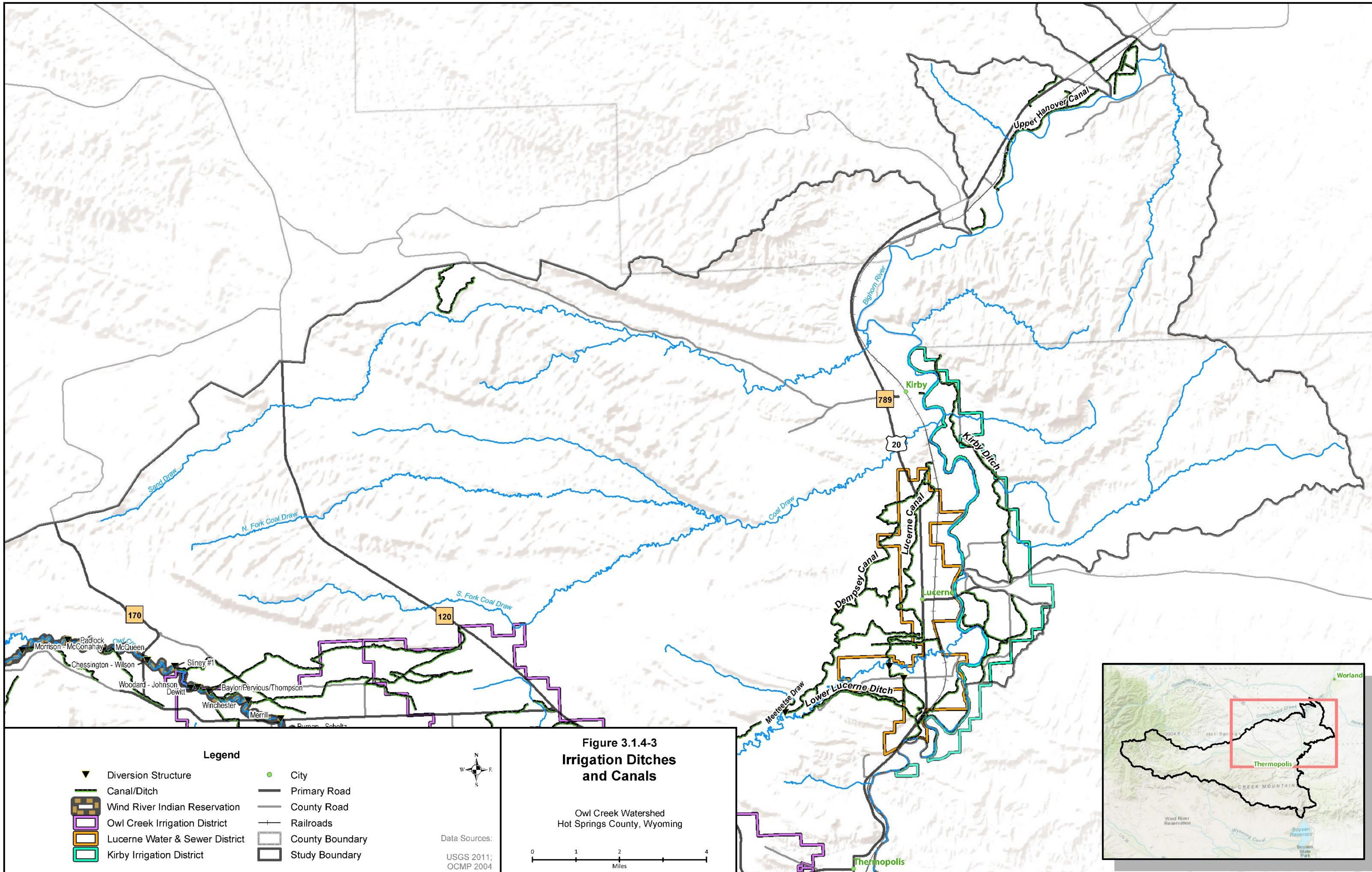
Figure 3.1.4-3
Irrigation Ditches and Canals
Owl Creek Watershed
Hot Springs County, Wyoming
Legend
Diversion Structure
Canal/Ditch
Wind River Indian Reservation
Owl Creek Irrigation District
Lucerne Water & Sewer District
Kirby Irrigation District
City
Primary Road
County Road
Railroads
County Boundary
Study Boundary
Data Sources:
USGS 2011;
OCMP 2004
0 1 2 4
Miles
Upper Hanover Canal
Bighorn River
Kirby
789
20
Kirby Ditch
Lucerne Canal
Dempsey Canal
Lucerne
Lower Lucerne Ditch
Meeteetse Draw
Coal Draw
Sand Draw
N. Fork Coal Draw
S. Fork Coal Draw
170
120
Padlock
Morrison - McConahay
McQueen
Chessington - Wilson
Sliney #1
Woodard - Johnson
Dewitt
Baylor/Pervious/Thompson
Winchester
Merrill
Thermopolis
Worland
Wind River Reservation
Boysen Reservoir
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The 2010 Wind-Bighorn Update lists 22,520 irrigated acres within the Owl Creek Drainage. This area includes the tributaries of the Big Horn River on the west from the Owl Creek Mountain Divide but does not include water from the Bighorn River or drainages, such as Kirby Creek, in that figure. Using data from the WSEO Hydrographer's Report (2016), water from Kirby Ditch was used to irrigate 3,165 acres, and water from the Lucerne Canal was used to irrigate 4,378 acres for a total estimate of 30, 063 acres irrigated within the study area in recent years. However, a detailed GIS evaluation of actively irrigated acres performed for this study identified only 18,019 acres in irrigation, based on 2014 NAIP imagery, and shown in **Table 3.1.4-1**. This acreage breakdown is likely more accurate than the 30,000 acre estimate listed above, and suggest that not all available acreage is irrigated on a yearly basis.

Table 3.1.4-1 Irrigated Acres in 2016 in Study Area

Region	Pivot	Side Roll	Other	Totals
Upper/Middle	442	43	13,381	13,866
Lucerne	153	17	N/A	170
Kirby	330	103	N/A	433
Upper Hanover	754		890	1,644
Outlier (N of Thermop Bluff Canal)	265		940	1,205
Outlier (S of Thermop)	116		585	701
Totals	**2,060**	**163**	**15,796**	**18,019**

Historic aerial imagery and the Owl Creek Master Plan Level 1 Study completed in 2004 indicate that irrigated acreage has, over time, remained stable in the study area. For Owl Creek in particular, fluctuations in runoff most likely influence the variation in irrigated acreage each year. The canals, fed by the Bighorn River, have adequate water for irrigation each year. Flood irrigation is, by far, the most common irrigation method used in the study area. Based on a review of 2014 aerial imagery, two center pivots are located north of the Hot Springs County airport and appear to use well water, two center pivots located south of Thermopolis and adjacent to the Big Horn River appear to use river water, and two center pivots are located adjacent but up-gradient of the Kirby Ditch. It is not known how many acres within the study area are irrigated with gated pipe although, based on field observations, the number is quite small.

Crops grown, typical yield, etc.

Table 3.1.4-2 lists the dominant crops produced within the Owl Creek Watershed and the amount of acres in production by crop type. Sugar beets, dry beans, corn, and barley are primarily grown in the lower reaches of the study area that are irrigated by the Bighorn River, while alfalfa, pasture grass, and pastureland are principle uses of land irrigated by Owl Creek.

Table 3.1.4-2 Crop Type and Acres in Production per Crop Type

Crop Type	Acres
Corn	173
Barley	1,924
Alfalfa	5,270
Pasture grass	8,143
Sugar beets	602
Dry Beans	502
Rangeland/Pastureland	530,979

Source: USDA. 2016. 2015 Cropland Data Layer. https://www.nass.usda.gov/index.php

The crop irrigation requirement (CIR) represents the theoretical amount of water that is needed by the crop. Water is transported from a river to the crop through a series of conveyance facilities and on-farm facilities. These facilities lose a portion of the water that is transmitted through them before the water reaches the crops due to headgate leakage, evaporative losses, seepage, etc. These inefficiencies must be accounted for in determining the monthly diversion requirement for any crop.

The CIR is divided by efficiency to determine full supply diversion requirements. Efficiencies shown below were estimated from previous WWDC basin studies, watershed studies and irrigation plans within the Wind-Bighorn Basin. Average annual efficiencies developed for the Wind-Bighorn Basin Plan Update (2010) are based on a spreadsheet model and range from 24 percent on smaller irrigation systems to 43 percent on larger systems A summary of estimated conveyance efficiencies, CIR and diversion requirements for the Owl Creek is presented in **Table 3.1.4-3**.and **Table 3.1.4-4**. Further information about water availability and gage data is found in **Section 3.3.4** through **Section 3.3.6.**

Table 3.1.4-3 Conveyance Efficiency Crop Irrigation Requirements for Owl Creek1, 2

March	April	May	June	July	Aug	Sept	Oct	Average
19%	19%	21%	28%	36%	41%	21%	17%	25%

[1] Source: Wind-Bighorn Basin Plan Update (2010)

[2] The Upper Bighorn River is not included in this table because it extends from Wedding of the Waters to Basin, WY, only a portion of which is in the study area.

Table 3.1.4-4 Crop Irrigation and Diversion Requirements for Owl Creek1, 2

Irrigated Acres	Annual CIR (ac-ft)	Annual CIR (ac-ft./ac)	Diversion Requirement (ac-ft.)	Diversion Requirement (ac-ft./ac)
22,518	40,957	1.82	140,220	6.23

[1] Source: Wind-Bighorn Basin Plan Update (2010)

[2] The Upper Bighorn River is not included in this table because it extends from Wedding of the Waters to Basin, WY, only a portion of which is in the study area.

3.1.5 Recreational Use

Federal, state, and local government and private lands provide many opportunities for recreation within the watershed. The BLM and USFS, whose federal mandates require them to manage land use not only for ecological and economic values, but recreation as well, administer approximately 33% of the land within the study area. The waters of the Bighorn River and its tributaries provide access for fishing, boating, and tubing, while bathers relax in the hot springs of Thermopolis. Activities such as hunting, camping, hiking, rockhounding, bird-watching, horseback riding, snow-shoeing, cross-country skiing, and snowmobiling are enjoyed in the uplands. There are seven areas within Hot Springs County that are formally categorized by the county commissioners as lands whose sole or principal use is for recreation (Hot Springs County 2002): Hot Springs State Park, Anchor Reservoir, Wedding of the Waters Boat Ramp Area, Cedar Mountain, the Bighorn River, H Diamond W 4-H Camp, and Shoshone National Forest.

3.1.6 Rangeland Use

Grazing Allotments and Administration

Grazing on federal lands within the Owl Creek watershed is administered by the United States Forest Service (USFS) and the BLM. Grazing on WRIR within the Owl Creek watershed is administered by the Bureau of Indian Affairs (BIA).

The USFS-administered allotments are located within the Shoshone National Forest at higher elevations in the western portion of the watershed. There are 3 USFS allotments covering 17,539 acres, or 0.02 percent, of the project area. The BLM allotments are located at lower elevations and extend across the north side of the Owl Creek drainage. There are 82 BLM allotments, covering 272,306 acres, or 73.5%, of the project area. There are 3 USFS allotments covering 17,540 acres, or 0.02% of the project area. The BIA-administered grazing lands are located on the south side of owl creek and its tributaries and include most of the drainages flowing north off the Owl Creek Mountains. There are six grazing units (similar to allotments) covering 222,996 acres, or 37.18%, of the project area. Only enrolled Tribal members can utilize WRIR grazing lands. A summary of grazing land information is shown in **Table 3.1.6-1**. Each of these land management areas are shown on **Figure 3.1.6-1**.

Table 3.1.6-1 BLM, USFS, and BIA Grazing Allotment Data within the Project Area

	BLM Grazing Allotments	USFS Grazing Allotments	Tribal Lands held in trust by BIA
Number of Allotments	82	3	6
Total Acres	272,306	17,540	222,996
Percentage of Project Area	73.5%	0.02%	37.18%

Source: Cody, WY USFS Office and Worland BLM Field Office

BLM and USFS allotments consist entirely of public lands managed by the federal government. Note that some of these allotments may be located primarily in adjacent watersheds and “spill” over the watershed divide. On USFS lands, livestock grazing is permitted and governed through a permit system, Allotment Management Plans (AMPs) and Annual Operating Instructions. General grazing management on Shoshone National Forest lands is addressed in Shoshone National Forest Land Management Plan (LMP) 2015 Revision (USFS 2015 LMP, pages 69 – 72). The Shoshone National Forest uses AMPs, which are long-term operating plans for grazing allotments on public land prepared and agreed to by the permittee and appropriate agency (USFS 2015).

The BLM-administered allotments are overseen by the Worland Field Office (BLM 2015). The Worland RMP provides a comprehensive framework for managing and allocating use of public lands and resources administered by the BLM in the Worland Field Office.

Under the umbrella of this plan, BLM and USFS grazing allotments are managed in accordance with the principles of multiple use and sustained yield embodied in the Federal Land Policy and Management Act

(1976) and the Taylor Grazing Act (1934). More information describing the BLM's grazing management standards and guidelines can be found online: http://www.blm.gov/wy/st/en/programs/grazing.html.

The BLM's grazing management guidelines that are pertinent for this watershed study include the following summaries (BLM 1997).

- Ensure that conditions after grazing use will support infiltration, maintain soil moisture storage, stabilize soils, release sufficient water to maintain overall system function, and maintain soil permeability rates and other appropriate processes
- Restore, maintain, or improve riparian plant communities to sustain adequate residual plant cover for sediment capture and groundwater recharge
- Implement riparian improvements to maintain or enhance stream channel morphology
- Develop springs, seeps, reservoirs, wells or other water development projects in a manner protective of watershed ecological and hydrological functions
- Implement range improvements away from riparian areas to avoid conflicts in achieving or maintaining riparian function
- Adopt management practices and implement range improvements that protect vegetative cover and thereby maintain, restore, or enhance water quality

A set of six standards have been established to meet the above guidelines (BLM 1997). Each standard sets a specific objective, explains the function and importance of the objective, and provides indicators to assess the attainment of the objective.

Most of the state lands within the study area are leased to private landowners for grazing. These leases are typically issued by the Wyoming Board of Land Commissioners (WBLC) and administered by the Wyoming Office of State Lands and Investments (OSLI). Management practices and improvements on state lands are usually established and implemented by the lessee. Improvements are typically paid for and owned by the lessee. Upon transfer of the state lease, the new lessee reimburses the previous lessee for improvements (OSLI 2012).

WRIR lands are managed by the BIA, with technical assistance from the local Natural Resources Conservation Service (NRCS) staff or a range consultant.

Grazing practices on private lands are established by the landowner, often with technical assistance from the local NRCS staff or a range consultant. Range improvement projects implemented under NRCS programs (e.g., EQIP or PL566) follow the guidelines established in the plan of operations developed for the property and applicable NRCS technical guidelines as adapted for local conditions.

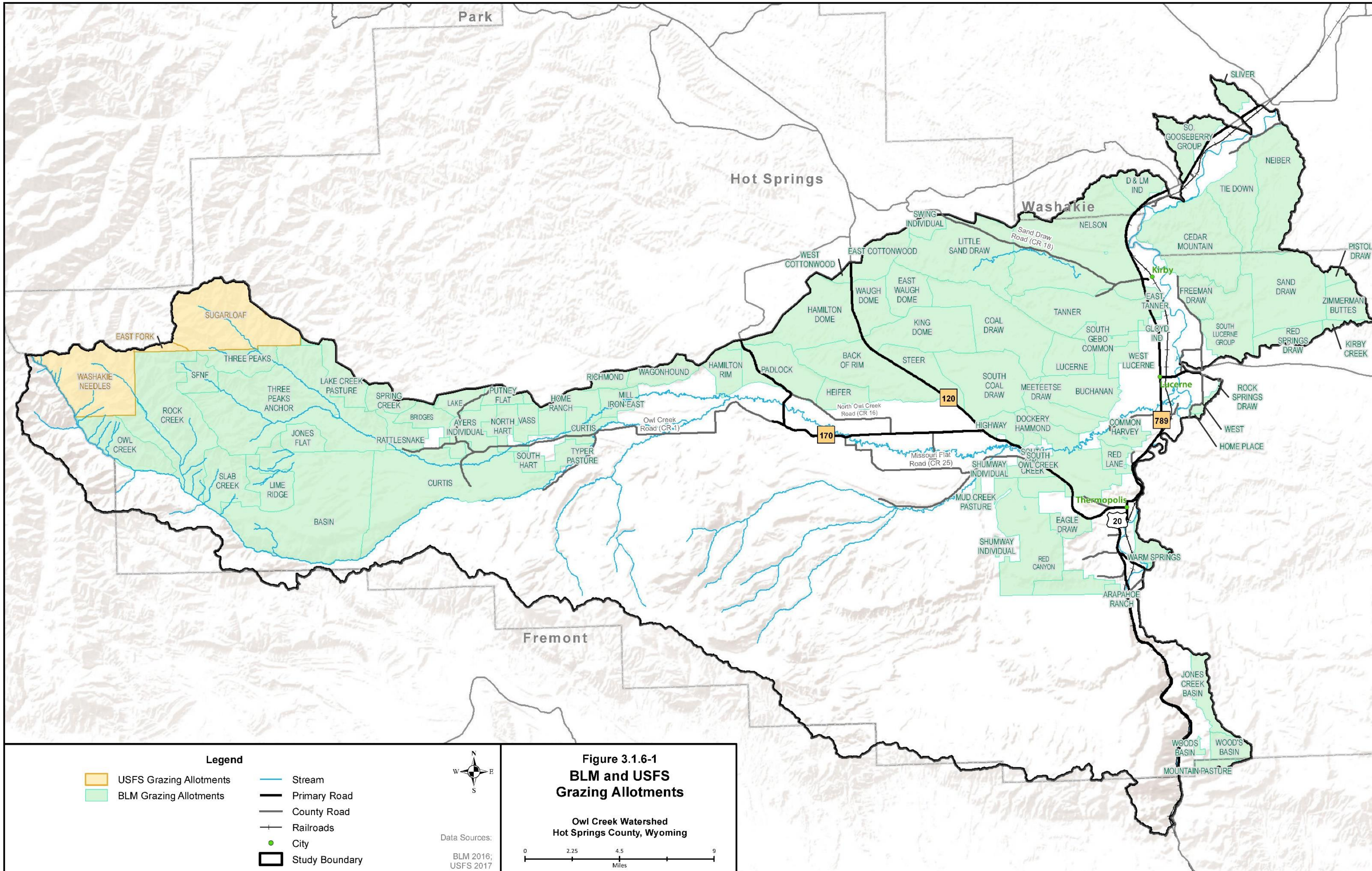

Figure 3.1.6-1
BLM and USFS Grazing Allotments

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Ecological Site Descriptions

An ecological site is a conceptual division of the landscape, defined as a distinctive kind of land based on recurring soil, landform, geological, and climate characteristics that differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its ability to respond similarly to management actions and natural disturbances (Caudle et. al 2013). Lands are classified considering discrete physical and biotic factors. Physical factors include soils, climate, hydrology, geology, and physiographic features. Biotic factors include plant species occurrence, plant community compositions, annual biomass production, wildlife-vegetation interactions, and other factors. Ecological dynamics, primarily disturbance regimes, such as grazing, fire, drought, management actions, and all resulting interactions are also a primary factor of ecological sites (NRCS 1997a).

Ecological site classifications and descriptions provide a consistent framework for stratifying and describing rangelands and their soil, vegetation, and abiotic features, thereby delineating units that share similar capabilities to respond to management activities or disturbance processes. Ecological site descriptions provide land managers the information needed for evaluating suitability of the land for various land-use activities, the capability to respond to various management activities or disturbance processes, and the ability to sustain productivity over the long term.

Using database tools provided by the NRCS, the available soils mapping was evaluated within the study area. (Please refer to **Section 3.2.3** for soils mapping). Ecological Site Descriptions (ESDs) provide information about natural vegetation, weeds, forestry, grazing, wildlife, and dynamic soil properties that land managers use to evaluate land suitability and respond to different management activities or disturbance processes (NRCS undated). ESDs are generally made up of two or more soil map units and have been identified for areas that have been surveyed. Major Land Resource Areas (MLRAs) are lands that are geographically associated and share similar geology, groups of soil map units, biological characteristics, water, climatic and/or land use characteristics (NRCS 2005). Like ESDs and soil map units, the larger-scale MLRA identification helps land managers understand and plan management and improvement efforts. Complete ESD reports are located in **Appendix A**.

The study area is located within two MLRAs: 043B-Central Rocky Mountains and 032X-Northern Intermountain Desertic Basins (NRCS 2006). NRCS soils data have not been completed in Hot Springs County; therefore, ecological site descriptions (ESDs) are either provisional or incomplete. Although ESDs are not available for the entire study area, those available and provided in this report can be a useful tool for understanding grazing resources, and to evaluate the potential value of project implementation by using the ESDs available as possible surrogate site descriptions. Based on the mapping that has been completed, three dominant precipitation zones occur within the watershed (NRCS 1995):

- Big Horn Basin
- Foothills and Mountains East (15-19 E)
- Foothills and Basins (10-14 E)

Based upon the provisional ecological site mapping that is available, the predominant ecological site within the watershed is Loamy (Ly) 10-14" East Precipitation Zone. The following descriptions discuss the common plant communities that currently occur within the watershed.

Perennial Grass/Big Sagebrush Plant Community: The dominant grasses include Griffith's and bluebunch wheatgrasses, rhizomatous wheatgrasses, and needleandthread. Grasses and grass-like species of secondary importance include prairie junegrass, blue grama, Sandberg bluegrass, and threadleaf sedge. Forbs commonly found in this plant community include scarlet globemallow, fringed sagewort, wavyleaf paintbrush, little larkspur, and Hood's phlox. Sagebrush can make up to 25% of the annual production. The overstory of sagebrush and understory of grasses and forbs provide a diverse plant community. The combination of an over story of sagebrush and an understory of grasses and forbs provide a very diverse plant community for wildlife. The crowns of sagebrush tend to break up hard crusted snow on winter ranges, so mule deer and antelope may use this state for foraging and cover year round, as would cottontail and jackrabbits. It provides important winter, nesting, brood rearing, and foraging habitat for sage grouse. Brewer's sparrows' nest in big sagebrush plants and hosts of other nesting birds utilize stands in the 20-30% cover range (NRCS 2008a).

Big Sagebrush/Bare Ground Plant Community: The dominant grasses are prairie junegrass, Sandberg bluegrass, and blue grama. Weedy annual species such as cheatgrass may occupy the site if a seed source is available. Cactus and sageworts often invade. Noxious weeds such as Russian knapweed, leafy spurge, or Canada thistle may invade the site if a seed source is available. The interspaces between plants have expanded leaving the amount of bare ground more prevalent. This plant community can provide important winter foraging for elk, mule deer and antelope, as sagebrush can approach 15% protein and 40-60% digestibility during that time. This community provides excellent escape and thermal cover for large ungulates, as well as nesting habitat for sage grouse (NRCS 2008a).

Salt Tolerant Shrub/Rhizomatous Wheatgrass Plant Community: This site is dominated by an over story of a variety of shrubs, such as Wyoming big sagebrush, rubber rabbitbrush, greasewood, and a variety of saltbushes. Some perennial cool season midgrasses have once again reestablished such as rhizomatous wheatgrasses and bottlebrush squirreltail. Other important grasses include prairie junegrass, Sandberg bluegrass and blue grama. Patches of annuals such as cheatgrass and other weedy annual forbs such as halogeton, Russian thistle, and kochia, will persist on this site. Noxious weeds such as Russian knapweed may also remain if not treated. The combination of an over story of sagebrush and an understory of grasses and forbs provide a diverse plant community for wildlife. The crowns of these shrubs tend to break up hard crusted snow on winter ranges, so mule deer and antelope may use this state for foraging and cover year round, as would cottontail and jack rabbits. It provides important winter nesting, brood rearing, and foraging habitat for sage grouse and other upland birds. Brewer's sparrows' nest in big sagebrush plants and hosts of other nesting birds utilize stands in the 20-30% cover range (NRCS 2008a).

It is possible for shifts, or transitions, to occur from one plant community, or state, to another within the described ESD. This state and transition model (STM) of the ESD describes the ecological dynamics between vegetation and soils, and the causes of changes that can occur on an ecological site.
The state is a suite of community phases that interact with the environment to produce a distinctive composition of plant species, with unique soil and vegetation functions. The transition describes the biotic and abiotic variables that contribute directly to loss of state resilience and result in shifts between states. A transition can be triggered by natural events (e.g., climatic events or fire), management

actions (e.g., grazing, burning, fire suppression, recreational use) or both. Transitions may be reversible, but may become irreversible and may go from a "disturbance" to an alternative state" for example by overgrazing or prolonged drought (BLM 2013).

The ESD assumes stocking rates for cattle under continuous season-long grazing under normal growing conditions. These are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. More precise carrying capacity estimates should eventually be calculated using this information along with animal preference data, particularly when grazers other than cattle are involved. Under more intensive grazing management, improved harvest efficiencies can result in an increased carrying capacity. The following production and stocking rates are presented by the NRCS:

- Perennial Grass/Big Sagebrush 400 - 900 lb/ac and 0.30 AUM/ac
- Big Sagebrush/Bare Ground 300 - 700 lb/ac and 0.20 AUM/ac
- Salt Tolerant Shrub/Rhizomatous Wheatgrasses 400 - 800 lb/ac and 0.22 AUM/ac (NRCS 2008a)

Range Conditions

Grazing management and the overall health of the watershed may benefit from well distributed, reliable water availability. The upper portions of the watershed provide adequate water supply; however, the central area of the watershed lacks adequate water availability. This affects the amount of time, and timing (the time of the year) that livestock/wildlife can spend in any given area.

Overall range conditions were assessed through personal communication with county residents as well as the Worland BLM field office. According to local landowners and Worland BLM personnel, range resource impacts are most evident around water sources such as stock tanks or reservoirs, and riparian areas.

Plant community impacts can occur when grasses and other plants are not afforded time to recover from the last livestock/wildlife grazing event before being grazed again. Time is needed to allow food reserves in the roots to be utilized for new plant growth. If root reserves are not restored, desirable plants are weakened and may eventually die, leading to less desirable plants invasion and a decrease in overall plant density. In the absence of well-distributed livestock/wildlife water, areas near water (frequently riparian areas) are potentially grazed heavily while other areas may be under-utilized.

Development of alternate water sources may allow improved grazing distribution by spreading animals more evenly over the range, opening up more range to grazing, or providing new grazing areas that can lengthen the season of use. Stocking rates must also be adjusted in relation to adequate drinking water for livestock.

An analysis of existing water sources within the study area that were permitted through the BLM or the WSEO, was completed. A two mile radius was drawn around existing, permitted stock reservoirs to represent the distance livestock generally walk to water. Areas that were outside the two mile radius were analyzed for features such as slope, natural water sources, and current land use to determine if these areas were accessible to livestock or produced good forage. The topography of the landscape was examined and lands that were greater than or equal to a 27 degree slope were eliminated as suitable water development areas. The results of this analysis showed that steep areas are uncommon and scattered. Most of the land within the study area are accessible to cattle and many areas could be developed as watering sites if groundwater can be found there (**Figure 3.1.6-2**). No data was available for WRIR and Arapaho Ranch.) While there may be flowing streams, springs, or unpermitted stock wells present, this level of detail is not known. The development of additional reservoirs in the non-shaded areas of Figure 3.1.6-2 should be considered for water developments. In addition, as is explained more thoroughly in **Section 3.9.3,** some of the reservoirs included in this evaluation were identified as non-functional. Rehabilitation of these reservoirs could improve range utilization, and could decrease impacts to plant communities in areas with functional reservoirs.

Projects identified include:

- The use of solar or other pumps to (a) pump water from wells or (b) move water from a well/spring to develop water sources;
- Rehabilitation of non-functioning stock reservoir dams,
- Spring developments that protect sensitive soils and vegetation at the spring while providing water for livestock away from the spring,
- Converting a gravel pit to a reservoir, and
- Re-using irrigation return water for livestock watering.

Because sensitive wildlife species such as sage grouse are found within the watershed, care must be taken to ensure that rangeland improvement practices are beneficial rather than detrimental to their habitat values. Examples of this include the need for mixed age stands of sagebrush, adequate vegetative residues, wildlife escape ramps from livestock tanks, and provisions for wildlife water.

3.1.7 Residential Land Use

The U.S. Census (2012) reported 2,582 residential housing units, and a population density of 2.4 inhabitants/square mile within Hot Springs County in 2010. These figures are representative of the generally rural study area. Residential land use is found throughout the study area east of Shoshone National Forest, but is at highest density along maintained roads, including the Hwy 20/789, Hwy 120, Hwy 170 corridors, and particularly in the towns of Thermopolis, Lucerne, and Kirby. Many residents have acreage devoted to agriculture and livestock production. In recent years there has been increased purchase and development of small acreage farms. While many of these landowners have irrigation rights to their land, there is often not infrastructure available to direct water to the more numerous and smaller fields, or the irrigation rights are newer and the land seldom receives irrigation water. This has put pressure on the irrigation district and the existing irrigation infrastructure (Hot Springs County 2002, Owl Creek Irrigation District 2017, NRCS 2017).

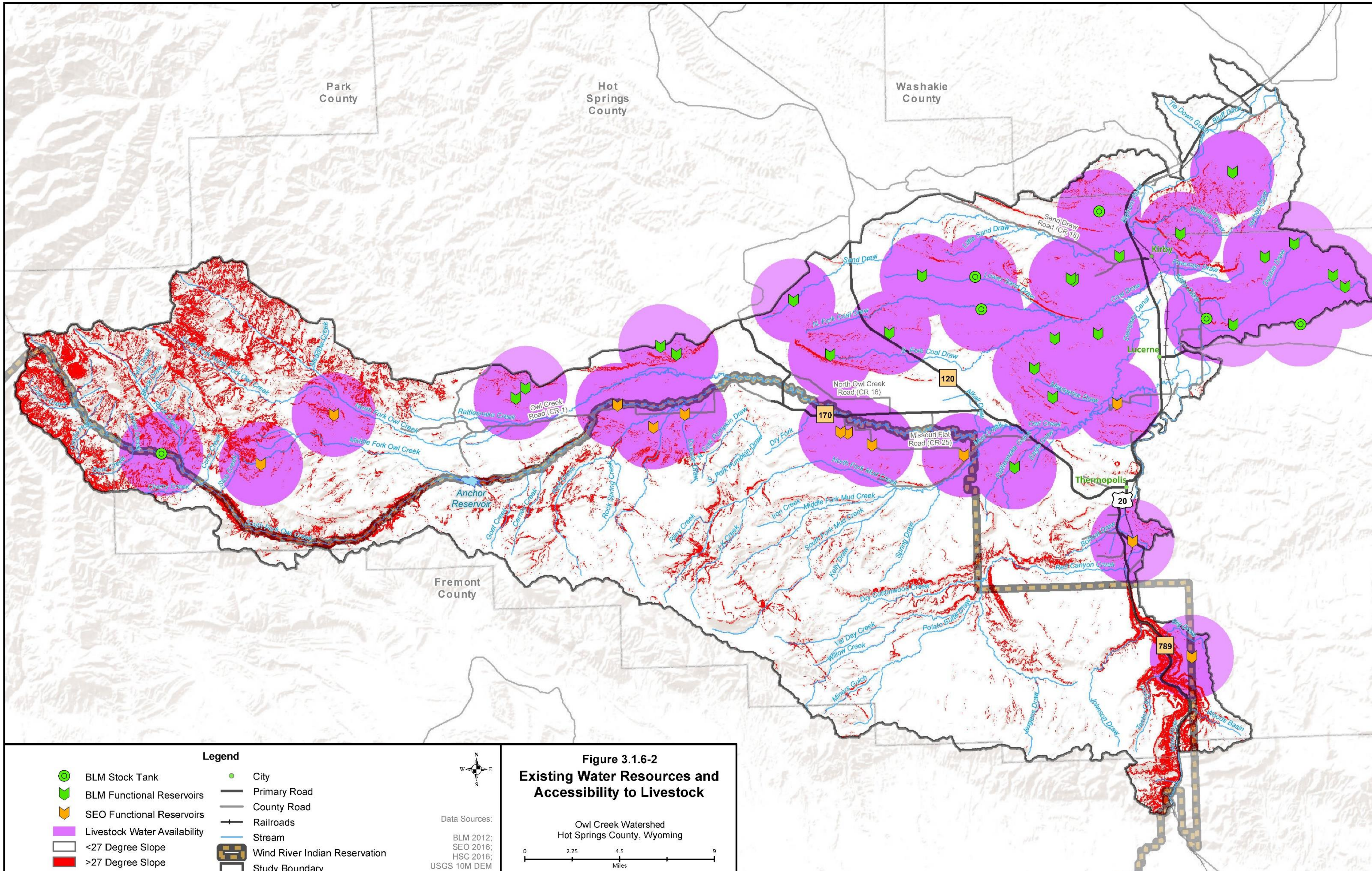

Figure 3.1.6-2
Existing Water Resources and Accessibility to Livestock

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3.1.8 Industrial Land Use

Natural resource extraction is the primary driver of economic development within the Owl Creek watershed and the surrounding region. In the late 1800s to the early 1900s, coal mining was the principal industry (Hot Springs County 2014). Today, oil and natural gas drives the region's industrial economy, with coal mining, bentonite mining, fossils, and the mineral hot springs also playing important roles (Hot Springs County 2014).

Extracting natural resources necessitates some disturbance to the landscape, the most obvious of which are habitat loss and alteration. Once the productive lifespan of a site is at an end, the site developer is required to reclaim the landscape to a stable and non-erosive condition. This generally includes re-vegetation with native plants. Reclamation of industrial-use lands can be crucial to maintain the health of watersheds (e.g., Ketcheson and Price 2016).

Mines and wells for mineral, oil, and natural gas extraction are a common surface disturbance within the watershed. There are 28 permitted mines used for mineral extraction. Wyo-Ben, the sole bentonite mining company operating in the watershed, has one permit that covers a very large swath of land. However, bentonite mining is generally conducted at a few localized pits, called active pit sequences, within that permit. These active pit sequences cast newly excavated material back onto previously disturbed areas in combination with concurrent reclamation in an effort to minimize the acreage of surface disturbance (Smith 2016, Scyphers 2017).

Given the importance of healthy rangeland to the health of the watershed, the authors conducted a desktop assessment of land conditions for actively permitted mines, reclaimed mines, and active or reclaimed (plugged and abandoned [P&A'd]) oil or gas well sites as part of the inventory of watershed conditions. Assessments of reclamation conditions were completed by two natural resource specialists who used aerial imagery from Google Earth (version 7.1.7.2606; imagery dated 2014) to categorize vegetation establishment into five categories. Methods were derived from the Upper North Platte River Watershed Study (Anderson Consulting Engineers [ACE] 2015). **Figure 3.1.8-1** shows locations, activity and reclamation status of permitted mining areas within the watershed. Of these, 8 are terminated, or the company is released from further reclamation responsibility, and 13 remain active. **Figure 3.1.8-2** shows the locations of all 208 recorded P&A'd oil and gas wells (companies no longer responsible for reclamation). The following outlines the five categories used to classify mines and wells:

Vegetated: Obvious vegetation establishment and a lack of discernible erosion.
Partially Vegetated: Mixed establishment of vegetation and/or minor erosion.
No Vegetation: Distinct lack of established vegetation and/or obvious erosion.
Redeveloped: Previously terminated/abandoned site has been redeveloped.
UNK: Unknown status due to inability to confirm location via aerial imagery.

Based on 2014 imagery (Google), overlain by GIS well site data from the Wyoming Oil and Gas Conservation Commission (WOGCC) (available in, 126 former well sites were vegetated, 32 were partially vegetated, 33 were not vegetated, three were either not vegetated or currently in use for another purpose (with equipment present on the site), one was redeveloped, and 13 were of unknown status (WOGCC 2016; **Figure 3.1.8-3**). This preliminary assessment only identifies ground cover relative to the surrounding areas, and cannot identify species composition. Vegetated sites may be dominated by undesirable plant species, such as noxious weeds. **Figure 3.1.8-4** illustrates the assessment process.

The GPS locations of the disturbances reviewed for this section of the study area located in the set of GIS layers titled “Industry”.

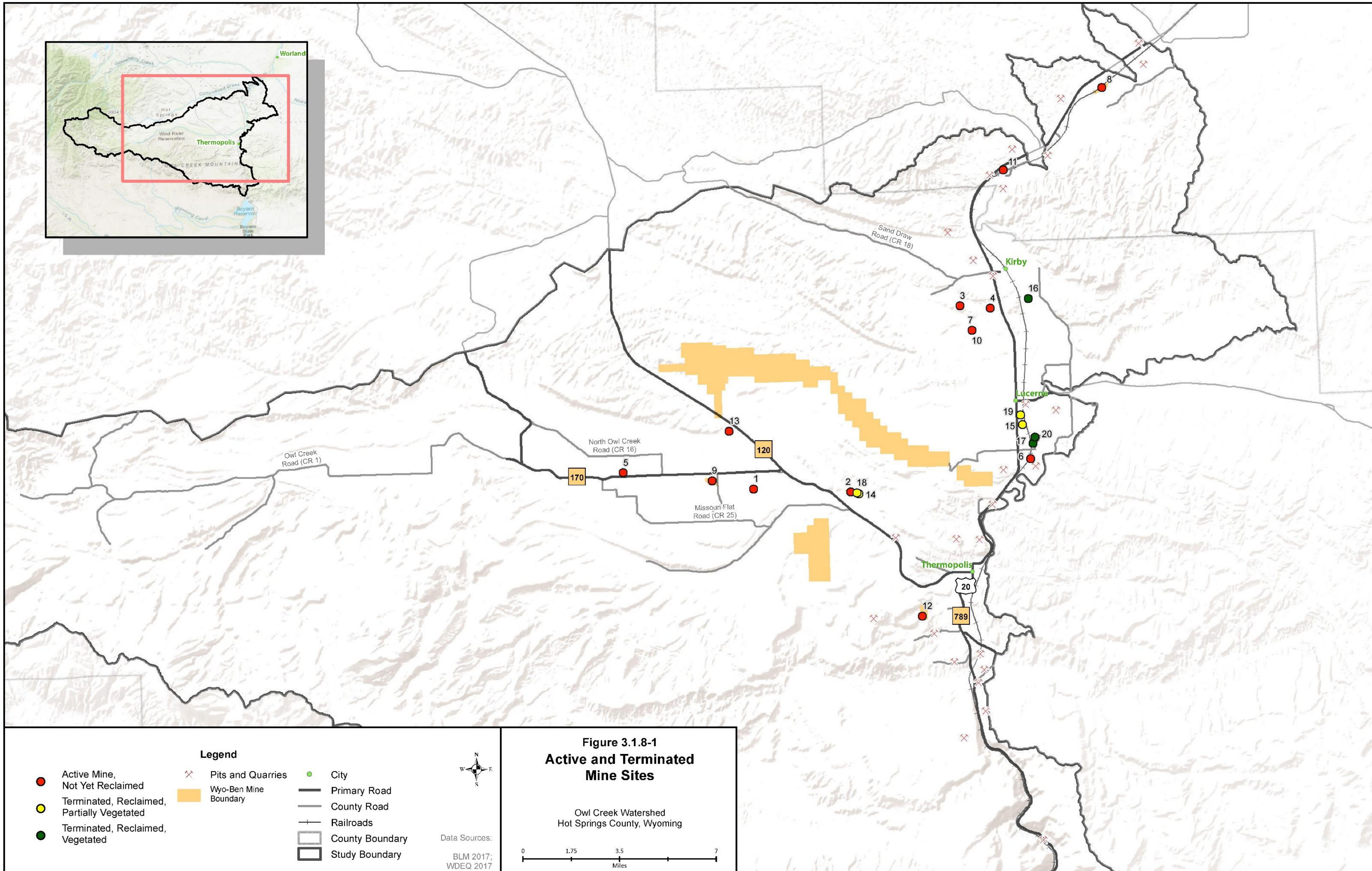

Figure 3.1.8-1
Active and Terminated Mine Sites

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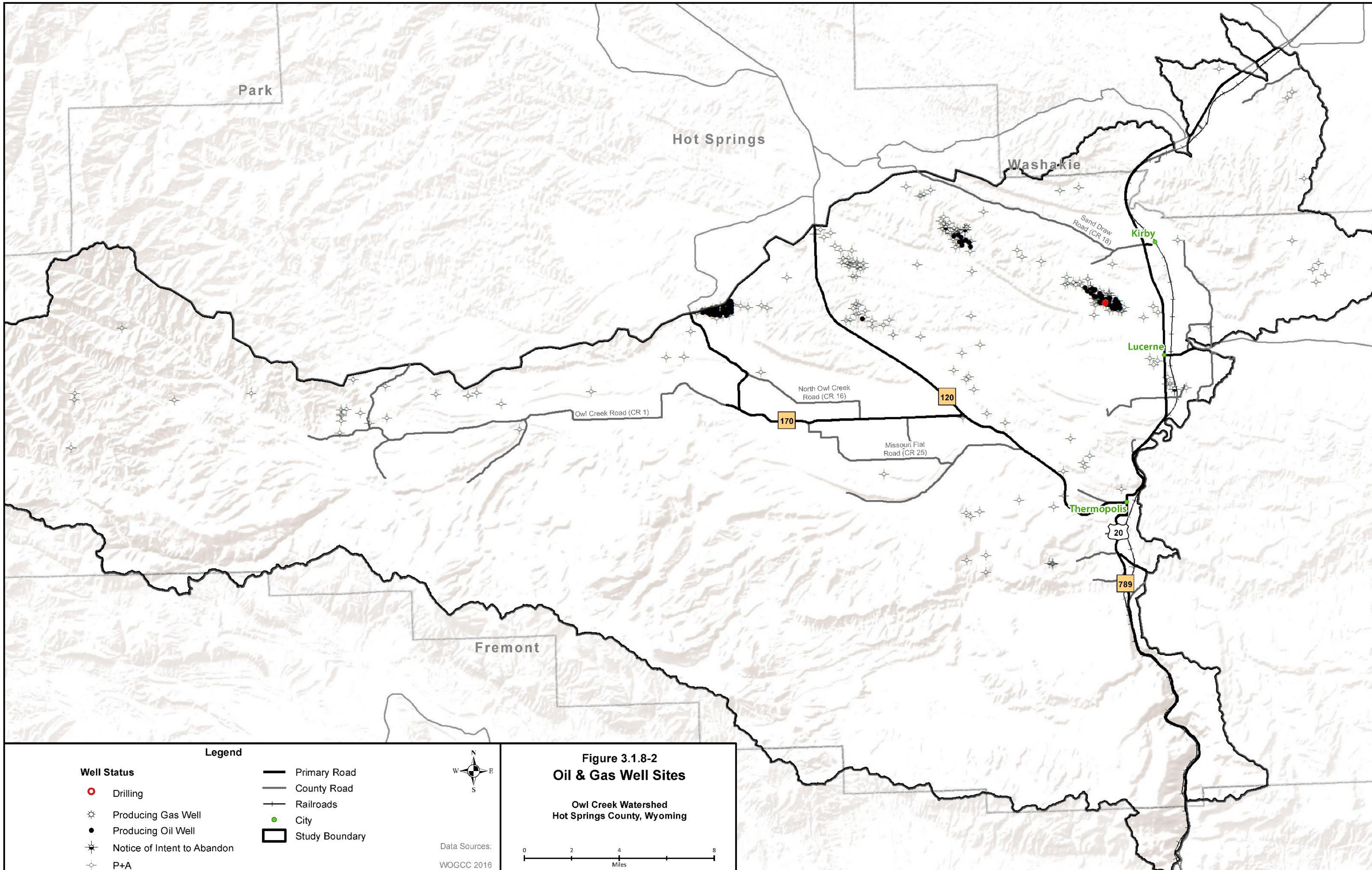

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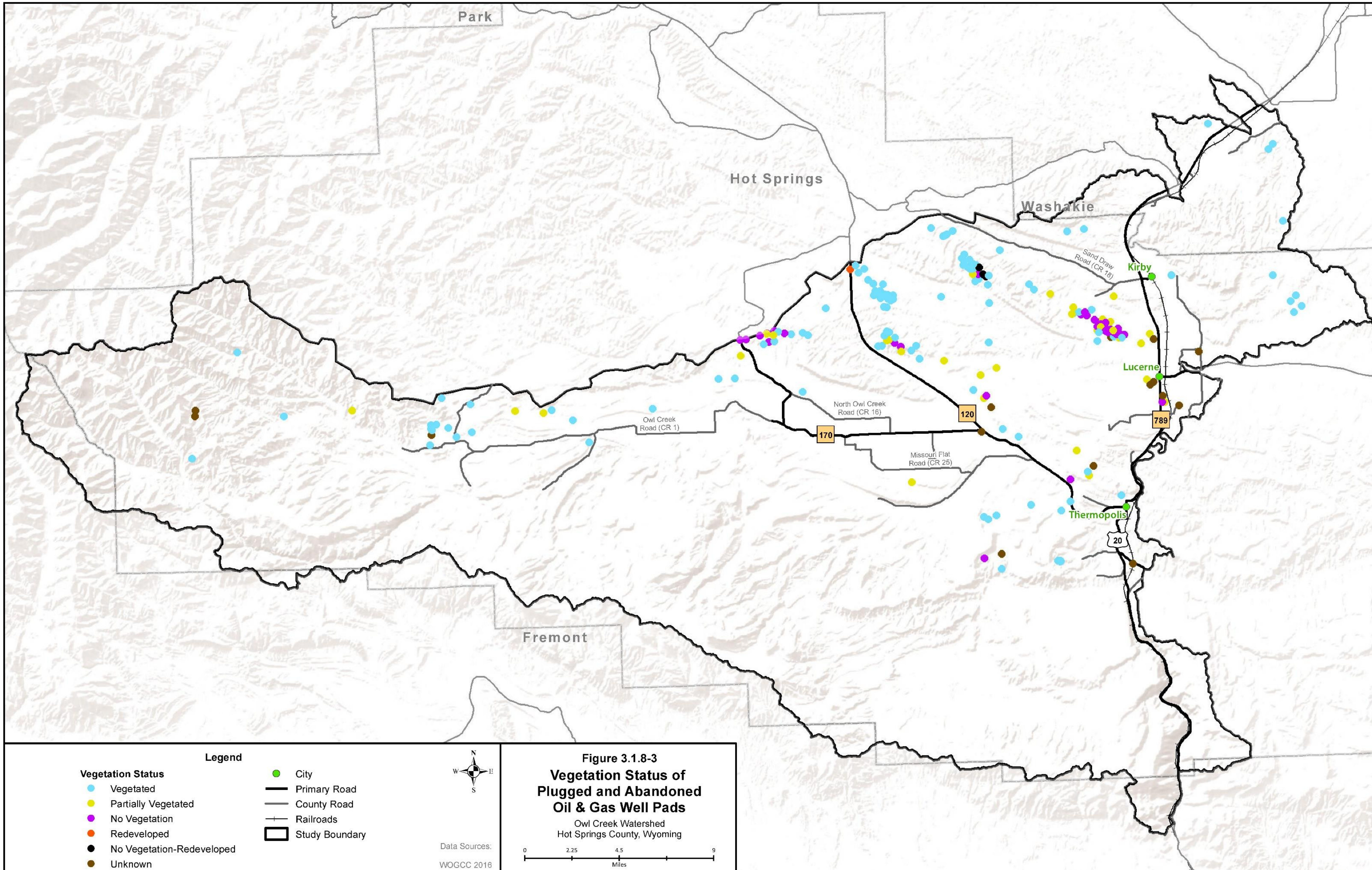

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Figure 3.1.8-4 Three examples of Vegetation Cover at an Abandoned Oil/Gas Well Site.

No Vegetation

Partially Vegetated

Vegetated

3.1.9 Cultural Resources

The Owl Creek watershed lies within a region with a long history of human use. Prehistoric petrolglyph sites, such as Legend Rock on Cottonwood Creek, are found throughout the region (Hot Springs County 2014). More recently, Native American tribes, including the Blackfeet, Crow, Gros Ventre, Sioux, Arapahoe, and Shoshone lived, hunted, or camped here as well, followed by European explorers and immigrants from around the world (Hot Springs County 2014). The historic Bridger Trail, which provided a route from the Oregon Trail to the goldfields of southern Montana, crosses through the northeast corner of the Owl Creek watershed, following the Bighorn River before striking east along the Kirby Creek drainage (Wyoming State Historic Preservation Office 2016; **Figure 3.1.9-1**). There are nine sites within the Owl Creek watershed on the National Register of Historic Places (**Table 3.1.9-1**). One of the sites is a Wyoming State Park, four are within the city limits of the Town of Thermopolis, and the other four are bridges or old homesteads.

Table 3.1.9-1 The National Register of Historic Places lists Nine Sites in the Owl Creek Watershed

National Register of Historic Places	Lat	Long
Callaghan (Plaze) Apartments and Hotel	43.650556	-108.198333
CQA Four Mile Bridge	43.603611	-108.196667
Downtown Thermopolis Historic District	43.646111	-108.210278
EFP Bridge over Owl Creek	43.691111	-108.392778
Alex Halone House	43.641667	-108.203333
Kirby Jail and Town Hall	43.804981	-108.180161
Legend Rock Petroglyph Site	43.8004619	-108.5991947
US Post Office, Thermopolis Main	43.6475	-108.209167
Woodruff Cabin Site	43.714444	-108.671667

In addition to those known sites of historical significance, there are many areas of the Owl Creek watershed that have not been surveyed for cultural resources (Natural Resource and Energy Explorer [NREX] 2016), or are within the Wind River Indian Reservation with records available only to tribal members. In **Figure 3.1.9-1**, pink square-mile sections have been partially or completely field surveyed for cultural or historical resources. Darker pink areas indicate higher numbers of known cultural resources. A cultural resource inventory and project review is required for (1) any project taking place on federal lands, using federal funds, or requiring federal permitting under Section 106 of the National Historic Preservation Act of 1966 (54 U.S.C. 300101 *et seq.*), particularly if 1) the site has not been previously disturbed, or 2) cultural resources have been previously documented at that site.

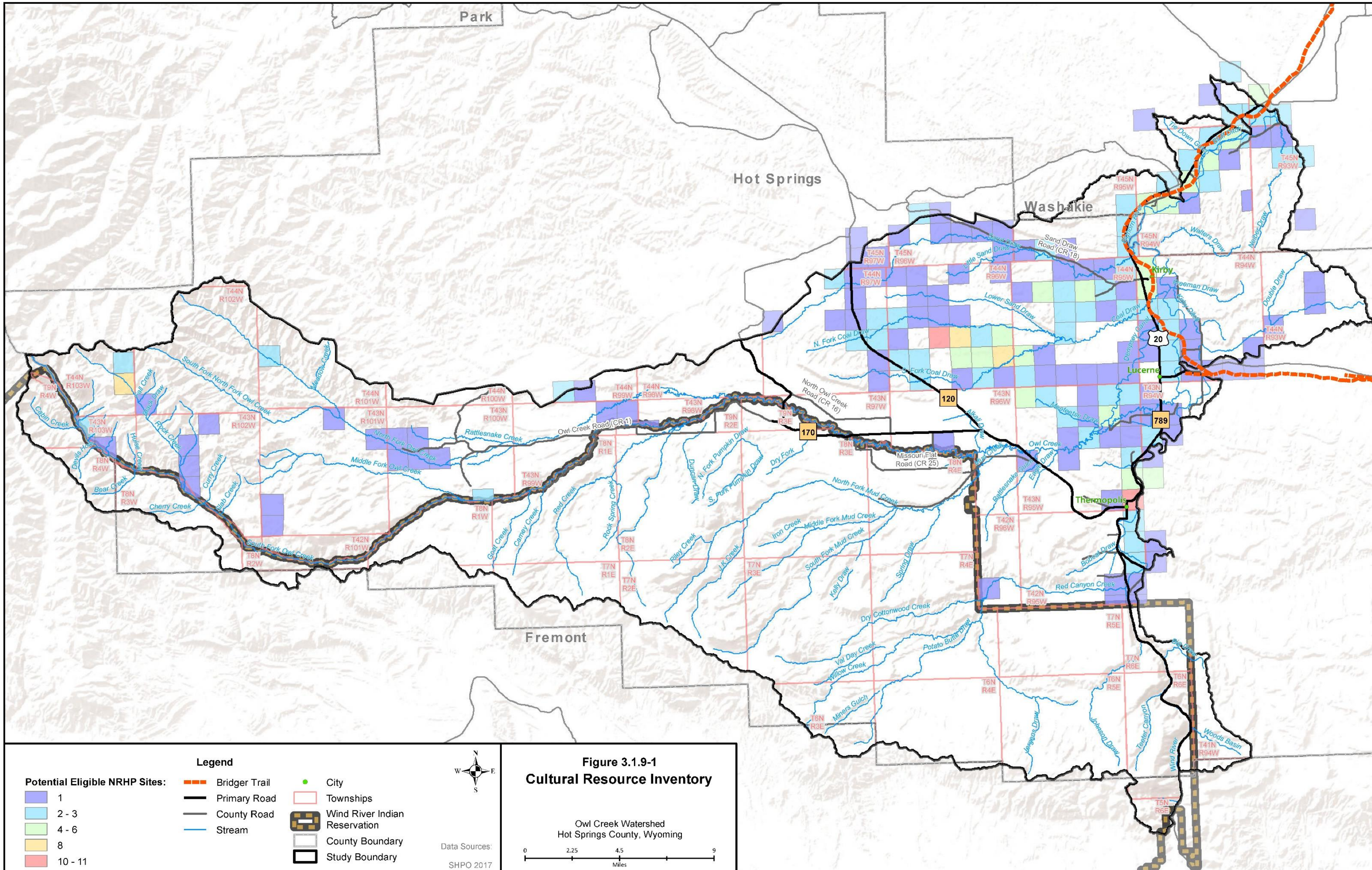

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Figure courtesy of Natural Resource and Energy Explorer 2016; https://nrex.wyo.gov/2016

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3.1.9.1 History and Pre-history of Area

Lands in the study area have been used by native peoples for millennia, in part because of the large hot springs, considered sacred to the Shoshones, located near the current town of Thermopolis. Settlement of Hot Springs County by European Americans began in the 1880s near the mouth of Owl Creek. Even though the area was recognized as challenging country for agriculture, John Woodruff trailed cattle to Owl Creek in 1878 and stayed. Other ranches dating back to that period include the Embar, Hayes Ranch, and Keystone Ranch. Sheep have been grazed in the area since the late 1800s. Farming began around 1900 with the development of irrigation in Owl Creek. Alfalfa and grass for hay for livestock feed were and are still the main crops in the Owl Creek area.

Coal was mined within the study area starting in 1898 near the town of Gebo, now a ghost town. Oil was developed at Hamilton Dome, located on the north edge of the Owl Creek watershed, in 1915. Both Boysen Dam and Anchor Dam are important to the study area. The dams were built using federal funds available through the Pick-Sloan Missouri Basin program, designed to develop irrigation and hydropower within the Missouri River watershed. Irrigation water used in the Lucerne area of Owl Creek comes from the Bighorn River, which is dammed by Boysen Dam. Lucerne irrigators exchanged their rights to Owl Creek water, which was to be augmented by water stored in Anchor Dam, shown in the photo below. While Boysen Reservoir provides power and irrigation water today, Anchor Dam, completed in 1960, has significantly reduced storage due to geologic integrity issues within the pool of the reservoir. Today it supplies limited mid- to late-season irrigation water in wet years and remains an issue to Owl Creek irrigators (Hein, Annette, undated).

Figure 3.1.9-2: Photo of Anchor Dam, located on South Fork Owl Creek

3.1.10 Level of Development, Dominant Land Use, and Relative Water Use

The lands within Hot Springs County were homesteaded as early as 1880 and by 1910 the majority of suitable lands were claimed for crop production or rangeland. In 1906 coal was discovered and in 1916 oil exploration exploded, but coal mining was nearly extinct in the area by 1960. Today, the dominant land use is farming and ranching.

Currently, the County has 20,000-22,000 acres of productive, irrigated lands which make up only a fraction of its total acreage. There are approximately 10,000 acres of marginal cropland, 3,000 acres of urbanized land, and 369,000 acres of other private lands that are available for development (Hot Springs County Land Use Plan [HSCLUP], 2014).

There are three dominant land uses within the county; agricultural, recreation and tourism, and industrial. All rural land within the County is considered agricultural land, unless described otherwise.

Agricultural lands are defined as cultivated land used for raising crops, and lands used for feeding, breeding, and raising animals for the commercial production of food or fiber (HSCLUP 2002, 2014). Additional, less dominant land uses include institutional land (e.g., churches, schools, or hospitals), and commercial land (e.g., hotels, retail, or government buildings) (HSCLUP 2014).

Each respective land use utilizes water in varying capacities within the project area. The most recent estimate of total water use by category for Hot Springs County was conducted in 2005 (USGS 2008), and is shown in **Figure 3.1.10-1**. The data includes water withdrawn from surface and groundwater sources and includes only fresh, non-saline water use. Irrigation for agriculture uses the largest volume of water in the county (76.7 million gallons per day [Mgal/d]), while mining uses the second largest volume of water (12.7 Mgal/d). Public water supply systems, which include water used for fire fighting, maintaining parks, swimming pools, and similar community-oriented activities, used an estimated 1 Mgal/d in 2005 while domestic consumption, which includes culinary water, water for washing clothes, flushing toilets, watering lawns and other household uses, consumes only 0.1 Mgal/d, or 100,000 gallons per day. More specific information on municipal and industrial water use is found in **Section 3.7.**

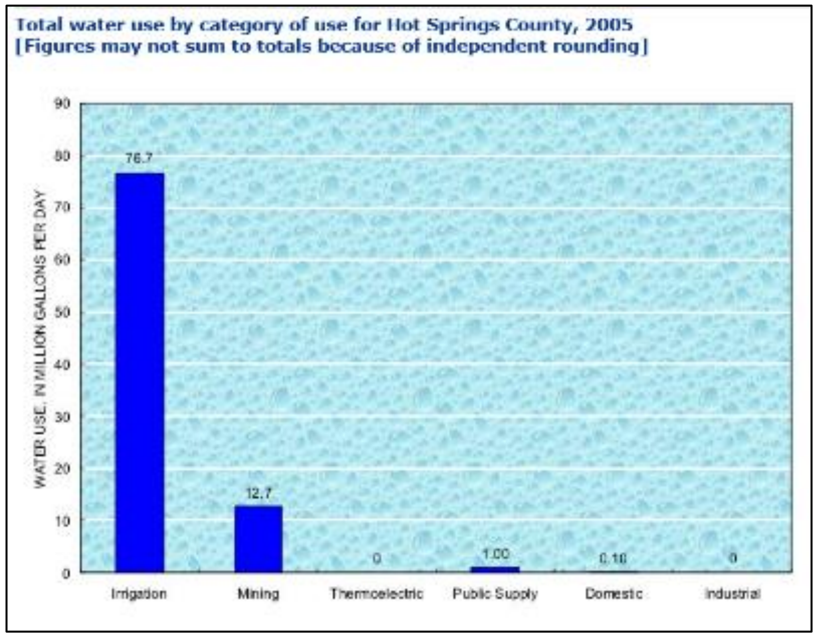

Figure 3.1.10-1 Total water use by category of use for Hot Springs County, 2005

3.1.11 Economic Contributions of Different Land Uses to Hot Springs County

The three principal sources of income within the county are mineral production, tourism (scenic and historic lands) and agriculture. The relative percentages that each of these industries contribute to the tax base varies considerably with the cost and production of petroleum and petroleum related activities on a year-to-year basis. For example, in 1993 State assessed activities (oil, natural gas, hard minerals, public utilities, railroads and pipelines) comprised 84.41% ($78,922,054) of valuation. Local valuation only comprised 15.59% ($14,574,240) of the valuation. In 2000 the ratio was 72.32% ($62,670,618) State assessed and 27.68 ($23,986,680) locally assessed. Of the total area of the County only 404,619 acres – 31% of the land is taxable. Depending on mineral production, the importance of agriculture and tourism becomes more or less important with regard to employment and tax payments (HSCLUP 2014)

3.2 Climate, Geology, Soils, and Ecology

3.2.1 Climate and Climatological Zones

The Owl Creek watershed is a semi-arid landscape with a limited water supply. Precipitation ranges from as little as 5 in. per year in the lowlands to greater than 20 per year in the foothills and upper reaches of the watershed. Most of the annual precipitation in the higher elevations comes as snow and the area may see snowfall in all months of the year. Peaks in precipitation, generally via rainfall, come in May and September for the lowlands and foothills (NRCS 2006). Snowmelt runoff in the spring typically has a very short duration.

Figure 3.2.1-1 displays the isohyetals (lines of equal precipitation) within the study area. This figure shows the relationship between elevation and precipitation amounts. The data used to generate this figure were obtained from the Wyoming Geographic Information Center (WyGISC). These data represent the results of PRISM spatial climate data generated at the Oregon Climate Center, Oregon State University. As indicated in this figure, the mean annual precipitation varies significantly between the lower elevations and higher elevations, with the majority of the central watershed receiving 8 to 12 inches of precipitation annually.saw

Historic climate data for four National Oceanic and Atmospheric Administration (NOAA) Cooperative Weather Stations within the study area were obtained through the Western Regional Climate Center website (http://www.wrcc.dri.edu/). The recorded temperatures at all stations were typically cool, with average daily temperatures ranging between 22°F and 24°F in winter and 62°F to 70°F during summer. The annual average total precipitation for the study area is 11.06 inches. **Table 3.2.1-1** presents the average temperature range and average total precipitation recorded by the weather stations located within the study area.

3.2.2 Geology

Information on surficial and bedrock geology of the study area is available at the regional scale (1:250,000 and smaller) from the Wyoming Geological Survey (WGS) and the United States Geological Survey (USGS), in both printed map and digital files suitable for inclusion in a GIS. A summary of surficial and bedrock geology characteristics is included below.

Surficial Geology

Information on surficial geology of the study area was obtained from the preliminary 1:500,000-scale digital surficial geology map of Wyoming (Case et al., 1998) and is presented in **Figure 3.2.2-1**. These data were obtained in the form of a digital geodatabase and clipped to the study area boundary in GIS. T Ground-Water Vulnerability to Pesticide Contamination Project (Hamerlinck and Arneson, 1998). This information was combined and used to develop symbology for the surficial geologic map presented in this report and is tabulated in **Table 3.2.2-1**.

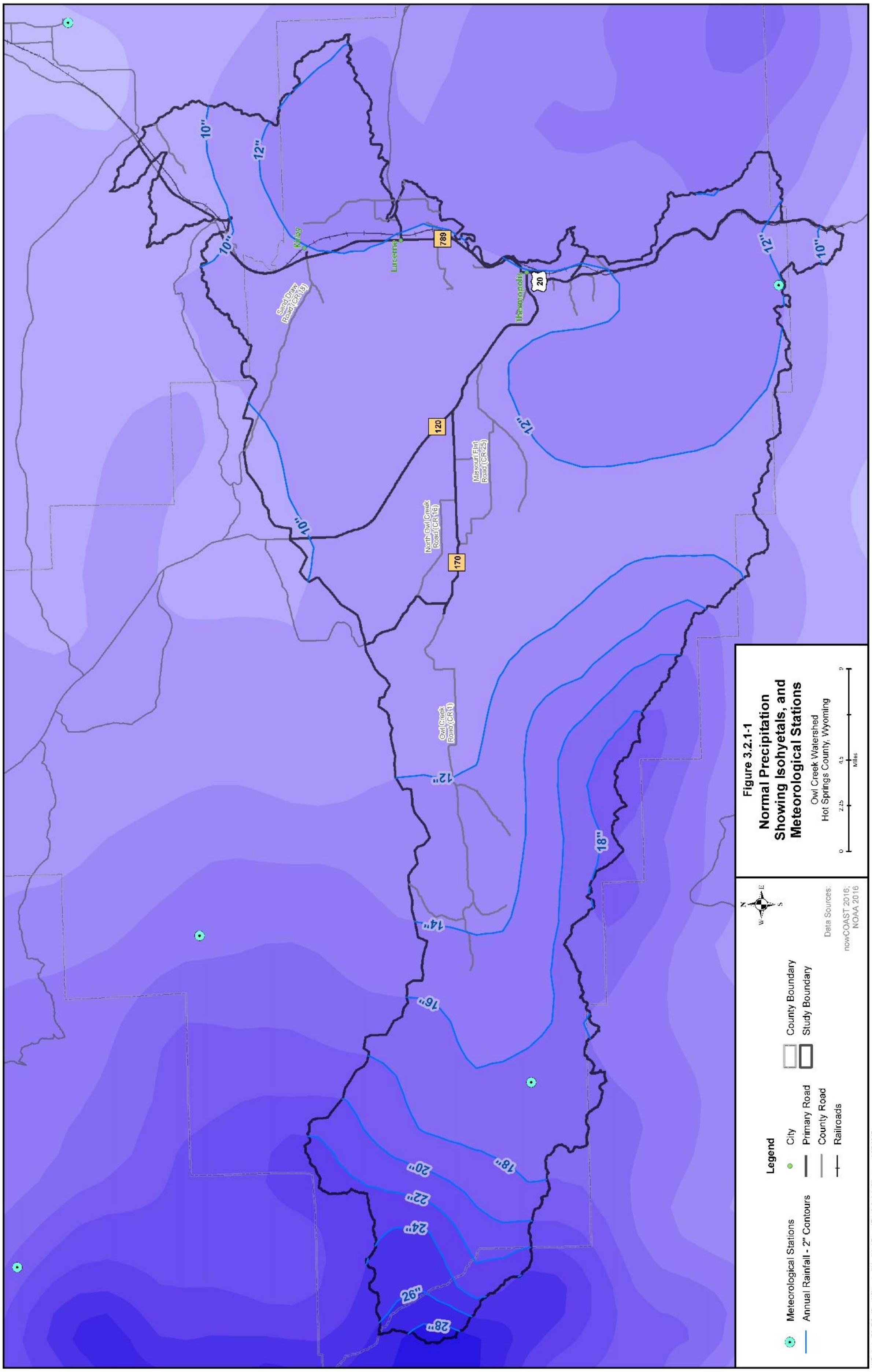
Figure 3.2.1-1
Normal Precipitation Showing Isohyetals, and Meteorological Stations
Owl Creek Watershed
Hot Springs County, Wyoming
Miles
Legend
Meteorological Stations
Annual Rainfall - 2" Contours
City
Primary Road
County Road
Railroads
County Boundary
Study Boundary
Data Sources: nowCOAST 2016; NOAA 2016
Kirby
Lucerne
Thermopolis
789
20
120
170
Sand Draw Road (CR 15)
North Owl Creek Road (CR 16)
Missouri Flat Road (CR 25)
Owl Creek Road (CR 1)
10"
12"
14"
16"
18"
20"
22"
24"
26"
28"

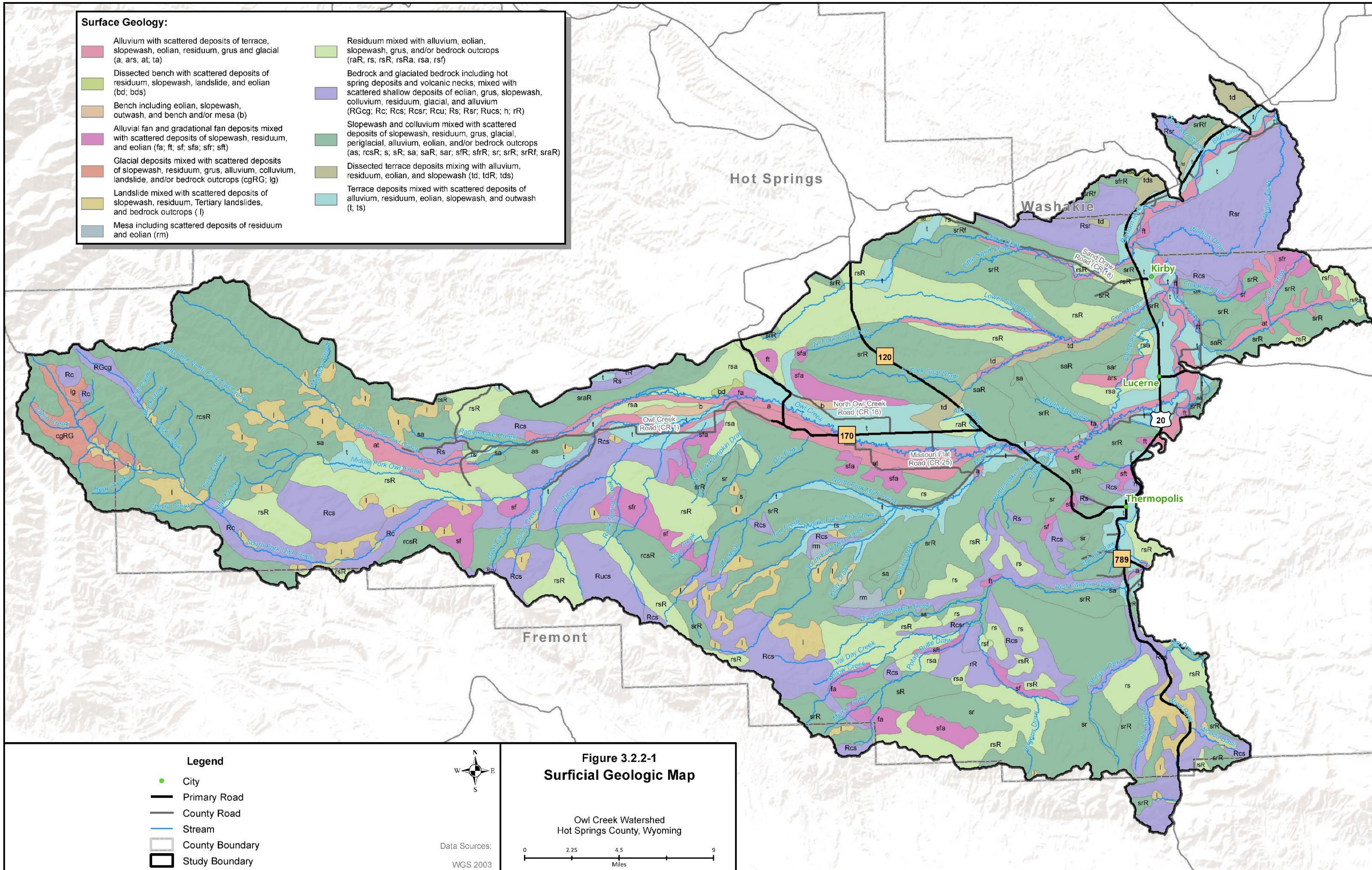

Figure 3.2.2-1
Surficial Geologic Map

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Table 3.2.1-1 Summary of Monthly Climatic Data: Owl Creek Watershed

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
THERMOPOLIS 25 WNW, WYOMING (488888): 05/25/1951 to 03/31/2012													
Average Max. Temperature (F)	37.2	40.1	47.9	55.7	65.2	74.9	83.1	82	71.6	60	45.3	38.1	58.4
Average Min. Temperature (F)	7.9	12.3	19.5	27.2	36.3	43.7	49.6	48.2	38.5	28.8	17	9.8	28.2
Average Total Precipitation (in.)	0.33	0.32	0.67	1.38	2.35	1.94	1.34	1.02	1.23	0.92	0.46	0.32	12.29
ANCHOR DAM, WYOMING (480228): 04/19/1967 to 09/30/1979													
Average Max. Temperature (F)	33.3	39.4	42.5	51.5	62.6	72	81.4	80.1	68.1	58.4	43.7	36.3	55.8
Average Min. Temperature (F)	5.4	11.3	15.8	25.3	34.7	42.7	49	47.1	37.5	28.2	16.8	8	26.8
Average Total Precipitation (in.)	0.51	0.36	1.09	2.11	2.68	2.41	1.33	1.2	1.4	1.05	0.57	0.48	15.2
THERMOPOLIS, WYOMING (488875): 05/01/1899 to 06/10/2016													
Average Max. Temperature (F)	35.2	40.8	50.7	61.4	71.4	82	91.2	89.5	78.6	64.4	48.6	37.2	62.6
Average Min. Temperature (F)	6.4	12.3	21.6	31.6	40.5	48.1	54.3	52.3	42.3	31.3	19.3	9.6	30.8
Average Total Precipitation (in.)	0.37	0.41	0.77	1.67	2.26	1.46	0.84	0.58	1.11	1.09	0.58	0.38	11.5
THERMOPOLIS 9 NE, WYOMING (488884): 12/01/1991 to 06/10/2016													
Average Max. Temperature (F)	32.9	36.6	53.1	58.1	66.6	78.2	89.7	86.3	76.4	60.3	49.1	29.8	59.8
Average Min. Temperature (F)	1.1	6.9	19.3	25.9	35.8	45.2	53.2	48.6	37.6	28.8	15.8	-1.2	26.4
Average Total Precipitation (in.)	0.4	0.45	0.92	1.56	2.4	1.5	0.81	0.59	1.07	1.47	0.61	0.45	12.23

Source: Western Regional Climate Center. 2016. Western U.S. Climate Historical Summaries. Accessed November 2016. Available at: http://www.wrcc.dri.edu/summary/Climsmwy.html

Table 3.2.2-1 Symbology for Surficial Geologic Map of Owl Creek Study Area

Map Symbol	Geologic Description
Ai	Old alluvial plain with scattered deposits of eolian, residuum, and slopewash
Ai	Alluvium with scattered deposits of terrace, slopewash, eolian, residuum, grus and glacial
aR	Shallow Alluvium mixed with scattered bedrock outcrops
bi	Bench including eolian, slopewash, outwash, and bench and/or mesa
bdi	Dissected bench with scattered deposits of residuum, slopewash, landslide, and eolian
tdi	Dissected terrace deposits mixing with alluvium, residuum, eolian, and slopewash
ti	Terrace deposits mixed with scattered deposits of alluvium, residuum, eolian, slopewash, and outwash
tre	Shallow terrace deposits mixed with scattered deposits of eolian and residuum
fi	Alluvial fan and gradational fan deposits mixed with scattered deposits of slopewash, residuum, and eolian
fdi	Dissected alluvial fan and gradational fan deposits mixed with scattered deposits of slopewash and residuum
mi	Mesa including scattered deposits of residuum and eolian
ei	Eolian mixed with scattered deposits of residuum, alluvium, and slopewash
oai	Glacial outwash and alluvium mixed with scattered deposits of glacial, terrace, hot spring, bedrock outcrops, residuum, slopewash and grus
gi	Glacial deposits mixed with scattered deposits of slopewash, residuum, grus, alluvium, colluvium, landslide, and/or bedrock outcrops

Table 3.2.2-1 Symbology for Surficial Geologic Map of Owl Creek Study Area	
Map Symbol	**Geologic Description**
li	Landslide mixed with scattered deposits of slopewash, residuum, Tertiary landslides, and bedrock outcrops; landslides too small and numerous to show separately
pea	Playa deposits mixed with scattered deposits of alluvium, eolian, and residuum; playa deposits too small to show separately
sci	Slopewash and colluvium mixed with scattered deposits of slopewash, residuum, grus, glacial, periglacial, alluvium, eolian, and/or bedrock outcrops
ri	Residuum mixed with alluvium, eolian, slopewash, grus, and/or bedrock outcrops
ui	Grus mixed with alluvium, eolian, slopewash, and/or bedrock outcrops
Ri	Bedrock and glaciated bedrock including hot spring deposits and volcanic necks; mixed with scattered shallow deposits of eolian, grus, slopewash, colluvium, residuum, glacial, and alluvium.
Mi	Mined areas mixed with scattered deposits of residuum, slopewash, and/or bedrock outcrops
Ki	Karst areas mixed with scattered deposits of residuum, slopewash, alluvium and/or bedrock outcrops
ki	Clinker mixed with scattered deposits of residuum, slopewash, alluvium and/or bedrock outcrops
xi	Truncated bedrock mixed with scattered shallow deposits of eolian, terrace, residuum, alluvium, old alluvial plain, bench, and slopewash
Ti	Structural terrace including and/or mixed with deposits of alluvium, eolian, residuum, slopewash, and terrace.

Bedrock Geology

Bedrock geology as digitally derived from the Wyoming State 1:500,000 scale map (Love and Christiansen, 1985) is presented in **Figure 3.2.2-2**. A generalized bedrock stratigraphic column of the Bighorn Basin is presented in **Figure 3.2.2-3**.

A description of the stratigraphic framework of the Absaroka Volcanic Supergroup rocks is available from the USGS (Smedes and Prostka, 1972) and the WGS (Sundell 1982). Descriptions of some individual sedimentary rock units are available in various annual guidebooks published by the Wyoming Geological Association (e.g., Agatston, 1952; Keefer et al., 1998), and in petroleum hydrocarbon resource reports of various agencies (e.g., Finn et al., 2010; Fox and Dolton, 1996).

In a broad sense, the Owl Creek study area drainage basin can be subdivided into four regions based on dominant bedrock geology. The northwest and west end of the Owl Creek basin generally includes rock types categorized as Absaroka volcanic/volcaniclastic (upper watershed; orange, pink, and brown shading), Paleozoic sedimentary rocks occurring predominantly in the lower-middle basin (blue to violet shading), Mesozoic sedimentary rocks occurring in the lower basin (east half; yellow, green, and striped shading), and Precambrian igneous rocks outcropping along the southern central basin margin (mauve with white speckles). The dominant rock type in these regions likely influences water quality of groundwater surface water to some degree.

By a wide margin, the Paleozoic and Mesozoic sedimentary rocks make up the bulk of the entire study area watershed (generally in the central and eastern areas, lower in the basin), and underlie the area in where most human-related disturbances take place (cultivation, irrigation, grazing, etc.). The regions underlain by these sedimentary rocks do not host headwaters (except for the extreme southeast portion of the Buffalo Creek-Bighorn River watershed). In this area, Red Canyon Creek and its tributary Jergens Draw are sourced from the crests of the Northwest-Southeast-trending Nostrum Mountain and Owl Creek Mountains. Further descriptions of these geology types are included on the following pages.

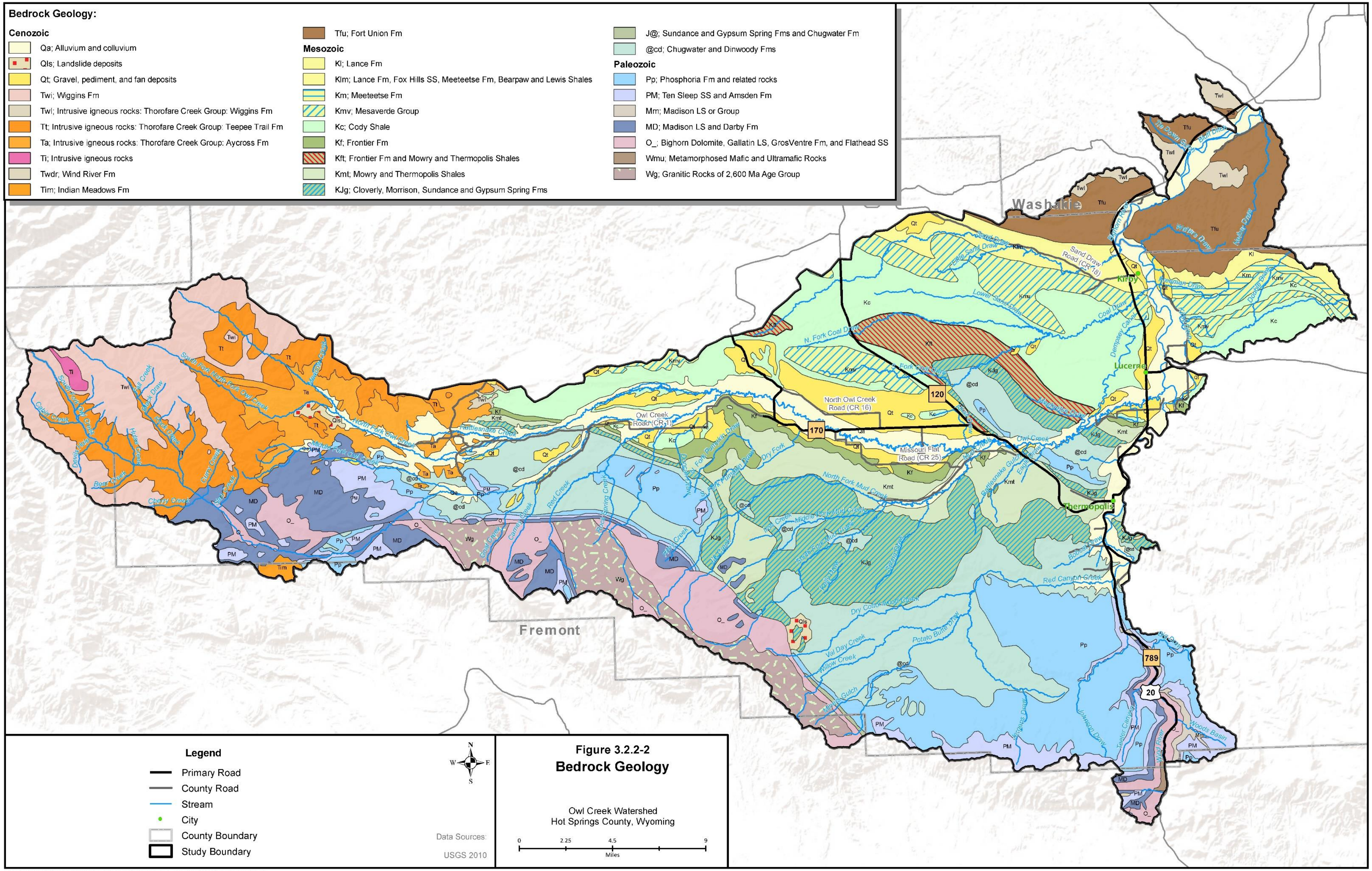

Figure 3.2.2-2
Bedrock Geology

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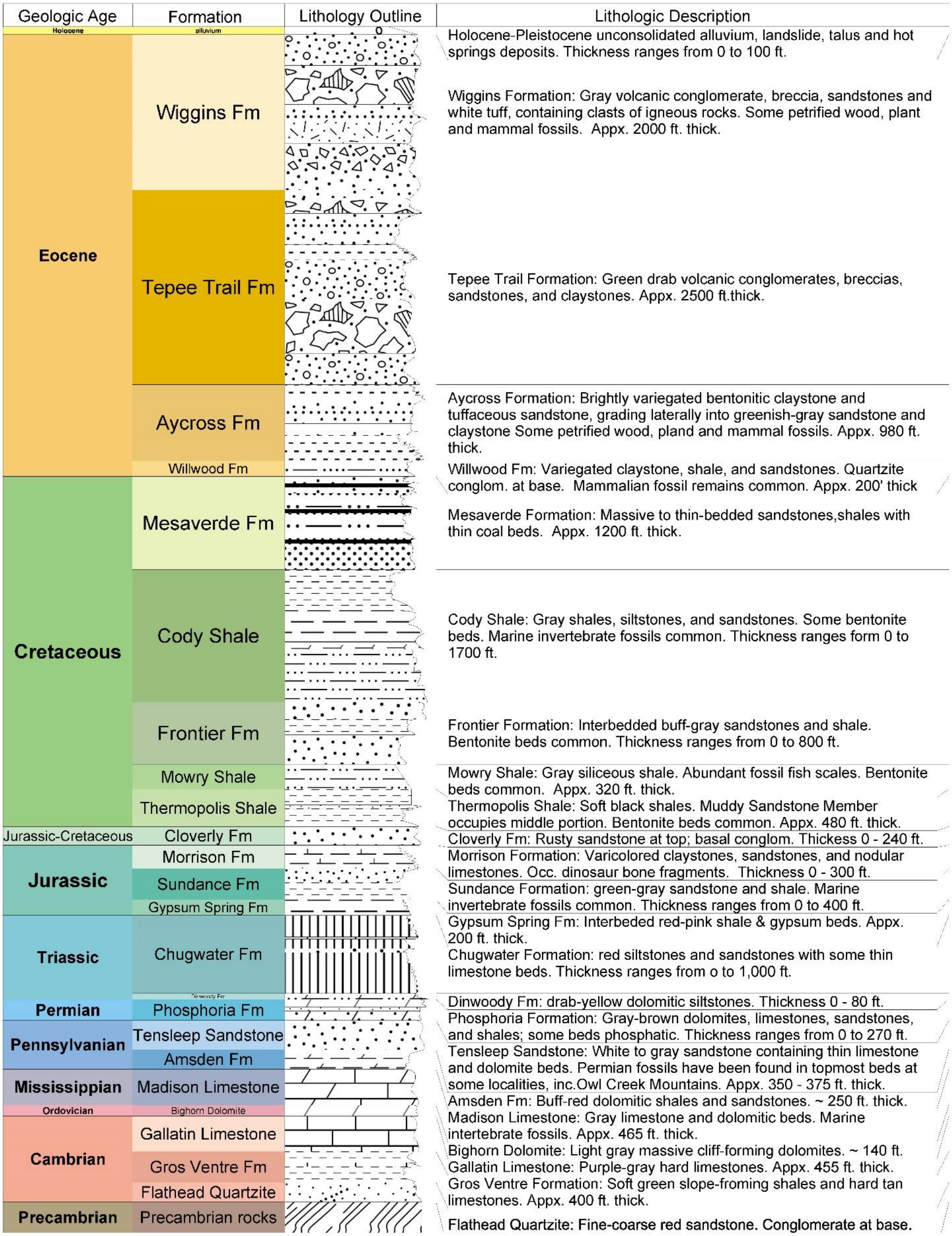

Data from Berry and Littleton (1961); Sundell (1982); Bown (1982).

Fig 3.2.2-3 Composite Stratigraphic Column, Owl Creek Area, Wyoming

Absaroka Volcanic Region

In general, the west half of the Owl Creek Basin is underlain by rocks of the Absaroka Volcanic Supergroup sequence. For the most part, this area represents a headwaters region and is situated at higher elevation than the rest of the Owl Creek basin.

These rocks consist mainly of Eocene andesitic, basaltic, and dacitic volcanoclastic rocks and comprises from oldest to youngest, the Washburn Group, Sunlight Group, and the Thorofare Creek Group (Smedes and Prostka, 1972; Love and Christiansen, 1985). The origin of these rocks is a deeply eroded field of andesitic and basaltic stratovolcanoes in northwest Wyoming and southwestern Montana, and coalesced deposits of reworked material derived from them, some ash-flow tuffs, and a variety of related intrusive bodies.

The Absaroka geologic region represents headwaters for numerous sub-watersheds in the study area. The Absaroka geologic region includes the headwater source areas for:

- Upper South Fork Owl Creek Sub-Watershed
- South Fork North Fork Owl Creek Sub-Watershed
- Upper North Fork Owl Creek Sub-Watershed
- West half of the Lower North Fork Owl Creek Sub-Watershed
- West and north edges the Middle Fork Owl Creek Sub-Watershed
- West end of the Middle South Fork Owl Creek Sub-Watershed

Paleozoic Sedimentary Rocks Region

In general, the middle and lower portions of the upper Owl Creek Basin is underlain by Paleozoic sedimentary rocks. These rocks include (oldest to youngest) Flathead Sandstone, GrosVentre Formation, Gallatin Limestone, Bighorn Dolomite, Madison Limestone (inc. Darby formation), Amsden Formation, Tensleep Sandstone, and the Phosphoria Formation (Love and Christiansen, 1985).

Mesozoic Sedimentary Rocks Region

Mesozoic sedimentary rocks occur principally in the east half of the Owl Creek basin at relatively lower elevations. These rocks include (oldest to youngest) Dinwoody Formation, Chugwater Formation, Gypsum Spring Formation, Sundance Formation, Morrison Formation, Cloverly Formation, Thermopolis Shale, Mowry Shale, Frontier Formation, Cody Shale, Mesa Verde Formation, Meeteetse Formation, and Lance Formation.

Most of the Mesozoic sedimentary rocks are of saline marine origin, many are soft and erodible (e.g., Chugwater, most shales), and some contain large quantities of evaporate minerals (e.g., Gypsum Spring), or bentonitic clays (e.g., Thermopolis, Mowry, Frontier). These qualities can have a detrimental effect on water quality with respect to suspended sediment, and total dissolved solids, and possibly impact water quantity due to channel spreading and braiding leading to increased infiltration or evaporation. This geologic region also underlies the area in where most human-related disturbances take place (cultivation, irrigation, grazing, etc.) and therefore impacts may be enhanced by the interaction of non-ideal natural geologic conditions and disturbance related to land use.

Precambrian Granitic Rocks Region

The Precambrian granitic geologic region is essentially restricted to two large intrusive bodies of Neoarchean (2.6 billion-year-old) granitic rocks occurring along the ridge of the Owl Creek Mountains bounding the south middle edge of the Owl Creek Basin (Love and Christiansen, 1985). The Precambrian granitic geologic region forms headwater source areas for:

- South end of the Lower South Fork Owl Creek Sub-Watershed (Goat Creek, and numerous unnamed tributaries of South Fork Owl Creek which drain the region to the south of Anchor Reservoir).
- Red Creek sub-watershed (Red Creek, Dry Cottonwood Creek and Rock Spring Creek)
- North Fork Mud Creek sub-watershed (North Fork Mud Creek and J K Creek)
- South Fork Mud Creek sub-watershed (South Fork Mud Creek)
- Dry Cottonwood Creek sub-watershed (Dry Cottonwood Creek[2]
- Willow Creek sub-watershed (Willow Creek, Miners Gulch, Black Rock Draw)

These streams all drain the north-northeast facing slopes of the Owl Creek Mountains at elevations up to approximately 9,000 feet and may be important sources of surface water in later months of the year from late snow melt associated with reduced solar exposure. Water quality would be expected to be high in this geologic region. However, all these streams, while originating as headwaters in the Precambrian Region, shortly enter downstream regions underlain by Paleozoic or Mesozoic rocks. In all cases, the lower portions of these streams eventually enter the Mesozoic geologic region and may experience degraded water quality or quantity for reasons discussed earlier.

Geologic Structure

The Owl Creek area has not been structurally mapped in detail, but there are regional-scale publications and existing data from oil and gas related publications which provide a level of understanding sufficient for a watershed study at this scale.

The Owl Creek Basin is located in the southwest end of the Bighorn Basin, the present structural configuration of which resulted from Laramide-age uplift and related compressional stress. The Bighorn Basin forms a geologic structural basin filled with more than 20,000 feet (6,100 m) of sedimentary rocks from Cambrian to Miocene in age. Large blocks of Precambrian-age crustal blocks were displaced upwards, generally along reverse or ramp faults of variable dip (Fanshawe, 1971). During this time, the Bighorn, Washakie and Owl Creek ranges (among others) were uplifted and smaller anticlinal features formed at the periphery of the basin. The central portion of the Bighorn basin was generally left undeformed during this event and received sediment eroded from the uplifted regions at the edge of the basin.

[2] Not to be confused with the identically named Dry Cottonwood Creek which is contained within the Red Creek Sub-watershed.

During Miocene time, approximately 10-12 million years ago, a period of broad regional uplift and extension began, which has continued into the present (Fanshawe 1971). This broad general uplift triggered increased erosional activities, leading to excavation of deep canyons, (e.g., Cottonwood Canyon, Wind River Canyon), as well as removal of thousands of feet of basin sediment via large rivers and their tributaries. Streams such as the Shoshone River, the Bighorn River, Porcupine Creek, and Cottonwood Creek were rejuvenated during this time of uplift and began to incise deep canyons into the underlying Paleozoic shales, limestones, and dolomites.

Geologic Hazards

Little specific study has been carried out with respect to geologic hazards. Commonly, geologic hazards include earthquakes, landslides, and hazards associated with the area's proximity to the Yellowstone Caldera, and possibly flood hazards related to concentrated storm cells or unexpectedly large run-off events. Small scale mapping at the 1:1,000,00 scale completed by the Wyoming Geological Survey (Larsen and Wittke, 2013) reveals several areas within the Owl Creek Basin where previous landslides have been mapped (**Figure 3.2.2-1**).

This mapping indicates that landslide deposits occur generally in three regions: (1) the Absaroka geologic region on steep slopes bordering stream channels (mainly the South Fork Owl Creek, North Fork Owl Creek, and South Fork North Fork Owl Creek), (2) steep north-facing slopes of the Owl Creek Mountains in the Mud Creek sub-watersheds, and (3) steep slopes in Wind River Canyon in the Cottonwood Creek-Wind River Watershed.

Due to the proximity of the study area to the Yellowstone Caldera, hazards related to future volcanic activity would be expected to be significant and widespread. However, the low degree of certainty with regard to future eruptions related to the Yellowstone Caldera makes planning for such events practically futile.

3.2.3 Soils

Soils are diverse within the study area because of the variable characteristics of the watershed's underlying geology, topography and elevation, climate and precipitation, and vegetation. Consequently, soils in the watershed vary considerably. Available soils information and data were obtained from the NRCS and compiled for the watershed. Detailed soils mapping is not available for the entire watershed and it is important to note that there is currently no completed soil survey in Hot Springs County; only a generalized survey has been completed and published. Completion of a detailed soil survey and soils mapping would greatly enhance the capabilities of the HSCD to conduct local and regional planning efforts. For the most current soils information, landowners and managers should access soils data via the Web Soil Survey (WSS) at http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm,which provides soil maps and data for almost all counties in the United States and is updated regularly by the NRCS.

Figure 3.2.3-1 displays a general soils map of the study area prepared using data mapped at the 1:250,000 level of detail and obtained from the NRCS (NRCS 2016).

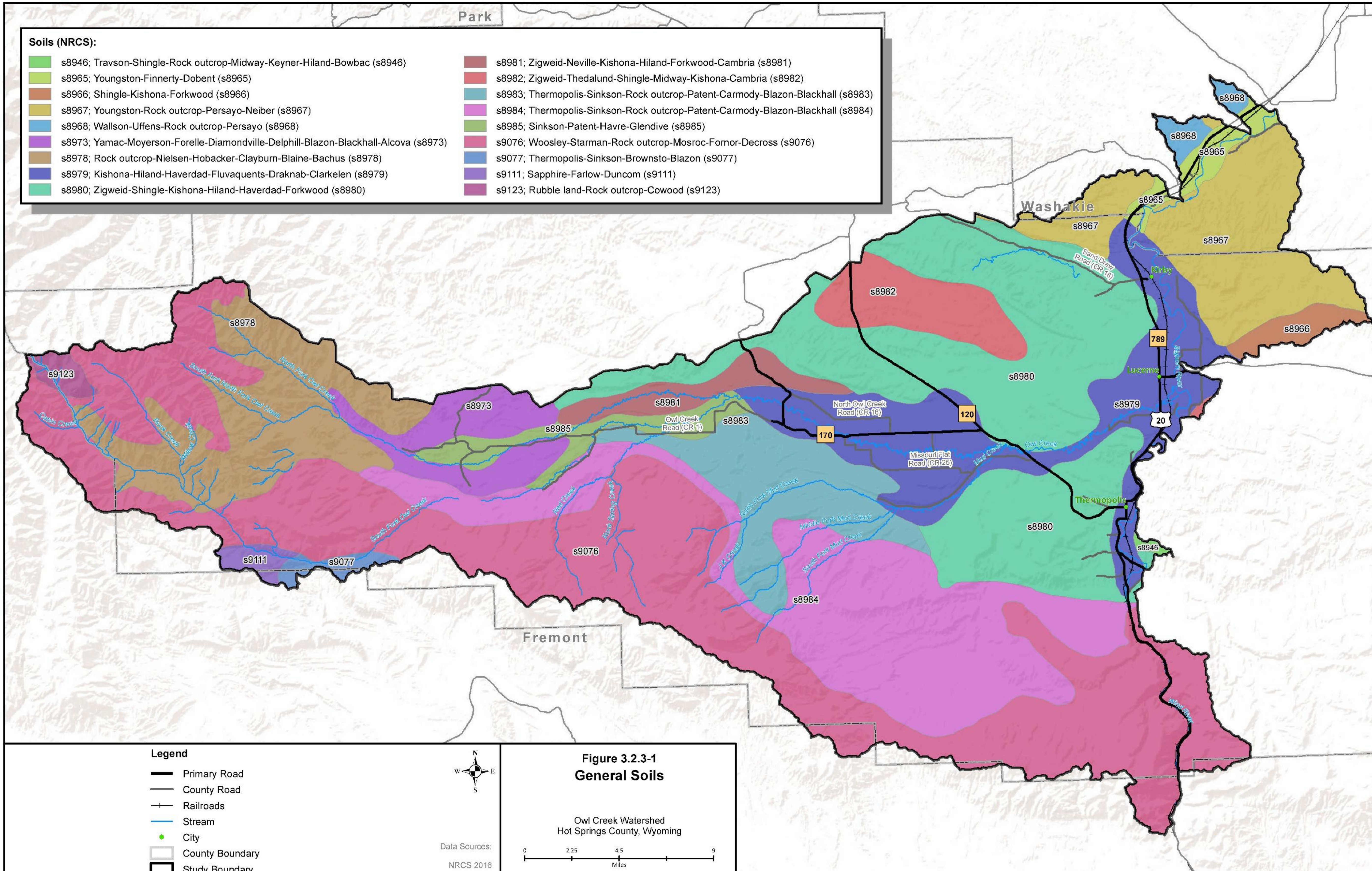

Figure 3.2.3-1
General Soils

Owl Creek Watershed
Hot Springs County, Wyoming

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3.2.4 Land Cover, Wetlands, and Riparian Areas

General Land Cover

This section discusses the dominant vegetation community land cover types of the undeveloped areas of the watershed, which are illustrated in **Figure 3.2.4-1**.

Sagebrush steppe dominates the majority of the Owl Creek watershed and is found from the basin to the mid-elevation foothills. The dominant plant species in this community is Wyoming big sagebrush (*Artemisia tridentata* ssp. *Wyomingensis*), with bunchgrasses and forbs growing in the interspaces. In the sagebrush uplands, other commonly found native plants include needle and thread grass (*Hesperostipa comata*), Sandberg bluegrass (*Poa sandbergii*), blue grama grass (*Bouteloua gracilis*), alkali sacaton (*Sporobolus airoides*), bluebunch wheatgrass (*Pseudoroegneria spicata*), western wheatgrass (*Pascopyron smithii*), bottlebrush squirreltail (*Elymus elymoides*), scarlet globemallow (*Sphaeralcea coccinea*), asters (family *Asteraceae*), phlox (family *Polemoniaceae*), buckwheats (family *Polygonaceae*), rabbitbrushes (*Chrysothamnus sp.*), black sage (*Artemisia nova*), three-tip sage (*Artemisia tridentata*), winterfat (*Krascheninnikovia lanata*), snakeweed (*Gutierrezia sarothrae*), greasewood (*Sarcobatus vermiculatus*), and saltbushes (*Atriplex sp.*).

At higher elevations surrounding the headwaters of the watershed, mixed spruce-fir forests made up of Engelman spruce (*Picea engelmanii)* and subalpine fir (*Abies lasiocarpa*) are dominant. Spruce-fir forests transition to lodgepole pine forests as elevation decreases. Dominant species within the lodgepole pine forest include lodgepole pine (*Pinus contorta*), Douglas fir (*Pseudotsuga menziesii*), and aspen (*Populus tremuloides*). Patchy woodlands of limber pine (*Pinus flexilis*) and juniper (*Juniperus scopulorum*) are found along lower elevation cliffs and hillsides, transitioning to areas dominated by sagebrush steppe as elevation decreases.

Near the lowest elevations of the basin, areas of shale badlands and greasewood flats intermingle with sagebrush steppe. These badlands and flats are dominated by greasewood and saltbush while sagebrush, forbs, and grasses are sparse. Much of the rangelands have been invaded by cheatgrass (*Bromus tectorum*). Designated noxious weed infestations include Russian knapweed (*Rhaponticum repens L.*), spotted knapweed (*Centaurea stoebe L.*) and Canada thistle (*Cirsium arvense L.*).

Based on aerial imagery review and visits to the study area, there are expansive, though narrow, cottonwood galleries along the bottomlands of the North and South Forks of Owl Creek. These native tree stands are at risk due to encroachment by saltcedar and Russian olive, which use more water than the native cottonwoods and outcompete them. These two invasive exotic species proliferate along waterbodies, stream banks, riparian zones, and irrigation ditches. This can increase in soil salinity, and consuming larger quantities of water than native trees (Wyman 2007).

Wetlands

The term “wetlands” means those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (33 CFR 328.3 [51 Federal Register 41250]). Activities in wetlands are regulated by the U.S. Army Corps of Engineers (USACE).

According to the 1987 USACE Manual (Environmental Laboratory 1987), wetlands are characterized by the following three distinct environmental characteristics, which distinguish them from adjacent uplands:

(1) *Vegetation*. The prevalent vegetation consists of species that are typically adapted to life in soil that is inundated with water at least part of the year. This specialized vegetation can persist in soil that is wet and lacking oxygen for at least part of the year.
(2) *Soils*. Soils in wetlands are classified as "hydric", or they possess characteristics that are associated with lack of oxygen, or "anaerobic" conditions. A common visible indicator is soils mottled with rusty red or grey spots, patches, or streaks.
(3) *Hydrology*. The area must be inundated with water either permanently or periodically at average water depths of less than 6.6 feet, or the soil is saturated at the surface for some time during the growing season.

The hydrology of any site or region is ultimately linked to precipitation, but the development of wetlands is dependent on the longer term presence of available water. Wetlands in the project area likely originate primarily from surface water, groundwater, or both.

Wetland soils differ from upland soils due to the prolonged presence of water. Hydric soils would be expected to be found within the project area on active floodplains, floodplain terraces, depressional areas, swales, playas, and drainages.

According to the National Wetlands Inventory (NWI), there are approximately 5,014 acres of presumed wetlands mapped within the Owl Creek study area. The majority are located in the bottomland areas in irrigated and sub-irrigated hay meadows. Most of these wetlands are freshwater emergent wetlands located along stream edges and riparian areas (USFWS 2016a). Wetlands are classified based on Cowardin et al. (1979), which is a widely used system that categorizes wetlands based on structure, class, subclass, and dominance types. The dominant wetland types found in the Owl Creek watershed are described below and summarized in **Table 3.2.4-1**. Wetland locations are shown in **Figure 3.2.4-2**.

Freshwater emergent wetlands (PEM)

Freshwater, or palustrine, emergent wetlands are characterized by erect, rooted, herbaceous plants. PEM wetlands usually are dominated by perennial herbaceous plants, although some woody plants may be present. (Cowardin et al. 1979).

Freshwater Scrub-Shrub Wetlands (PSS)

Freshwater, or palustrine, scrub-shrub wetlands include freshwater wetlands dominated by woody vegetation less than 20 feet in height or with trunks less than 3 inches diameter at breast height (dbh). PSS wetlands include true shrubs, saplings, young trees, and trees or shrubs that are small or stunted because of environmental conditions (Cowardin et al. 1979).

Freshwater Forested Wetlands (PFO)

Freshwater, or palustrine, forested wetlands are commonly dominated by water-loving trees. Some of these wetlands contain trees displaying buttressed roots, a morphological adaptation to wetland hydrologic conditions (Cowardin et al. 1979).

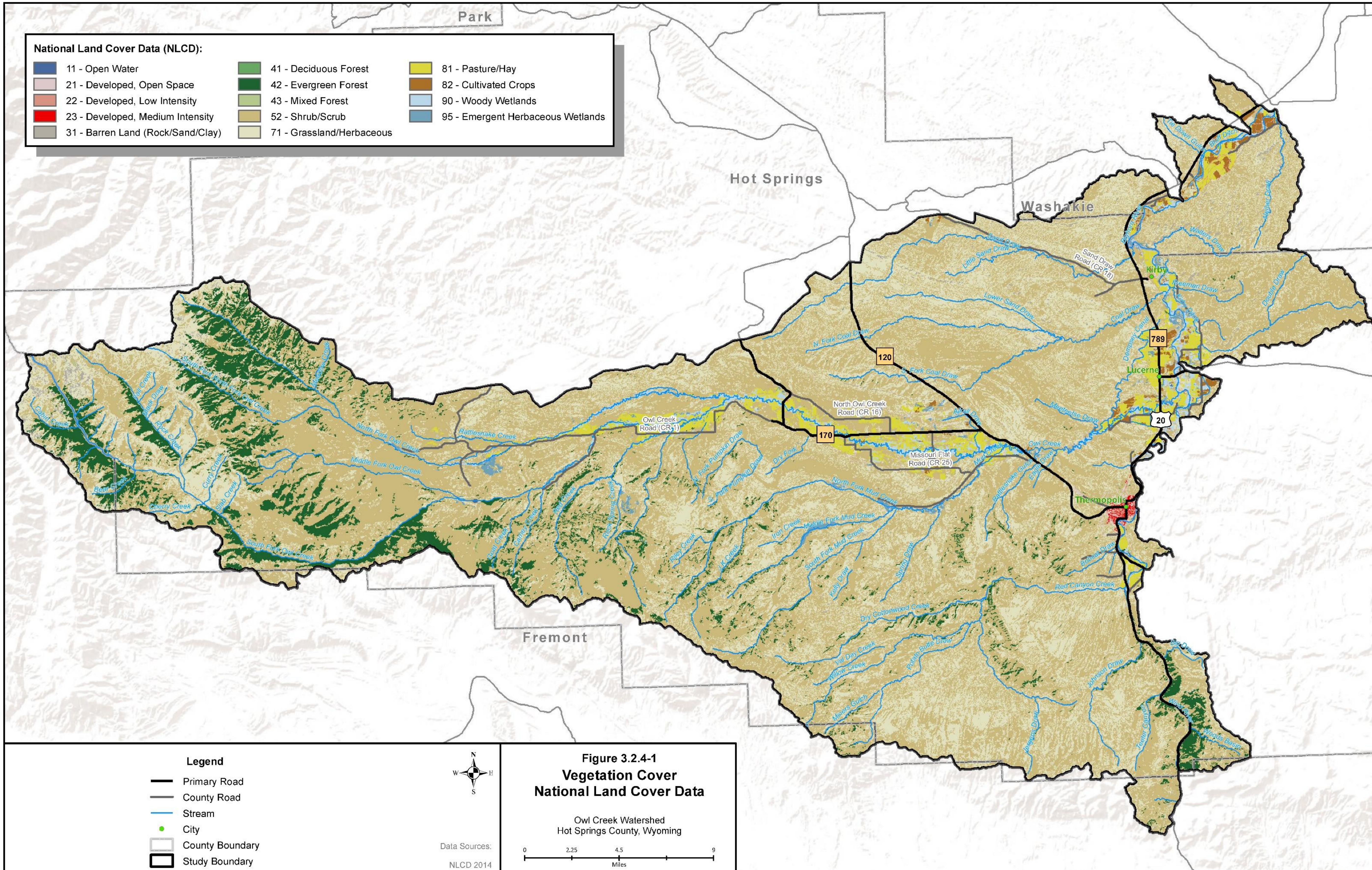

Figure 3.2.4-1
Vegetation Cover
National Land Cover Data

Owl Creek Watershed
Hot Springs County, Wyoming

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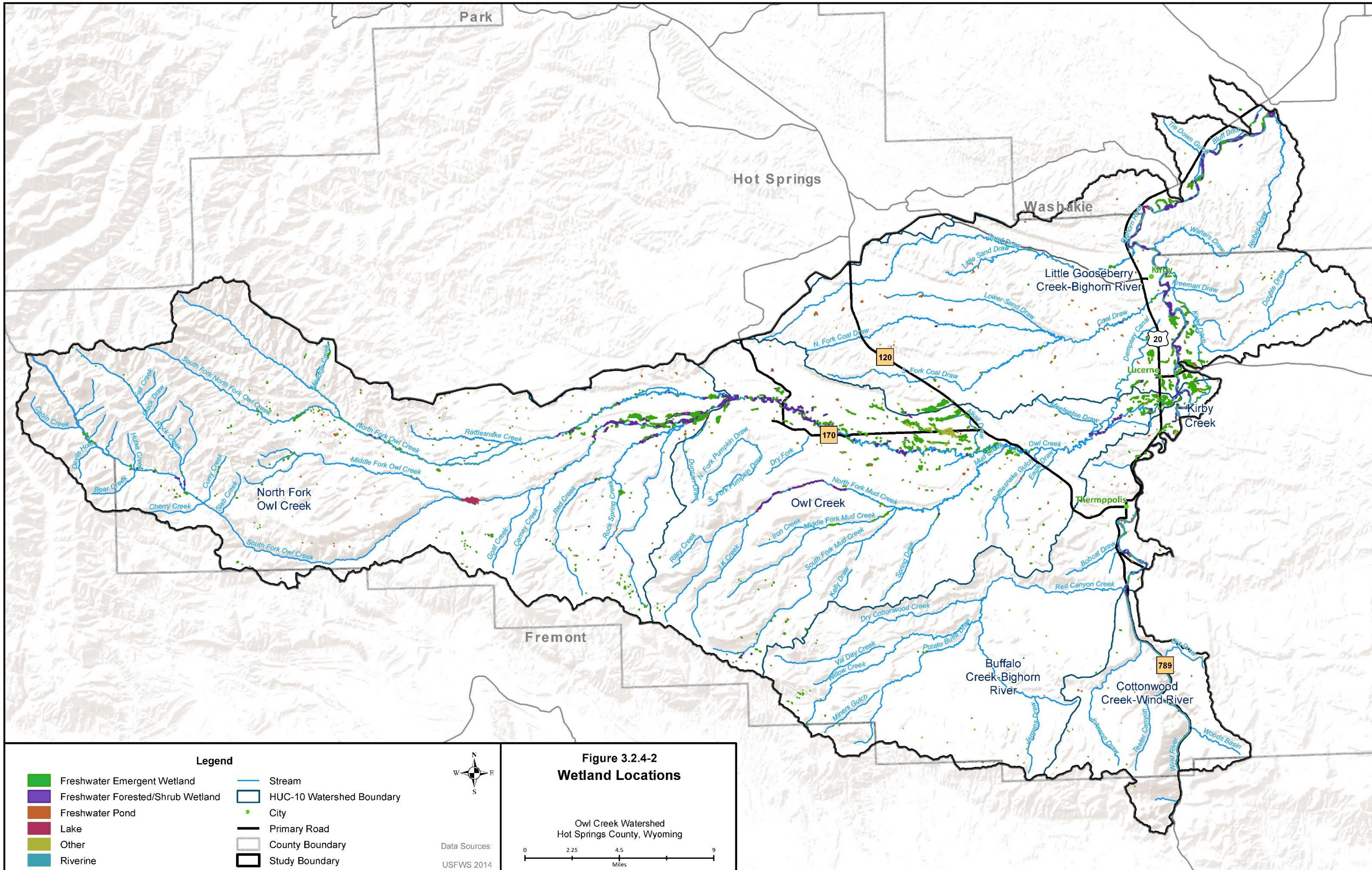

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Ponds and Lakes

Ponds and lake are part of the lake, or lacustrine, system of wetlands that includes bodies of open water that may or may not be wet year-round. Ponds and lakes provide habitat for fish, insects, and other animals within the water and on the floor of the water body.

Riverine

Riverine systems are rivers, creeks, and intermittent drainage areas. These are usually, but not always, flowing. Riverine systems are contained within a channel and bounded on the landward side by upland, by the channel bank (including natural and man-made levees), or by wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. (FGDC 2013).

Other

This category includes other areas that are wet at least part of the year but do not fit in previously listed categories due to aerial extent, water depth, lack of surface vegetation, location, or other factors.

Table 3.2.4-1 National Wetland Inventory Data for the Owl Creek Watershed, Hot Springs County, WY

Sub-Watershed	Wetland Type (Acres)						Total Acres
	Freshwater Emergent Wetland	Freshwater Scrub-Shrub and Forested Wetland	Ponds	Lakes	Other	Riverine	
Buffalo Creek-Bighorn River	156	77	20	--	5	369	627
Cottonwood Creek	--	--	--	--	--	--	0
Cottonwood Creek-Wind River	5	6	2	--	3	226	242
Little Gooseberry Creek-Bighorn River	634	399	73	16	9	567	1698
North Fork Owl Creek	533	365	45	89	6	121	1159
Owl Creek	809	341	37	--	100	1	1288
Total	2137	1188	177	105	123	1284	5014

As part of this study, wetlands greater than 10 acres in size as mapped by NWI were analyzed using aerial imagery to document any significant changes over time. Based on a review by a wetland biologist of aerial imagery using Google Earth over a 20 year period from 1994 to 2014, it was noted that most wetlands in the watershed fluctuate in size seasonally and yearly, based on precipitation. Some wetlands in the Owl Creek watershed have decreased in size over time, apparently due to conversion to irrigated agriculture fields and planted grass and alfalfa meadows. Wetlands and riparian areas throughout the Owl Creek drainage also appear to have experienced an increase in Russian olive and saltcedar populations over time. These species outcompete and displace native riparian vegetation, degrade soil chemistry, and alter hydrologic processes due to their increased demand for water versus native vegetation (Wyman 2007).

Riverine wetlands located along the Bighorn River have experienced conversions from PSS to PEM classes. This is most likely due to Russian olive and saltcedar treatment and removal. Removal of these trees and shrubs will likely allow increased water storage in the lowlands due to decreased evapotranspiration as native herbaceous wetland vegetation replaces trees. This could result in wetland expansion in these areas (Saige 2015).

Riparian Areas

Riparian areas are lands that occur along watercourses and water bodies (NRCS 1996). Typical examples include flood plains and streambanks. They are distinctly different from surrounding lands because of unique soil and vegetation characteristics that are strongly influenced by the presence of water. Riparian areas in the Owl Creek watershed include wetland areas, vegetated communities along streams, and irrigated and sub-irrigated wet meadows. Riparian areas serve many of the same functions as wetlands such as water storage, flood flow attenuation, nutrient cycling, water quality improvement, and wildlife habitat.

In the Owl Creek watershed, riparian areas are abundant and in many places wide, especially along the lower portions of the South Fork and main channel of Owl Creek. These lowland riparian areas are located in the broad flood plain of owl creek which is underlain by quaternary gravel, pediment, and fan deposits (WSGS 2012) which supports a shallow groundwater table and associated water-loving plants. The flood plain is bounded by low escarpments on either side of the river, above which drier rangeland persists. This flood plain area contains the best land in the drainage for agricultural crops as soils are typically sandy to clay loams and deeper than upland soils (NRCS 2013). Irrigation ditches in the Owl Creek drainage are generally earthen and some leakage to surrounding land occurs. This supports a ribbon of lush, non-agricultural land supporting grasses and shrubs, including willows, depending on the ditch or canal. Most agricultural producers on Owl Creek use flood irrigation. Waters applied to agricultural fields using this method cannot be precisely applied and some excess water runs off, collecting in low-lying areas or flowing back to Owl Creek itself. This “waste” water supports small areas of habitat for a wide variety of mammals, birds, reptiles, and other critters. As irrigation ditches are replaced with pipe, or center pivot systems replace flood irrigation, water use efficiency increases, but these small islands and ribbons of habitat may disappear.

The upper reaches of the South and North Forks of Owl Creek have narrower riparian corridors due to topography. These riparian areas contain willows, aspen, and cottonwoods and in the most upper reaches pine, fir, and spruce. These trees support herons, raptors, and other bird species and contribute to a diverse ecosystem.

Noxious Weeds

The Hot Springs, Fremont, and Washakie County Weed and Pest Districts administer treatments and control of state listed noxious weeds as well as county declared weeds within the watershed. **Table 3.2.4-2** lists the state listed noxious weeds and declared weeds by county.

Table 3.2.4-2 State-listed Noxious Weeds and County Declared Weeds within the Owl Creek Watershed

Common Name	Scientific Name	Status
Field bindweed	*Convolvulus arvensis*	State Noxious
Canada thistle	*Cirsium arvense*	State Noxious
Leafy spurge	*Euphorbia esula*	State Noxious
Perennial sowthistle	*Sonchus arvensis*	State Noxious
Quackgrass	*Agropyron repens*	State Noxious
Hoary cress (whitetop)	*Cardaria draba*	State Noxious
Perennial pepperweed	*Lepidium latifolium*	State Noxious
Ox-eye daisy	*Chrysanthemum leucanthemum*	State Noxious
Skeletonleaf bursage	*Franseria discolor*	State Noxious
Russian knapweed	*Centaurea repens*	State Noxious
Yellow toadflax	*Linaria vulgaris*	State Noxious
Dalmatian toadflax	*Linaria dalmatica*	State Noxious
Scotch thistle	*Onopordum acanthium*	State Noxious
Musk thistle	*Carduus nutans*	State Noxious
Common burdock	*Arctium minus*	State Noxious
Plumeless thistle	*Carduus acanthoides*	State Noxious
Dyers woad	*Isatis tinctoria*	State Noxious
Houndstongue	*Cynoglossum officinale*	State Noxious
Spotted knapweed	*Centaurea maculosa*	State Noxious
Diffuse knapweed	*Centaurea diffusa*	State Noxious
Purple loosestrife	*Lythrum salicaria*	State Noxious
Saltcedar	*Tamarix spp.*	State Noxious
Common St. Johnswort	*Hypericum perforatum*	State Noxious
Common Tansy	*Tanacetum vulgare*	State Noxious
Russian olive	*Elaeagnus angustifolia*	State Noxious
Black Henbane	*Hyoscyamus niger*	State Noxious
Baby's Breath	*Gypsophila paniculata*	Fremont County Declared
Cheatgrass	*Bromus tectorum*	Fremont, Hot Springs, Washakie County Declared
Puncturevine	*Tribulus terrestris*	Fremont, Hot Springs, Washakie County Declared
Swainsonpea	*Sphaerophysa salsula*	Fremont, Washakie County Declared
Bull thistle	*Cirsium vulgare*	Hot Springs County Declared
Curlycup gumweed	*Grindelia squarrosa*	Hot Springs County Declared
Wild oat	*Avena fatua*	Hot Springs County Declared
Absinth wormwood	*Artemisia absinthium*	Washakie County Declared
Common crupina	*Crupina vulgaris*	Washakie County Declared
Common mullein	*Verbascum thapsus*	Washakie County Declared
(Woolly) Distaff thistle	*Carthamus lanatus*	Washakie County Declared
Iberian starthistle	*Centaurea iberica*	Washakie County Declared
Italian thistle	*Carduus pycnocephalus*	Washakie County Declared

Table 3.2.4-2 State-listed Noxious Weeds and County Declared Weeds within the Owl Creek Watershed		
Common Name	**Scientific Name**	**Status**
Meadow knapweed	*Centaurea pratensis*	Washakie County Declared
Medusahead	*Taeniatherum caput-medusae*	Washakie County Declared
Orange hawkweed	*Hieracium aurantiacum*	Washakie County Declared
Purple starthistle	*Centaurea calcitrapa*	Washakie County Declared
Rush skeltonweed	*Chondrilla juncea*	Washakie County Declared
Sandbur	*Cenchrus incertus*	Washakie County Declared
Scentless chamomile	*Matricaria perforata*	Washakie County Declared
Scotch broom	*Cytisus scoparius*	Washakie County Declared
Squarrose knapweed	*Centaurea virgata*	Washakie County Declared
Sulfur cinquefoil	*Potentilla recta*	Washakie County Declared
Tansy ragwort	*Senecio jacobaea*	Washakie County Declared
Tall Mountain Larkspur	*Delphinium occidentale*	Washakie County Declared
Teasel	*Dipsacus fullonum*	Washakie County Declared
Venice mallow	*Hibiscus trionum*	Washakie County Declared
Wild licorice	*Glycyrrhiza lepidota*	Washakie County Declared
Yellow hawkweed	*Hieracium fendleri*	Washakie County Declared
Yellow starthistle	*Centaurea solstitialis*	Washakie County Declared

Source: Wyoming Weed and Pest Council. 2016. State Designated and 2016 County Declared Weed & Pest List. Available at: http://www.wyoweed.org/weeds/state-designated-weeds

Noxious weeds replace native vegetation, reduce agricultural productivity, can cause wind and water erosion, and pose an increased threat to communities from wildfire. Each Weed and Pest District's goal is to prevent the introduction of new invasive species, eradicate species with isolated or limited populations, and contain and manage those invasive species that are well-established and widespread.

Owl Creek watershed is divided into seven zones by Hot Springs County Weed and Pest to help record and plan control for noxious weed infestations. Weed control often focuses on waterways and roadways as these are two ways noxious weeds are spread. According to Lindsey Woodward of Hot Springs County Weed and Pest, leafy spurge is the highest priority weed for control by the agency. Other common noxious weeds of concern in Hot Springs County are Russian knapweed, Canada thistle, saltcedar, and Russian olive. Recorded infestations of noxious weeds on public lands in Hot Springs County are shown in **Figure 3.2.4-3**. This is not an exhaustive list because at the time of contact, the shapefiles were not fully updated for 2017 (Woodward 2017).

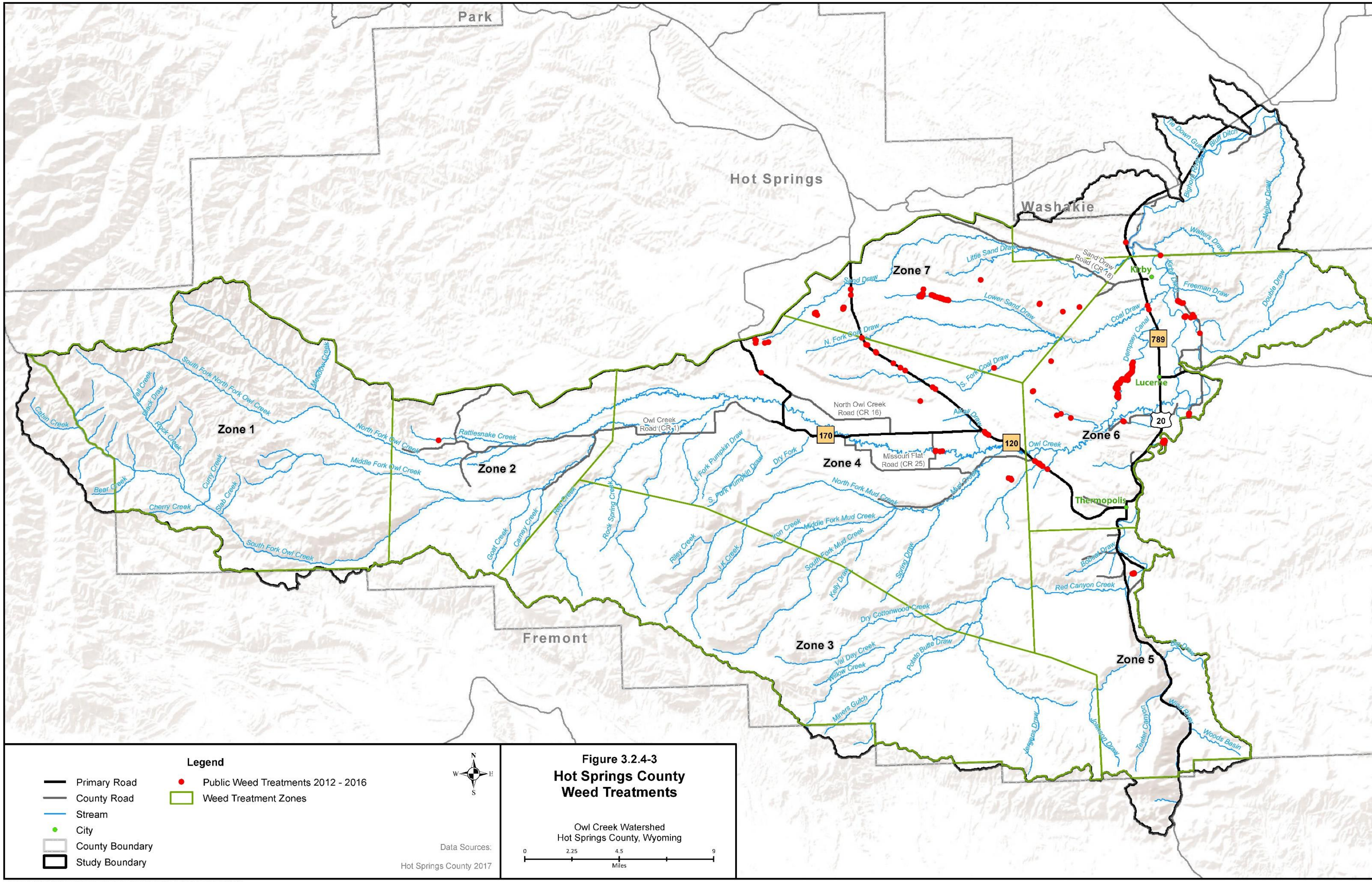

Figure 3.2.4-3
Hot Springs County Weed Treatments
Owl Creek Watershed
Hot Springs County, Wyoming

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3.2.5 Fisheries and Wildlife

The Owl Creek watershed provides aquatic and terrestrial habitat that supports diverse wildlife and fisheries populations. There are several "species of conservation concern" (SPCC) that are known to be found, or may be found, within the watershed (WISDOM 2016). Improving watershed health and function may benefit these species over time. Habitat improvements would likely cause short-term disturbance associated with construction work but if done using Best Management Practices, impacts would be expected to heal over one to a few years.

State and federal regulations regarding the timing and location of surface disturbances may affect a project's construction timeframe. Construction activities should be planned to take place between August 1 and November 14 to minimize short-term construction-related impacts to fish, big game, migratory birds, raptors, and the Greater sage-grouse. However, site-specific project assessments are recommended, and coordinating with state and federal agencies regarding permits, disturbance guidelines, environmental documentation, or analysis prior to project construction may be required for the species and habitats discussed below. Please see **Section 9** of this report for further details on permitting and disturbance guidelines.

Fisheries

The waterways within the Owl Creek watershed study boundary provide habitat that supports several fisheries. The fisheries within the Owl Creek watershed study boundary are integral to a functioning ecosystem, and contribute to subsistence living, recreation, and tourism within the region (HSCLUP 2014). Regulations and permitting for stream projects falls under the authority of USACE and the WDEQ. The WGFD reviews projects and suggests ways to minimize potential impacts to fisheries, particularly for aquatic habitat that is particularly valuable to conservation, such as reaches designated as Crucial Stream Corridors or Blue Ribbon Trout Streams.

Diversions for irrigation systems can have significant effect on fish populations, depending on whether the diversion is passable by fish or not. Diversion data was acquired from WGFD and is shown with stream classification information in **Figure 3.2.5-1**. It is important to note that the WGFD diversion data indicates the presence of a structure in the creek, but does not specify whether the diversion is passable (such as presence or a fish ladder) or impassable to fish. In addition, Sam Hochhalter, the WGFD fisheries department supervisor, stated that this data is not a comprehensive list (personal communication, 5/11/2017). Diversion data for the WGFD is largely gathered by field crews as they find them, rather than while conducting a specific diversion mapping effort.

Fish Population Data

Many species of fish have been documented within the waterways of the Owl Creek watershed study area (WISDOM 2016; **Table 3.2.5-1**). Of these species (Table 3.2.5-1), the Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*) ranks highest for conservation concern and efforts. As early as the early 1900s, Yellowstone cutthroat trout numbers plummeted following introductions of non-native trout species, including brook, rainbow, brown, and lake trout. Consequently, WGFD has worked to remove non-native trout and to improve habitat in waters where the Yellowstone cutthroat trout remains. An ecologically and economically important inland trout species in Wyoming, the Yellowstone cutthroat requires cold, clean water in streams and lakes. Unlike most non-native trout, some populations of this species migrate up smaller streams to spawn, where they become an important food source for other species, including osprey, bald eagles, river otters, mink, and grizzly bears. The Yellowstone cutthroat trout have a varied diet, but rely primarily on aquatic insects, such as mayflies, stoneflies, and caddisflies, as well as terrestrial insects that fall into the water, and small aquatic animals, such as fish, fish eggs, and frogs, although they also consume algae, some aquatic plants, and plankton for nutrients.

Owl Creek above Anchor Reservoir contains a population of Yellowstone cutthroat trout, and has therefore been designated a WGFD aquatic crucial priority area (WISDOM 2016). No projects were identified upstream of Anchor Reservoir in this Study.

In any areas that support Yellowstone cutthroats or other game fish, The WGFD requests that in-channel work be conducted in ways that provide a net benefit or no net loss of stream habitat, such as using "natural channel design" when stream channels are modified to control erosion or headcutting. A short two-minute video from Georgia Tech University introducing this concept can be found at https://www.youtube.com/watch?v=FeF9zuKUVSg. All proposed projects are located below Anchor Dam; therefore any potential construction is likely to have no impact on the species.

The WGFD and USACE recommend that in-channel work be conducted from mid-July to mid-April to avoid the spawning of the Yellowstone cutthroat trout (generally occurring between late April through early July). Further, the State Wildlife Action Plan (WGFD 2010) identifies problems and solutions that should be considered for the conservation of this fish:

Problems

- Available habitat that is not affected by anthropogenic influences is located in headwater streams with limited connectivity and some are located within wilderness areas. Restoration or introductions can be problematic in these areas. Construction of exclusionary barriers to limit non-native salmonid introgression or competition can also be a problem given the soil types and erosive nature of the Absaroka volcanics that dominate the range of Yellowstone Cutthroat trout.
- Nonnative salmonids introduced into waters with Yellowstone cutthroat almost always eliminate cutthroat populations over time through hybridization, predation and/or competition.
- Previous introduction of nonnative salmonids has diminished the genetic integrity of many Wyoming populations. In some cases there continues to be hybridization.
- Lack of connectivity resulting from low flows or other physical barriers (natural and man-made) may significantly limit access to upstream habitats.

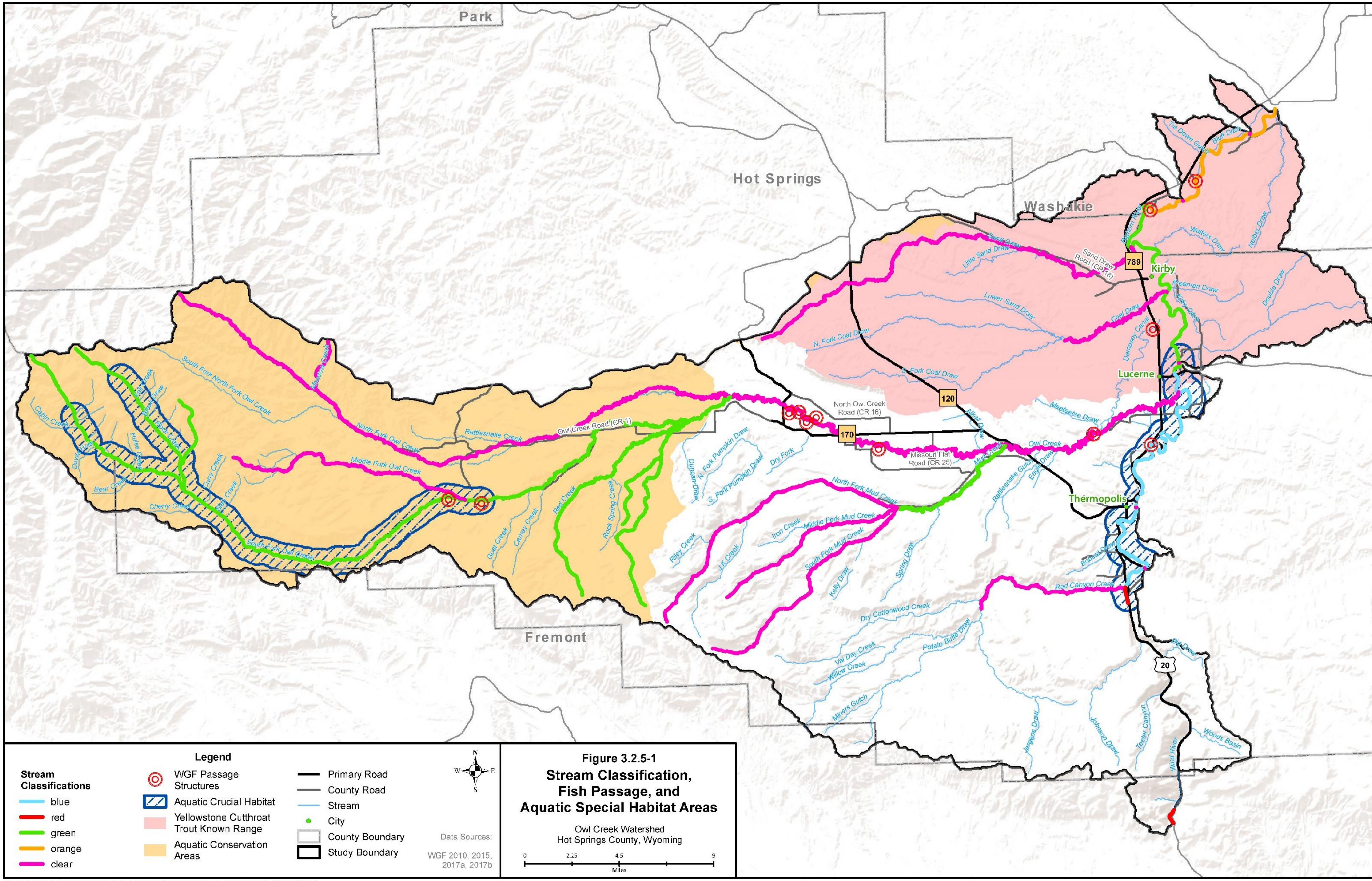

Figure 3.2.5-1
Stream Classification, Fish Passage, and Aquatic Special Habitat Areas

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Conservation Actions

- Continue efforts to remove competing and hybridizing nonnative species to secure, enhance and restore populations.
- Continue to remove anthropogenic barriers limiting gene flow and the expression of fluvial life history strategies.
- File for instream flow water rights to protect habitat of conservation populations.
- Continue regulations to restrict harvest of vulnerable populations.
- Prevent stocking of public or private waters with non-native species that may impact conservation populations.
- Protect and manage riparian areas for native riparian vegetation that will filter runoff, maintain a higher water table, provide late season stream recharge, and stabilize stream banks. Use riparian fencing, grazing management, fire management, and invasive species control to promote native vegetation.
- Identify and characterize all populations within their native range in Wyoming.
- Develop refugia for pure populations in lakes or streams to act as backup for hatchery brood sources.

Information on fish species found within the Owl Creek watershed study area is based on stream and lake surveys conducted by the WGFD (**Table 3.2.5-1**). Refer to **Table 3.2.5-2** for a key to the stream names associated with each waterway code. Species of Greatest Conservation Need (SGCN) Tiers are defined by the WGFD's 2010 State Wildlife Action Plan as: Tier I – highest conservation priority, Tier II – moderate conservation priority, Tier III – lowest conservation priority. Species that are not designated as a SGCN, have not been assigned a Tier designation.

Table 3.2.5-1 Fish Species Found in the Owl Creek Watershed

Common Name	Scientific Name	Wyoming Native (Y/N)	SGCN Tier	Stream Reach Code (See Table 3.2.5.2)
Yellowstone Cutthroat Trout	*Oncorhynchus clarkii bouvieri*	Y	I	2,5,10,13,14
Burbot	*Lota lota*	Y	II	1,2,3,15
Mountain Whitefish	*Prosopium williamsoni*	Y	II	1,3,10,15
Snake River Cutthroat Trout	*Oncorhynchus clarkii behnkei*	Y	II	1,3,13
Western Silvery Minnow	*Hybognathus argyritis*	Y	II	2
Plains Minnow	*Hybognathus placitus*	Y	II	2
Sauger	*Sander canadense*	Y	II	2,15
Flathead Chub	*Platygobio gracilis*	Y	III	2,5,15
Northern Plains Killifish	*Fundulus kansae*	Y	III	4,5,7
Longnose Sucker	*Catostomus catostomus*	Y		1,2,3,5,7,15
Mountain Sucker	*Catostomus platyrhynchus*	Y		1,2,3,5,6,7,9,10,15
River Carpsucker	*Carpiodes carpio*	Y		1,2,15
Shorthead Redhorse	*Moxostoma macrolepidotum*	Y		1,2,3,15

Table 3.2.5-1 Fish Species Found in the Owl Creek Watershed

Common Name	Scientific Name	Wyoming Native (Y/N)	SGCN Tier	Stream Reach Code (See Table 3.2.5.2)
Stonecat	*Noturus flavus*	Y		1,2,3,15
Longnose Dace	*Rhinichthys cataractae*	Y		1,2,3,4,6,7,9,10,15
White Sucker	*Catostomus commersonii*	Y		1,2,3,4,5,6,7,15
Fathead Minnow	*Pimephales promelas*	Y		2,4,5,7
Sand Shiner	*Notropis stramineus*	Y		2
Lake Chub	*Couesius plumbeus*	Y		4,5,6,7,15
Creek Chub	*Semotilus atromaculatus*	Y		15
Black Bullhead	Ameiurus melas	Y		16
Brown Trout	*Salmo trutta*	N		1,3,6,7,15
Common Carp	*Cyprinus carpio*	N		1,3,5,6,7,15
Emerald Shiner	*Notropis atherinoides*	N		1,6,7
Rainbow Trout	*Oncorhynchus mykiss*	N		1,2,3,5,10,11,13,15
Smallmouth Bass	*Micropterus dolomieu*	N		2
Walleye	*Sander vitreum*	N		2,15
Brook Trout	*Salvelinus fontinalis*	N		8,10,11,12
Black Crappie	*Pomoxis nigromaculatus*	N		15
Yellow Perch	*Perca flavescens*	N		15

Table 3.2.5-2 Waterways Overlapping the Owl Creek Watershed Study Area and their Codes (in reference to Table 3.2.5.1)

Waterway	Stream Reach Code
Bighorn River - Black Mountain Rd. to Winchester	1
Bighorn River, Winchester to Robertson Dam	2
Bighorn River, WW to Black Mountain Bridge	3
Little Gooseberry Creek	4
Cottonwood Creek	5
Kirby Creek	6
Owl Creek	7
Mud Creek, North and South Fork	8
Owl Creek, North Fork	9
Owl Creek, South Fork	10
Red Creek	11
Dry Cottonwood Creek	12
Rock Creek	13
Willow Creek	14
Wind River, Section 1	15
Wakely Reservoir	16

Wildlife Habitat and Distribution

The Owl Creek watershed supports a diversity of wildlife. Five species of big game – moose, elk, mule deer, big horn sheep, and pronghorn, have crucial range (habitat necessary to maintain local populations) within the watershed (WISDOM 2016; **Figures 3.2.5-2** and **Figure 3.2.5-3**). Additionally, moose, elk, and bighorn sheep have parturition areas within the watershed (WISDOM 2016), where the birthing of young takes place. The Worland Field Office of the BLM, which manages BLM lands within the Owl Creek watershed, closes some important big game winter habitat to human activity from November 15 to April 30, and some big game birthing areas from May 1 to June 30. Potential livestock-wildlife conflicts can occur when grazing periods and high stocking rates overlap with wildlife parturition and winter crucial range. However, no livestock-wildlife conflicts have been recorded in this area as of the date of this report.

The watershed also provides habitat considered by the USFWS as Areas of Influence (AOI) for federally designated species of conservation concern. These AOI's encompass areas beyond the documented distribution of species, because activities adjacent to known habitat can still affect these sensitive species. The USFWS recommends considering potential effects to the species and their habitat within these areas and includes grizzly bear, grey wolf, Canada lynx, North American wolverine, and the black-footed ferret. While some spatial information is known about where these species live, give birth, and migrate, information is still limited. What is available can be viewed at http://wyoming-wgfd.opendata.arcgis.com/datasets. Black-footed ferrets, while protected by law, are a special case. In 2015, Wyoming was designated with a 10(J) designation as this species only persists in a few experimental populations within Wyoming, none of which occur within the Owl Creek watershed (USFWS 2015a). The other four species listed are highly mobile animals that are generally restricted to higher elevation habitats. The limited scope of disturbance associated with the improvements proposed by this study, both in space and time, combined with the mobility of those species, makes substantive disturbance to these species resulting from improvement projects unlikely.

3.2.6 Sensitive, Threatened and Endangered Plant and Animal Species

Federally identified species of conservation concern with known or predicted occurrence within the Owl Creek watershed study area are listed below.

Ute Ladies'-tresses

The Ute Ladies'-tresses (*Spiranthes diluvialis*) is an orchid listed as Endangered under the Endangered Species Act (USFWS 1973; 16 U.S.C. Sections 1531-1544). The Owl Creek watershed study area falls within the AOI for Ute Ladies'-tresses (USFWS 2016b). As described by the USFWS (2016c), projects within an AOI could affect Threatened, Endangered, Proposed, or Candidate species, and therefore, potential effects of such projects should be considered.

Ute Ladies'-tresses are riparian habitat specialists, occurring in early successional habitat typically consisting of short vegetative cover maintained by periodic flooding, grazing, or mowing within wetland and riparian areas. Suitable habitat includes human-modified wetlands such as irrigation canals and irrigated meadows. It typically does not occur at elevations above 5,500 ft. in Wyoming (Fertig et al. 2005). A long-lived perennial forb, this species typically blooms from early July through late October. In habitat surrounding perennial streams, Ute Ladies'-tresses typically occur on shallow sandy loam, silty-loam, or clayey-silt alluvial soils overlying more permeable cobbles, gravels, and sediments, and across a range of soil pH values from slightly acidic to slightly alkaline (pH 6.6 - 8.1; Fertig et al. 2005). In habitat surrounding groundwater-fed springs and irrigated meadows, the orchid is associated with a high water table and silty to loamy calcic soils with surface accumulations of crumbly, limey marl (Fertig et al. 2005). Soils suitable for this species typically remain moist through most of the growing season.

Critical habitat has not been designated for this species (USFWS 2016d), but suitable riparian habitat for Ute Ladies'-tresses could be found within the project area's streams, irrigation ditches, and irrigated meadows. Because Ute ladies' tresses appear to be dependent on riparian areas, **Figure 3.2.6-1** shows the area of influence for Ute ladies' tresses in relation to streams and potential riparian areas within the study area. Surveys should be conducted prior to any surface disturbance activity in areas of suitable habitat to identify any individuals of this species. Field surveys for Ute Ladies'-tresses are conducted in suitable habitat during the local blooming period, which is monitored and reported by the BLM. Please see **Section 3.2.4.3** pertaining to riparian areas in this report for further information.

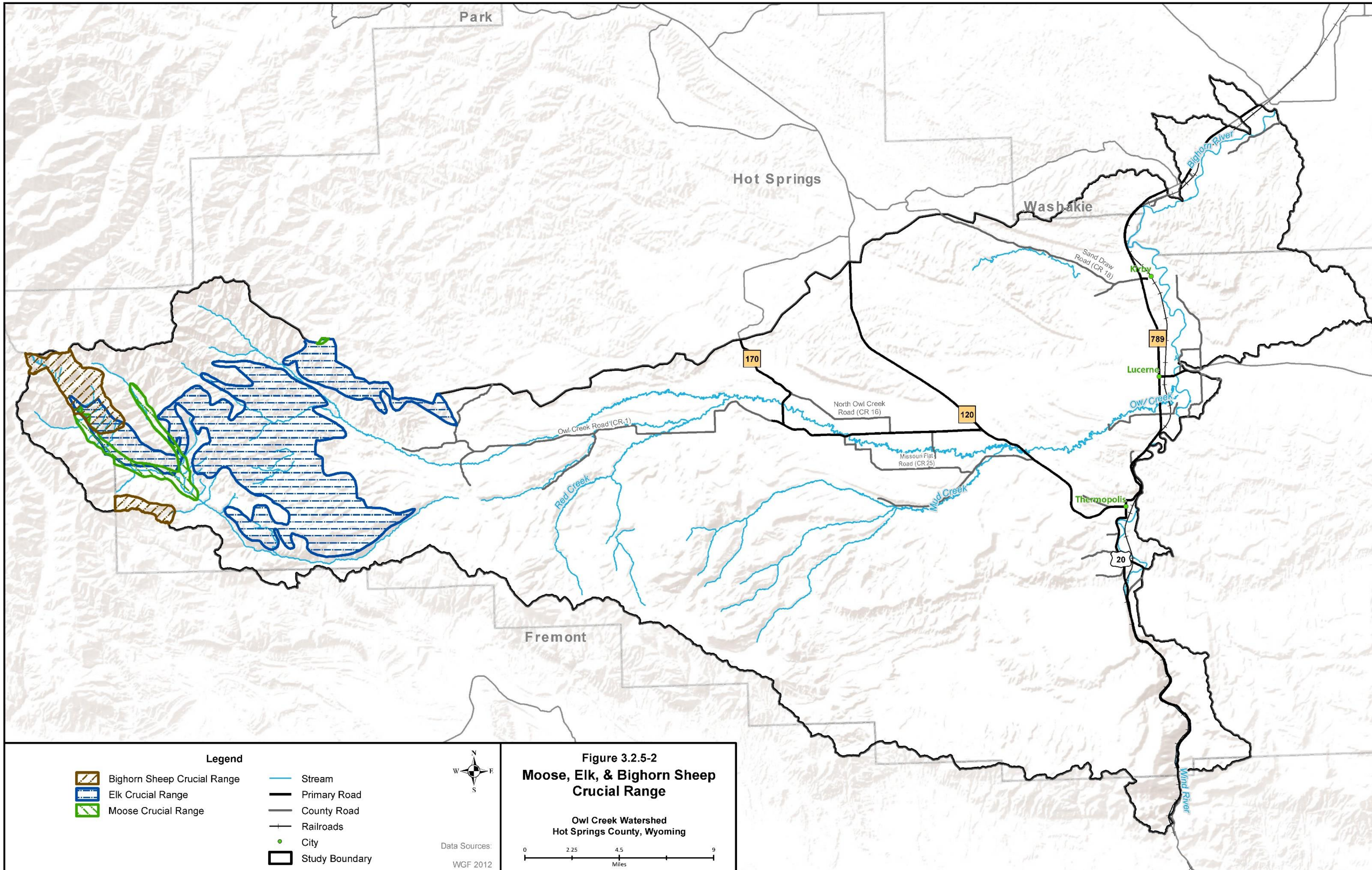
Whitebark pine

The whitebark pine (*Pinus albicaulis*) is a Candidate for listing under the Endangered Species Act, and the Owl Creek watershed falls within its potential range and within its AOI (**Figure 3.2.6-2**) (WISDOM 2016). Considered a keystone species of high-elevation forests in the northwestern U.S., the whitebark pine maintains snow pack and mitigates run-off and erosion with the shade and duff it provides, is an early successional species after fires, and provides an important food source for a variety of wildlife through its nutritious seeds (BLM 2016). Numbers of whitebark pine are in decline due to mountain pine beetle and white pine blister rust infestations, altered fire regimes, and the effects of climate change (Federal Register 2011). In Wyoming, this species is usually found above 8,000 feet of elevation in subalpine to alpine sites characterized by rocky, poorly developed soils, cold temperatures, and wind-swept exposures. Given the whitebark pine's range and habitat associations, it is unlikely to be affected by watershed improvement activities, but loss of whitebark pine may speed runoff or increase sediment to the Owl Creek drainage.

Boreal Toad

The Boreal Toad (*Anaxyrus boreas boreas*) is classified as extremely rare in the state of Wyoming (WGFD 2010), and is under review for federal listing under the Endangered Species Act (USFWS 2016e). This amphibian appears to be in a state of severe decline attributed primarily to habitat alteration, environmental pollutants, climate change, and disease (WGFD 2010). Documented within the South Fork of Owl Creek (WISDOM 2016), the Boreal Toad occurs in wet areas in foothill, montane, and subalpine habitats from 6,500 to 11,500 feet of elevation (Baxter and Stone 1985). Hibernating in burrows dug into the ground through the winter, the boreal toad emerges shortly after snowmelt. During the day, it is generally found near water, although at night it visits more terrestrial habitats to forage. Ants, beetles, moths and other invertebrates make up the majority of this toad's prey (WGFD 2010).

At the current time, no actions are required to protect toads or their habitat. If the species were to be listed under the Endangered Species Act, this might change. However, all current irrigated lands are located below the toad's expected habitat elevations.



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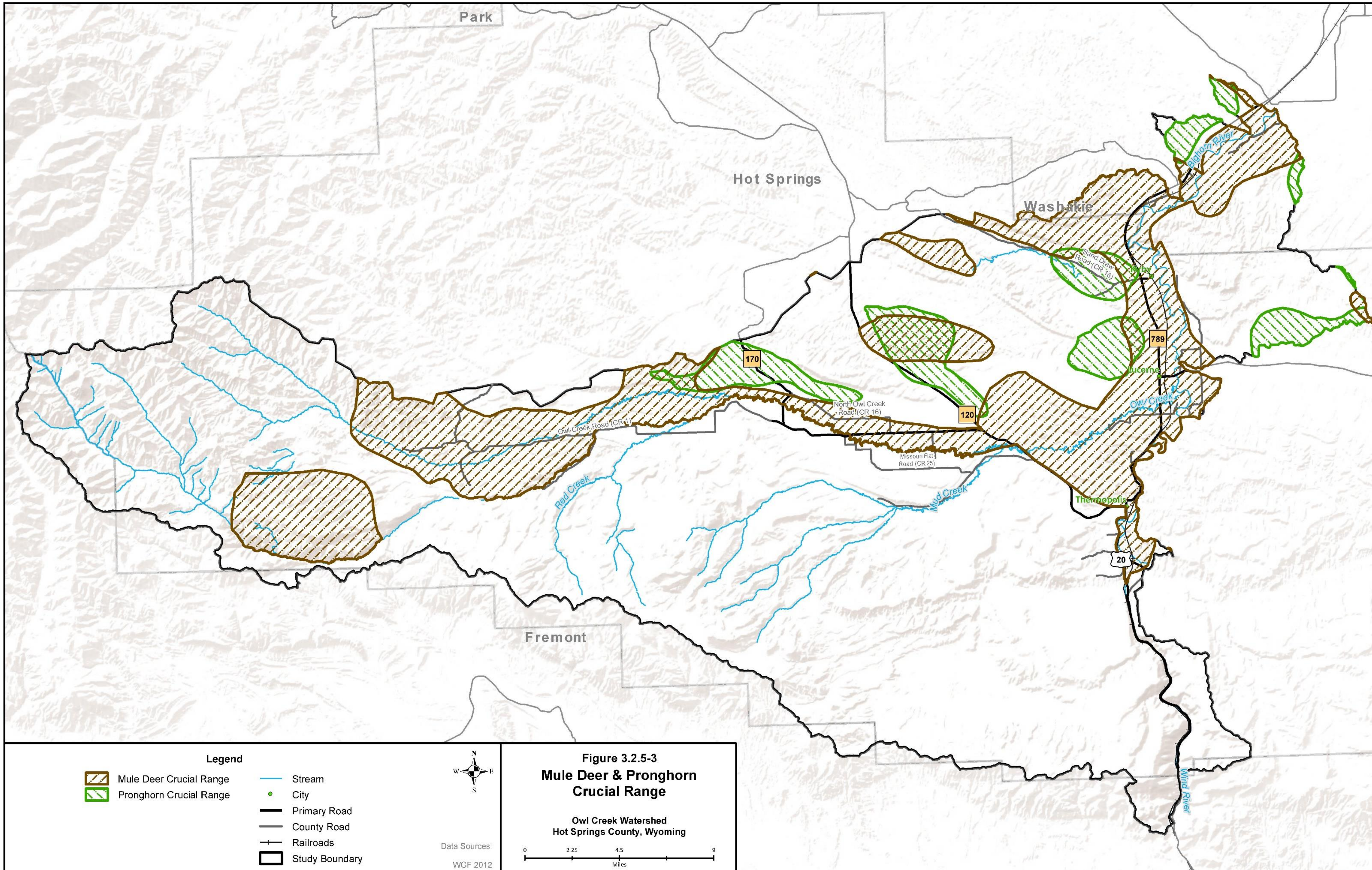

Figure 3.2.5-3
Mule Deer & Pronghorn Crucial Range

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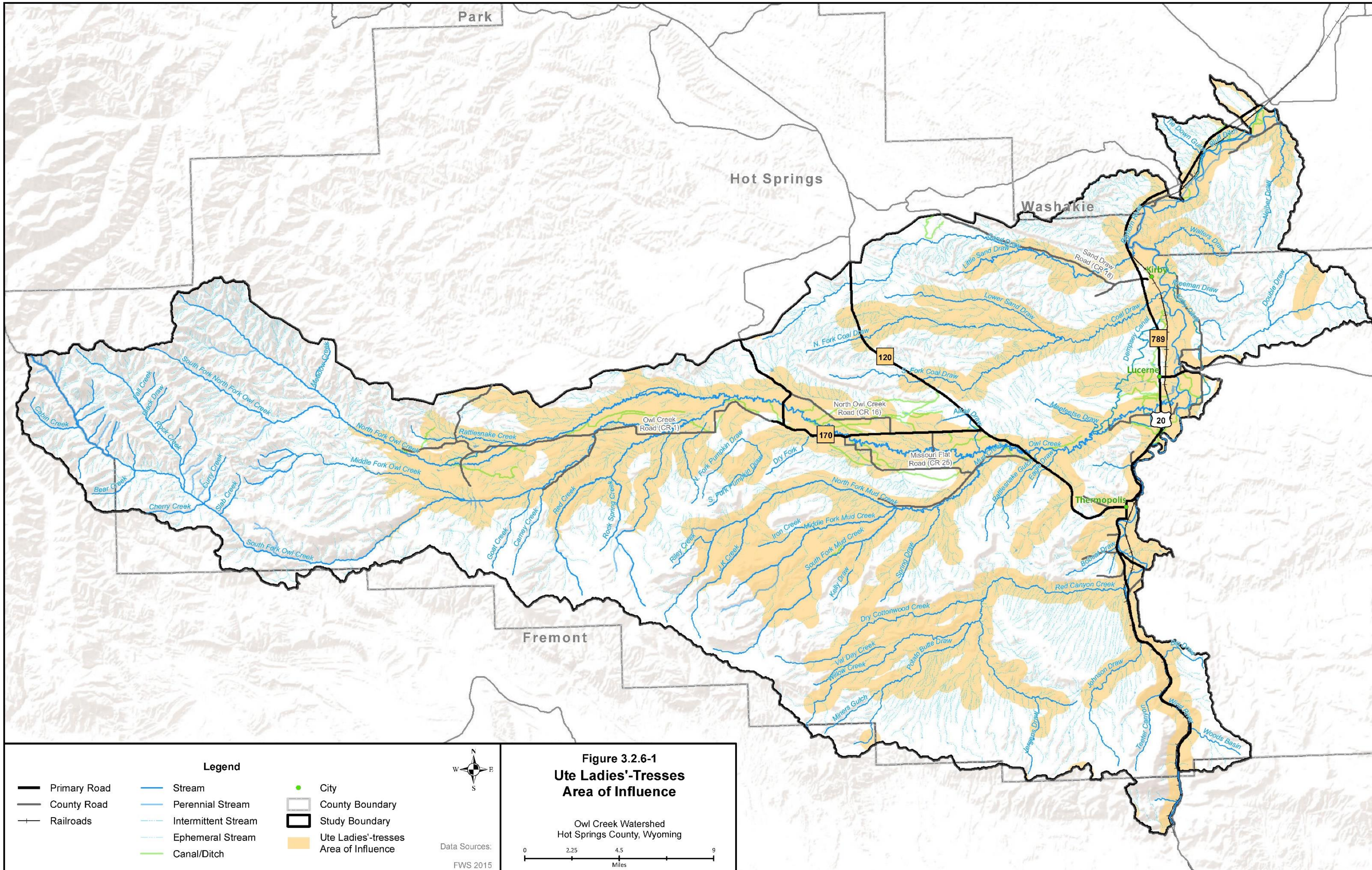

Figure 3.2.6-1
Ute Ladies'-Tresses Area of Influence

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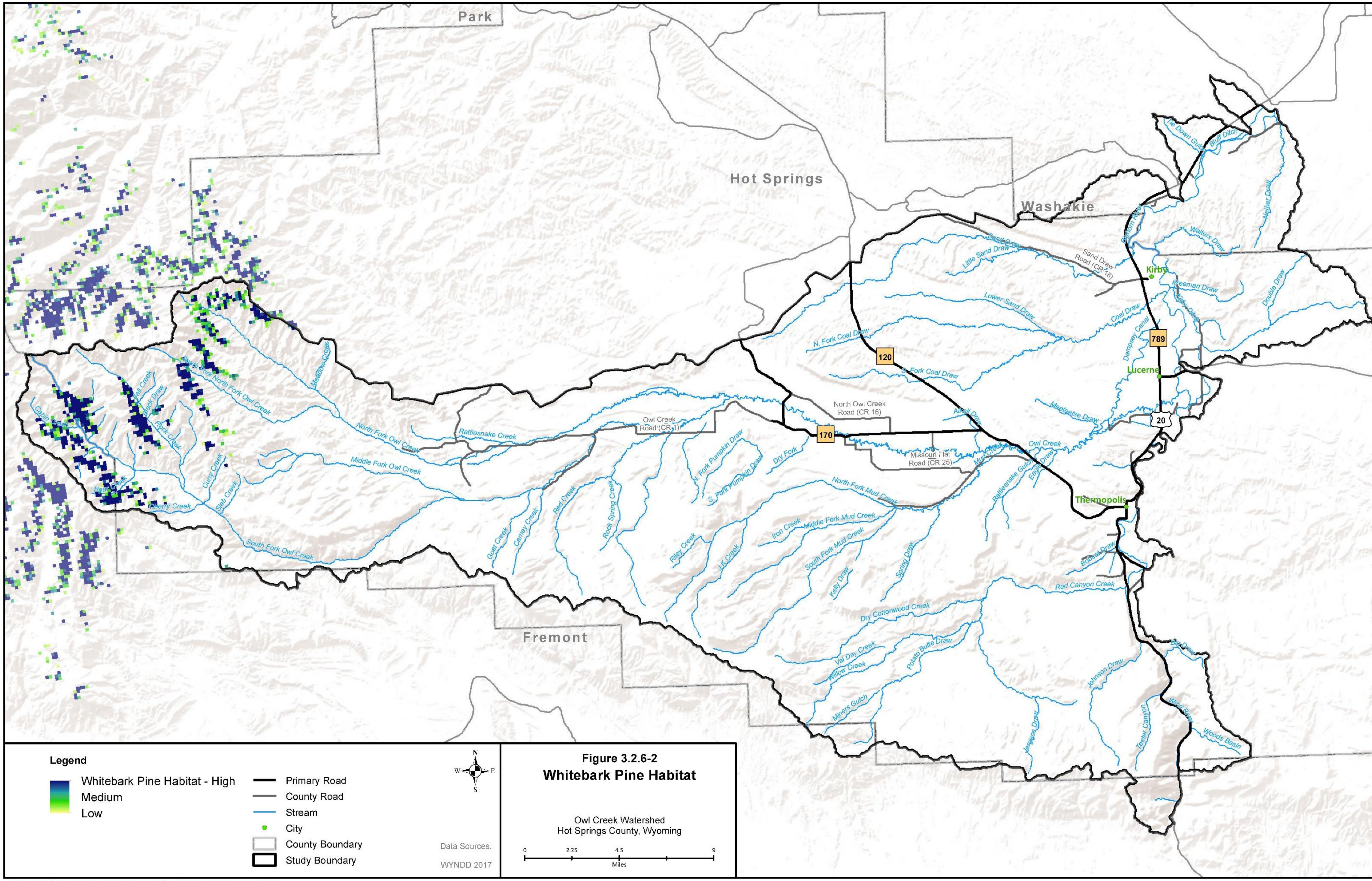


Figure 3.2.6-2
Whitebark Pine Habitat

Greater Sage-Grouse

The Greater Sage-Grouse is an upland game bird that is closely associated with sagebrush steppe habitat, although wetter areas dominated by forbs are also necessary for successful brood-rearing. Once widespread across the sagebrush sea of the American west, the Greater Sage-Grouse is currently found in only about 56% of its historic range (Schroeder et al. 2004, Federal Register 2015). Its decline has been attributed primarily to habitat loss and alteration (Schroeder et al. 2004, USFWS 2015b). In an effort to recover its numbers and to preclude federal listing under the Endangered Species Act, the Greater Sage-Grouse and its habitat receive special protections from the state of Wyoming and the BLM. Most of the Owl Creek watershed is potentially suitable habitat for the Greater Sage-Grouse, and three Greater Sage-Grouse Core Areas (Thermopolis, Grass Creek, and Oregon Basin) lie entirely or partially within the watershed (**Figure 3.2.6 3**). Based on preliminary research, there are approximately 11 active breeding grounds (called leks) within the watershed, and approximately 19 leks within 2 miles of the watershed. Stipulations apply to construction and development when it is within Greater Sage-Grouse Core Areas, particularly near occupied leks. Stipulations vary slightly depending on the resource management agency. On BLM lands or projects funded by BLM programs, the BLM Worland Field Office recommends prohibiting activities and surface use from February 1 to July 31 and November 15 to April 30 to avoid the disruption of Greater Sage-Grouse reproduction and wintering activity. The State of Wyoming's Executive Order 2015-4 for activities considered "exempt" would include most of the projects proposed in this document are categorized as Exempt Activities from Attachment C of the State of Wyoming's Executive Order. Exempt Activities are allowed in areas greater than 0.6 miles from the perimeter of an occupied lek, and can occur less than 0.6 miles of occupied leks from July 1 – March 14, after a habitat evaluation has been conducted, and provided there is no development on the lek itself. Furthermore, WGFD recommends no surface occupancy within 0.25 miles of occupied leks outside of Core Areas. There are also stipulations regarding the timing of activities for projects located less than 2 miles of occupied leks outside of core areas.

Raptors and Migratory Birds

The watershed supports an abundant bird community year round, with Bald Eagles roosting in the area during winter, high numbers of birds following the Bighorn River corridor during spring and fall migration, and 51 documented raptor nests (**Figure 3.2.6-4**). Natural resource management agencies do not share precise locations of raptor nests with the general public in an effort to minimize disturbance. In addition to species listed as endangered or threatened under the Endangered Species Act (16 U.S.C. 1531), many birds of the U.S. are protected by two other pieces of federal legislation, the Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703) and the Bald and Golden Eagle Protection Act (16 U.S.C. 668).

The USFWS recommends avoiding disturbance within 0.5 miles of communal Bald Eagle winter roosts from November 1 to April 1, and the BLM Worland Field Office recommends avoiding areas with high density of wintering raptors from November 15 to April 30. Projects receiving federal funding or located on federal lands, and proposed for construction within these time windows, may require field surveys to identify raptor winter roost areas.

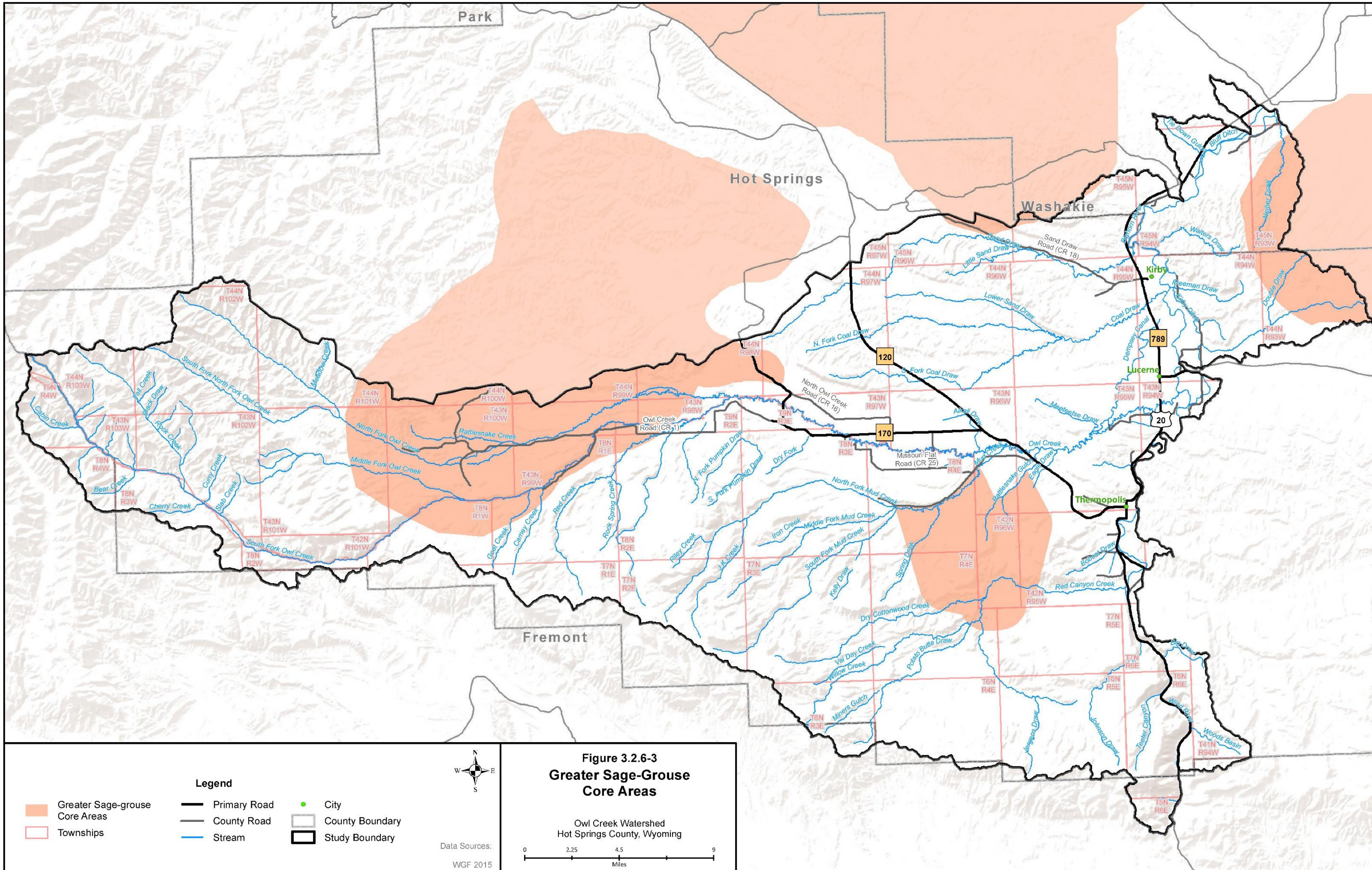
Active raptor nests of all species are also protected, and specific stipulations regarding the timing and proximity of surface disturbance may apply (**Table 3.2.6-1**). Similarly, the MBTA prohibits the destruction of eggs, young, and adults of other species of migratory birds, so projects receiving federal funding or located on federal lands, and proposed for construction within these time windows, should be planned to avoid the breeding season (approximately April through July). Alternatively, surveys could be conducted directly before watershed improvement activities commence to ensure no eggs or young of species protected by the MBTA will be destroyed. If no birds, eggs, or young are found, construction can proceed legally.

Table 3.2.6-1 Spatial and Seasonal Buffers for Active Raptor Nests, as recommended by the USFWS Wyoming Ecological Field Services Office and by the BLM Worland Field Office.*

Species	USFWS spatial buffer (mi)	USFWS seasonal buffer	BLM seasonal buffer
Golden Eagle	0.5	Jan 15 - Jul 31	Feb 01 - Jul 31
Ferruginous Hawk	1	Mar 15 - Jul 31	
Swainson's Hawk	0.25	Apr 01 - Aug 31	
Bald Eagle	0.5	Jan 01 - Aug 15	
Prairie Falcon	0.5	Mar 01 - Aug 15	
Peregrine Falcon	0.5	Mar 01 - Aug 15	
Short-eared Owl	0.25	Mar 15 - Aug 1	
Burrowing Owl	0.25	Apr 01 - Sep 15	
Northern Goshawk	0.5	Apr 01 - Aug 15	
Osprey	0.25	Apr 01 - Aug 31	
Cooper's Hawk	0.25	Mar 15 - Aug 31	
Sharp-shinned Hawk	0.25	Mar 15 - Aug 31	
Red-tailed Hawk	0.25	Feb 01 - Aug 15	
Northern Harrier	0.25	Apr 01 - Aug 15	
Merlin	0.5	Apr 01 - Aug 15	
American Kestrel	0.125	Apr 01 - Aug 15	
Common Barn Owl	0.125	Feb 01 - Sep 15	
Northern Saw-whet Owl	0.25	Mar 01 - Aug 31	
Boreal Owl	0.25	Feb 01 - Jul 31	
Long-eared Owl	0.25	Feb 01 - Aug 15	
Great Horned Owl	0.125	Dec 01 - Sep 31	
Northern Pygmy-Owl	0.25	Apr 01 - Aug 01	
Eastern Screech -Owl	0.125	Mar 01 - Aug 15	
Western Screech-Owl	0.125	Mar 01 - Aug 15	
Great Gray Owl	0.25	Mar 15 - Aug 31	

Source: USFWS 2015c

* The BLM Worland Field Office recommends no surface disturbance from February 1 through July 31 for all raptor species.



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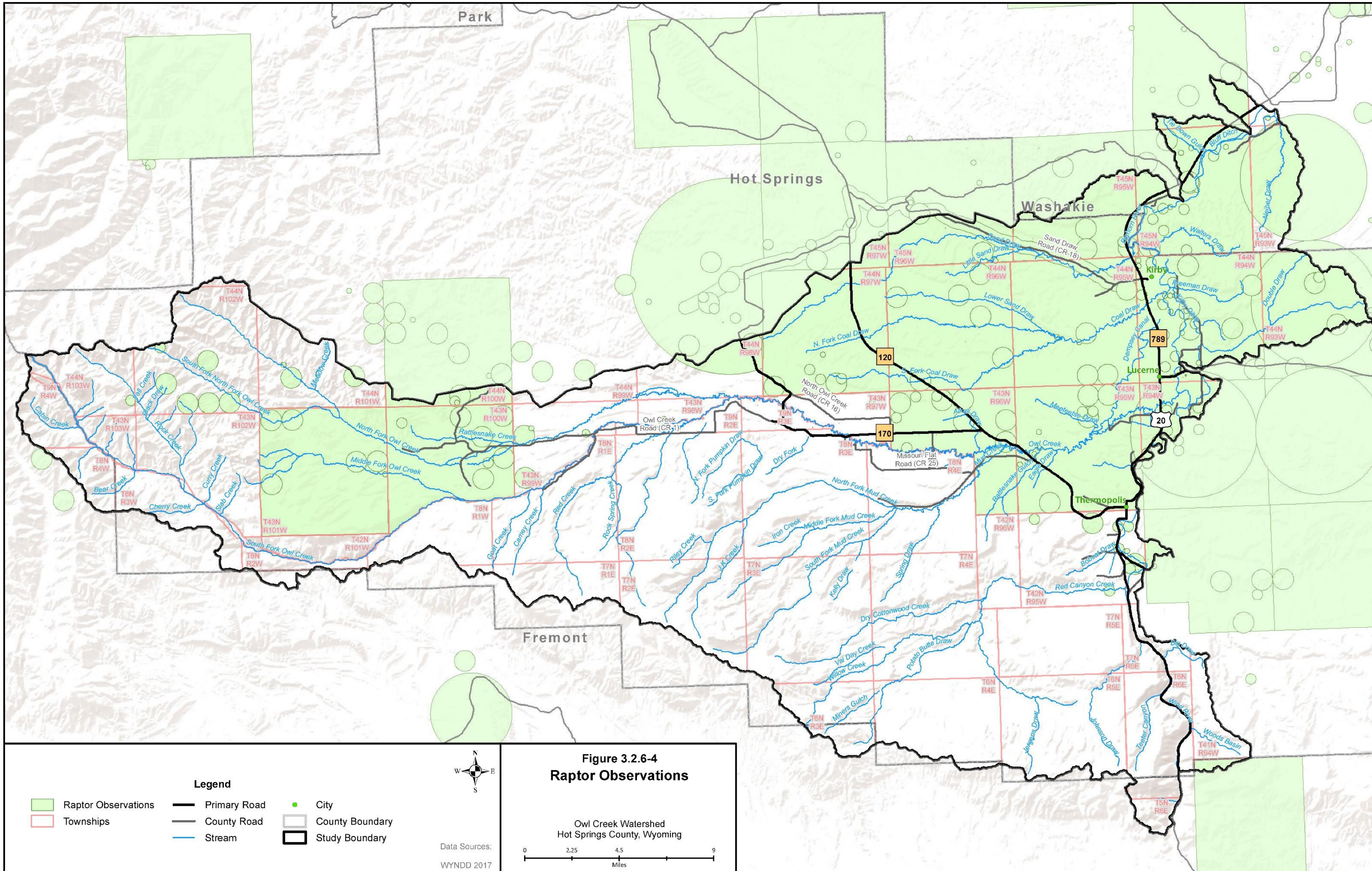

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3.3 Hydrology

3.3.1 Groundwater

Recharge-Discharge Areas

Recharge. There are little data available with respect to specific identification or characterization of recharge-discharge areas. Quaternary unconsolidated deposits in the study area region are usually recharged by leakage from streams, by precipitation, and in agricultural areas, by seepage from irrigation and irrigated lands (Berry and Littleton 1961; Plafcan and Ogle 1993). Individual geologic units might be recharged by leakage form overlying saturated alluvium or terrace deposits or through fractured zones along anticlinal structures (Lowry et al. 1976). In the Owl Creek drainage basin groundwater in the Frontier Formation, Cody Shale, and Cloverly Formation is recharged locally by leakage from overlying saturated alluvium or terrace deposits (Berry and Littleton 1961).

General principles of hydrology suggest that recharge to deeper portions of the basin takes place in regions of higher elevation where snow accumulates, melts, and infiltrates or where rain or snow directly infiltrates, usually in flatter terrain at lower elevations. Mountain and foothill areas are characterized by higher recharge than basin lowlands because of factors such as greater precipitation, less evapotranspiration, and structural features such as faults fractures, and upturned bedding planes (Taucher et al. 2012).

The north slope of the Owl Creek Mountains is a likely recharge area for deeper aquifers under artesian pressure where water from direct precipitation or melting snow percolates into strata exposed at land surface and surface water may enter this system where small stream flow across outcrops (Berry and Littleton 1961).

Discharge. In general, groundwater is discharged through pumped wells, springs and seeps, wetlands, gaining stretches of streams (where the channel bottom is lower than the surrounding groundwater table so water tends to move from the ground to the channel), and anywhere that evapotranspiration can operate. Areas underlain by alluvium also discharge groundwater by evaporation and transpiration by plants (Plafcan and Ogle 1993). Near the base of mountainsides, the water table intersects the steep valley wall some distance up from the base of the slope. This results in perennial discharge of ground water and, in many cases, the presence of springs and wetlands.

Typically, groundwater flows from regions of higher energy (higher pressure, elevation) where recharge often occurs, to areas of lower energy (lower pressure, elevation) where discharge often occurs. In the case of the Owl Creek basin, the general overall expectation of groundwater flow direction is West (high elevation recharge area) to East (lowest elevation being the course of the Bighorn River). Groundwater would also be expected to flow north from recharge areas along the crest of the Owl Creek Mountains, with perhaps some component of southerly flow from the divide that separates the Owl Creek basin from the Cottonwood and Grass Creek area (**Figure 3.3.1-1**). Conditions that can affect groundwater movement include pumping wells or losing streams that recharge to alluvium or tilted or faulted geologic structures (Plafcan and Ogle 1993).

Groundwater movement in the terrace deposits and alluvium along Owl Creek generally follows the same direction as the stream itself (indicating discharge to the stream as baseflow) and toward the Bighorn River (Berry and Littleton 1961).

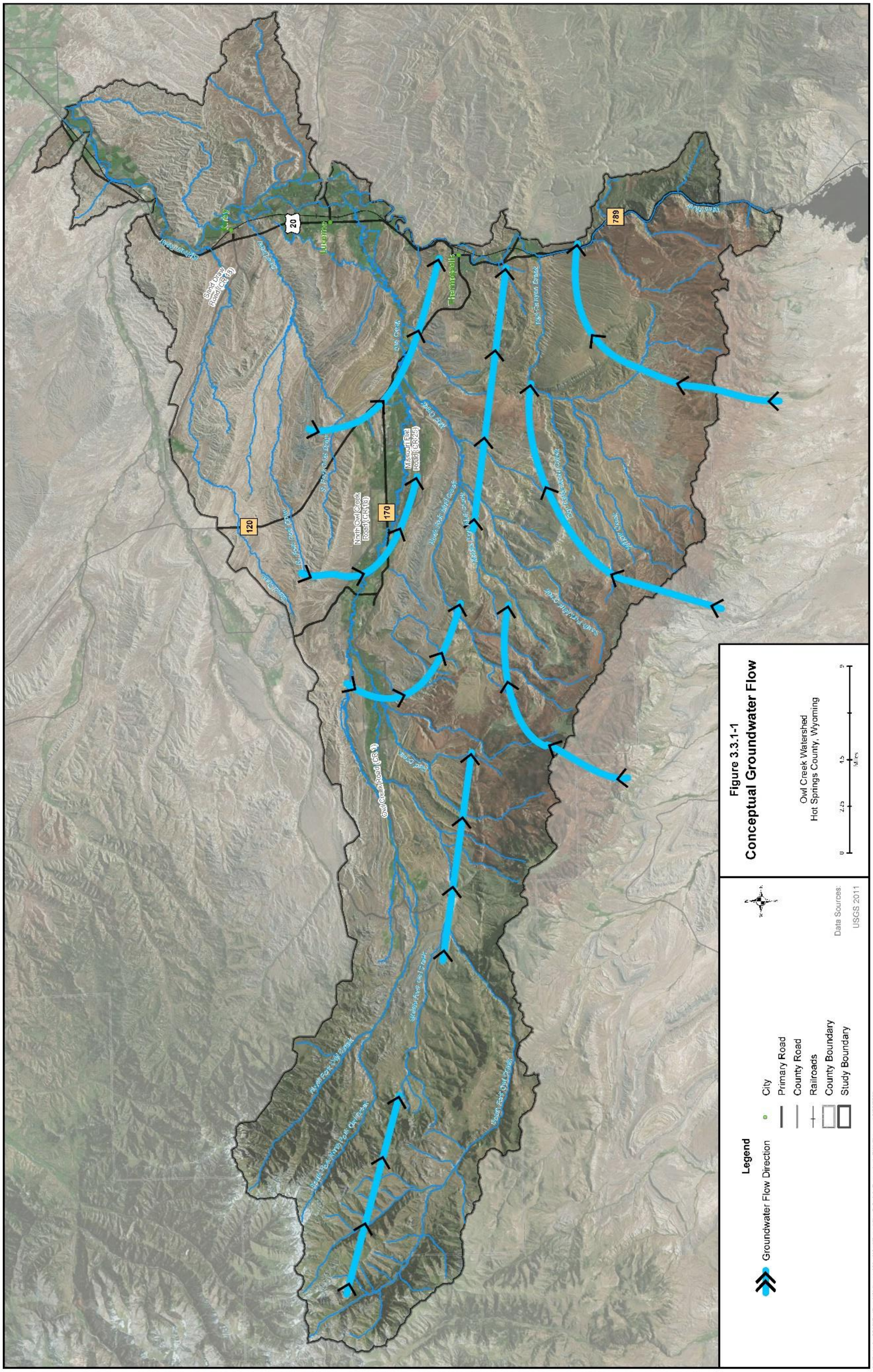
Figure 3.3.1-1
Conceptual Groundwater Flow
Owl Creek Watershed
Hot Springs County, Wyoming
0
2.25
4.5
9
Miles
Data Sources
USGS 2011
Legend
Groundwater Flow Direction
City
Primary Road
County Road
Railroads
County Boundary
Study Boundary
20
789
120
170
Lucerne
Thermopolis
North Owl Creek Road (CR 10)
Missouri Flat Road (CR 25)
Owl Creek Road (CR 1)

Between storm and snowmelt periods (generally in late spring), streamflow is sustained by discharge from the ground-water system (baseflow). During intense storms, most precipitation reaches streams very rapidly by partially saturating and flowing through highly conductive soils, or by direct overland flow on steeper slopes where precipitation intensity exceeds infiltration capacity. If streams of the Owl Creek basin were significantly connected hydraulically to any intermediate or regional flow systems, baseflow in these streams would likely be more reliable throughout the year, as groundwater contributions to baseflow would be more evenly applied throughout the year.

3.3.2 Aquifers and Artesian Conditions, Spring Locations

In general, aquifers containing useable amounts of groundwater[3] are present in numerous consolidated rock units and unconsolidated material represented by terrace deposits and alluvium contained in the floodplains of the various streams in the basin. Intervening rock units of lower permeability represent aquitard or confining units that serve to bound flow hydrostratigraphic flow units.

Taucher et al. (2012) grouped water-bearing units into four aquifer systems, listed here from highest (youngest) to lowest (oldest) stratigraphic position:

- *Quaternary unconsolidated deposit aquifers* - includes alluvium, colluvium, and terrace, landslide, fan, eolian, and glacial deposits. Where present with sufficient thickness, these constitute important aquifers.
- *Lower Tertiary/Upper Cretaceous aquifer system* - lenticular, discontinuous sandstone bodies that are hydraulically isolated to various degrees by interbedded fine-grained confining units.
- *Lower and middle Mesozoic aquifers and confining units* - aquifers and confining units dominated by sandstone, siltstone, and shale lithologies. While some of the aquifers are lenticular and discontinuous, the major aquifers are generally more continuous and laterally extensive than those in the Lower Tertiary/Upper Cretaceous aquifer system mentioned above.
- *Paleozoic aquifer system* – represented by carbonate and sandstone lithologies. Can produce high volumes of groundwater at and near the flanks of the Laramide uplifts surrounding the basins where permeability has been structurally enhanced by solution-enlarged fractures.

A table illustrating more detailed information about the water-bearing characteristics of geologic units in the vicinity of the study area is found in Table B-1 of **Appendix B**.

Artesian (Confined) Aquifers

Principal artesian aquifers of the Owl Creek basin include Paleozoic rocks represented by the Mississippian-age Madison Limestone and Pennsylvanian-Age Tensleep Sandstone, and Cretaceous-age rocks presented by the Cloverly Formation, Frontier Formation and Cody Shale where permeable zones are present as coarser-grained seams within the upper portion of the shale (Berry and Littleton 1961).

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[3] For this discussion, the definition of an "aquifer" follows that of Heath (1983), where an aquifer is defined as a rock unit, including unconsolidated sediments, that will yield water in a usable quantity to a well or spring.

The Madison Limestone outcrops along the north-facing slope of the Owl Creek Mountains and continues at depth in the Owl Creek Basin, containing groundwater at elevated temperatures. The Tensleep Sandstone is exposed only in the south-central and southwestern portions of the Owl Creek area, cropping out in narrow bands along the flanks of slopes at Anchor and Embar. Both these units are recharged by direct infiltration of precipitation and by seepage of small streams that flow across the outcrop area (Berry and Littleton 1961). Most groundwater development is in the outcrop area because the steep dip of these beds toward the center of the Bighorn Basin puts the drilling depth to the Paleozoic aquifers beyond economic reach of most domestic and stock uses (Plafcan and Ogle, 1993).

The Cloverly Formation crops out along flanks of major structural features in the lower-central portion of Owl Creek basin, and dips steeply away into the subsurface, resulting in artesian conditions that probably intensify with distance (Berry and Littleton 1961). The Frontier Formation crops out generally north and south of Owl Creek along the slopes above the drainage. Reportedly, water is available in quantities sufficient only for domestic or stock use generally under artesian conditions, flowing to land surface locally, but some water is available under water table conditions (Plafcan and Ogle 1993). Both the Cloverly and Frontier formations are recharged mainly by precipitation falling on extensive slope exposures of sandstones contained within these units on the south side of Owl Creek valley (Berry and Littleton, 1961).

Cody Shale is exposed almost continuously along the north side of Owl Creek and only in a few places along north-facing slopes on the south side of Owl Creek. Water for domestic and stock use can be obtained in limited quantities from the sandy upper portion of the formation and where fracturing is prevalent. While groundwater is under artesian conditions, it is generally not under sufficient pressure to flow at land surface. Most wells completed in Mesozoic-age rocks units inventoried by Plafcan and Ogle (1993) were deriving water from the Frontier and Chugwater Formations.

Other consolidated rock aquifers may lie within the study area, but either do not crop out at land surface in the Owl Creek basin or anywhere in the study area (e.g., Fort Union, Lance, and Meeteetse formations). These formations are either absent or presumed to lie at depths too deep for exploitation under current economic conditions.

Water Table (Unconfined) Aquifers

Unconfined aquifers occur principally in Quaternary-age unconsolidated deposits along the flood plains and bordering slopes of stream channels within the study area (Berry and Littleton 1961; Cooley and Head 1982). These deposits include alluvium and colluvium gravels derived from ancient stream channels, landslides and fan deposits. These deposits are thin and laterally discontinuous, thus not representing a reliable source of groundwater under all conditions and seasons. (Plafcan and Ogle 1993, A description of hydrologic units comprising unconfined aquifers is found in Table B -2 **Appendix B.**

Terrace Deposits. Terrace deposits occur at heights ranging from about 20 to 500 above Owl Creek. The terrace deposits are similar to alluvium described above. Cooley and Head (1982) delineated seven terrace deposit map units. Three of the seven terrace map units are conspicuous through the area: an unnamed terrace at 500 ft. above Owl Creek (Qt4), the Embar Ranch terrace 160 to 120 ft. above the creek, and the Arapaho Ranch terrace 50 to 20 ft. above the creek (Cooley and Head, 1982). Only the Embar Ranch and the Arapaho Ranch deposits are widely distributed through the Owl Creek basin. The remaining map units are remnants that occur only scattered locations (**Figure 3.3.2-1**).

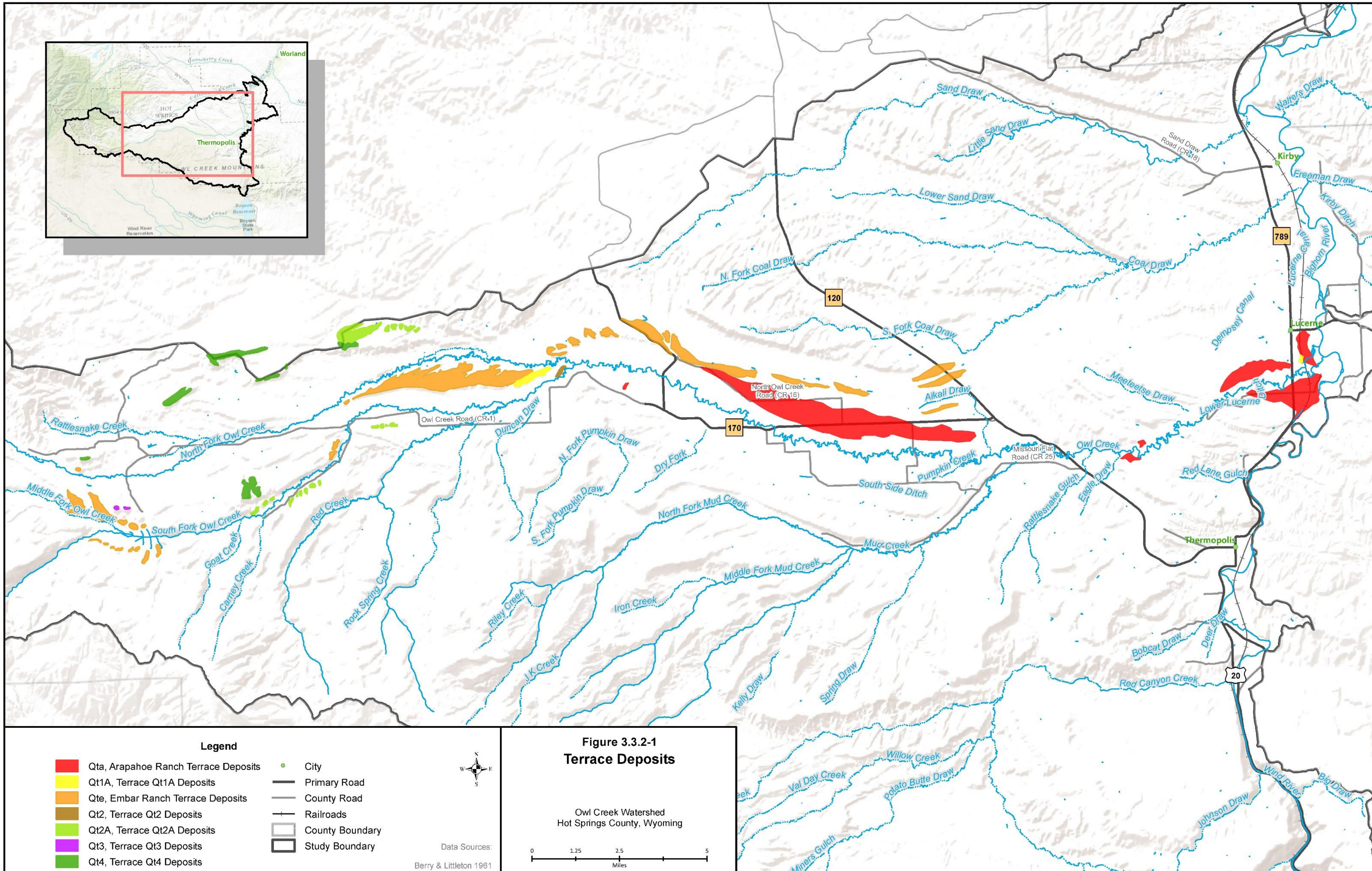

Figure 3.3.2-1
Terrace Deposits

Owl Creek Watershed
Hot Springs County, Wyoming

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The Embar Ranch terrace is named for a well-preserved remnant between the north and south forks of Owl Creek, north of Embar Ranch. This terrace is about 120 ft. to 160 ft. high near where it is crossed by Highway 120, about 2.5 miles north of Owl Creek. The deposit thickness, where exposed along the edges of the terrace remnants, is not more than 15 ft. The coarse-grained terrace material is overlain by more than 2 ft. of silty to sandy sediments, which in part represent an old soil. In general, the areal extent of the Embar terrace is too small for ground-water development (Cooley and Head, 1982). In places, however, the remnant of the deposits north of Embar Ranch is more than 0.5 mile wide. If this remnant were farmed, some of the irrigation water would recharge the terrace deposits; but the water thus recharged would move laterally and discharge along the edges of the terrace remnant.

Remnants of the Arapaho Ranch terrace are distributed in the Owl Creek drainage principally downstream from the Embar anticline. The largest remnant of the terrace is downstream from Arapaho Ranch. It forms a continuous exposure for about 8 miles along the north side of the valley. The height of the terrace decreases progressively eastward from 50 ft. near Arapaho Ranch to about 20 ft. above the creek bed in Secs. 16 and 17, T. 43 N., R. 96 W. and on downstream to the mouth of Owl Creek. Downstream from Arapaho Ranch the deposits are farmed extensively. The large terrace remnant east of Arapahoe Ranch is capped by a 2- to 3-ft. layer of sandy to silty sediments, including remnants of an old soil. The terrace deposits are less than 15 ft. thick except in two buried channels; one located near the mouth of Owl Creek in Secs. 7 and 8, T. 43 N., R. 94 W. and the other extending southeastward from sec. 11, T. 43 N., R. 97 W., where logs of water wells indicate a maximum thickness of 42 ft.

Recent concern has been expressed regarding effects on the Arapaho Ranch terrace aquifer from nearby sand and gravel mining operations (WWDC, 2003). As a result, the Wyoming Department of Transportation (WYDOT) commissioned a study to characterize the hydrologic function of the alluvial terrace groundwater (WWDC, 2003). Landowner concerns are that operations at the Duke gravel pit in Section 14, T 43 N., R. 97 W, have, or will have impacted groundwater supplies in nearby irrigation, stock, or domestic wells.

For six months in 2003, groundwater level monitoring was conducted in 26 wells (13 existing stock, irrigation, and domestic wells) and thirteen monitoring wells were installed. The intent of this effort was to determine if the gravel pit (since reclaimed) was contributing to low water levels in nearby wells, and assess potential impacts if the pit were to be expanded. The study concluded that the pit had no measurable effect on down-gradient wells, and that water levels as measured in the terrace aquifer respond to leakage of irrigation water from nearby (upgradient) ditches. Most of the shallow perched groundwater in the Arapaho Ranch terrace aquifer originates as conveyed or applied surface water, particularly in years of low precipitation and the reportedly low yields in nearby wells was due to naturally low seasonal groundwater levels (WYDOT, 2003).

The authors of the WYDOT study did, however, warn that further expansion of the pit to the north could truncate the surficial aquifer to such a degree to impact downgradient wells, and that if irrigation ditches were lined to prevent leakage, the groundwater available to shallow wells could diminish accordingly. These conclusions seem plausible from the data presented, however, from aerial photos obtained from the 2012-2015-time period, two bodies of standing water contained within berms appear on the Duke pit site (presumably the reclaimed pits). These bodies of standing water, if hydraulically connected to the shallow system could create a groundwater sink as surface water is removed from the impoundment by evaporation. The creation of an evaporation-driven sink could also have the effect of diminishing available supplies to wells and concentrating salts in the shallow aquifer.

The findings of the WYDOT study were applied several years later to another proposed gravel mining operation in Section 17, T. 43 N., Range 46 W (Tonn Pit). The same concerns were raised in that mining at the edge of the Arapaho Ranch terrace deposit could intercept groundwater, preventing its use by downgradient users. Potential remedies proposed by the Hot Springs County Land Use Planning Commission included a pit design that disallowed “daylighting” the Tonn Pit in such a way to allow groundwater to escape the Arapaho Ranch terrace to the lower Owl Creek flood plain. It was also proposed that pit walls be sealed with impermeable materials such as bentonite and that dewatering the pit and discharging extracted groundwater to the surface would not be allowed.

Spring Locations

Springs are ubiquitous throughout the Owl Creek basin (**Figure 3.3.2-2**), but for the most part cluster in the higher elevations of the western part of the basin and north-facing slopes of the lower part of the basin. Spring flow data is largely unavailable, and therefore the contribution of spring groundwater to surface waters is not known.

Hot Springs

The hot springs at Thermopolis are the principal geothermal feature in the vicinity of the study area. The Thermopolis hydrothermal system covers an area of approximately 50 sq. miles along the crest of the Thermopolis anticline (Heasler 1985). The principal surface discharge of this system is in Hot Springs State Park (Big Spring). In addition, six private flowing wells north of the state park have temperatures of 115 to 130°F. Analysis of thermal data reveals that temperatures of up to 161°F occur along the crest of the Thermopolis Anticline within 500 ft. of the surface (Hinkley et al. 1982).

According to Laney and Brizzee (2003), two other geothermal occurrences (spring and groundwater well) are noted south of Thermopolis, Wind River Canyon Spring near Wedding of the Waters (reportedly flowing 72°F water at over 900 gpm) and a groundwater well near the mouth of Buffalo Creek. Based on proximity alone, these latter two occurrences are likely related to the system at Thermopolis.

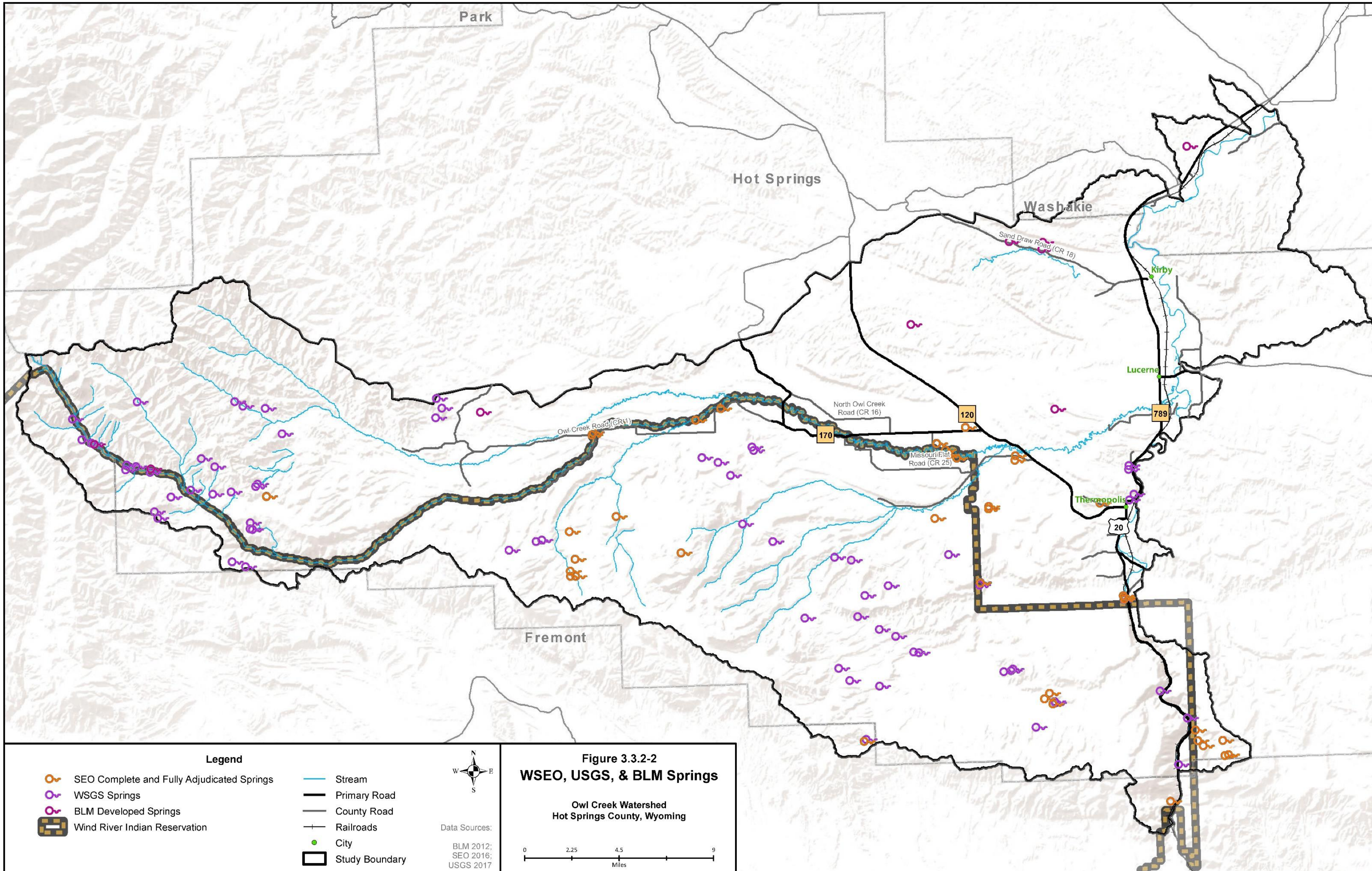

Figure 3.3.2-2
WSEO, USGS, & BLM Springs

Owl Creek Watershed
Hot Springs County, Wyoming

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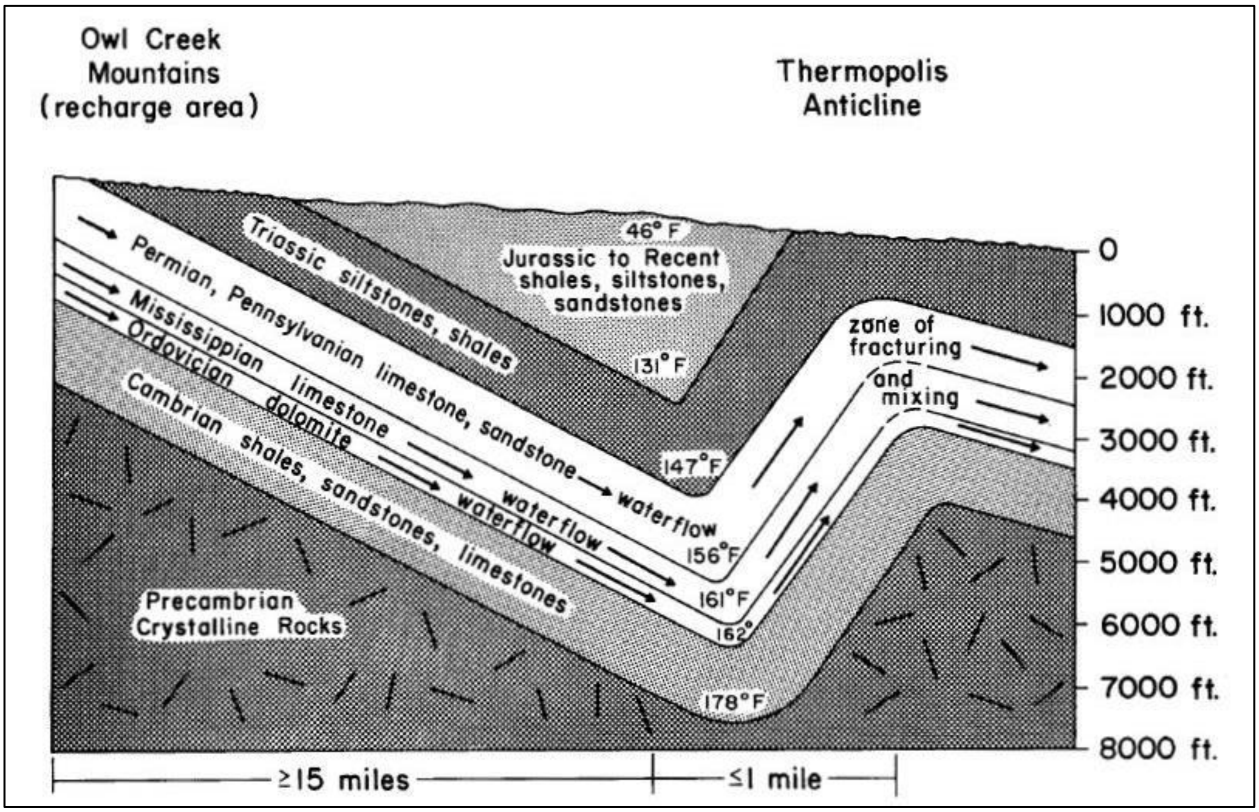
Unlike the hydrothermal system at Yellowstone, there are no known igneous rock bodies or volcanic sources nearby which could supply the geothermal heat necessary for the hot springs at Thermopolis. Analysis of geologic structure and thermal considerations by Hinkley et al. (1982) led to the conclusion that conductive heating of deeply circulating groundwater flowing generally west to east as the mechanism for the geothermal resource. Groundwater originating from high elevation recharge areas near the Owl Creek Mountains enters the regional flow system and moves east down-dip under confined conditions. As this water moves deeper, it adsorbs heat from the natural geothermal gradient. As this deeply circulating water approaches the Thermopolis anticlinal structure it is brought to the surface where the rocks hosting the aquifer (Chugwater Formation) are breached by fracturing along the crest of the Thermopolis anticline (**Figure 3.3.2-3**). Total discharge from the Thermopolis hydrothermal system is about 4,900 gpm (Hinkley et al. 1982).



Source: Hinkley et al. 1982.

Figure 3.3.2-3 Diagrammatic cross section of the geothermal heating model for the Thermopolis hydrothermal system

Citizens of Hot Springs County have concern that activities occurring up gradient from the hot springs or within its zone of capture could impact the geothermal resource. As previously discussed, the northern flank of the Owl Creek Mountains is thought to host the zone of recharge for the aquifer which feeds the springs. If a deep well field of sufficient size was developed in the same aquifer somewhere between the headwaters of the Middle Fork Owl Creek on the west and the Bighorn River on the east, it is conceivable that such a development could eventually impact discharge at the hot springs. Similarly, if concentrated oil and gas production tapping the deep water-bearing carbonate rocks were to significantly increase, or if say, the Town of Thermopolis were to continue to develop and rely on groundwater resources from the deep confined aquifer, impacts to flow at the Hot Springs could result. Picard (2000) casts doubts on such scenarios due to the sheer size of the resource. However, as he admits, the resource is not limitless (Picard, 2000). The effect of oil and gas development at Hamilton Dome on thermal spring discharges at Thermopolis was studied by Plafcan and Ogle (1993). Their review of data from the timeframe 1918 to 1988 indicated that the activities at Hamilton Dome do not directly affect the Thermopolis hydrothermal system.

Recharge Rates

Groundwater recharge rates are not currently quantifiable with available data. At a minimum, long-term measurements of precipitation, evaporation/evapotranspiration rates, run-off, groundwater levels, soil moisture, etc. would be required. Taucher et al. (2012) estimated recharge on a regional basis and developed a map of recharge efficiency (recharge as a percentage of precipitation) for the Wind River-Bighorn Basin. Their study concluded that estimated average annual recharge in their study area ranges from less than 1 in. per year in interior areas of the basins to more than 55 in. per year in the surrounding mountains. Review of their dataset suggests that recharge efficiency ranges from 2-5% in the middle and lower elevation portions of the Owl Creek basin and may be as higher as 40-80% at the extreme west end of the basin (headwaters area).

On the basis of correlation between four alluvial wells and precipitation measured at the Thermopolis weather station, Berry and Littleton (1961) concluded that 1 in. or less or precipitation of an average annual precipitation of 13 in. (less than about 7%) was recharged in the owl Creek area (at least to the alluvium). Plafcan and Ogle (1993) note that water level response in wells completed in consolidated units show delayed and muted responses to precipitation events owing to their lower permeability in comparison to unconsolidated alluvial units. Water levels from two wells, one penetrating the Phosphoria Formation near the old Thermopolis airport, and one in the Tensleep Sandstone (southwest of the Lucerne pumping station) showed that water level response to annual precipitation is on about a one-year delay cycle (Plafcan and Ogle, 1993).

If deeper recharge was significantly occurring throughout the Owl Creek basin it would be logical to assume that some portion of that recharge would be available as baseflow in a quantity sufficient to sustain streams in a more reliable fashion throughout the year. This seems to not be the case as we understand the historical dynamics of the watershed. Except in localized areas where geologic structure provides conduits between deeper aquifers and surficial aquifers or where upward leakage from consolidated rocks could recharge unconsolidated surficial materials, water recharging to deeper flow systems is largely unavailable throughout most of the drainage basin unless exploited by deep wells.

Groundwater Usage

The earliest mention of groundwater usage in the Owl Creek watershed appears to be a passing remark by Fisher (1906) who noted a “number of shallow wells along Owl Creek that furnish water that are more or less ‘alkali’ in quality.” This means that the water contains relatively more sodium ions than divalent calcium and magnesium ions and the total concentration of salts is generally not very high. Fisher (1906) also noted that in the vicinity of Embar near the mouth of Mud Creek, “artesian water might be possibly obtained from the Cloverly Formation at moderate depths.”

Total water use, including both ground and surface water, is briefly outlined in **Section 3.1.10**, based on USGS data from 2005. Some insight to current groundwater use can be obtained from review of WSEO water rights data, which identifies 506 point locations for groundwater usage in the study area. Some of the data points appear to be developed springs (spring boxes, driven culverts, etc.) which for this analysis, are considered simply as shallow wells. Usage as recorded in the WSEO database included domestic (249 wells), domestic/stock (233 wells), domestic/stock/irrigation (5 wells), domestic/irrigation (one well), domestic/miscellaneous (one well) and municipal (17 wells) for the towns of Thermopolis and Kirby.

The wells obtained from the database query are shown in **Figure 3.3.2-4** and are sorted by depth below ground surface (bgs). Approximately 78 of the locations carried a zero for the depth field indicating that this metric is unknown or not recorded. The available data indicate that virtually all of the wells are located in the floodplain of various streams within watersheds of the study area, with most located along the Bighorn River and Owl Creek proper. Generally, deeper wells are located along the Bighorn River while shallower wells are located to the west in less developed parts of the study area. Including the data points containing zeros for depth, 67% of the locations (319 wells) were 75 ft. or less in depth. Wells with recorded depths ranging from 80 to 191 ft. (117 wells) make up approximately 23% of the data, wells 195 to 400 ft. in depth (62 wells) represent about 12% of the data, and wells with depths ranging from 560 to 1,135 ft. (seven wells) represent about 7%. One well had a recorded depth of 2,910 ft.

Effects of Geology and Soils on Watershed Characteristics

Owl Creek watershed characteristics are largely dependent on the geology, geomorphology, and soils of the area. Throughout the study area, drainage and run-off has dissected the landscape and formed mostly small, steeply-sided creeks which drain to the master streams traversing the basin, which in turn are underlain by alluvial deposits and in some cases bordered by terrace deposits (former alluvial floodplains subsequently eroded as hydrologic conditions undergo change and re-adjustment.

The degree of structural influences all play a part in the resulting characteristics of the watershed. Higher elevation areas in the western part of the basin are underlain by volcanic material that generally supports the development of steep-walled, high-gradient canyons, floored by free-rock stream bottoms with thin-to-non-existent, minimally vegetated floodplains and abundant woody debris. The proximity of this area to a reliable surface water supply (snow pack and relatively abundant rain) provides for perennial stream-flow. The Precambrian rocks exposed along the spine of the Owl Creek Mountains on the south side of the basin provide similar conditions.

The rocks underlying these high elevation areas give way to Paleozoic rocks at lower elevations. Here, stream valleys begin to open up, gradients decrease and rocks are likely more erodible.

3.3.3 Surface Water

Description of HUCs in the Project Area

Data used for the description and evaluation of surface water resources include the Watershed Boundary Dataset (WBD) and its companion, the National Hydrography Dataset (NHD). The WBD is designed as a comprehensive collection of hierarchical hydrologic unit (HU) data based drainage characteristics mapped at the 1:24,000 scale. The WBD defines the aerial extent of surface water drainage to a point where it joins another surface water HU. Starting with the largest of drainage areas and ending with the smallest, six hierarchical HUs are defined, the smallest units routinely defined are coded with a 12-digit hydrologic unit code (HUC) and are referred to as sub-watersheds; the largest hydrologic units are coded with a two-digit number and are referred to as regions.

Table 3.3.3-1 presents the hierarchy for the Owl Creek drainage, and **Figure 3.3.3-1** presents the Owl Creek drainage area in context of the geographical boundaries of the HU hierarchy as delineated by the WBD (USGS, USDS-NRCS, and USEPA 2016). Note that the HUCs do not correspond with the Owl Creek Irrigation District divisions of Owl Creek into “upper”, “middle”, and “lower” sections.

Table 3.3.3-1 Hierarchy of Hydrologic Units for the Owl Creek Drainage.

Level	Unit	Digits	Code	Name
First	Region	2-digit	10	Missouri
Second	Sub-Region	4-digit	1008	Big Horn
Third	Basin	6-digit	100800	Big Horn
Fourth	Sub-Basin	8-digit	10080007	Upper Bighorn
Fifth	Watershed	10-digit	1008000701	North Fork Owl Creek
Sixth	Sub-Watershed	12-digit	100800070101 100800070102 100800070103 100800070104 100800070105 100800070106 100800070107 100800070108	Upper South Fork Owl Creek Middle South Fork Owl Creek Middle Fork Owl Creek Red Creek South Fork North Fork Owl Creek Upper North Fork Owl Creek Lower North Fork Owl Creek Lower South Fork Owl Creek
Fifth	Watershed	10-digit	1008000702	Owl Creek
Sixth	Sub-Watershed	12-digit	100800070201 100800070202 100800070203 100800070204 100800070205	South Fork Mud Creek North Fork Mud Creek Mud Creek Upper Owl Creek Lower Owl Creek

Source: USGS, USDS-NRCS and USEPA (2016).

The Owl Creek drainage is wholly contained in the Upper Bighorn sub-basin and is comprised of two WBDs at the fifth (10-digit) watershed level: The upstream North Fork Owl Creek watershed (HUC 1008000701) – which includes the South Fork Owl Creek– and the downstream Owl Creek watershed (1008000702). These two watersheds in turn are comprised of a total of 12 sixth-level sub-watersheds.

Note that for the purposes of the present study, small portions of adjoining watersheds are included within the study area. These adjoining areas include portions of the 10-digit Buffalo Creek-Bighorn River (HUC 1008000703), and Little Gooseberry Creek-Bighorn River (1008000711) drainages, all contained within the 8-digit Upper Bighorn Sub-Basin (10080007). The lower portion of the 10-digit Cottonwood Creek-Wind River (1008000506) is included in the study area boundary, though this watershed is located upstream of Owl creek and is part of the 8-digit Lower Wind Sub-Basin (10080005).

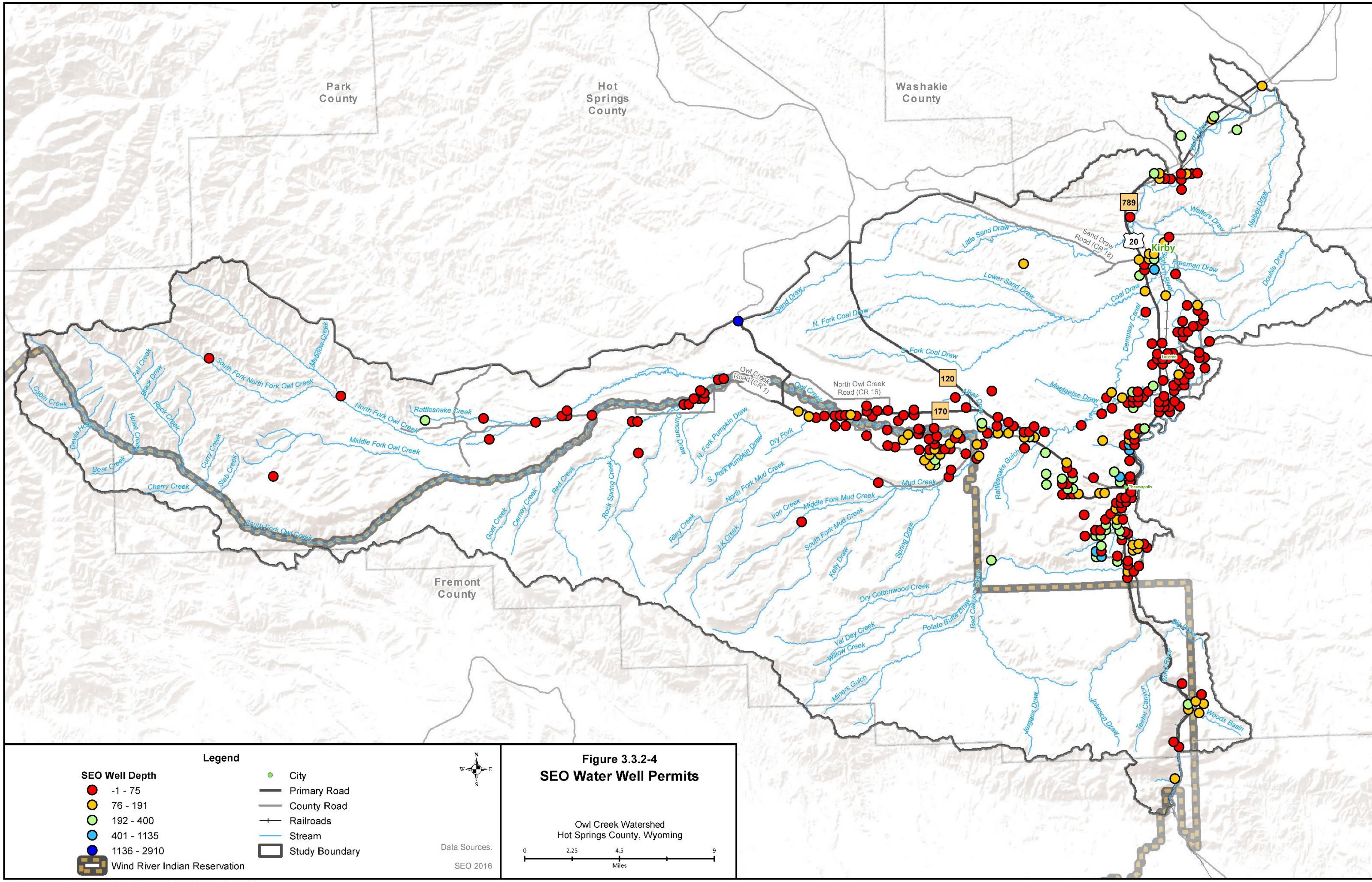


Figure 3.3.2-4
SEO Water Well Permits

Owl Creek Watershed
Hot Springs County, Wyoming

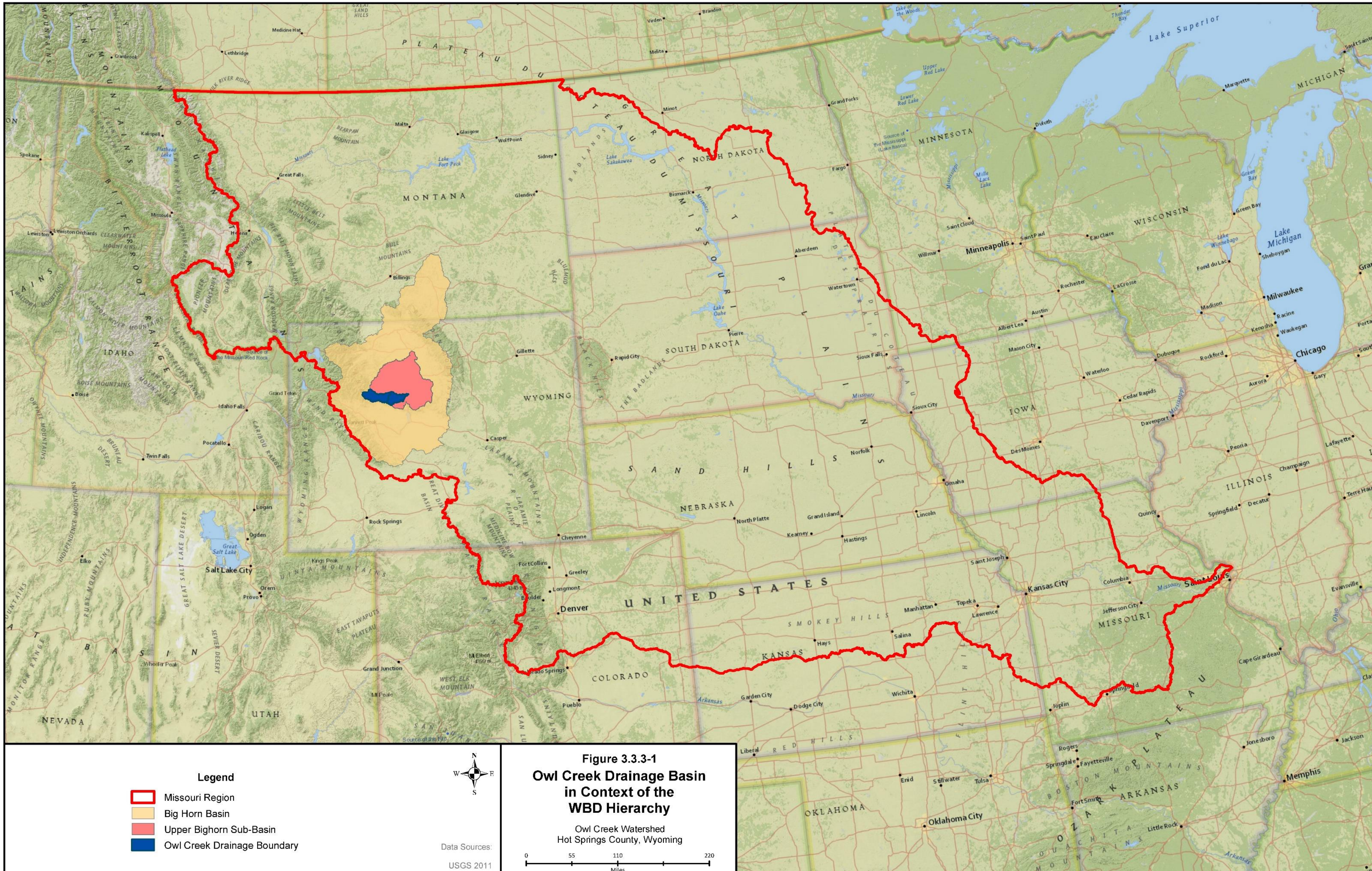


Figure 3.3.3-1
Owl Creek Drainage Basin in Context of the WBD Hierarchy
Owl Creek Watershed
Hot Springs County, Wyoming

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Figure 3.3.3-2 presents the Owl Creek drainage area (Owl Creek watershed and North Fork Owl Creek watershed and their respective sub-watersheds, outlined in red) and portions of adjoining watersheds/sub-watersheds included in the study area.

Each 10-digit sub-watershed and related 12-digit sub-watersheds within the study area are discussed separately below.

North Fork Owl Creek 10-digit Watershed (1008000701) (includes South Fork Owl Creek)

The North Fork Owl Creek 10-digit watershed is composed of eight 12-digit sub-watersheds as presented in **Table 3.3.3-2 and Figure 3.3.3-3**.

Table 3.3.3-2 12-digit Sub-watersheds of the North Fork Owl Creek Watershed (HUC10 1008000701)

12-digit HUC	Sub-watershed Name	Area (acres)	Additional Named Streams[1]
100800070101	Upper South Fork Owl Creek	33,169	Bear Creek, Hulse Creek, Additional Creek, Klicker Creek, Cabin Creek, Vass Creek, Needle Creek, Rock Creek, Willow Creek, Fall Creek
100800070102	Middle South Fork Owl Creek	22,263	Slab Creek, Curry Creek, Cherry Creek.
100800070103	Middle Fork Owl Creek	21,507	North Branch Middle Fork Owl Creek, Middle Branch Middle Fork Owl Creek, South Branch Middle Fork Owl Creek
100800070104	Red Creek	27,333	Rock Spring Creek, Dry Cottonwood Creek
100800070105	South Fork North Fork Owl Creek	12,009	
100800070106	Upper North Fork Owl Creek	18,980	Meadow Creek
100800070107	Lower North Fork Owl Creek	34,439	Rattlesnake Creek
100800070108	Lower South Fork Owl Creek	21,508	Carney Creek, Goat Creek

NOTES

1. As included in the National Hydrography Dataset

The North Fork Owl Creek Watershed encompasses approximately 191,208 acres (773.8 km^2) and represents the western half and the higher elevations of the Owl Creek drainage. It includes the headwaters for the North Fork Owl Creek, South Fork Owl Creek, and Middle Fork Owl Creek.

The outlet for this watershed is formed by the confluence of the North Fork and South Fork Owl Creek, and at that point, the main stem Owl Creek is formed. Just upstream from this confluence to the west, the Red Creek Sub-Watershed empties into South Fork Owl Creek.

Upper South Fork Owl Creek

The Upper South Fork Owl Creek is one of three uppermost sub-watersheds in the 10-digit North Fork Owl Creek Watershed, and is the largest in terms of area. The elevation of this sub-watershed ranges from 12,115 ft. (at County Peak) to about 8,360 ft. at its outlet (confluence with Rock Creek). This sub-watershed includes and essentially represents the headwaters of South Fork Owl Creek and is located within the Absaroka Volcanic geologic region. Because this sub-watershed is high in the basin and the geology consists of Absaroka volcanics, water quality would be expected to be good.There is no gaging data available in this sub-watershed and there is very little water quality data available.

South Fork North Fork Owl Creek Sub-Watershed

The South Fork North Fork Owl Creek sub-watershed contains the headwaters of the South Fork of North Fork Owl Creek and is the smallest of the three headwaters sub-watersheds in in terms of area. There is no gaging or monitoring data available for streams within this sub-watershed. Future gaging may be helpful at the bottom exit of this watershed to differentiate water coming from the Upper North Fork Owl Creek sub-watershed from this sub-watershed. Because this sub-watershed is high in the basin and the geology consists of Absaroka volcanics and intrusive igneous rock, water quality would be expected to be good. If this sub-watershed is a significant source of surface water to the North Fork Owl Creek and a suitable location for storage is available, late season flows could be made available.

Upper North Fork Owl Creek Sub-Watershed

The Upper North Fork Owl Creek sub-watershed contains the headwaters of the North Fork Owl Creek proper. There are no gaging data or monitoring data available for this sub-watershed. Gaging may be helpful at the bottom exit of this watershed to differentiate water coming from the South North Fork Owl Creek sub-watershed from this sub-watershed. This watershed probably represents a major source of surface water to the North Fork Owl Creek and would be expected to support much of any late-season flows on the North Fork Owl Creek. Compared to other sub-watersheds, the Upper North Fork Owl Creek has a large range in topographic elevation, ranging from about 11,300 ft. to 5,320 ft. elevation. However, because much of this sub-watershed is high in the basin and the geology consists of Absaroka volcanics intrusive igneous rock, water quality would be expected to be good. If this sub-watershed is a significant source of surface water to the North Fork Owl Creek and a suitable location for storage is available, late season flows could be made available.

Middle Fork Owl Creek Sub-Watershed

The Middle Fork Owl Creek sub-watershed drains the central portion of the North Fork Owl Creek Watershed. The sub-watershed is moderate in size (21,507 acres) and intermediate in elevation, ranging from about 9,800 ft. at its headwaters to about 6,470 ft. at its outlet at Anchor Reservoir where it flows into the South Fork of the Owl Creek. There is a gaging station near the outlet of this sub-watershed (USGS 6260200) above Anchor Reservoir. Limited gaging data were obtained at this location from 1959 to 1965. Data collection could be resumed at the former gage site on the Middle Fork Owl Creek. This may result in better characterization of the upper sub-watershed, which may be helpful in providing more certainty to the understanding of surface water loss at Anchor Reservoir.

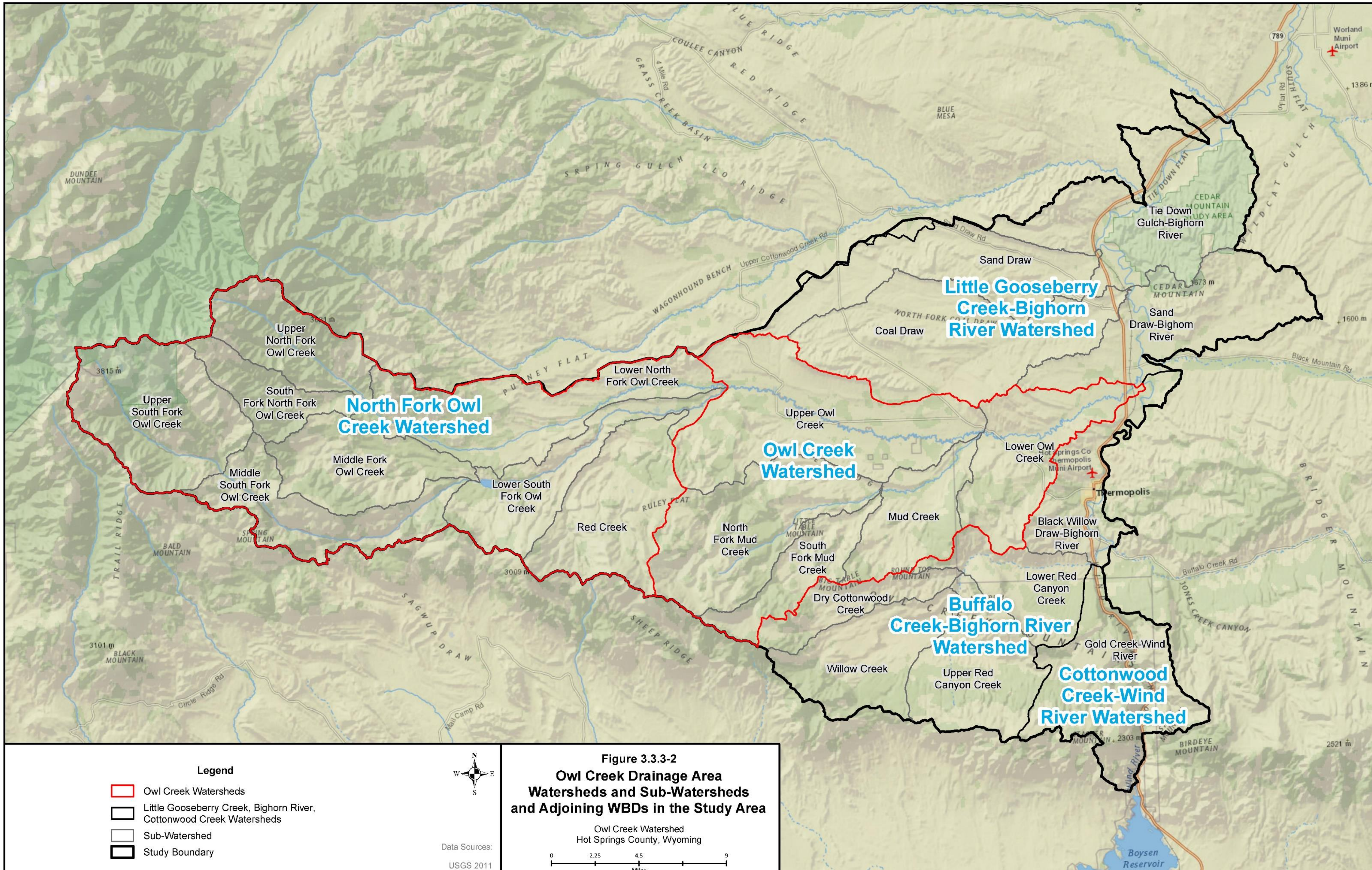

Figure 3.3.3-2
Owl Creek Drainage Area Watersheds and Sub-Watersheds and Adjoining WBDs in the Study Area
Owl Creek Watershed
Hot Springs County, Wyoming

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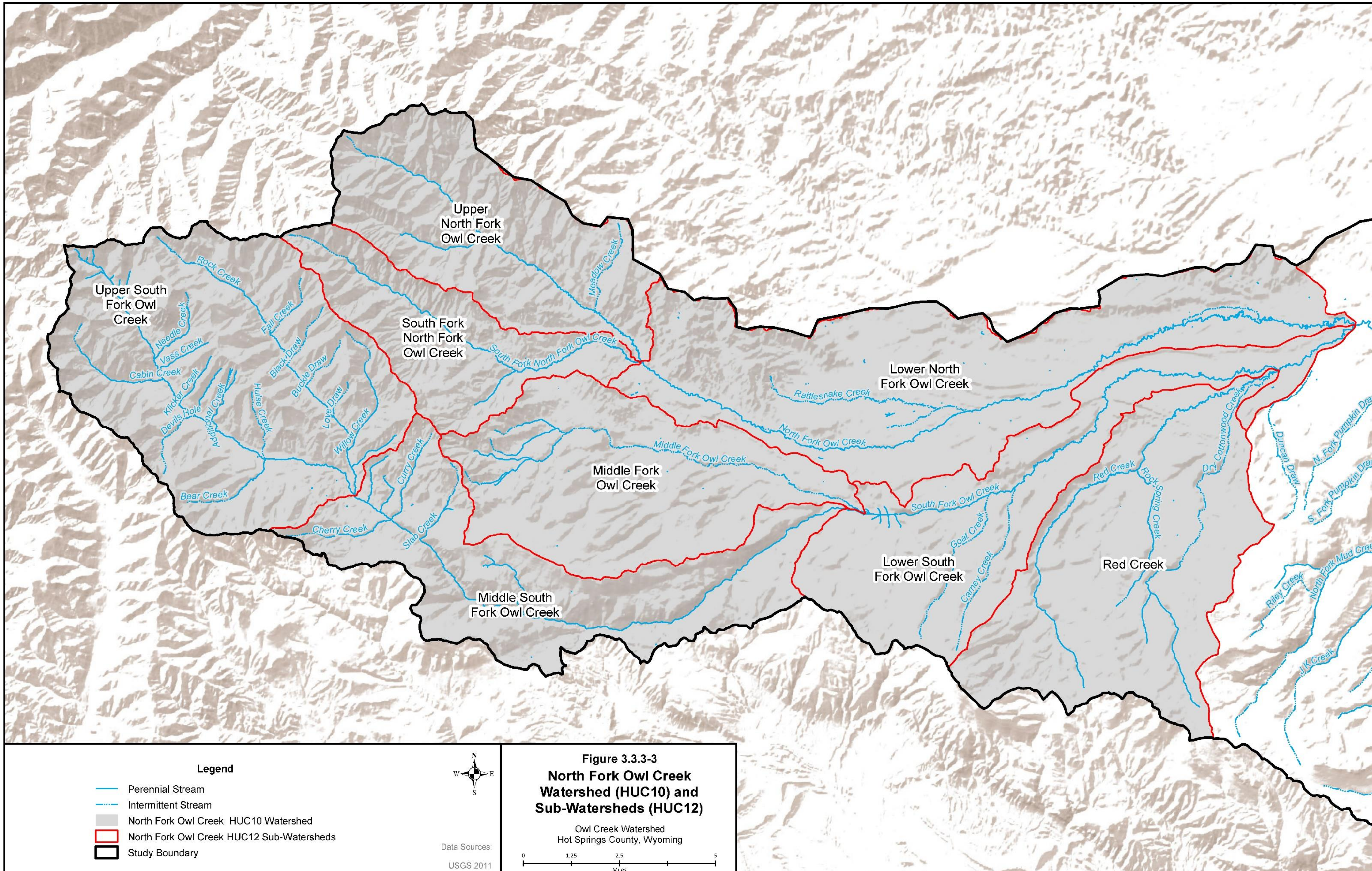

Figure 3.3.3-3
North Fork Owl Creek Watershed (HUC10) and Sub-Watersheds (HUC12)
Owl Creek Watershed
Hot Springs County, Wyoming

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Lower Basin Area

Lower basin areas of the North Fork Owl Creek Watershed essentially includes the lower elevation portions of the North Fork Owl Creek and the South Fork Owl Creek, plus Red Creek and its tributaries. The South Fork Owl Creek is divided into two additional sub-watersheds with the boundary between the middle and lower sub-watersheds located at Anchor Reservoir.

Middle South Fork Owl Creek Sub-watershed

The Middle South Fork Owl Creek sub-watershed terminates just above where the Middle Fork Owl Creek joins the South Fork Owl Creek, approximately 1.4 miles upstream from the Anchor Dam. Most of this sub-watershed is underlain by Paleozoic sedimentary rocks. There is gaging information available from 1940 to 1995 from USGS 06260000, and from 1997 to present from WSEO gage 0305OC01, which appears to be a continuation of the earlier dataset from the USGS gage. In addition, two spring samples obtained high in the watershed and four NHD point sampling events also appear to exist, two at the top of the sub-watershed and two at the bottom.

Lower South Fork Owl Creek Sub-Watershed

The Lower South Fork Owl Creek sub-watershed connects to the middle South Fork Owl Creek Sub-watershed at Anchor Reservoir. Thus, this sub-watershed contains Anchor Dam near the top of the watershed. Surface water is derived from tributaries draining slopes off the higher slopes to the south of Anchor Reservoir. This sub-watershed and the North Fork sub-watershed form the main stem of Owl Creek. There numerous sources of stream gaging information available. Several gages have operated in this sub-watershed at one time or another, including:

- USGS 06260400 - South Fork Owl Creek below Anchor reservoir (operated 1959 to2004);
- USGS 06260500 - South Fork Owl Creek above Curtis Ranch near Thermopolis , WY (operated 1943 to1959);
- USGS 06261000 South Fork OWL Creek A C RN near Thermopolis, Wyo. (operated 1938 to1943);
- USGS 06261500 South Fork Owl Creek near Thermopolis Wyo. operated 1921 to1932); and
- South Fork Owl Creek below Anchor Reservoir, WY (probable continuation of USGS 06260400, currently monitored by WYSEO since 1997).

It is recommended that gaging below Anchor Reservoir be continued to provide data to understand the water loss at Anchor Reservoir and help formulate solutions and/or alternatives to water issues within the Owl Creek watershed.

Red Creek Sub-Watershed

The Red Creek sub-watershed is tributary to South Fork Owl Creek, entering South Fork Owl Creek about 2.5 miles above where South Fork Owl Creek is joined by North Fork Owl Creek. This sub-watershed is comparatively large (27,333 acres) and appears to be a significant source of surface water to the extreme lower portion of South Fork Owl Creek. This sub-watershed appears to be underlain by Paleozioc sedimentary rocks and portions of two large granitic intrusive bodies. The headwaters for Red Creek are derived from the North-facing slopes of the Owl Creek Mountains at approximately 9,800 ft. The outlet to Red Creek is at approximately 5,460 ft. where it flows into the South Fork Owl Creek. There are no gaging data available for Red Creek. Limited USGS Water Quality Data are available from a station near the bottom of the Red Creek sub-watershed. It is therefore recommended gaging be carried out at a location below where Dry

Cottonwood Creek enters Red Creek to better understand the contribution of the Red Creek sub-watershed to downstream flows.

Lower North Fork Owl Creek Sub-Watershed

The Lower North Fork Owl Creek sub-watershed joins with the Lower South Fork Owl Creek sub-watershed, below which is the Owl Creek Watershed. This sub-watershed is underlain by Absaroka volcanic rocks at the upper end and Triassic sedimentary rocks (Chugwater and Dinwoody Formations) and Cody Shale at the middle and lower ends.

Rattlesnake Creek is the sole named watercourse tributary to North Fork Owl Creek in this sub-watershed and may be a significant source of water to North Fork Owl Creek due to its relatively long length and large basin area. Other than Rattlesnake Creek, there are no significant tributaries feeding this reach of North Fork Owl Creek, and only a few springs (north of Rattlesnake Creek).

Owl Creek 10-digit Watershed (1008000702)

The Owl Creek 10-digit watershed (1008000702) contains five 12-digit sub-watersheds as presented in **Table 3.3.3-3** and **Figure 3.3.3-4**. The Owl Creek Watershed represents the lower elevation eastern end of the Owl Creek Basin and encompasses an area of approximately 135,129 acres (546.9 km^2). The outlet of the Owl Creek Watershed is at the Bighorn River near Thermopolis.

Table 3.3.3-3 12-digit Sub-watersheds of the Owl Creek Watershed (HUC10 1008000702).

12-digit HUC	Sub-watershed Name	Area (acres)	Additional Named Streams[1]
100800070201	South Fork Mud Creek	13,197	Kelly Draw
100800070202	North Fork Mud Creek	33,865	Middle Fork Mud Creek, Iron Creek, JK Creek, Riley Creek
100800070203	Mud Creek	17,097	Spring Draw
100800070204	Upper Owl Creek	46,500	Alkali Draw, Dry Fork, Dunkin Draw, Pumpkin Creek, Pumpkin Draw, North Fork Pumpkin Draw, South Fork Pumpkin Draw
100800070205	Lower Owl Creek	24,472	Eagle Draw, Meeteetse Draw, Rattlesnake Gulch

NOTES 1. As included in the National Hydrography Dataset

The Owl Creek Watershed is formed at its head by the confluence of the North Fork and South Fork Owl Creek which provide the bulk of its flow based on area. The principal tributary contributor to the watershed based in area is the North Fork Mud Creek. The Upper Owl Creek and Lower Owl Creek sub-watersheds probably represent the most heavily used areas of the Owl Creek basin with livestock grazing, grass, alfalfa, and other agricultural production, and some oil and gas development occurring.

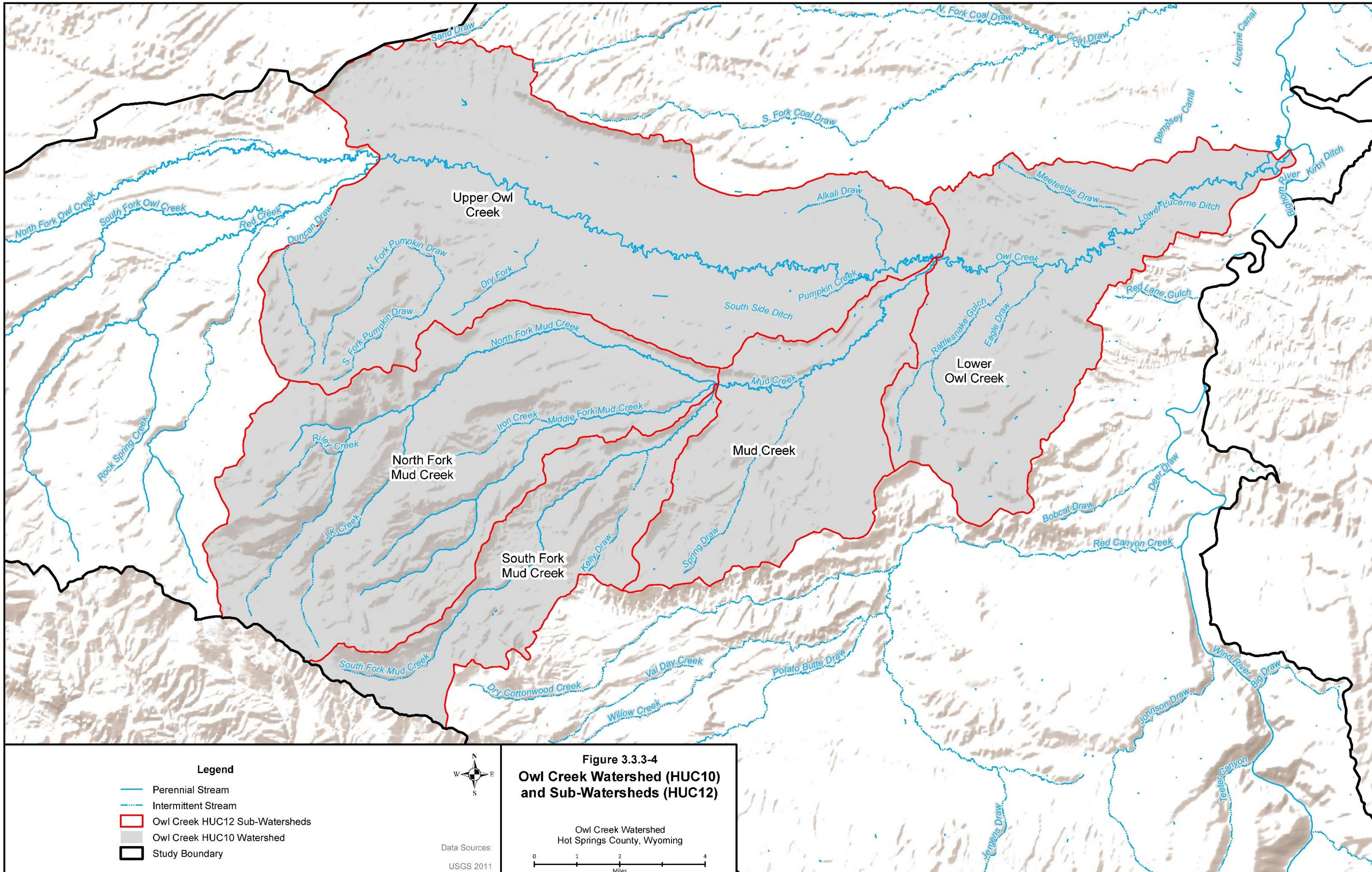

Figure 3.3.3-4
Owl Creek Watershed (HUC10) and Sub-Watersheds (HUC12)

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Upper and Lower Owl Creek Sub-Watersheds

As stated earlier, the bulk of activity within the Owl Creek Watershed takes place within these sub-watersheds, principally within the riparian zone and flood plain of Owl Creek, due to the proximity to surface water supplies to support such activities. The bulk of the flow in Owl Creek is supplied by the North Fork Owl Creek Watershed in the upper basin (which includes both the North and South Forks of Owl Creek). Mud Creek is a significant sub-watershed. Land surface elevations range from approximately 5,320 ft. at the head of Upper Owl Creek to 4,600 ft. at the head of Lower Owl Creek (confluence with Mud Creek) to approximately 4,290 ft. at the outlet of Lower Owl Creek at Bighorn River.

The geology underlying these area of the watershed is principally Mesozoic marine sedimentary rocks, including extensive areas underlain by saline fine-grained shales which can have a negative impact on water quality due to salt loading and erodible soils.

Two USGS stream gages have operated in the past within the upper and lower owl Creek sub-watersheds including:

- USGS 06264000 Owl Creek near Thermopolis, WY (1911 to1969); and
- USGS 06264500 Owl Creek near Lucerne, WY (1932 to1953).

More recent gaging data has been collected by the WSEO at:

- Station 0305OC06 Owl Creek above McManus Ditch near Thermopolis, WY (2011 to current); and
- Station 0305OC03 Owl Creek at Arapahoe Ranch Bridge (1997 to current).

WSEO station 0305OC06 may represent the reactivation of the USGS gage 06264000 as they appear to be located at or very near the same location.

Mud Creek Sub-Watershed

Mud Creek and its tributaries represent a major addition of drainage area to the Owl Creek Watershed, together contributing approximately 47% of the total area of the watershed. The sub-watershed begins on the north-facing slopes of the Owl Creek Mountains at elevations ranging from about 8,000 to 9,300 ft..

Geology underlying the headwater areas of Mud Creek is composed primarily of Precambrian granitic rocks transitioning to Paleozoic sedimentary rocks and eventually Mesozoic marine sedimentary rocks at lower elevations to the north. In the headwater areas, due to elevation and rock type, water quality is likely high. However, most land within the sub-watershed is underlain by Mesozoic marine sedimentary rocks which can have a negative impact in water quality due to salt loading and erodible soils.

The main stem Mud Creek is fed by perennial and intermittent streams flowing from the south of the north-facing slopes of Big Table Mountain (elevation 6,554 ft.) and Round Top Mountain (elevation 6,155 ft.), which are fed by named springs. The outlet of Mud Creek at the confluence with Owl Creek is located at an approximate elevation of 4,620 ft.

One stream gage has operated for a brief time during the past in the Mud Creek sub-watershed (1938-1939). This gage was located upstream near the confluence of Mud Creek with Owl Creek. Because Mud

Creek may represent a significant contribution of surface water to Owl Creek, it is recommended that gaging be reestablished at or near the preexisting gage to acquire data to better understand the contribution of the Mud Creek sub-watersheds to flow in lower Owl Creek.

Buffalo Creek-Bighorn River 10-digit Watershed (1008000703)

The Buffalo Creek-Bighorn River 10-digit watershed (1008000703) contains five 12-digit sub-watersheds within the Study Area as presented in **Table 3.3.3-4 and Figure 3.3.3-5**. Though contained within the Upper Bighorn Sub-Basin, the Buffalo-Creek-Bighorn River watershed is not within the Owl Creek basin and all sub-watersheds in this watershed drain directly to the Bighorn River upstream of Owl Creek's outlet to the Bighorn River. Though it is unrelated hydrologically to owl Creek it is included in the Study Area by request of WWDC for reasons of proximity and the fact that it has not been included in another WWDC study.

Table 3.3.3-4 12-digit Sub-watersheds of the Buffalo Creek-Bighorn River Watershed Included in the Study Area

12-digit HUC	Sub-watershed Name[1]	Area (acres)	Additional Named Streams[3]
100800070301	Willow Creek	22,127	Val Day Creek, Black Rock Draw, Miners Gulch, Potato Butte Draw
100800070302	Dry Cottonwood Creek	11,381	none
100800070303	Upper Red Canyon Creek	24,107	Jergens Draw
100800070304	Lower Red Canyon Creek	16,662	none
100800070309	Black Willow Draw-Bighorn River[2]	17,472	Bobcat Draw, Deer Draw, Red Lane Gulch

NOTES

1. Excludes the east side of Black Willow Draw-Bighorn River sub-watershed (east of Bighorn River). Total size of this sub-watershed is approximately 28,966 acres.
2. As included in the National Hydrography Dataset, USGS 7.5-minute topographic quadrangle maps.

Little Gooseberry Creek-Bighorn River 10-digit Watershed (100800071)

The Little Gooseberry Creek-Bighorn River 10-digit watershed (1008000711) contains four 12-digit sub-watersheds within the Study Area as presented in **Table 3.3.3-5** and **Figure 3.3.3-6**.

Table 3.3.3-5 12-digit Sub-watersheds of the Little Gooseberry Creek-Bighorn River Watershed Included in the Study Area

12-digit HUC	Sub-watershed Name[1]	Areas (acres)	Additional Named Streams[2]
100800071101	Coal Draw	44,194	Lower Sand Draw, North Fork Coal Draw, South Fork Coal Draw, Wagon Gulch,
100800071102	Sand Draw-Bighorn River	31,937	Coal Draw, Double Draw, Freeman Draw
100800071103	Sand Draw	29,042	Little Sand Draw
100800071105	Tie Down Gulch-Bighorn River	42,344	Neiber Draw, Walters Draw

NOTES

1. Little Gooseberry Creek and Horse Gulch-Bighorn River are 12-digit sub-watersheds included in Little Gooseberry Creek-Bighorn River Watershed, but are not included in the study area, and therefore are not listed here.
2. As included in the National Hydrography Dataset, USGS 7.5-minute topographic quadrangle maps.

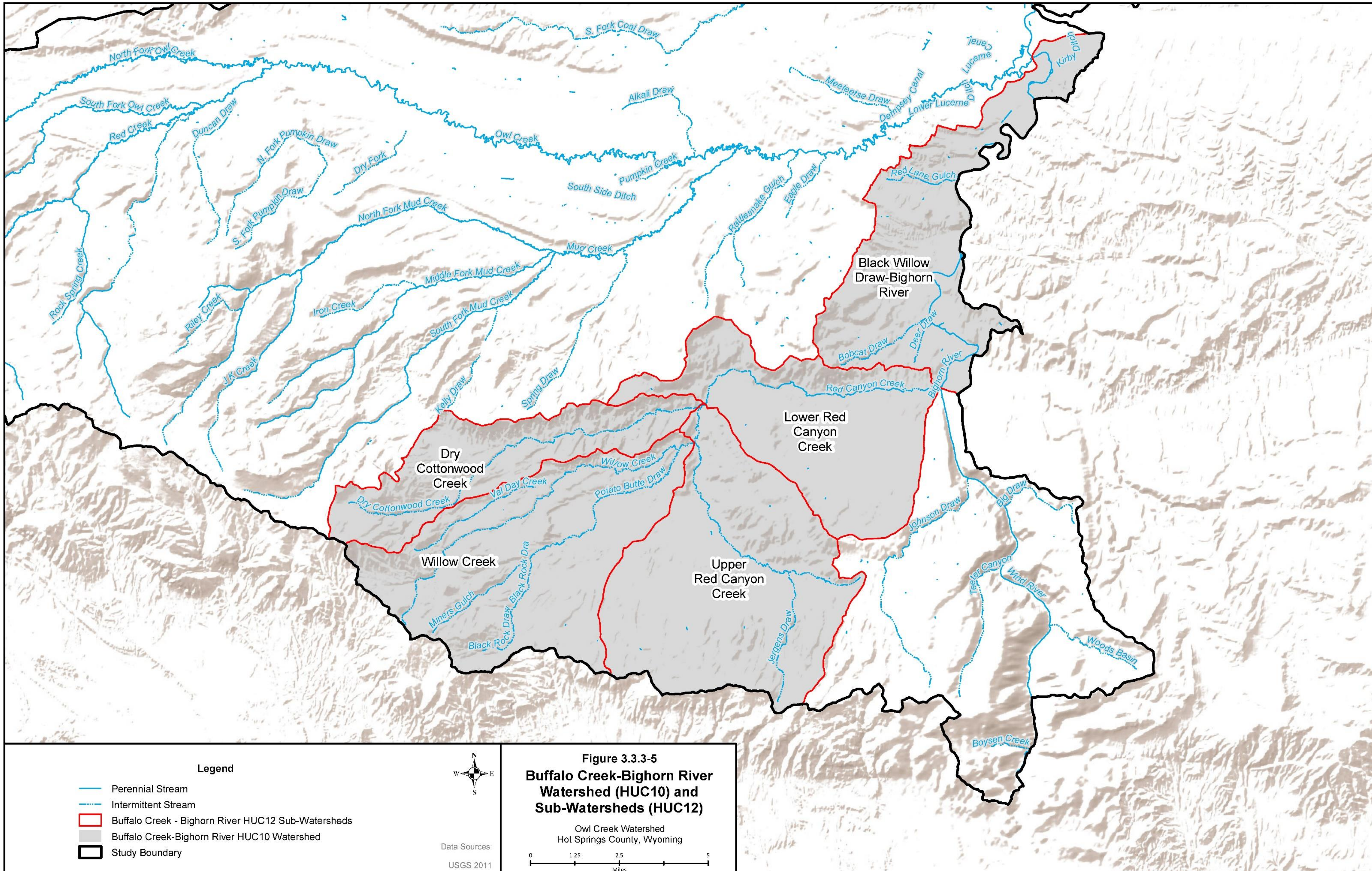

Figure 3.3.3-5
Buffalo Creek-Bighorn River Watershed (HUC10) and Sub-Watersheds (HUC12)

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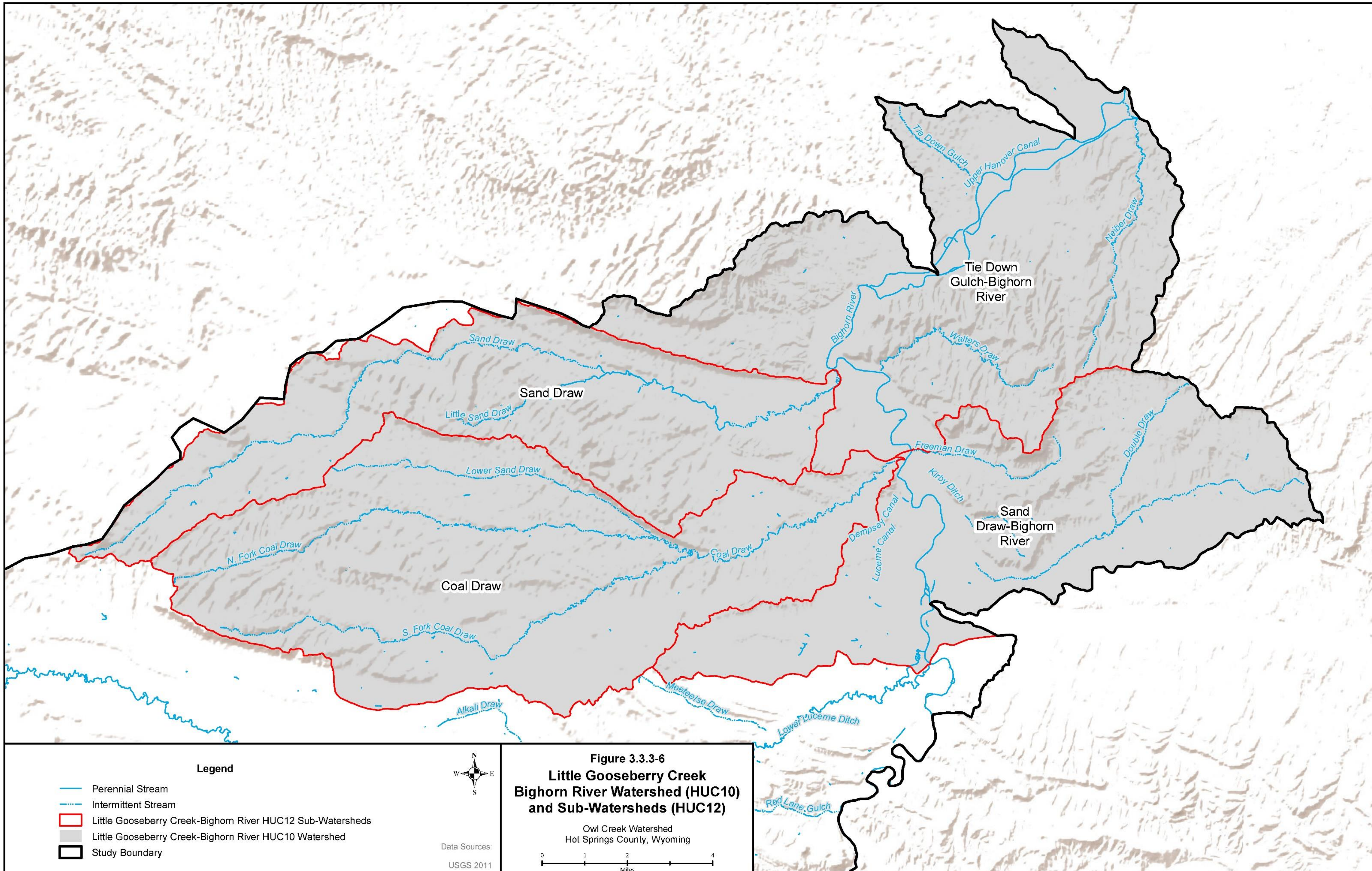

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Though contained within the Upper Bighorn Sub-Basin, The Little Gooseberry Creek-Bighorn River Watershed is not truly a basin connected to the Owl Creek system (generally located to the north of Owl Creek watersheds), but parts of it are included in the study area for reasons of proximity and the fact that it has not been included in another WWDC study. All drainages of this watershed that are included within the study area boundary, drain to the Bighorn River downstream from the confluence of Owl Creek with the Bighorn River.

Cottonwood Creek-Wind River 10-digit watershed (1008000506)

The Cottonwood Creek-Wind River 10-digit watershed (1008000506) is not contained within the Upper Bighorn Sub-Basin, but in the Lower Wind Sub-Basin. This watershed was included in the Study Area by request of the WWDC. Only the northern portion of this watershed is included within the Study Area boundary as presented in **Table 3.3.3-6** and **Figure 3.3.3-7**.

Table 3.3.3-6 12-digit Sub-watershed of the Cottonwood Creek-Wind River Watershed Included in the Study Area

12-digit HUC	Sub-watershed Name[1]	Area (acres)	Additional Named Streams[3]
100800050608	Gold Creek-Wind River[2]	32,485	Johnson Draw, Teeter Canyon, Boysen Creek, Wood Basin, Big Draw

NOTES

1. Only the northern portion of Gold Creek-Wind River Sub-Watershed is included in the Study Area. The total size of this sub-watershed is approximately 38,977 acres,
2. As included in the National Hydrography Dataset, USGS 7.5-minute topographic quadrangle maps.

The Cottonwood Creek-Wind River Watershed is not a basin connected to the Owl Creek system. It is included in the study area for reasons of proximity and the fact that it has not been included in another WWDC study. This sub-watershed is located immediately downstream of Boysen Reservoir and all drainages of this sub-watershed included within the study area boundary drain to the Wind River. Note that the Wind River and the Bighorn River are the same watercourse, the titles of which simply represent a historic renaming from the Wind to the Bighorn River upstream from the City of Thermopolis at the point known as the "Wedding of the Waters."

3.3.4 Stream Gages, Period of Record, Location

Surface water flow data at various gaging stations have been collected in the area as far back as the early 1900s by the USGS and continues through to the present at selected locations by the WSEO. The U.S. Bureau of Reclamation (USBR) also currently operates one gage at the Anchor Reservoir Dam that essentially collects reservoir pool elevation data.

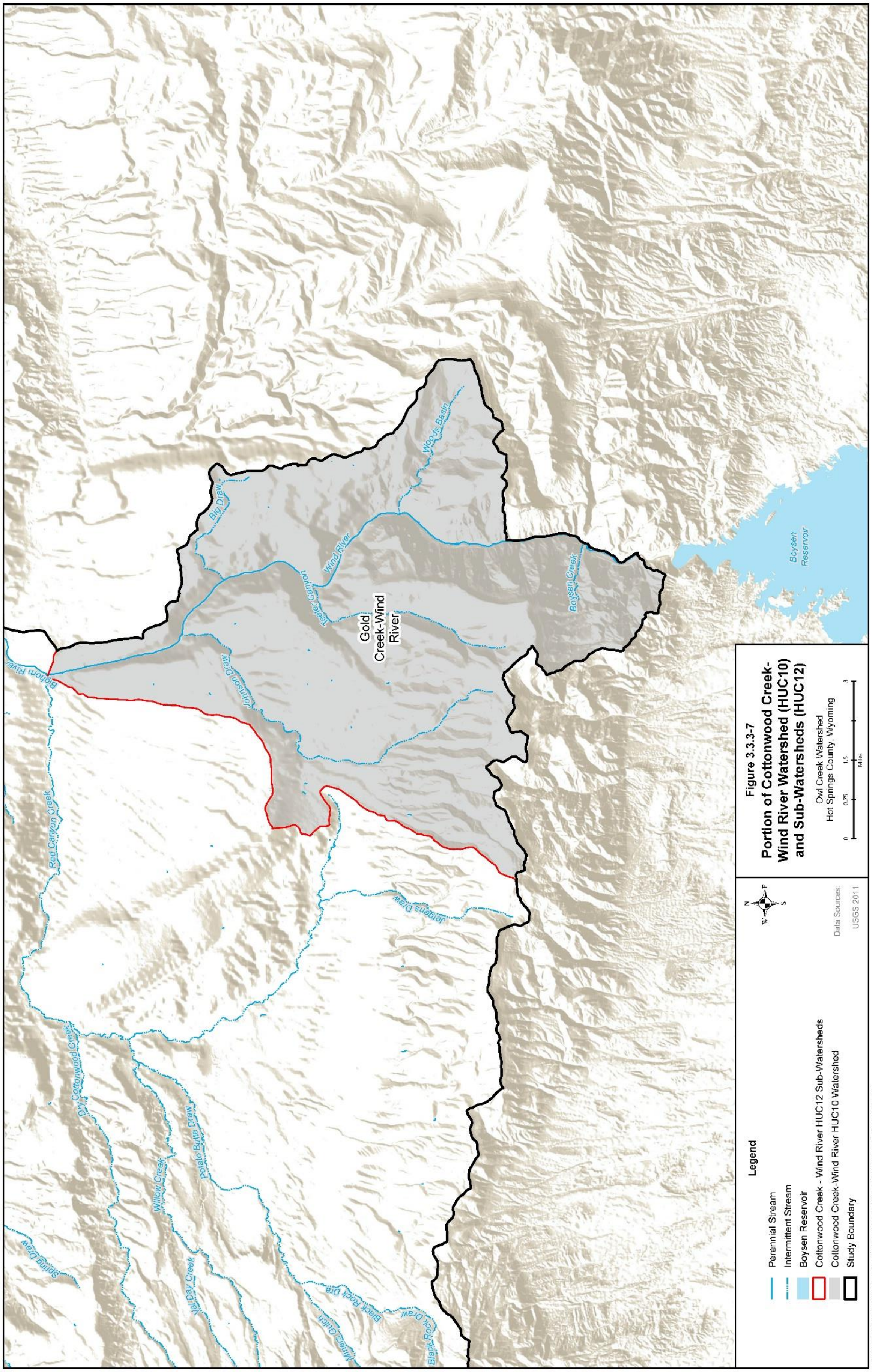
Figure 3.3.3-7
Portion of Cottonwood Creek-Wind River Watershed (HUC10) and Sub-Watersheds (HUC12)
Owl Creek Watershed
Hot Springs County, Wyoming
Legend
Perennial Stream
Intermittent Stream
Boysen Reservoir
Cottonwood Creek - Wind River HUC12 Sub-Watersheds
Cottonwood Creek-Wind River HUC10 Watershed
Study Boundary
Data Sources:
USGS 2011
Gold Creek-Wind River
Wind River
Bighorn River
Boysen Reservoir
Boysen Creek
Woods Basin
Big Draw
Teepee Canyon
Johnson Draw
Red Canyon Creek
Dry Cottonwood Creek
Willow Creek
Potato Butte Draw
Dry Creek
Spring Draw
Black Rock Draw
Miners Gulch

As shown in **Table 3.3.4-1**, a total of 19 gages formerly operated by the USGS with various periods of record are available in and about the study area boundary, 13 of which are within the Owl Creek drainage boundary.

Table 3.3.4-1 Stream gages formerly operated by the USGS within the Study Area.

Description	Years of Record	Watershed
USGS 06264500 OWL CREEK NEAR LUCERNE, WY	1932-1953	Owl Creek
USGS 06264000 OWL CREEK NEAR THERMOPOLIS, WY	1911-1969	Owl Creek
USGS 06263500 MUD CREEK NR THERMOPOLIS WYO	1938-1939	Owl Creek
USGS 06263000 NORTH FORK OWL CREEK NR THERMOPOLIS WYO	1930-1932	N. Fork Owl Creek
USGS 06261500 SOUTH FORK OWL CREEK NR THERMOPOLIS WYO	1921-1932	N. Fork Owl Creek
USGS 06262500 N.F. OWL CREEK AT CRANN RANCH NR THERMOPOLIS, WY	1938-1939	N. Fork Owl Creek
USGS 06261000 SF OWL C A C RN N THERMOPOLIS WYO	1938-1943	N. Fork Owl Creek
USGS 06260500 S F OWL CREEK AB CURTIS RANCH, NR THERMOPOLIS, WY	1943-1959	N. Fork Owl Creek
USGS 06262300 NORTH FORK OWL CR AB BASIN RANCH NR ANCHOR WYO	1962-1995	N. Fork Owl Creek
USGS 06260400 SOUTH FORK OWL CREEK BELOW ANCHOR RESERVOIR, WY	1959-2004	N. Fork Owl Creek
USGS 06260000 SOUTH FORK OWL CREEK NEAR ANCHOR, WY	1940-1995	N. Fork Owl Creek
USGS 06260200 MIDDLE FORK OWL CREEK ABOVE ANCHOR RESERVOIR, WY	1959-1995	N. Fork Owl Creek
USGS 06262000 NORTH FORK OWL CREEK NEAR ANCHOR, WY	1941-1962	N. Fork Owl Creek
USGS 06259500 BIGHORN RIVER AT THERMOPOLIS, WYO	1911-1953	Buffalo Creek-Bighorn River
USGS 06265000 KIRBY CREEK NR LUCERNE WYO	1941-1945	Little Gooseberry Creek-Bighorn River
USGS 06265200 SAND DRAW NEAR THERMOPOLIS, WY	1960-1981	Little Gooseberry Creek-Bighorn River
USGS 06265600 TIE DOWN GULCH NEAR WORLAND, WY	1961-1984	Little Gooseberry Creek-Bighorn River
USGS 06259000 WIND RIVER BELOW BOYSEN RESERVOIR, WY	1951-2016	Cottonwood Creek-Wind River
USGS 06265337 COTTONWOOD C AT HIGH ISLAND RNCH NR HAMILTON DOME	1993-2011	Outside study area

Source: USGS National Water Information Service (NWIS), downloaded 07/09/2016

A total of 13 stream gages currently in operation and monitored by WSEO are tabulated in **Table 3.3.4-2** and presented in **Figure 3.3.4-1**. Several of the stream gage locations operated by the WSEO are former USGS gage sites, and continue the period of record abandoned by the USGS at some time in the past. WSEO gaging data also include sites on ditches and canals to monitor the various irrigation improvements in the area.

Table 3.3.4-2 Stream Gages Currently operated by WSEO within the Study Area.		
Description	**Period**	**Watershed**
0305OC01 South Fork Owl Creek above Anchor Reservoir, WY	1997-current	North Fork Owl Creek
0305OCBL South Fork Owl Creek below Anchor Reservoir, WY	1997-current	North Fork Owl Creek
0305OC12 Basin Ditch	2010-current	North Fork Owl Creek
0305OC11 North Fork Owl Creek near Anchor Reservoir, WY	1997-current	North Fork Owl Creek
0305OC06 Owl Creek above McManus Ditch near Thermopolis, WY	2011-current	Owl Creek
0305OC03 Owl Creek at Arapahoe Ranch Bridge	1997-current	Owl Creek
0303BH01 Kirby Canal at Headworks	1997-current	Buffalo Creek-Bighorn River
0303BH03 Lower Lucerne Canal	1997-current	Buffalo Creek-Bighorn River
0303BH02 Upper Lucerne Canal	1997-current	Buffalo Creek-Bighorn River
0303BH4T Upper Hanover Canal near Headworks	1997-current	Little Gooseberry Creek-Bighorn River
0303UBWY-C Upper Bluff Non-District Pumps	2008-current	Little Gooseberry Creek-Bighorn River
0303TFWY Tiedown Flats Pumps	1997-current	Little Gooseberry Creek-Bighorn River
0303BH05 Bluff Canal	1997-current	Little Gooseberry Creek-Bighorn River

Source: Wyoming State Engineer's Office, downloaded 07/12/2016.

Of the 13 WSEO-operated gages, six are located within the Owl Creek drainage area, the remaining are located within the Little-Gooseberry-Bighorn and Buffalo Creek-Bighorn River Watershed and general consist of gage sites monitoring irrigation operation. The data from Owl Creek gages were used to perform a quantitative analysis of water availability as allowed by the data, by month, for wet, average, and dry years. Individual irrigators' provided qualitative data based on their experience with water availability and crop growth. This information is included in **Sections 3.3.6** and **3.3.7**.

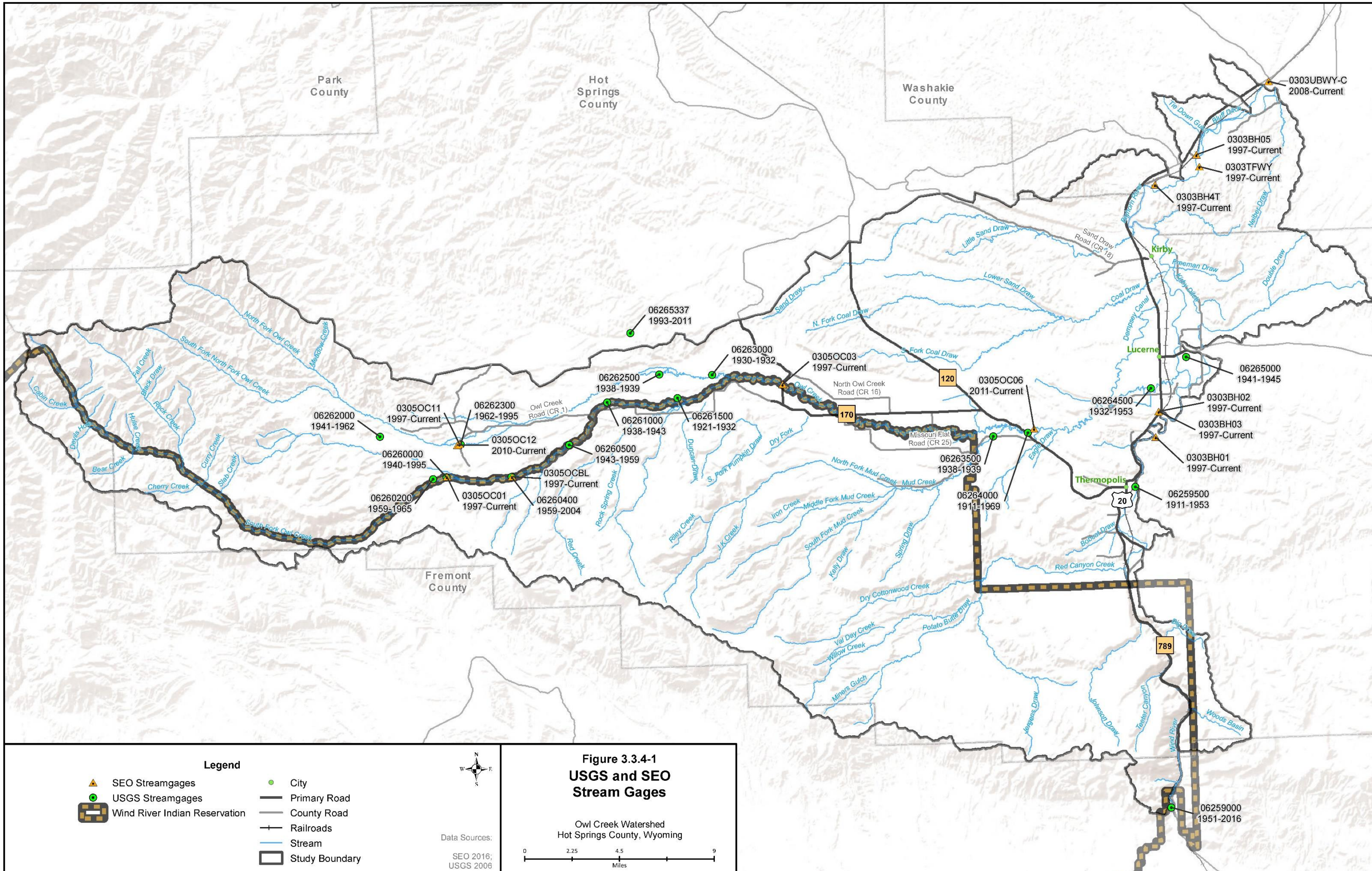

Figure 3.3.4-1
USGS and SEO Stream Gages

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3.3.5 Analysis of water availability – Wet, Average, Dry Years Based on Gage Data

In general, perennial surface water flows in the Owl Creek Basin are transmitted by the North Fork and the South Forks of Owl Creek, which collect water from higher in the basin from numerous smaller tributaries of their respective watersheds. The basin discharges most its flow in the spring and early summer. Flows can be minimal in late summer, fall and winter, augmented by stormwater, and sometimes dry up on occasion (Nelson Engineering, 2004). There is a disparity between water available for irrigation within the Owl Creek Irrigation District (estimated at about 17,000 acres) and filed water rights (approximately 30,000 acres).

Wet, normal, and dry year scenarios for the watershed were determined by using an index streamflow gaging station. USGS streamflow gaging station 0626000 was used as the index gage for the Owl Creek watershed during the 2010 Wind-Bighorn Basin Plan Update (MWH, 2010) and it was used as the index gage for this study as well. This gage is located upstream of Anchor Reservoir and is the furthest upstream gage in the Owl Creek watershed. It is not significantly influenced by upstream diversions, storage, or return flows. This station was operated by the USGS from 1940 to 1995. WSEO began monitoring at this site in 1997 and presently maintains the station. The records of the two gages are treated as the same for the purposes of this study, i.e. gage 0305OC01 is considered an extension of the record of gage 0626000.

No significant changes to storage or conveyance have occurred in the watershed during this period. Annual streamflow at this station was used to determine the hydrologic conditions. The hydrologic year classifications were used to model flow availability at nodes and reaches throughout the watershed.

An annual summary of hydrologic classification for the Owl Creek watershed is presented in **Tables 3.3.5-1** and **3.3.5-2**. Over the period of study the driest 20% are considered dry years, the wettest 20% are considered wet years, and the middle 60% are considered normal years. The period of study presented, 1973 to 2015, is an extension of the period of study used in the Wind-Bighorn Basin Plan Update, 1973 to 2008.

Table **3.3.5-1** illustrates the distribution of wet, dry, and normal year conditions as measured at the USGS gage 06260000. The highest concentration of wet years over the period of study occurred in the 1990s and the highest concentration of dry years occurred during the early to mid-2000s.

Table 3.3.5-1 Distribution of wet, dry, and normal year conditions as measured at the USGS gage 06260000

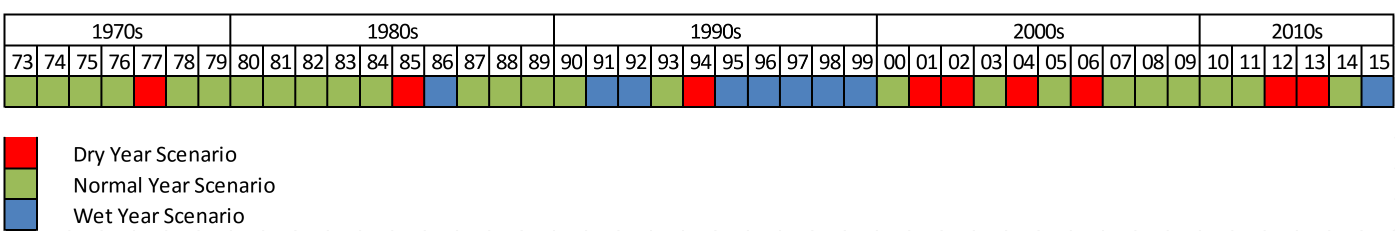


Table 3.3.5-2 summarizes annual streamflow at gaging station 0626000. The table is organized from lowest to highest cumulative streamflow over the period of study. Hydrologic conditions for the Owl Creek watershed were determined using these flow values. Streamflow at the gage ranged from 8,082 ac-ft. to 40,669 ac-ft. Years with total flow less than 14,761 ac-ft. are classified as dry years; years with

cumulative flows ranging from 14,761 ac-ft. to 31,129 are classified as normal years; and years with flows greater than 31,129 ac-ft. are classified as wet years.

Table 3.3.5-2 Annual streamflow at gaging station 0626000

Hydrologic Condition	Year	Streamflow (ac-ft)
Dry	2001	8082
	2006	8375
	1994	9868
	2002	10103
	1985	10269
	1977	10813
	2012	13268
	2004	13745
	2013	14761
Normal	2007	15296
	2000	15850
	1988	17064
	1979	18270
	2005	19085
	2003	19733
	1982	21021
	1981	21961
	2008	22430
	1984	22709
	1990	24184
	1973	24702
	1989	24718
Normal	1993	25955
	2010	26473
	1980	27103
	2014	27326
	1976	28021
	1987	28312
	1974	28519
	2009	29226
	2011	30154
	1978	30736
	1983	30938
	1975	31129
Wet	2015	31945
	1992	32065
	1998	32716
	1996	33696
	1997	35570
	1995	38295
	1999	39706
	1986	40411
	1991	40669

The hydrologic database and model developed for the *2010 Wind-Bighorn Basin Plan Update* (MWH, 2010) was updated for this study in order to determine estimated available flows at nodes and reaches throughout the watershed. Nodes are defined as points of diversion, gage locations, or storage. Reaches are comprised of nodes. In basic terms, the model is a water budget computation tool that accounts for diversions and gaged streamflow data. This data, coupled with flow estimates at ungaged nodes, is used to calculate flows that are legally and physically available for future use without causing a shortage to any existing water users. The model simulates these available flows for each of the wet, dry, and normal year hydrologic conditions and provides estimated available flow data for nodes and reaches for each month in the year. A detailed description of the hydrologic database and model is provided in *Technical Memorandum 4A – Surface Water Hydrology* and *Technical Memorandum 4B – Spreadsheet Model and Hydrologic Database* (MWH, 2010). These technical memos were included as appendices to the *2010 Wind-Bighorn Basin Plan Update*.

The model run completed for this study estimated monthly available flow data for each of the hydrologic conditions for eighteen stream reaches comprised of eighty nodes. A schematic (**Figure 3.3.5-1**) of the Owl Creek watershed developed for the model illustrates the relative location of each reach in the watershed. **Appendix C** contains a table that includes available flow for each of the eighty nodes used in the model. A detailed Owl Creek Basin Model Schematic (MWH, 2003) is also included in **Appendix C** to illustrate the relative locations of each stream node in the watershed.

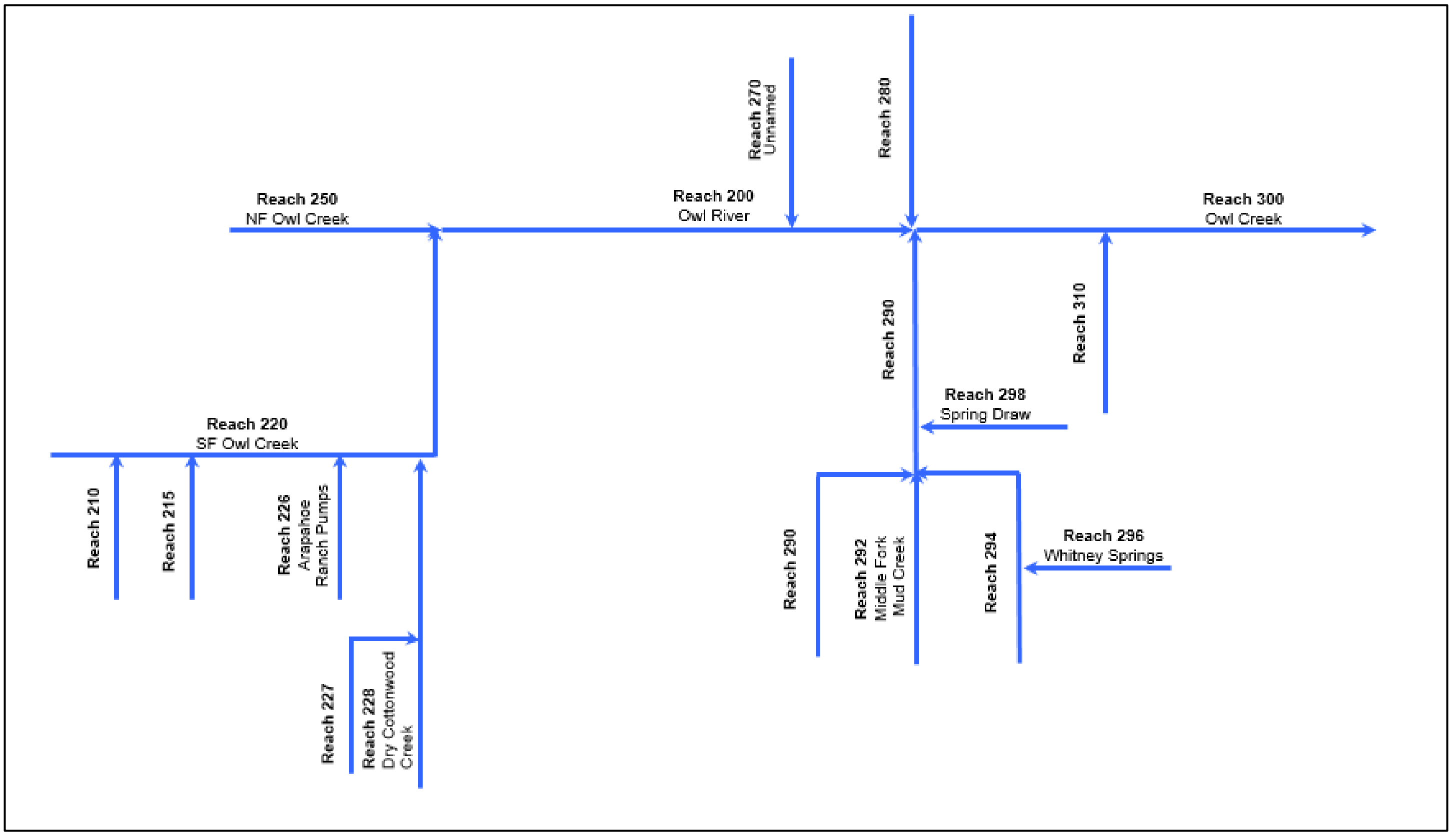


Figure 3.3.5-1 Schematic of Owl Creek Watershed

Tables 3.3.5-3 and 3.3.5-4 (following page) summarize estimated available flow by reach during wet, dry, and normal year scenarios. Reaches marked in yellow indicate that they are a part of a "main stem" channel of the watershed and offer the greatest potential for future storage.

Reach 220 runs the length of South Fork Owl Creek. It begins upstream of Anchor Reservoir at USGS gaging station 0626000 and ends at the confluence of North Fork and South Fork Owl Creek (Reach 235). During dry hydrologic conditions there is little to no available streamflow in the reach. *Approximately 1,500 ac-ft. of water is available in the channel during times of peak runoff in May and June combined, but there appears there is not significant additional available flow in the channel until October*, near the end of the irrigation season. During normal hydrologic conditions there appears to be available flow in the reach from May until July. A sharp decrease in available streamflow occurs from August to September. Wet years also follow the same pattern, but it appears there would be significant available streamflow in the channel until September.

Table 3.3.5-3 Estimated available flow by reach during wet, dry, and normal year scenarios

Comparison of Available Streamflow by Reach for Wet, Normal, and Dry Hydrologic Conditions

	April			May			June			July		
Reach	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet
200	191	542	1475	1660	3108	7671	856	6105	15041	1596	3522	5433
210	11	23	64	45	169	376	0	330	933	0	0	44
215	7	13	41	112	224	416	89	537	1197	6	52	155
220	0	0	213	726	2106	4686	750	5321	11493	0	1590	3476
226	0	0	0	23	21	11	17	14	0	79	80	80
227	19	90	297	225	760	1567	0	1279	3110	0	0	454
228	50	154	480	422	1250	2635	259	2026	5037	165	350	916
235	692	707	1030	3062	5150	8322	4673	10158	18298	3319	5345	7584
250	477	478	536	1473	2174	2740	2526	3435	5390	1867	2239	2581
270	0	0	0	97	89	48	71	57	0	333	336	335
280	0	0	0	0	0	0	0	0	0	0	0	0
290	164	516	1353	610	2273	5000	0	2343	7032	0	0	549
292	0	0	0	0	0	365	0	0	779	0	0	0
294	73	152	356	195	619	1281	0	636	1820	0	0	128
296	14	41	108	63	211	445	0	141	454	0	0	0
298	167	301	586	314	830	1583	34	581	1464	0	15	98
300	0	0	14	7	40	3535	0	338	9375	2	83	114
310	6	14	37	34	96	197	1	45	135	0	0	2

Yellow box = main stem

Table 3.3.5-4 Estimated available flow by reach during wet, dry, and normal year scenarios

Comparison of Available Streamflow by Reach for Wet, Normal, and Dry Hydrologic Conditions

	August			September			October		
Reach	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet
200	2702	3460	4585	2579	2868	3558	3630	4767	5858
210	0	0	0	0	0	0	14	27	42
215	0	12	30	2	10	23	11	22	35
220	0	309	1637	15	172	408	985	1318	1770
226	97	96	96	53	52	51	0	0	0
227	0	0	0	0	0	0	72	133	208
228	92	212	301	63	143	219	135	264	410
235	2445	2963	4383	2135	2432	2808	2292	2683	3255
250	1215	1359	1439	1031	1111	1190	758	785	875
270	379	377	377	217	215	209	0	0	0
280	0	0	0	0	0	0	0	114	74
290	0	0	0	0	0	33	295	542	794
292	0	0	0	0	0	0	34	64	98
294	0	0	0	0	0	8	52	100	150
296	0	0	0	0	0	0	8	16	24
298	0	2	8	2	13	20	40	75	113
300	34	86	886	61	181	929	3786	4979	6100
310	0	0	0	0	0	0	1	2	4

Reach 250 is comprised of North Fork Owl Creek, beginning upstream of the Heiden Ditch at a natural flow site determined for the model and ending at the confluence with South Fork Owl Creek (Reach 235). *It appears there is available streamflow in this reach throughout the year, regardless of hydrologic condition.*

Reach 200 is a segment of Owl Creek that begins at the confluence of North Fork and South Fork Owl Creek (Reach 235) and ends at the confluence of Owl Creek and Mud Creek. *It appears there is available streamflow in this reach throughout the year during each hydrologic condition.*

Reach 300 is the furthest downstream segment of Owl Creek in the watershed. It begins at the confluence of Owl Creek and Mud Creek and terminates at the Bighorn River. *There is very little available streamflow in the reach from April through September during dry and normal hydrologic conditions and there is limited opportunity for storage, but during wet hydrologic conditions there is available water in May, June, August, September, and October with the peak runoff months of May and June having the most available streamflow.*

While some water is available for storage, the Wind-Bighorn Plan Update (2010) found that shortages within the Owl Creek Basin appear substantial and the amount of available flow is limited (**Figure 3.3.5-2**). Although there is some flow available in wet and average years, this available flow was considered inadequate to meet shortages in the wet and average years. However, this analysis was completed as part of a larger, basin-wide study and did not take into account other variables such as water right distribution, proposed changes in irrigation efficiency, and other factors, which are described in **Section 3.3.7.**

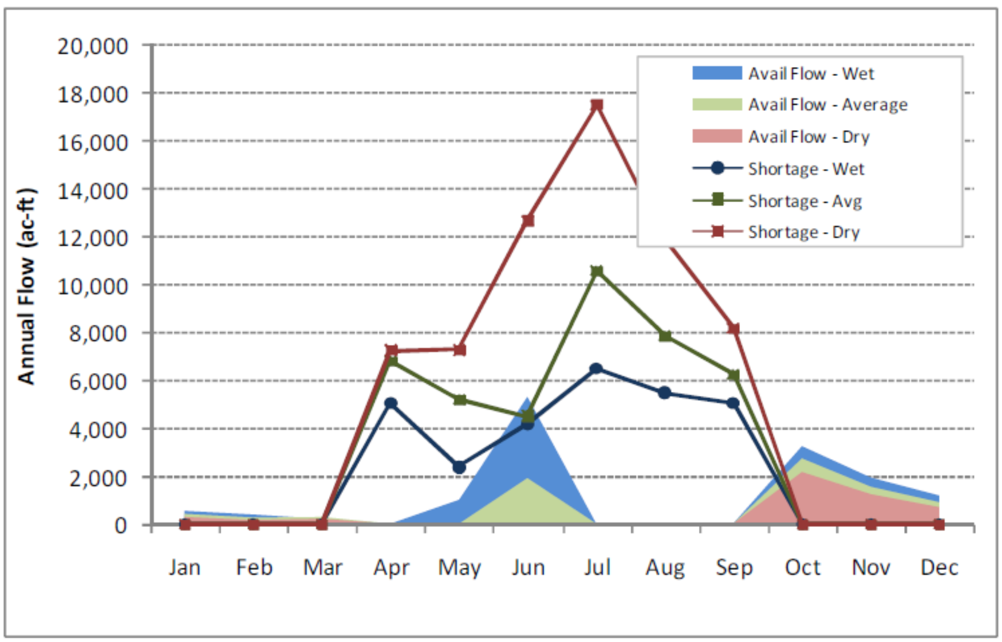


Figure 3.3.5-2 Owl Creek Summary of Available Flows and Shortages (Wind-Bighorn Plan Update 2010)

3.3.6 Analysis of water availability based on Landowner Interviews

Due to the lack of gaging on individual ditches and canals, quantifying water availability within each ditch is not possible. To get some sense of water availability among individual ditches, LW analysts compared landowner responses to “length of irrigation season” and their project locations.

An analysis of the length of water availability as compared to specific ditches was completed using data sheets gathered in the field during on-site visits and "workshop" sessions. It is important to note that any data gathered during the on-site interviews is likely to be more accurate as the workshop sessions did not allow for the necessary time required to gather the same level of detail as compared to the field visits. **Table 3.3.6-1** summarizes the number of each type of interview and where land associated with the interview were located within the watershed. Analyzing the data in this manner allowed the LW team to make an "educated guess" about which portions of the watershed run out of water first and when this generally occurs.

Thirty-seven landowners were interviewed during the study. Of the 21 total field visits made, 2 were located in the upper portion of the watershed, 11 were located in the middle, and 8 were located in the lower portion. Of the 16 total workshop interviews conducted, 3 project sites were located in the upper portion, 5 were located in the middle, and 8 were located in the lower reaches.

Table 3.3.6-1 Summary of type, number, and location of interviews		
Field Visits		
Upper	**Middle**	**Lower**
2	11	8
	Total	**21**
Workshop interviews		
Upper	**Middle**	**Lower**
3	5	8
	Total	**16**

Table 3.3.6-2 indicates that landowners in the lower portions of the watershed, which includes the Upper and Lower Lucerne Canal and Kirby Ditch and are fed by the Bighorn River, have a consistent water supply from April thru October, whereas landowners in the middle and upper portions of the watershed, who are dependent on water flow in Owl Creek and its tributaries, can run out of water as early as June. Clear, definitive data on the start and end of the irrigation season was successfully gathered from seventeen landowners.

Table 3.3.6-2 Irrigation Season

Landowner	Start of Irrigation Season	End of Irrigation Season	Location	Ditch
Landowner 1	April	October	Lower	Cyclone
Landowner 2	April	October	Lower	Kirby
Landowner 3	April	October	Lower	Kirby
Landowner 4	April	October	Lower	Upper Lucerne
Landowner 5	April	October	Lower	Upper Lucerne
Landowner 6	April	October	Lower	South Side Ditch
Landowner 7	April	October	Lower	Upper Lucerne
Landowner 8	April	October	Lower	Upper Lucerne
Landowner 9	April	July	Middle	Chessington-Wilson & Woodard-Johnson

Table 3.3.6-2 Irrigation Season				
Landowner	Start of Irrigation Season	End of Irrigation Season	Location	Ditch
andowner 10	April	July	Middle	Merrill & Winchester
Landowner 11	February	September	Middle	Hale & Thompson
Landowner 12	March	October	Middle	Woodard-Johnson
Landowner 13	May	July	Middle	Martin
Landowner 14	May	July	Middle	Ready
Landowner 15	May	September	Middle	Chessington-Wilson
Landowner 16	April	July	Upper	Red Creek
Landowner 17	May	June	Upper	North Fork Owl Creek

3.4 Water Quality

3.4.1 Ground Water Quality

Spring Water Quality

Limited water quality data (17 samples) from 11 springs in the study area are available from the USGS (**Figure 3.4.1-1**). Formations hosting sampled springs include Tertiary-age Absaroka Volcanic Group igneous rocks, Triassic-age Chugwater Group, Jurassic/Cretaceous-age Cloverly-Morrison Formations, Cretaceous-age Mowry/Thermopolis Shale and Frontier Formation, and Quaternary alluvium/colluvium (**Table 3.4.1-1**).

In general, USGS spring sample data indicate a wide variety of water quality characteristics, such that different outcomes from spring development may be the result. Accordingly, additional sampling at these springs and others which may be located advantageously for development should be carried out to characterize water quality and gauge possible impacts from the use of these waters in domestic, agricultural or industrial applications. Further information on groundwater quality is found in **Appendix D**.

Table 3.4.1-1 Summary of USGS Spring Water Quality Sampling Locations			
USGS Site Number	Spring ID	Host Formation	Sub-Watershed
434017109065101	8N-3W-16add01	Absaroka Volcanics	Middle S.F. Owl Creek
434130109041901	43N-102W-15daa01	Absaroka Volcanics	Middle S.F Owl Creek
434341108511201	43N-100W-4aad01	Absaroka Volcanics	Lower N.F. Owl Creek
434220108441301	43N-99W-9dac01	Chugwater Group	Lower N.F. Owl Creek
434102108353401	8N-2E-12bcc01 (Knight Spring)	Frontier Formation	Upper Owl Creek
434113108363001	8N-2E-11bac01 (Blue Hill Spring)	Frontier Formation	Upper Owl Creek
433744108323401	8N-3E-32abc01 (Iron Creek Spring)	Mowry/Thermopolis shale	N.F. Mud Creek
433828108341601	8N-3E-30bca01 (Chokecherry Spr.)	Mowry/Thermopolis shale	N.F. Mud Creek
434030108345501	8N-2E-13aba01 (Love Spring)	Frontier Formation	Upper Owl Creek
434301108362701	9N-2E-35bdb01	Alluvium and colluvium	Lower S.F. Owl Creek
434148108133901	43N-95W-14bdb01	Cloverly-Morrison Fms.	Lower Owl Creek

Source: USGS National Water Information Service (NWIS) Water Quality Database, accessed 7/19/2016.

3.4.2 Surface Water Quality

Surface Water Quality Program Results

Surface water quality for the Owl Creek basin area are available from a variety of government agency program sources. This includes the USGS National Water Information Services, Wyoming Department of Environmental Quality (WDEQ) Water Quality Division, and Wind River Environmental Quality Commission (WREQC). Due to differences in data gathering methods, number of samples obtained, and the variety of analytes tested, it is difficult to draw conclusions.

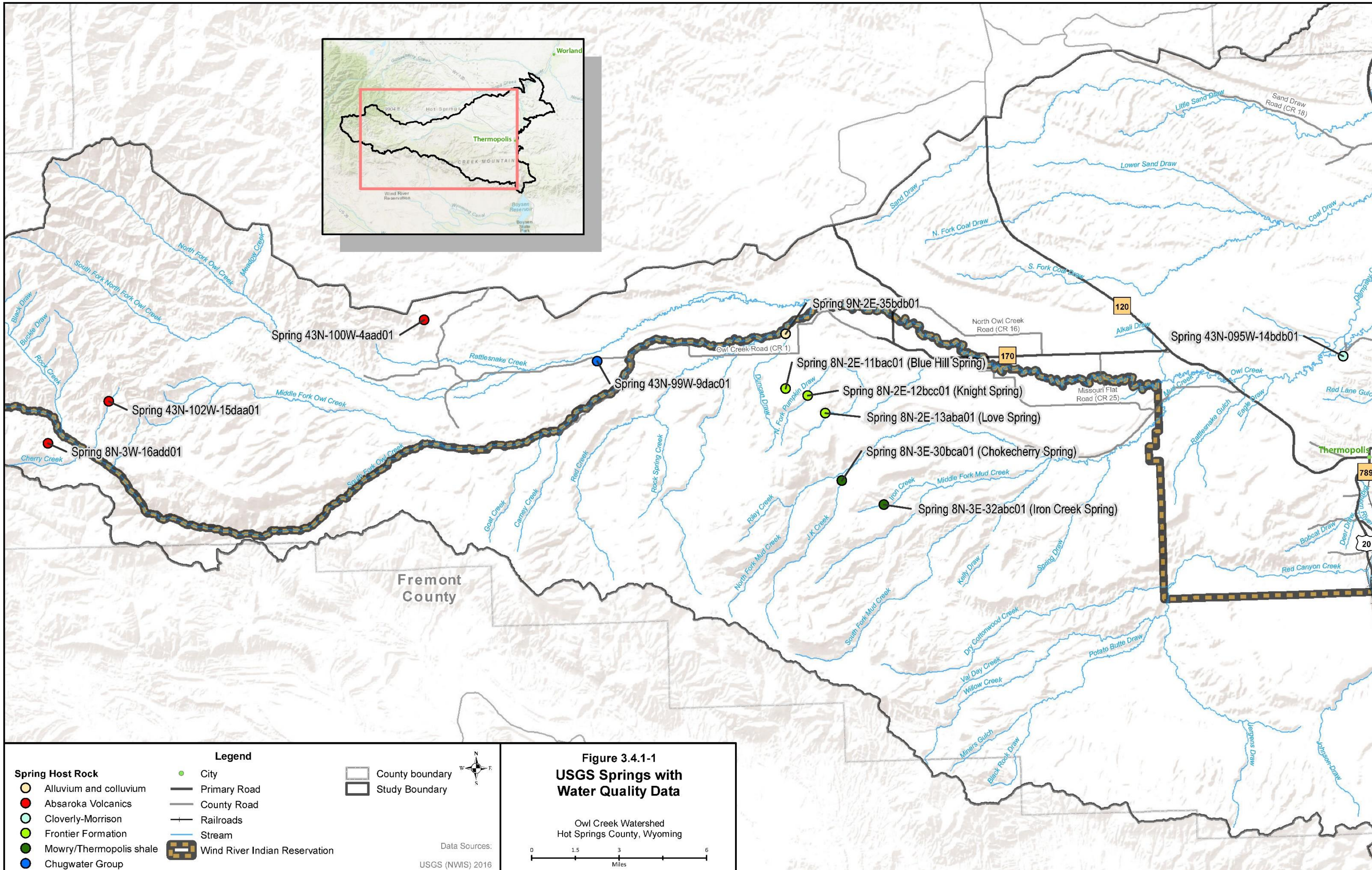
Overall water quality for all sample stations indicates that the samples from Owl Creek basin streams contain water generally classified as calcium sulfate or bicarbonate water. None of these samples are considered saline. Further information on study area surface water quality is found in **Appendix E**.

Total Maximum Daily Load

A Total Maximum Daily Load (TMDL) study was completed on the Bighorn River and lower Owl Creek in 2014. The TMDL is the maximum quantity of a contaminant permitted in a waterbody that still enables that waterbody to satisfy established water quality standards and meet state determined designated uses. TMDLs must be quantifiable and they must examine both point and nonpoint contaminant source loads, natural background contamination levels, and a margin of safety. A TMDL explicitly prescribes a contaminant reduction goal and the necessary pollutant load capacity reductions for each source of stream impairment. The reduction goal and load capacity reductions are used to develop appropriate control measures for the waterbody. The Clean Water Act stipulates that every state must develop and submit TMDLs for approval by EPA for each of the waters identified in their respective Section 303(d) lists of impaired and threatened waters. The TMDL process helps improve the water quality of impaired waterbodies by linking water quality standards and control measures designed to attain those standards.

A single stream reach in the Owl Creek watershed is classified as threatened in Wyoming's 2014 Integrated 305(b) and 303(d) Report (WDEQ, 2016). The threatened stream segment is found in the lower reach of Owl Creek and stretches from the confluence of Owl Creek and the Bighorn River to a point 3.8-miles upstream. Wyoming Surface Water Quality Standards (WDEQ, 2013) classify Owl Creek as 2AB, which is considered a high quality water. Class 2AB waters support game fish populations and are presumed to have sufficient water quality and quantity to support drinking water demand. Additionally, Class 2AB waters are protected for nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value uses.

Fecal coliform exceedances of the contact recreational use criterion were found during a USGS study (2003) and the reach was subsequently added to Wyoming's 303(d) list as a threatened waterbody in 2002. The Hot Springs Conservation District continued monitoring eight sites within the within the Owl Creek watershed for E. coli as part of the Owl Creek Watershed Water Quality Management Plan that was adopted by the Owl Creek Watershed Steering Committee in 2006. A TMDL assessment was completed for WDEQ in October, 2013 and was submitted to EPA. EPA approved the TMDL in April, 2014 which requires a fecal coliform overall load reduction of 78% (RESPEC, 2013) to meet the primary recreation standard. Owl Creek was unaffected by the WDEQ's decision to reclassify the usage designation of low flow channels from primary to secondary contact recreation (WDEQ, 2016a). A summary of the 2013 TMDL findings is shown in **Figure 3.4.2-1**.



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Total Maximum Daily Load Summary

Waterbody Name/Description	Owl Creek (from the confluence with the Big Horn River to a point 3.8 miles upstream)
Assessment Unit I.D.	WYBH100800070305_01
Size of Impaired Waterbody	3.8 miles (6.1 kilometers)
Size of Watershed (Cumulative)	517.7 square miles (1,338.3 square kilometers)
Location	12-digit Hydrologic Unit Code (HUC): 100800070305
Impaired Designated Use(s)	Recreation
Impairment	Fecal Coliform (written for *E. coli*)
Stream Class	2AB
Cause(s) of Impairment	Unknown
Cycle Most Recently Listed	2012
Total Maximum Daily Load Water-Quality Targets	Indicator Name: *E. coli* Primary Contact Recreation: Summer Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 126 organisms per 100 milliliters (org/100 mL). These criteria apply from May 1 through September 30. Winter Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 630 org/ 100 mL. These criteria apply from October 1 through April 30.
Analytical Approach	**HSPF**, Load Duration Curves

E. coli Total Maximum Daily Load Component (expressed as 10^9 cfu/day)	Flow Zone				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 169 cfs	**169–76 cfs**	**76–31 cfs**	**31–4 cfs**	**< 4 cfs**
Load Allocation	682	415	178	49	8
Wasteload Allocation	0	0	0	0	0
Margin of Safety	98	70	53	39	3
Total Maximum Daily Load	780	485	231	88	11

cfu/day = colony-forming units per day
cfs = cubic feet per second

Figure 3.4.2-1 Total Maximum Daily Load Summary

3.5 Channel Structure, Geomorphology, Stability

3.5.1 Hydrologic Geomorphology

The geologic characteristics of an area, along with climatic conditions, are responsible for stream channel geomorphology, such as stream longitudinal profile. The main factors that affect geomorphologic channel characteristics include transport capacity (slope, discharge and boundary shear stress) and sediment supply (basin size area and size/shape of material available for transport (Hack, 1957; Montgomery and Buffington, 1998). In general, discharge increases down-basin. According to Montgomery and Buffington (1997), the typical downstream sequence of channel morphologies is characterized by a progressive decrease in valley-wall confinement. Sediment transport capacity generally decreases downstream due to the slope decreasing faster than the volume of water and sediment increases: total sediment supply generally increases downstream with drainage area.

To better understand basin dynamics, it is important to recognize the relationships between geomorphological characteristics and stream response/performance characteristics such as intermittence, rapid runoff, losing or gaining stretches, potential for accelerated erosion, flooding, bank or floodplain storage, or areas where potential for recharge/discharge may exist.

As discussed in previous sections, the Owl Creek basin typically discharges a large component of its annual flow in the spring during a very limited span of time, resulting in run-off characteristics described as “flashy.” Drainage attributes that support this type of flow likely include lack of vegetative cover, lack of significant bank or flood plain storage opportunities, presence of steep gradients, channel confinement by steep valley walls, and a climate regime that favors snowfall over rain that tends to concentrate high flows during annual snowmelt.

To further understand basin geomorphology in the Owl Creek drainage, stream flowlines from the USGS National Hydrography Dataset (NHD) were brought into GIS and a graphical analysis was performed. The main streams of the Owl Creek Basin were classified based on three primary channel-reach substrates, bedrock, alluvium and colluvium (Montgomery and Buffington, 1997). Each of the 10-digit watersheds were evaluated to determine if the general characteristics of stream morphology presented above reflected conditions in the Owl Creek study area. As one example, North Fork Owl Creek (NFOC) was evaluated from its headwaters in Upper North Fork Owl Creek sub-watershed to its outlet in Lower North Fork Owl Creek sub-watershed. The NFOC headwaters are located at an elevation of approximately 10,450 ft. NFOC flows for approximately 11.4 mi., where it leaves the upper sub-watershed and enters the lower sub-watershed where it flows for an additional 28.7 mi. to its terminus. The total channel length of NFOC from headwaters to mouth, where it joins the South Fork Owl Creek to form Owl Creek (main) is approximately 40.2 mi. The longitudinal profile of the entire reach of NFOC is shown in **Figure 3.5.1-1**.

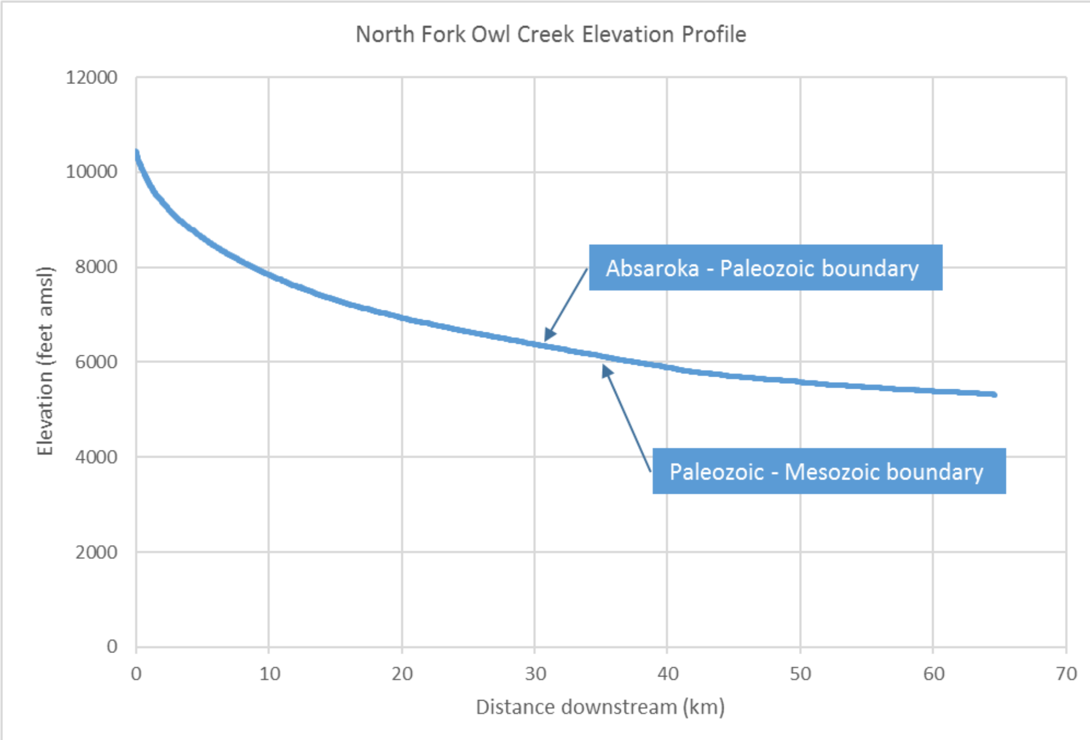


Figure 3.5.1-1 Longitudinal Profile for North Fork Owl Creek.

The NFOC profile shows a typical concave-up morphology in which the steep headwater region reflects either bedrock-substrate dominated reaches or colluvial reaches resulting from sediment delivered from valley walls accumulating as colluvial valley fill with little stream capacity to transport or sort the material. This is typical of stream basin morphology controlled by fluvial channel processes (in contrast to relict or paraglacial terrains (Weekes et al., 2012)). The profile transitions to shallower slopes, reflecting wider floodplains, less valley-wall confinement and a long-term pattern of downstream deposition where the sediment supply exceeds the capacity of the stream to fully transport the load. This model is consistent among the sub-watersheds evaluated regardless of the geology exposed along the stream profile.

3.5.2 Hydrogeology

Overall, based on the geology, dominant climate, drainage characteristics, and geographic pattern of water use of the watersheds that comprise the Owl Creek system[4], it does not appear that groundwater does, or can play a large role in providing more efficient and reliable surface water resources to water users. In general, water sources are of limited extent or of poor quality in shallower aquifers due in part to the alluvial or marine sediments these aquifers are often located in. Deeper aquifers are more costly to reach, though they produce higher-quality waters. No direct connection between the Thermopolis hot springs and currently accessed aquifers has been made and it is unlikely that accessing deep water aquifers for use as a water source would affect the hot springs because of the extent of the resource (Picard, 2000).

[4] To include the nearby drainages that are also part of this study, but are outside the Owl Creek Watershed

3.5.3 Rosgen Inventory and Evaluation

Rosgen Classification System

The Rosgen stream classification system is a widely accepted methodology to characterize different stream systems based on various parameters of channel morphology. The BLM includes a description of the Rosgen Classification scheme in its *Riparian Area Management, Riparian and Wetland Classification, Review and Application* manual for guidance to land managers in applying classification to various locations in order to provide assistance in solving land management problems (USDOI 2005). The Rosgen approach stresses that the categorization of discrete stream types can lead to the consistent assessment and development of restorative prescriptions. As described in *Applied River Morphology* (Rosgen 1996), the specific objectives of the Rosgen system include:

- Defines stream morphology and condition in a consistent manner;
- Provides a framework for extrapolating site-specific data to different categories of stream reaches;
- Provides specific sediment and hydraulic patterns for different stream types and their state of condition; and
- Predicts its behavior from its appearance.

The Rosgen approach provides different levels of classification, which vary based on the objectives of the study, the type of classification being conducted, or budgetary constraints. There are four levels, which vary in spatial scope and the level of specificity (**Figures 3.5.3-1**). Level I is the least prescriptive and based on a general geomorphic characterization, whereas Level IV is a validation level, where specific channel measurements are taken to establish empirical relationships to predict channel behavior. The Level II (morphological description) and the Level III (stream condition) are typically used to assist in completing the Level IV analysis.

A Level I characterization was completed for this study. The Level I geomorphic characterization is qualitative and utilizes aerial photography and topographic maps. Streams are divided into eight broad types on the basis of their channel and floodplain geometry. Rosgen's classification system stream types can be thought of in their relative location within the watershed, from their headwaters through lowlands. The major stream types reflect their location in the watershed. For example, "A" type streams are located in headwaters; "C" & "E" stream types are located in meandering lowlands (**Figures 3.5.3-2** and **3.5.3-3**) (Anderson Consulting 2015).

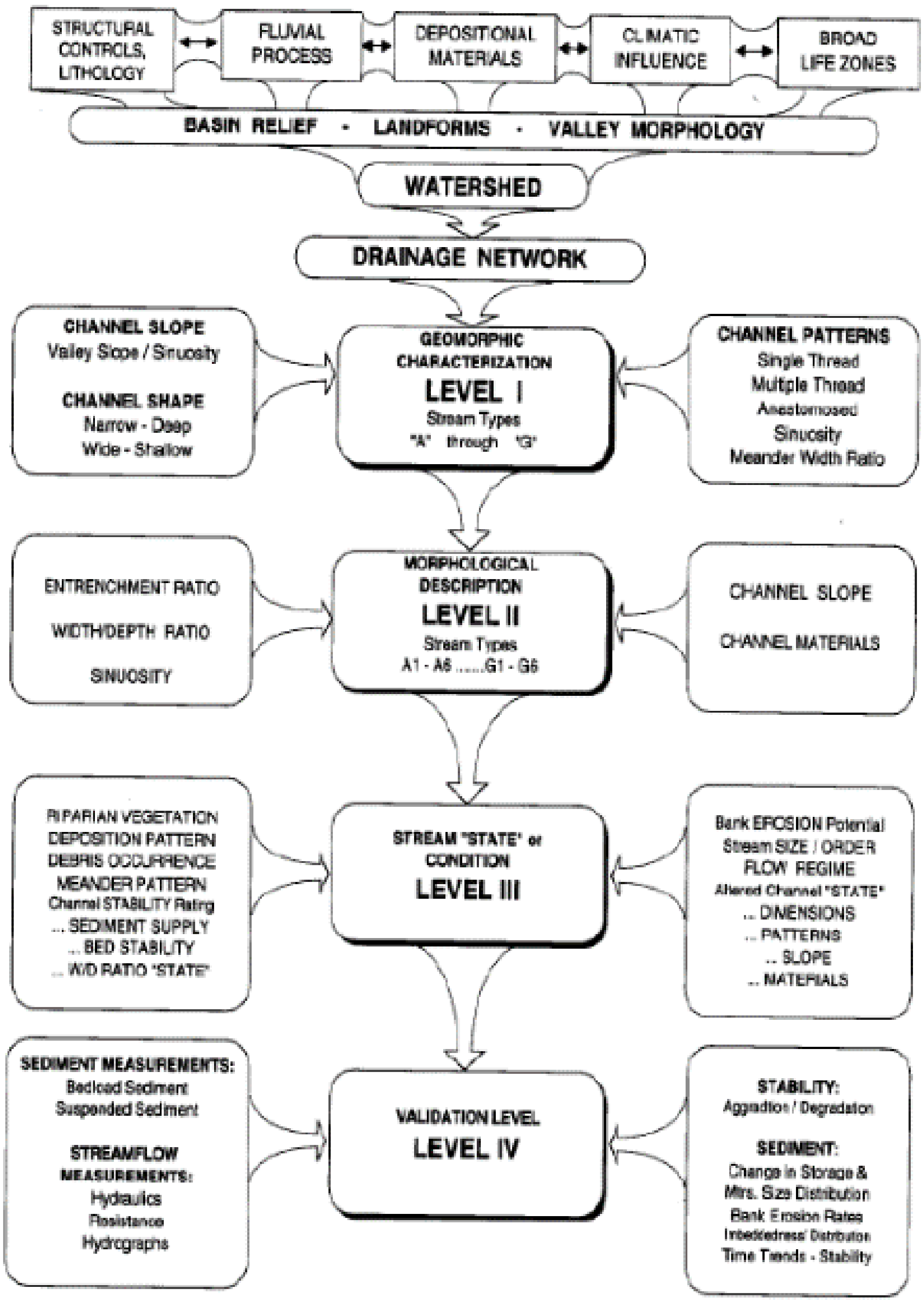


Figure 3.5.3-1 Rosgen Classification System Hierarchy (Rosgen 1996)

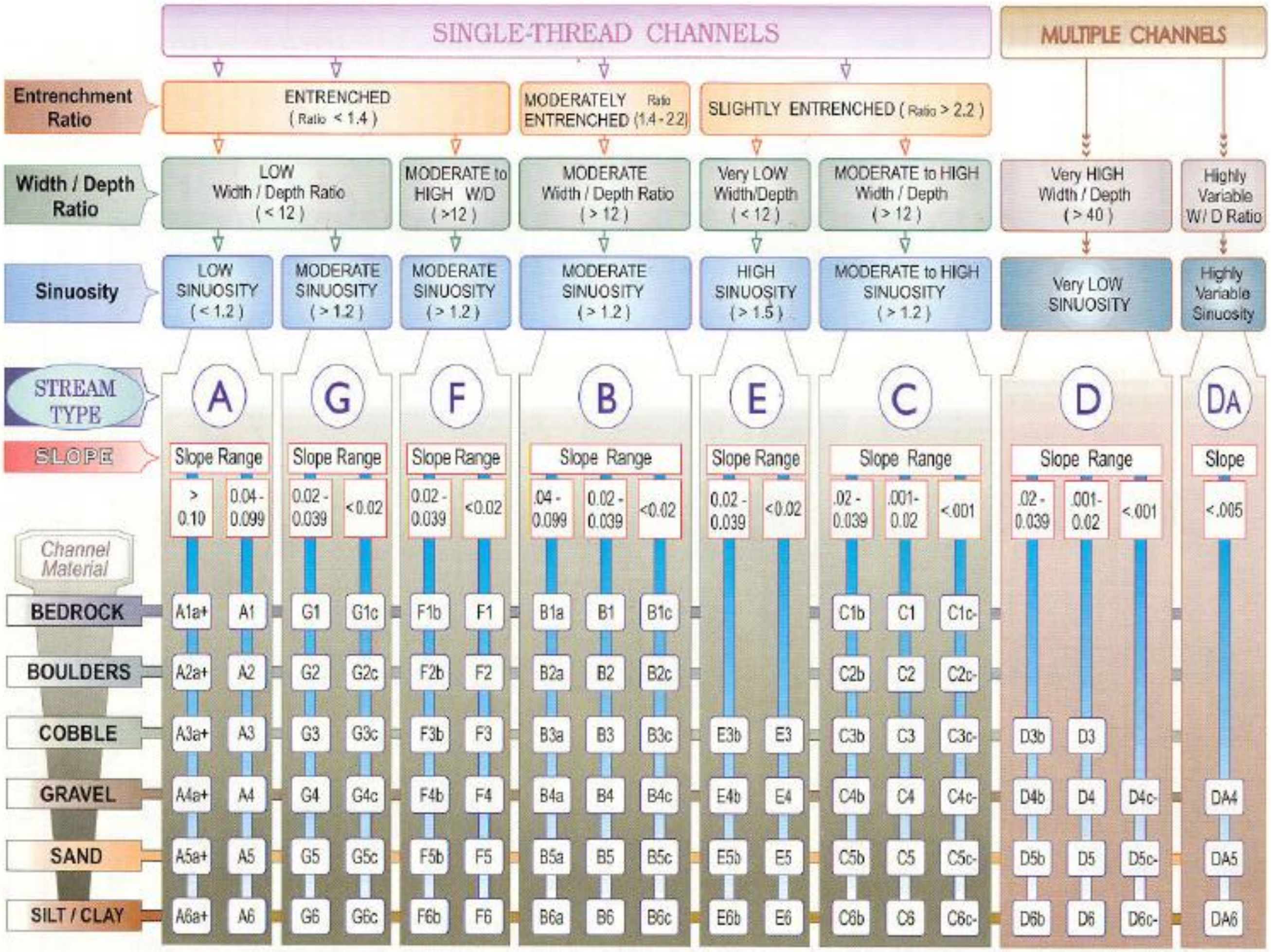


Figure 3.5.3-2 Rosgen Classification Matrix (Rosgen 1996)

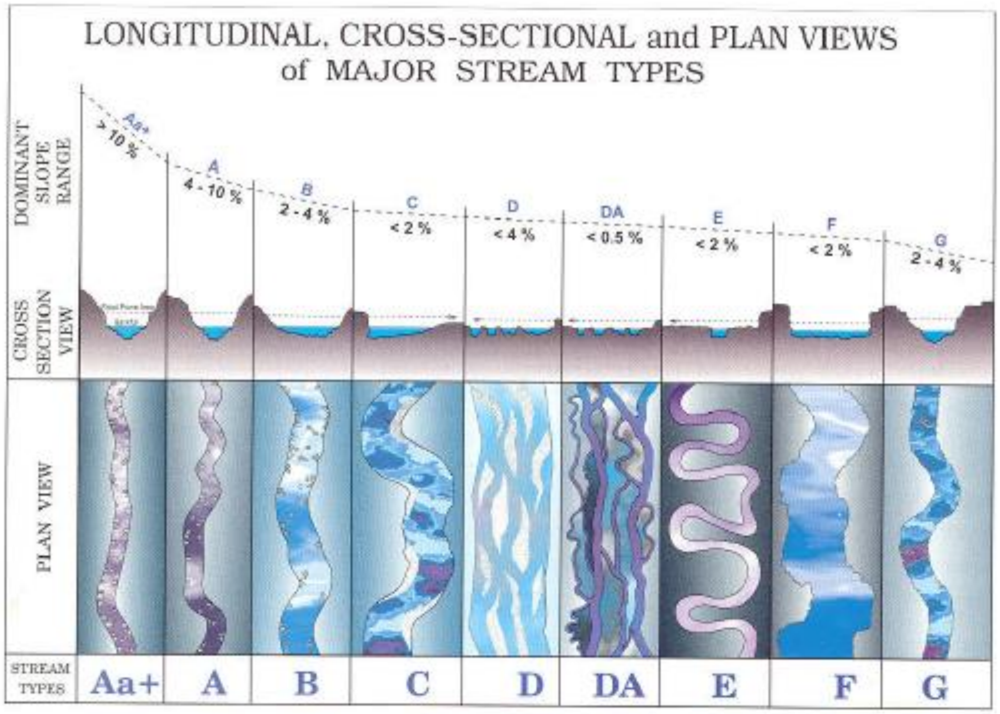


Figure 3.5.3-3 Major Stream Types in the Rosgen Classification System (Rosgen 1996)

Methods

The Level I classification effort was conducted using existing information incorporated into the project GIS and limited field truthing. Several analytical tools were used to evaluate various geomorphic parameters (sinuosity, slope, stream station determination). The data included digital aerial photography, USGS topographic maps, digital elevation model (DEM) stored in our ArcGIS mapping database, and digitized hydrography information. The most current data available were used in the geomorphic evaluation. Because the DEM was limited to a 10-meter grid, elevations and subsequent slope calculations are approximate. Stream alignments were digitized using 2011 aerial photography and represent the best available estimate of current channel alignment. The streams evaluated were divided into reaches based upon definable geographic factors (e.g. confluences with tributaries, major road crossings, etc.) or where their geomorphic character displayed changes. Each reach was evaluated in light of the characteristics required at the Level I classification. These parameters, as indicated in Figure 3.5.3-3, were channel slope, channel shape, channel patterns, and valley morphology. Note that in the Level I classification, these parameters are not typically quantified and the relative magnitude (i.e., “moderate”, “slightly”, etc.) is utilized to classify the stream.

A field reconnaissance was conducted on November 14, 2016 to compare aerial imagery points identified via desktop analysis against on-the-ground conditions to assist with determining Rosgen stream type of each reach. A total of eight individual locations were visited along Mud Creek and Owl Creek. Upon arrival on site, left or right descending banks (LDB or RDB) were noted, GPS points and a series of photos were taken, and geomorphic characteristics were recorded using the Rosgen Stream Classification Technical Supplement 3E (USDA, 2007a). This included bank-full measurement (**Figure 3.5.3-4**), stream bank and bed sediment size and composition, presence and size of woody debris, location (inside/outside bend) of erosion and likely causes (e.g. livestock, log jam, or irrigation structure), headcuts, grade control features (e.g. diversion dams), and the overall riparian conditions (vegetation composition and wildlife use). These measurements were used to calculate the entrenchment ratio at the selected sites. The entrenchment ratio is a measure of the extent of vertical containment of a channel relative to its adjacent flood plain and is important to determining stream bank stability and susceptibility to erosion. The information gained through the field exercise was extrapolated to aid in the desktop interpretation of remaining stream reach sections.

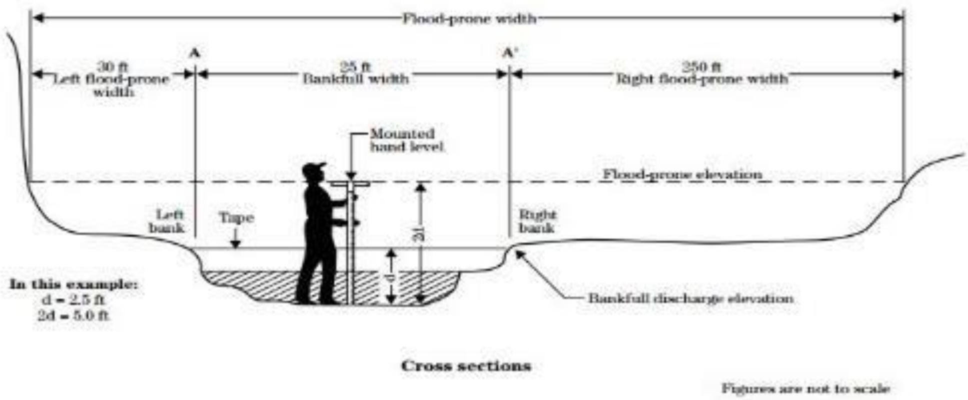


Figure 3.5.3-4 Depiction of bank-full and flood-prone width on a stream cross section

A second informal field reconnaissance of four Rosgen classified stream reaches took place on April 18, 2017 to conduct a post-Rosgen classification evaluation of stream reaches. Photos and locations were recorded.

Findings

Figures 3.5.3-5 through 10 are photographs of stream reaches representing the different Rosgen classifications that are found within the project area. Results of the Level I classification effort are shown graphically on **Figure 3.5.3-11** and are also presented in **Table 3.5.3-1.** Rosgen data points as shown on Figure 3.5.3-11 represent points taken in the field to aid in the Rosgen analysis. Rosgen photo points are additional points taken in the field that correlate to figures 3.5.3-3 thru 10 and offer a more accurate representation of the stream types within the watershed.

Figure 3.5.3-5 Type C Stream RDB of Owl Creek, looking southeast, Reach 6.1

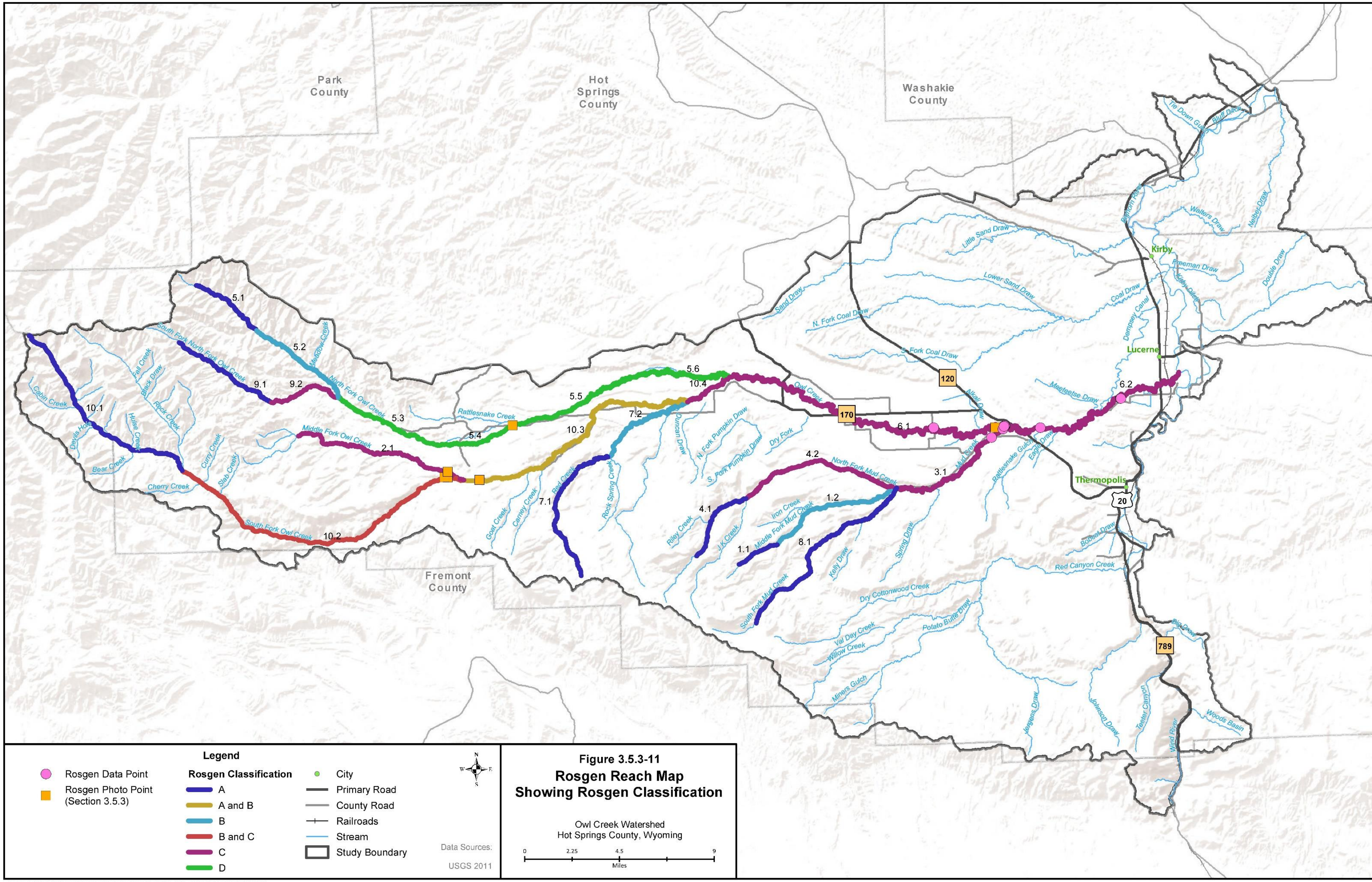
Figure 3.5.3-6 Type C stream, Middle Fork Owl Creek, Reach 2.1

Figure 3.5.3-7 Type B stream. South Fork Owl Creek, Reach 10.2

Figure 3.5.3-8 Type C stream, South Fork Owl creek near confluence with Middle Fork

Figure 3.5.3-9 Type A stream, Directly below Anchor Dam, Reach 10.3

Figure 3.5.3-10 Type D stream, North Fork Owl Creek, Reach 5.5



Park County
Hot Springs County
Washakie County
Fremont County
Kirby
Lucerne
Thermopolis
Legend
Rosgen Data Point
Rosgen Photo Point (Section 3.5.3)
Rosgen Classification
A
A and B
B
B and C
C
D
City
Primary Road
County Road
Railroads
Stream
Study Boundary
Data Sources:
USGS 2011
Figure 3.5.3-11
Rosgen Reach Map
Showing Rosgen Classification
Owl Creek Watershed
Hot Springs County, Wyoming
0 2.25 4.5 9
Miles
U:\Projects_2015\OwlCreekWatershed\Map\Mxd\Report\Fig_3_5_3-11_RosgenClass.mxd 11/13/2017

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Table 3.5.3-1 Stream reaches and channel characteristics and the associated Rosgen classification.					
Reach	**Stream Name**	**Stream Length (m)**	**Sinuosity**	**Slope (%)**	**Rosgen Class**
1.1	Middle Fork Mud Creek	3,491	0.94	6.3	A
1.2	Middle Fork Mud Creek	12,205	0.88	2.5	B
2.1	Middle Fork Owl Creek	15,798	0.89	2.2	C
3.1	Mud Creek	16,994	0.63	1.1	C
4.1	North Fork Mud Creek	6,985	0.91	4.0	A
4.2	North Fork Mud Creek	16,247	0.82	1.8	C
5.1	North Fork Owl Creek	6,596	0.96	7.5	A
5.2	North Fork Owl Creek	10,016	0.87	3.5	B
5.3	North Fork Owl Creek	10,708	0.87	1.9	D
5.4	North Fork Owl Creek	6,991	0.92	1.7	D
5.5	North Fork Owl Creek	14,118	0.80	1.4	D
5.6	North Fork Owl Creek	14,512	0.64	1.1	D
6.1	Owl Creek	48,316	0.55	0.8	C
6.2	Owl Creek	30,632	0.67	0.7	C
7.1	Red Creek	14,674	0.90	6.5	A
7.2	Red Creek	11,393	0.72	2.0	B
A	South Fork Mud Creek	17,881	0.90	4.2	A
9.1	South Fork North Fork Owl Creek	9,466	0.92	6.0	A
9.2	South Fork North Fork Owl Creek	6,796	0.91	3.9	C
10.1	South Fork Owl Creek	18,309	0.94	4.2	A
10.2	South Fork Owl Creek	26,851	0.96	3.1	B
10.3	South Fork Owl Creek	25,384	0.91	2.2	B
10.4	South Fork Owl Creek	5,219	0.77	1.4	C

Headcut/Nickpoint Locations

The Level I Rosgen analysis did not positively identify any naturally occurring headcuts within the Owl Creek drainage, although erosion issues and lack of bank stability were identified by seven landowner interviewees (see SCS issues, **Section 4.3.3**). From the upper limit of agriculture on the North and South Forks of Owl Creek to the Highway 120 crossing Owl Creek the stream channel is generally broad and often braided. It frequently shifts within the meandering floodplain due to the common flashy flows and cobbly substrates. Where the channel is very broad and braided, little to no soils or vegetation are present within the bank-full width (**Figure 3.5.3-10**), where a single channel exists, banks are generally more stable (**Figure 3.5.3-5**). Localized downcutting occurs in some areas, such as illustrated in proposed project SCS-001, discussed in **Section 4**. This can create a challenge for the land user if the channel shifting occurs near a building or fence line.

Geologic and Man-made Control Points

Geologic control points are infrequent to non-existent within the agricultural reaches of Owl Creek because soils and alluvium tend to be deep here. Alluvial materials include cobbles to sand and silt-sized materials, and are extensive below the confluence of North and South Fork Owl Creek. Geologic control points exist in (a) the canyon located directly below Anchor Dam, (b) the canyon about 2.5 stream miles above Anchor Dam, (c) in the headwaters of the North and South Forks of Owl Creek and (d) in the headwaters of Red and Mud creeks (see Section 3.5.1 for diagrams of this contact).

Man-made control points include diversions, described in the proposed projects listed in Section 4. Many of these diversions and dams are well over 30 years old, are made with river rock and need maintenance year-to-year. One diversion, SCS-004, is made of a combination of rock, metal, wood, and concrete. This diversion helps prevent rapid headcutting in the region above.

Two concrete structures, Anchor Dam, and the weir at SEO gage 035OC01 located above Anchor Dam, provide more permanent control points to limit headcutting. The rock diversions at the Kirby Ditch and Lucerne Canal, located in the Bighorn River, provide moderately stable control points to that water body.

Additional moderately stable control points are provided by culverts located where State Routes 20, 120 and various County roads cross Owl Creek.

3.5.4 Proper Function and Condition (PFC)

The BLM utilizes a procedure for assessing the health of a stream called Proper Functioning Condition assessment or PFC. PFC is described by the BLM as:

"A qualitative method for assessing the condition of riparian-wetland areas. The term PFC is used to describe both the assessment process, and a defined, on the-ground condition of a riparian-wetland area. The PFC assessment refers to a consistent approach for considering hydrology, vegetation, and erosion/deposition (soils) attributes and processes to assess the condition of riparian-wetland areas. A checklist is used for the PFC assessment, which synthesizes information that is foundational to determining the overall health of a riparian-wetland system" (BLM 1998).

The PFC assessment defines stream segments using one of three classes described below.

Proper Functioning Condition: A stream is said to be functioning properly when adequate vegetation, landform, or debris is present to:

- Dissipate energies associated with wind action, wave action, and overland flow from adjacent sites, thereby reducing erosion and improving water quality;
- Filter sediment and aid floodplain development;
- Improve flood water retention and groundwater recharge;
- Develop root masses that stabilize islands and shoreline features against cutting action;
- Restrict water percolation;
- Develop diverse ponding characteristics to provide the habitat and water depth, duration, and temperature necessary for fish production, water bird breeding, and other uses; and

- Support greater biodiversity.

Functional-At Risk: Riparian/wetland areas are classified as functioning-at-risk when they are in functioning condition but an existing soil, water, or vegetation attribute makes them susceptible to degradation. These areas are further distinguished based on whether or not they demonstrate an upward, not apparent, or downward trend.

Nonfunctioning: Riparian/wetland areas are classified as nonfunctioning when they clearly are not providing adequate riparian vegetation, physical structure, or large woody debris to dissipate stream energy associated with high flows.

The BLM Worland Field Office has PFC assessments in the Owl Creek watershed. Stream locations that have been evaluated for PFC are shown in **Figure 3.5.4-1**. According to the BLM Worland Field Office's Riparian/Aquatic Information Database System (RAIDS) database they have rated a total of approximately 87 miles of streams in the watershed. Approximately 32.4 miles (37%) of the stream reaches assessed are rated as Functional-At Risk (FAR), while approximately 8.6 miles (10%) are rated as Nonfunctioning (NF) and approximately 38 miles (44%) were rated as PFC. The remaining approximately 8 miles (9%) are rated as Unknown (U) (**Table 3.5.4-1**).

Table 3.5.4-1 BLM Worland PFC condition ratings for streams assessed in the Owl Creek watershed.

Sub-Watershed	Stream Name	Rating*	Number of Reaches	Total Stream Miles
Unknown	Wagon Gulch	U	3	1.58
Bighorn River-Buffalo Creek	Bighorn River	FAR	1	0.17
Bighorn River-Buffalo Creek	Bighorn River	PFC	12	4.55
Bighorn River-Buffalo Creek	Trib. Grass Creek	U	1	0.24
Bighorn River-Buffalo Creek	Red Canyon Creek	FAR	5	3.55
Bighorn River-Buffalo Creek	Red Canyon Creek	PFC	2	2.02
Bighorn River - Coal Draw	Bighorn River	FAR	11	3.1
Bighorn River - Coal Draw	Bighorn River	PFC	4	1.78
Bighorn River - Coal Draw	Little Sand Draw	FAR	4	1.86
Bighorn River - Coal Draw	Lower Sand Draw	PFC	5	6.37
Bighorn River - Coal Draw	Trib. Owl Creek	U	1	0.03
Bighorn River - Coal Draw	S. Fk. Coal Draw	U	2	0.32
Bighorn River - Coal Draw	Sand Draw	FAR	9	7.30
Bighorn River - Coal Draw	Trib. Sand Draw	PFC	1	0.78
Cottonwood Creek	Cottonwood Creek	U	1	0.19
Cottonwood Creek	Trib. Cottonwood Creek	PFC	2	1.30
Gooseberry Creek	Gooseberry Creek	PFC	3	1.84
North Fork Owl Creek	Additional Creek	FAR	2	0.80
North Fork Owl Creek	Black Draw	NF	3	0.87
North Fork Owl Creek	Curry Creek	NF	1	0.13
North Fork Owl Creek	Fall Creek	NF	3	0.16
North Fork Owl Creek	Klicker Creek	FAR	2	0.50

Table 3.5.4-1 BLM Worland PFC condition ratings for streams assessed in the Owl Creek watershed.

Sub-Watershed	Stream Name	Rating*	Number of Reaches	Total Stream Miles
North Fork Owl Creek	Meadow Creek	PFC	1	0.24
North Fork Owl Creek	North Fork Owl Creek	FAR	2	0.28
North Fork Owl Creek	North Fork Owl Creek	PFC	1	0.10
North Fork Owl Creek	North Fork Owl Creek	U	2	1.01
North Fork Owl Creek	Trib. North Fork Owl Creek	U	6	1.32
North Fork Owl Creek	Trib. North Fork Owl Creek	FAR	9	3.67
North Fork Owl Creek	Trib. North Fork Owl Creek	NF	1	1.01
North Fork Owl Creek	Trib. North Fork Owl Creek	PFC	9	2.45
North Fork Owl Creek	Rattlesnake Creek	FAR	1	0.80
North Fork Owl Creek	Trib. Rattlesnake Creek	U	1	0.39
North Fork Owl Creek	Trib. Rattlesnake Creek	FAR	2	0.51
North Fork Owl Creek	Trib. Rattlesnake Creek	PFC	1	0.55
North Fork Owl Creek	Rock Creek	FAR	4	0.94
North Fork Owl Creek	Trib. Rock Creek	FAR	1	0.32
North Fork Owl Creek	S. Br. Mdl. Fk. Owl Creek	NF	2	0.37
North Fork Owl Creek	S. Fk. Of N. Fk. Owl Creek	NF	1	0.31
North Fork Owl Creek	S. Fk. Of N. Fk. Owl Creek	PFC	7	2.19
North Fork Owl Creek	Trib. S. Fk. Of N. Fk. Owl Creek	NF	18	4.93
North Fork Owl Creek	Trib. S. Fk. Of N. Fk. Owl Creek	PFC	5	1.52
North Fork Owl Creek	South Fork Owl Creek	FAR	6	6.51
North Fork Owl Creek	South Fork Owl Creek	PFC	6	11.13
North Fork Owl Creek	Trib. South Fork Owl Creek	FAR	2	0.79
North Fork Owl Creek	Trib. South Fork Owl Creek	PFC	3	1.13
North Fork Owl Creek	Trib. South Fork Owl Creek	U	4	0.66
North Fork Owl Creek	Slab Creek	FAR	1	0.20
North Fork Owl Creek	Slab Creek	PFC	3	0.16
North Fork Owl Creek	Trib. Slab Creek	FAR	1	0.50
North Fork Owl Creek	Upper Slab Creek	FAR	1	0.43
North Fork Owl Creek	Unnamed Spring	FAR	1	0.02
North Fork Owl Creek	Vass Creek	NF	1	0.68
North Fork Owl Creek	Willow Creek	FAR	1	0.14
Owl Creek	Trib Owl Creek	U	3	1.16
Wind River	Unnamed	U	1	0.05
Wind River	Woods Basin	U	3	1.08
Source: BLM RAIDS Database				
* FAR=Functional-At Risk; PFC=Proper Functioning Condition; U=Unknown, more data needed.				

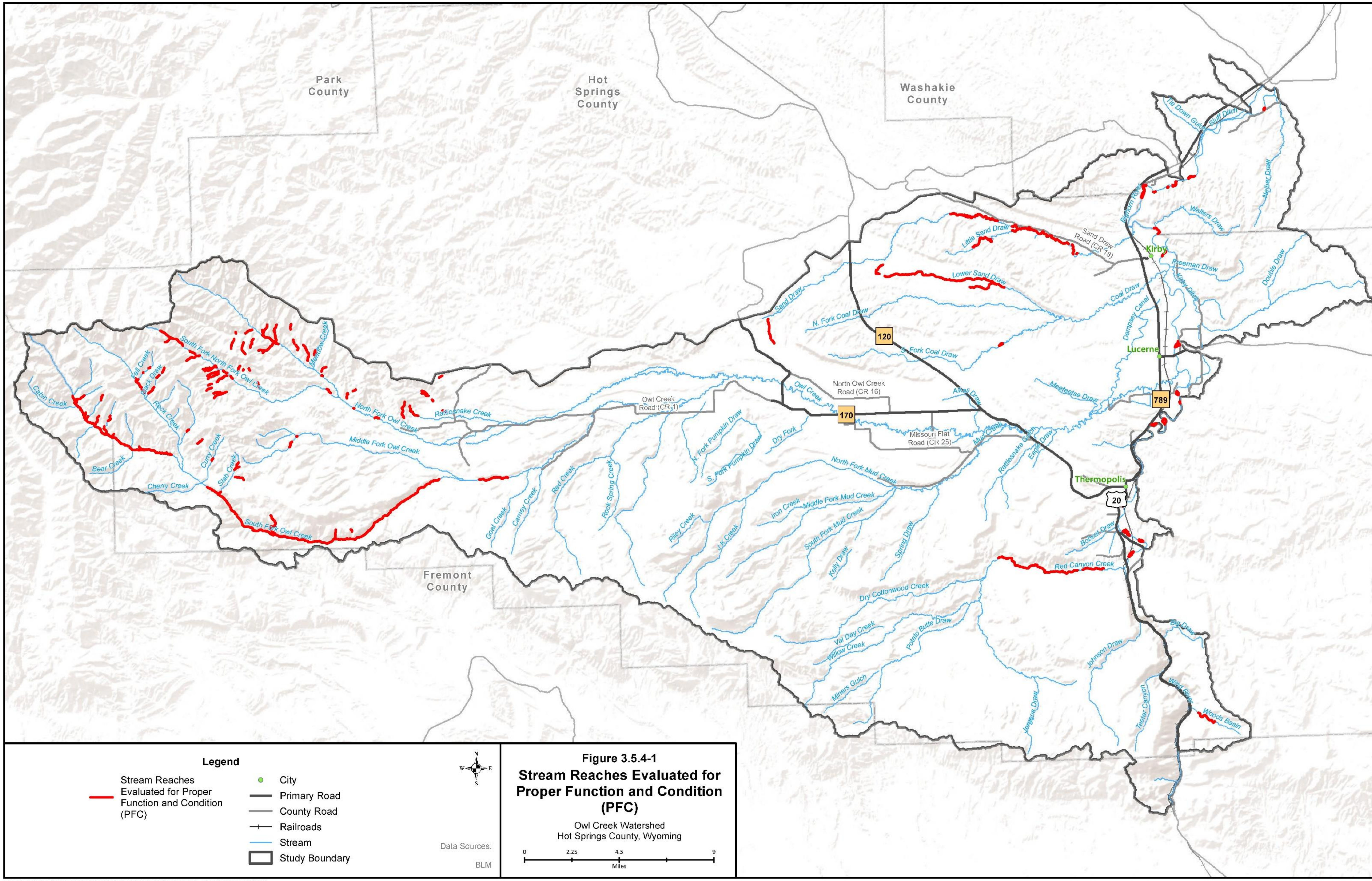

Figure 3.5.4-1
Stream Reaches Evaluated for Proper Function and Condition (PFC)
Owl Creek Watershed
Hot Springs County, Wyoming

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3.5.5 Stream Visual Assessment Protocol (SVAP)

The Stream Visual Assessment Protocol (SVAP) is a tool used by the NRCS that provides a simple procedure to evaluate the condition of a stream based on visual characteristics. It is intended to be conducted with the landowner and incorporates talking points for the conservationist to use during the assessment. The protocol provides an overall assessment of the condition of the stream and riparian ecosystems, identifies opportunities to enhance biological value, and conveys information on how streams function and the importance of protecting or restoring stream and riparian areas. No SVAP data has been collected by the NRCS for the Owl Creek Watershed.

3.5.6 FEMA Floodplain Connectivity

No FEMA floodplain mapping has been conducted for the Owl Creek watershed.

3.5.7 Overall Geohydrological Assessment

Basin Characteristics

Water resources of the Owl Creek basin are generally surface-water based. To date groundwater has not been a significant portion of the resource portfolio, although numerous wells, generally shallow in depth, provide some domestic and stock water to various farms, ranches, and grazing allotments within the basin. This alluvial groundwater can essentially be considered a resource tied to the surface water resource. Deeper wells, tapping confined groundwater resources in sedimentary or fractured crystalline rocks are likely insignificant in number.

Due to low annual precipitation, human land use can only take place where surface water can be withdrawn from natural stream courses or routed through irrigation system. This has an impact on land development, generally restricting development to a ribbon along major streams. Reliable surface water resources are largely dependent on annual snow pack, but increased surface flow does result from periodic precipitation events, generally rainfall in the spring months. The events are “flashy” in nature and there is little opportunity to capture this water without the development of storage infrastructure. Anchor Reservoir represents the principal storage facility in the basin, but so far has not provided a significant source of surface water due to geologic complications at the reservoir site.

Water quality is generally good in areas higher up in the basin, but most development takes place in the lower basin, and the quality of surface water can become degraded by the time it reaches most areas where it is needed. Contributors to this general observation are unfavorable geology between headwater areas and the lower basin, significant periods of low flow (lack of diluting water) which concentrate dissolved solids and increasing amounts of irrigation return flow in the down-basin direction. Due to the current lack of alternative water sources, surface water users are highly impacted by periodic drought conditions.

Unique Challenges

Outside of the challenges presented by a reliance on surface water, a unique pattern to land ownership presents challenges to water resource management in the Owl Creek basin. Land ownership on an areal basis is approximately split between tribal interests south of a line generally paralleling Owl Creek and South Fork Owl Creek, and private, state and other federal agency owners to the north of Owl

Creek. Unfortunately, the pattern of ownership is administrative in nature rather than functional based on the distribution and the use of water resources. For the most part, headwater areas are under tribal jurisdiction, except for a 28 square-mile area on the extreme west end of the basin which is Forest Service and this complicates the management of resources and can cause a perception of competition for resources juxtaposed against interests focused on protections. In addition, if not under private ownership, lands to north of the line generally paralleling Owl Creek and South Fork Owl Creek, are managed by the Bureau of Land Management, which due to its multiple use management mandate is subject to industrialization related to fluid mineral development. Further industrialization of the basin (e.g., oil and gas development, the new airport, inward migration of the rural-urban boundary, etc.) only applies additional pressure on water resources historically used for traditional land uses in the basin.

3.6 Water Rights

Water within the State of Wyoming are administered by the WSEO. To manage this water, the state is divided into four water divisions. All of the project area is included in Water Division III. The Division III superintendent administers water within the division with assistance from water commissioners and hydrographers. The WSEO and superintendent administer acquisition and implementation of both surface water and groundwater within each water division. The State Board of Control is made up of the four superintendents and the State Engineer. The Board of Control meets quarterly to consider petitions to make changes to water rights such as changing a point of diversion or amending a land description.

A general overview of Wyoming Water Law is provided in the document “Wyoming Water Law, a Summary” (Jacobs et al. 2003). Sections 3.6.1, 3.6.2, and 3.6.3 below are based on Jacobs et al. 2003 and the Wind Bighorn Plan Update, 2010, Section 3.3.1, pages 23 to 25 (WWDC 2010).

3.6.1 Surface Water

Wyoming’s earliest water rights date back to its territorial days, prior to its statehood in 1890. During these days, water rights were established through water rights claims with the territorial officials or through court decrees. Since statehood, water rights are only acquired through a permit from the WSEO. Obtaining a surface water permit requires an application, including the preparation of a map and payment of required fees. Once the proposed project is completed and water is put to beneficial use, the water right can be adjudicated.

For irrigation purposes, and based on the date of a water right, direct flow is distributed as follows:

> “a. Water rights for irrigation are adjudicated on the basis of one cubic foot per second (cfs) per 70 acres.
>
> b. Water rights with priority dates of March 1, 1945, or earlier are entitled to an additional 1 cfs per 70 acres. If you hold such a water right, you are entitled to divert water in the volume of 2 cfs for each 70 acres of land before any water is made available to the holder of a water right with a priority date after March 1, 1945.
>
> If there is not sufficient water to furnish 2 cfs to each pre-March 1, 1945, water right, but more than enough to furnish 1 cfs to each of such rights, then the surplus water is divided among those rights on a pro rata basis. If there is so little water that each pre-March 1, 1945, right cannot receive 1 cfs, they are regulated on a strict priority basis.

Any water beyond that required to furnish 2 cfs for each 70 acres of pre-March 1, 1945, water rights is first allocated to rights with priority dates after March 1, 1945, and before March 1, 1985. Wyoming's Excess Water Law states that each water right with a priority date of post-March 1, 1945, but pre-March 1, 1985, is entitled to 2 cfs per 70 acres before any water is made available to post-March 1, 1985, water rights. If there is not sufficient water to furnish 2 cfs to each post-March 1, 1945, and pre-March 1, 1985, water right, but more than enough to furnish 1 cfs to each of these rights, the excess water is divided among those rights on a pro rata basis. If there is so little water that each post-March 1, 1945, and pre-March 1, 1985, water right cannot receive 1 cfs, the rights are regulated on a strict priority basis.

For post-March 1, 1985, water rights, those rights are entitled to 1 cfs per 70 acres only after all pre-March 1, 1985, rights have received 2 cfs per 70 acres. Under Excess Water Law, the post-March 1, 1985, water rights may also receive 2 cfs if water is available." (Jacobs, Fassett, and Brosz 1995).

Tribal Water Rights

Much of the land within the Owl Creek Basin lies within the Wind River Indian Reservation (WRIR). With completion of the Wyoming Big Horn General Stream Adjudication in September 2014 (Case Number S-15-0008. See Robison 2015), certain reservation lands were awarded an 1868-reserved water right. The water duty awarded to these lands within the Owl Creek Watershed is 4.3 acre-feet/acre and is independent of the general state adjudication outlined above. Other non-Indian owned lands that were once part of the WRIR observe a similar award. These lands have what are known as "Walton Rights" and also have a priority date of 1868.

According to the 2016 hydrographer's usage report, roughly 20 percent of these water rights, or approximately 3,853 ac-ft. (ac-ft.) of water, was not utilized by those who own Tribal or Walton rights. The un-utilized portion of these rights was available to downstream users. If all Tribal water rights were utilized, it is likely that in all but the wettest year, downstream users would have significantly less water for irrigation. The General Adjudication has created a more precarious water supply situation for territorial and state water rights holders (Nelson 2004). State adjudicated water rights adhere to the standard of 1 cfs allocated for every 70 acres of irrigated land. This adjudication governs any appropriation with a recognized priority date after 1868 (Jacobs, Fassett, and Brosz 1995).

Simplified Permitting for Smaller Facilities

For some facilities, a simplified water right application process is available. This includes small stock reservoirs, fishing ponds and wetlands ponds, flood detention dams, small springs, small domestic uses and cisterns. The simplified procedure does not require maps and plans prepared by a registered engineer or surveyor (Jacobs, Fassett, and Brosz 1995).

Reservoirs and Water Rights

Reservoirs are entitled to fill in priority once per year during the period October 1st through September 30th. Any water left in the reservoir at the end of the year is accounted as part of the following year's fill. In general, once stored, water is not subject to the water rights allocation scheme described in previous paragraphs. Stored water may be delivered to specific lands or places of use, or may be generally allocated to downstream water users. Specific reservoir operations within the Wind-Bighorn River Basin are described in the Wind Bighorn Plan Update Technical Memorandum 3F - Reservoir Operations (2010) (Jacobs, Fassett, and Brosz 1995).

Instream Flow

In 1986, the Wyoming legislature declared that instream flow for maintenance or improvement of existing stream fisheries is a beneficial use of water that can be provided either by natural streamflow or from storage. Statutes were adopted that allow the WWDC to apply for a permit to appropriate instream flows in streams and at streamflow rates requested by the Wyoming Game and Fish Commission. To establish an instream flow right, the WWDC prepares a feasibility study that contains a hydrologic analysis of the reach. The feasibility study is provided to the WSEO for review. The WSEO then holds public hearings before granting or denying the application. Adjudicated water rights can be changed to instream flow rights by granting of a petition by the Board of Control. If such a petition were granted, the State of Wyoming becomes the owner of the water right (Jacobs, Fassett, and Brosz 1995). A description of instream flow water rights in the Wind-Bighorn Basin are described in the Wind Bighorn Plan Update Technical Memorandum 3D/3E – Recreational and Environmental Water Use (2010).

3.6.2 Ground Water

Wyoming's groundwater laws were originally enacted in 1945 and amended in 1947. These laws were replaced by new groundwater laws on March 1, 1958, which were then amended in 1969. Groundwater is administered on a permit basis. The acquisition of groundwater rights generally follows the same permitting procedures as surface water rights, except that a map is not required at the time of permit application. Applications are submitted to and approved by the WSEO prior to drilling a well. With the completion of the well and application of the water to a beneficial use, the appropriation can then be adjudicated. The issuance of well permits carries no guarantee of a continued water level or artesian pressure.

As with surface water rights, groundwater rights are administered on a priority basis. For all wells drilled prior to April 1, 1947, a statement of claim process was followed to determine the priority date of the well. For wells drilled between April 1, 1947 and March 1, 1958, the priority date is the date the well was registered. For wells drilled after March 1, 1958, the priority date is the date the application was received at the WSEO.

Domestic and stock wells are those wells used for non-commercial household use, including lawn and garden watering, that does not exceed one acre in aerial extent, and the watering of stock. The yield from these wells cannot exceed 25 gallons per minute (gpm). Prior to the 1969 amendment, domestic and stock wells were exempt from the requirement to obtain a permit and held a preferred right over other wells. The 1969 amendment established priorities for domestic and stock wells similar to those for other wells. The Groundwater Division also issues permits for spring developments where the total yield or flow of the spring is 25 gpm or less and where the proposed use is for stock and/or domestic purposes (Jacobs, Fassett, and Brosz 1995).

3.6.3 Board of Control

Wyoming water law defines preferred uses for both surface water and groundwater. In general, domestic and livestock water use, municipal use, and industrial use have "preferred" status over non-preferred uses such as irrigation. For surface water permits, preferred status does not imply that during times of shortage, a preferred use takes priority over a non-preferred use – the water right's priority establishes this allocation. Preferred status relates to how the water right use can be changed. The only way to obtain a preferred surface water right from a non-preferred right is by purchase or condemnation of the non-preferred right and petitioning the State Board of Control for the change of use. For groundwater permits, domestic and stock wells yielding less than 25 gpm have preferred rights and priority over wells for all other uses.

The point-of-diversion, location or type of surface water use of an adjudicated water right can only be changed through a petition filed with the Board of Control. Generally, a petitioner for a change in use does not lose priority of the water right as long as no other water rights are injured (including the location and amount of return flows) and the quantity of use remains the same. The Board of Control may consider economic losses to the community and the availability of water from other sources when making its decision (WWDC 2010).

3.7 Municipal Delivery Systems and Water Supply

The WWDC completed a Public Water System Survey in 2016 that reported on all known municipal and non-municipal community public water systems in the state (WWDC 2016). This report consists of six separate sub-reports, each of which expands on different aspects of water systems within the State of Wyoming. The different sections summarize various aspects of public water systems in Wyoming as follows:

- Sub-report 2: System data: Refers to the source of the entity's water supply, storage, treatment, and volumes of water.
- Sub-report 3: System use: Refers to information pertaining to water system usage, providing information on the total population served, amount of average use, and other factors that may affect water consumption levels.
- Sub-report 4: Billing rates: Refers to billing information for each entity.
- Sub-report 5: Fiscal data: Refers to the entity's budget and includes the primary breakdown of the annual budgets and details on funding capabilities and liabilities.

The following sections briefly outline the current water systems for the project area, including: Red Lane Domestic Water & Sewer District, Lucerne Water and Sewer District, the Town of Kirby and the Town of Thermopolis. The Town of Thermopolis sells water to South Thermopolis Water & Sewer District, Town of East Thermopolis, Red Lane Water & Sewer District, Lucerne Water & Sewer District, the high school football field, and Monument Hill Cemetery (WWDC 2006a). Specific data for the Town of Thermopolis, South Thermopolis, East Thermopolis, Red Lane, and Lucerne (including Kirby) is shown in **Tables 3.7-1** through **3.7-4**.

3.7.1 Town of Thermopolis

As its own entity, the Town of Thermopolis operates a direct diversion of surface water from the Big Horn River. It is then treated with fluoridation, filtration, chlorination, or is put through a conventional water treatment plant. Currently annual usage is 191,170,000 gallons, providing an estimated 3,500 people with municipal water (WWDC 2016). Annual usage includes East Thermopolis, South Thermopolis Water and Sewer District, and the Red Lane area.

3.7.2 Town of East Thermopolis

The Town of East Thermopolis purchases municipal water, taken from the Bighorn River, from the Town of Thermopolis. East Thermopolis does not maintain or operate any groundwater wells or springs as alternate water sources. Annual water usage is 650,400 gallons, providing an estimated 254 people with water (WWDC 2016). Additional water sources such as private wells, likely exist but have not been quantified.

3.7.3 South Thermopolis Water & Sewer District

Similar to East Thermopolis, South Thermopolis gets its municipal water from the Big Horn River, through the Town of Thermopolis water treatment and distribution system. It is unknown how many gallons the 112 residents in this area use annually (WWDC 2016).

3.7.4 Community of Owl Creek

The Owl Creek area does not currently have a community water system in place. The Owl Creek Rural Water Supply Level II Study (WWDC 2009)[5] (Study) was commissioned by the WWDC to evaluate the possibility of servicing the rural area approximately one mile west of the Town of Thermopolis with potable water. At the time of the study, an estimated 133 people lived on the lower Owl Creek drainage which is about 15,000 acres in size.

Individual wells serve the majority of the homes in this area. While some of these wells are permitted, water usage has not been quantified due to the variability in output of wells. Area wells typically produce between 5 to 25 gpm. Many residents haul potable water to their homes. Combined uses of well water and hauled water make it very difficult to quantify current domestic water usage.

The Study also focused on examining the feasibility of connecting this area to the Town of Thermopolis system. Multiple connection points were studied. One point on the west side of Roundtop Mountain was found to be favorable; however no forward movement has occurred to-date. (WWDC 2009).

[5] The Wyoming Water Development program is established to foster, promote and encourage the optimal development of the state's human, industrial, mineral, agricultural, water and recreational resources. The Wyoming water development program supports three levels of projects. Projects must be sponsored by a public entity that can legally receive state funds, incur debt, generate revenues to repay a state loan, hold title and grant a minimum of a parity position mortgage on the existing water system and improvements associated with the project, or provide other adequate security for the anticipated state construction loan. A project sponsor can be a municipality, irrigation district, joint powers board, or other approved assessment district that will realize direct benefits of the project. The sponsor may request that a Level I or Level II study be conducted to identify solutions and alternatives for addressing water supply issues or they may request funds for a Level III construction project, if it is determined the project is technically and economically feasible and serves to meet a water supply need or alleviate a water supply problem (WDO 2015).

3.7.5 Town of Kirby

The Town of Kirby is located north of Thermopolis, just outside of the project area. The Lucerne Water & Sewer District supplies municipal water to Kirby through a 6 inch transmission line. Currently, this entity uses 1,460,000 gallons annually, providing an estimated 50 people with water. All relevant data can be seen in Tables 3.6.1-13 thru 16 in the WWDC Public Water System Survey Report (WWDC 2016).

One of the objectives of the Town of Kirby Water Supply Project (WWDC 2006b) was to - assimilate a variety of surveying, mapping, water rights data and historical data into an ArcView GIS file to identify reasonable improvements to the water supply system. Five improvements were identified that were recommended to be implemented over the next decade. These include: modifying the chlorine control and injection systems, implementing a system flushing program, installing new waterlines, installing two new hydrants for flushing, and replacing the existing pressure reducing valve (Town of Kirby Water Supply Project, Executive Summary 2006).

3.7.6 Lucerne Water and Sewer District

The Lucerne Water and Sewer District (LWSD) was organized in 1976 to supply treated water to rural users located approximately 4 to 10 miles north of Thermopolis. Historically, the LWSD main water source came directly from the Big Horn River. Since its inception, the LWSD has developed new water sources and expanded their infrastructure to supply the Towns of Kirby and Winchester with water. As of 2009 this area became a part of the Big Horn Regional Water System (managed by the Big Horn Regional Joint Powers Board), making their primary water supply the Big Horn Regional Northern Supply Pipeline. This pipeline takes water from the Worland Well Field (WWDC 2011). The entire district, which is comprised of the Towns of Lucerne, Kirby, and Winchester, has a total annual usage of 7,000,000 gallons, serving approximately 375 people (WWDC 2016).

3.7.7 Red Lane

Similar to East Thermopolis and South Thermopolis, the Red Lane area gets its municipal water from the Big Horn River via the Town of Thermopolis Municipal Water System. Annual water usage is 4,000,000 gallons, for an estimated 60 people. (WWDC 2016).

Table 3.7-1 Thermopolis Area Source of water supply, storage, treatment, and volumes of water data [1]										
Entity	**Total Annual Water Use (gal)**	**Number of Wells**	**Number of Springs**	**Surface Water Source(s)**	**Type of Diversion(s)**	**Other Water Sources**	**System Capacity (gal/day)**	**Total Raw Water Storage (gal)**	**Treated Water Storage (gal)**	**Treatment Methods**
East Thermopolis, Town of		0	0	No data	No data	Thermopolis	0	0	0	No data
Kirby, Town of		0	N/A	None	N/A	Thermopolis	No data	0	50,000	Disinfection/ Chlorination
Lucerne Water & Sewer District		0	0	Consecutive system from Big Horn Regional Water	Alluvial Wells	Town of Thermopolis surface treated water (only for emergency)	16,000	0	200,000	Disinfection/ Chlorination
Red Lane Domestic Water, Inc.		0	0	Thermopolis Water	No data	No data	0	0	17,000	No data
South Thermopolis Water & Sewer District		0	N/A	None	N/A	Thermopolis	38	No data	271,709	No data
Thermopolis, Town of		3	0	Big Horn River	Direct	None	2,300,000	1,800,000	2,300,000	Fluoridation; Filtration, Chlorination, Conventional Water Treatment Plant

Table 3.7-2 Thermopolis Area water system usage, total population served, and average amount of water used								
Entity	**Total Population Served**	**Number of Taps inside Entity**	**Number of Taps outside Entity**	**Total Annual Water Use for the System (gal)**	**Peak Day Water use for the System (gal)**	**Water Sold to Whom?**	**Estimated Loss to Leakage**	
							(gal/day)	**(%)**
East Thermopolis, Town of	254	180	1	650,400	25,000	N/A	No data	10.5%
Kirby, Town of	50	41	2	1	1,460,000	6500	No data	0.0%
Lucerne Water & Sewer District	375	125	0	7,000,000	20,000	N/A	500	No data
Red Lane Domestic Water, Inc.	60	60	0	4,000,000	21,000	NA	No data	10.0%
South Thermopolis Water & Sewer District	112	112	0	No data	No data	None	No data	No data
Thermopolis, Town of	3,500	1,400	6	191,170,000	2,000,000	South Thermopolis, Red Lane, Owl Creek, Town of East Thermopolis & Hot Springs County Cemetery District	58,000	0.0%

Table 3.7-3 Thermopolis Area billing rates data						
Name of Entity	**Is the System Billed By Meter?**	**Average Monthly Water Bill**	**Residential tap Fees**	**Residential Base Water Rate**	**Residential Gallons Included in Base Water Rate**	**Rate for Each 1,000gal above Base Water Rate**
East Thermopolis, Town of	No	No answer	No answer	$ 33.00	2,000	$ 5.00
Kirby, Town of	Yes	$25.00	$750.00	$ 25.00	2,000	$ 7.00
Lucerne Water & Sewer District	Yes	$50.00	$3,500.00	$ 43.00	3000	$ 3.75
Red Lane Domestic Water, Inc	Yes	$60.00	Cost of meter	$ 37.50	0	$ 5.15

Table 3.7-3 Thermopolis Area billing rates data						
Name of Entity	**Is the System Billed By Meter?**	**Average Monthly Water Bill**	**Residential tap Fees**	**Residential Base Water Rate**	**Residential Gallons Included in Base Water Rate**	**Rate for Each 1,000gal above Base Water Rate**
South Thermopolis Water & Sewer District	Yes	$32.68	$1,000.00	$ 23.00	3,000	$ 4.68
Thermopolis, Town of	Yes	$57.70	1" - $592.32	$ 2,875.00	8000	$2.50/1000- over 42,000gal $3.25/1000- over 50,000gal

Table 3.7-4 Thermopolis Area fiscal budget and funding capabilities and liabilities									
Name of Entity	**Annual**							**Revenue cover Operating Costs?**	**Other Funding Sources**
	System Budget	**Operation & Maintenance**	**Water Quality Testing Costs**	**Sinking Fund Contributions**	**Emergency Replacement Fund**	**Water Bill Revenues**	**Tab Fee Revenues**		
East Thermopolis, Town of	$ 45,000.00	$ -	$ 800.00	$ -	$ -	$ -	$1,000.00	Yes	OSLI board
Kirby, Town of	$ 20,750.00	$4,064.00	$ 400.00	$ -	N/A	N/A	N/A	No	General Fund
Lucerne Water & Sewer District	$ 125,000.00	$20,000.00	$ 450.00	$10,000.00	$ 315,000.00	$ 6,500.00	Yes	N/A	N/A
Red Lane Domestic Water, Inc	$18,000.00	$ -	$ 2,500.00	$ -	$ -	$-	$ -	Yes	N/A
South Thermopolis Water & Sewer District	$ 119,625.00	$5,000.00	$ 350.00	$ -	NA	NA	NA	No	Sur Charge of $5

Table 3.7-4 Thermopolis Area fiscal budget and funding capabilities and liabilities

Name of Entity	Annual							Revenue cover Operating Costs?	Other Funding Sources
	System Budget	Operation & Maintenance	Water Quality Testing Costs	Sinking Fund Contributions	Emergency Replacement Fund	Water Bill Revenues	Tab Fee Revenues		
Thermopolis, Town of	$1,272,060.00	$1,221,031.00	$ 2,876.00	$ -	$ -	$864,649.00	$ -	No	The Town received WWDC funding for water storage and OSLI funding for water main replacement.

3.8 Irrigation Delivery Systems

3.8.1 Owl Creek

Owl Creek Irrigation District

The Owl Creek Irrigation District (OCID) was initially formed in 1935 and originally only included lands in the Lucerne Area served by the Cyclone Ditch System. In the 1940's, USBR began looking at storage possibilities in the upper basin as part of the Pick-Sloan Missouri River Basin Project (PS-MRBP). In 1955, the District entered into contract with the USBR to complete the Owl Creek Unit of the PS-MRBP. The Owl Creek Unit consisted of construction of Anchor Dam to provide stored water in the Upper Basin, and construction of a primary pump station and re-lift pump station at Lucerne to supply water from the Big Horn River and Boysen Reservoir to irrigators in the original OCID. The District was expanded at that time to include lands further up the basin. There is additional irrigated land that falls outside the boundary of the OCID, including the tributaries Red Creek and Mud Creek. These areas are included within this study area boundary, but were not part of the PS-MRBP project lands (**Figure 3.8.1-1**).

The expanded district was formed with three distinct areas: Upper, Middle and Lower (Lucerne). Irrigators in the Lower Area exchanged their direct flow appropriations from Owl Creek in the amount of 78.93 CFS for use by irrigators in the Upper and Middle Areas. Those rights and supply were replaced by the pumped water from the Big Horn River, amounting to 84 CFS. The pump stations were completed and turned over to the District for operation and maintenance in 1957. OCID controls and manages the system from the main pump station through the re-lift station on the Upper Canal. Water distribution downstream of the re-lift station is managed by the Lucerne Ditch Company, which operates as a sister company to OCID.

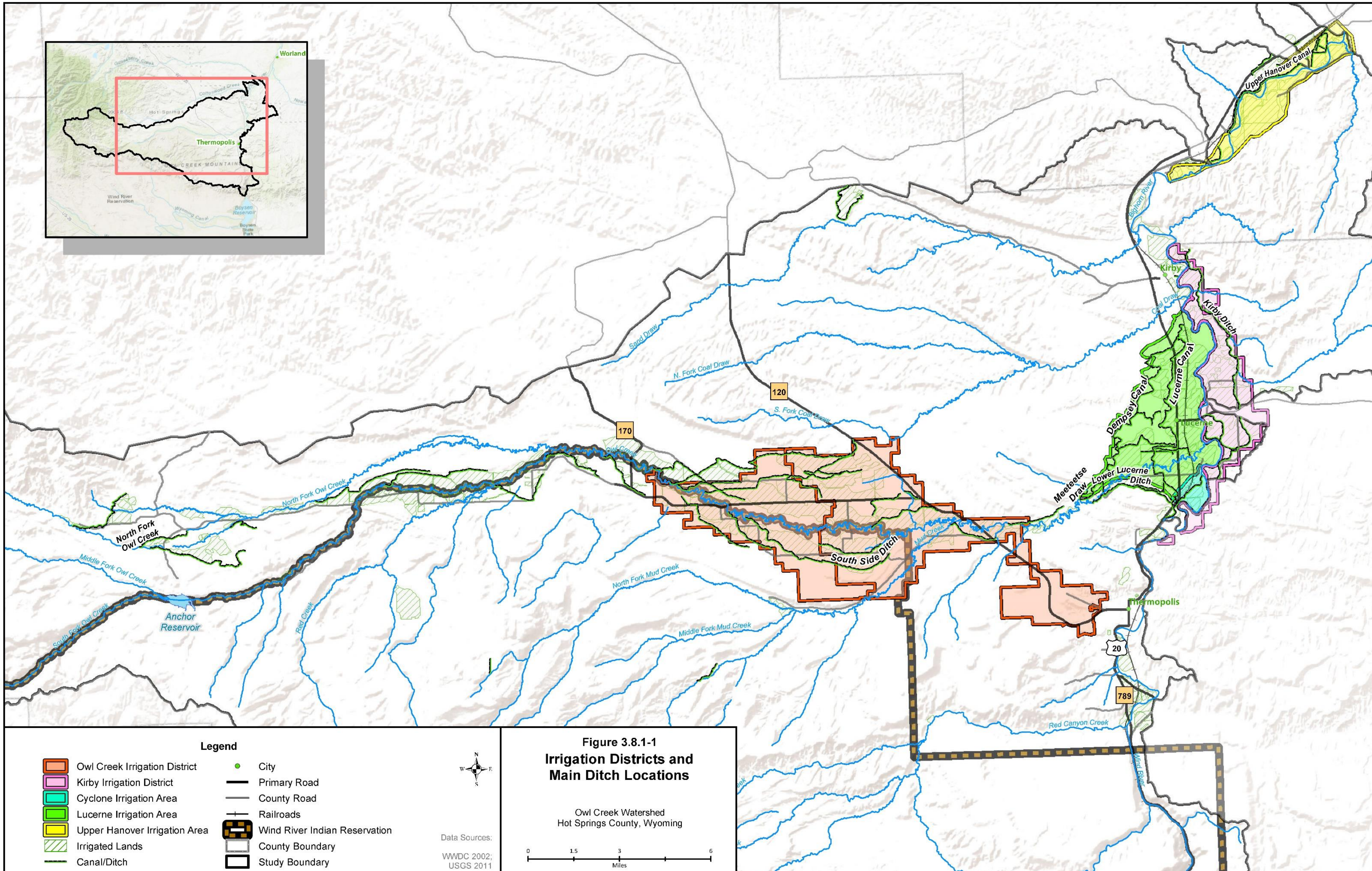

Figure 3.8.1-1
Irrigation Districts and Main Ditch Locations

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For the fiscal year 2016, the assessment for the Upper and Middle Areas for payment of operations, maintenance and repair of the distribution system was $4.58 per acre. Total assessed area was 9,286.17 acres.

No formal crop rotation data was available for the Upper and Middle Areas; however it was estimated by conversations with the Local NRCS and visual assessment to consist of the following (**Table 3.8.1-1**):

Table 3.8.1-1 Owl Creek Crop Summary

Crop	Percent of Total Acreage in Owl Creek Service Area
Grass Hay	52.5%
Alfalfa Hay	17.5%
Irrigated Pasture	30%

In 2004 a Level I Masterplan Study (Nelson Engineering 2004) was completed on the entire Owl Creek drainage for WWDC. The study provided an overview and inventory of all existing diversion and infrastructure features within the project. In 2008, a Level II study was conducted to investigate storage alternatives within the project area. This report concluded that implementing an alternative storage facility would be more economic than investigating and attempting further repairs to Anchor Reservoir. Several different site alternatives were presented. None of these have advanced to Level III due to lack of public support.

There are two areas within the Owl Creek drainage system that warrant special consideration. These are Anchor Reservoir and the Arapaho Ranch, both described below.

Anchor Reservoir

Anchor Reservoir was constructed between 1957 and 1960 with a planned active storage volume of 17,419 ac-ft. (Hein, Annette, undated.). Water was to be available for irrigation of agricultural lands downstream of the dam. Massive sinkholes developed within the reservoir body during and after construction and the reservoir "never held more than a small pond". The USBR attempted several times since the 1960s to grout, plug, or isolate sinkholes in the reservoir. In 1984, a proposal to line the entire reservoir floor with plastic or concrete was proposed for a cost estimated at $29 to $70 million. This project was never attempted (Jarvis 2003). Eventually the control and operation of Anchor was transferred to OCID under the provisions of an Amendatory Contract that has been in effect since 1993 (Nelson Engineering 2004). As part of the contract, the water elevation was limited to 6,400 feet providing about 5,000 AC-FT of storage. Refer to section 3.9.1 for a more complete history of Anchor Reservoir.

Upon completion and filling of Anchor Dam, the USBR planned to combine multiple diversions serving the bulk of irrigated lands within the Upper and Middle areas of OCID under several larger canal laterals. Because Anchor Reservoir proved insufficient to operate anywhere near capacity, this canal system was never constructed. As a result, there are 53 permitted diversion structures that are currently monitored by the SEO District Hydrographer within the Upper and Middle regions of the Owl Creek drainage. The total combined lengths for each of these open channel ditches is unknown at this time (Nelson Engineering 2004).

Arapaho Ranch

Arapaho Ranch encompasses some 2,300 acres of irrigated land and is situated near the lower end of the District's Upper Area. Several of the main canals in the Owl Creek drainage, including the Padlock, McQueen, Chessington Wilson, Sliney # 1, Woodward-Johnson, and Dewitt, either pass through the ranch or the diversion is located on the ranch (Nelson Engineering 2004). Tribal water rights, which are the oldest and represent the largest volume of water rights in the Owl Creek Drainage, are discussed further in **Section 3.6.1.**

3.8.2 Bighorn River

Lucerne Area

Lucerne Area is the lowest in elevation of the three distinct areas comprising Owl Creek Irrigation District (OCID). Although it varies slightly from year to year, there are about 4,400 irrigated acres in the Lucerne Area (**Figure 3.8.1-1**). The majority of the land is irrigated by some form of flood irrigation, while about 153 acres are under center pivot. The Lucerne Area water source is primarily the Big Horn River and Boysen Reservoir. When OCID was expanded in 1955, irrigators in the Lucerne Area exchanged their direct flow appropriation from Owl Creek in the amount of 78.93 cfs for use by irrigators in the Upper and Middle Areas. That supply was replaced by pumped water from the Big Horn River in like amount plus 5.39 cfs of abandoned right due to inundated lands under Anchor Reservoir. The Primary Pump Station for Lucerne area was designed to deliver 84 cfs. When water is available from Owl Creek, it can still be diverted into Dempsey Canal, the original supply canal for Lucerne.

The present distribution system consists of the diversion from the Big Horn River, the Primary Pump Station, the Lower Canal, the Dempsey Canal, the Upper Canal, and the Re-lift Pump Station. The Re-lift Pump Station lifts water from the Upper Canal into the Dempsey Canal. The canal lengths and diversion amounts are illustrated in **Table 3.8.2-1**:

Table 3.8.2-1 Lucerne Area Canal Summary

Canal	Length	Diversion Amount
Dempsey Canal	9.1 miles	33 cfs
Upper Canal	2.9 miles	44 cfs
Lower Canal	8.5 miles	40 cfs

The primary pump consists of four pumps, two 250 BHP pumps, one 300 BHP pump, and one 175 BHP pump. For fiscal 2016, Lucerne Area assessment for payment of operations, maintenance and repair of the distribution system was $21.81/acre. Total assessed area was 4,379 acres. **Table 3.8.2-2** outlines the main crops grown in the area and what percentage of the total acreage those crops comprise.

Table 3.8.2-2 Lucerne Area Crop Summary	
Crop	**Percent of Total Acreage in Lucerne Service Area**
Malt Barley	19%
Corn	19%
Alfalfa Hay	57%
Dry Beans	8%

Maximum irrigation demands occur in July and it has been estimated that under normal climatic conditions the irrigation supply of 84 cfs exceeds the demand of 69 cfs. Under dry climatic conditions the supply of 84 cfs is insufficient to satisfy irrigation demands of 96 cfs (Nelson Engineering 2004)**.**

As a result of recommendations from the 2004 Level I Masterplan, an additional study was completed for the Lucerne Area. In 2005, WWDC funded the Owl Creek Irrigation District Conservation Study-Level II (Short 2008). At the Sponsor's request, the study focused on evaluating seepage along the Lucerne Area canals, investigating canal lining options, estimating costs for lining and prioritizing implementation of seepage mitigation measures. Suspect leaky sections were identified along the canals and measurements were made in June 2005 and September 2006. Continuous measurements were not made nor recorded. So-called instantaneous measurements were made and repeated to verify accuracy. Results were extrapolated to try and depict what season long losses could be. Results showed losses of less than 15% due to seepage in the test sections that were found to have losses. Average Extrapolated Losses varied but reached up to 24%. A number of recommendations were made as a result of the work completed during the Level II Study, they included:

1) Six canal sections were identified for potential lining,
2) Installation of flow measurement devices throughout the system,
3) Utilization of "Allotment Charts" for more accurate delivery of water to small acreages,
4) Consider implementing a basic level of Supervisory Control and Data Acquisition (SCADA) system, and
5) Repair of leaky head gates throughout the system (SHE 2008).

Recent input from OCID representatives indicates that due to cost, minimal recommended improvements have been implemented.

Kirby Irrigation District (KID)

Kirby Irrigation District (KID) was formed in 1986 by the Kirby Irrigation Ditch Company, owner of the Kirby Ditch. KID encompasses about 5,100 acres of which less than 3,200 acres are historically irrigated lands. As of 2010 there were 51 users on the system. Kirby Ditch was initially constructed in 1904 and is about 10 miles long (**Figure 3.8.1-1**). The District responsibility for maintenance and operation is limited to the first 7 miles. The Ditch is predominantly an open earth ditch, however about 900 feet has been lined in high seepage areas, and a 900 lineal foot section has been buried in a 6 foot diameter pipe. Reportedly, the system structures are in fairly good condition. Irrigation is predominantly by flooding. In recent years more pumped irrigation has been employed, including pumping to lands above Kirby Ditch (Anderson Consulting 2010). Inspection during this study determined there are about 330 acres and 103 acres irrigated by center pivot and side roll systems respectively. The rest of the lands are irrigated by some form of flood irrigation. Assessments in 2016 for operation, maintenance and repair of the system was $75.00 for the first acre and $8.50 against the remaining 3150.68 acres.

Kirby Ditch diverts water from the Big Horn River about 1 mile north of the town of Thermopolis. Associated water rights are included in **Table 3.8.2-3**.

Table 3.8.2-3 Kirby Ditch Water Rights Summary

Type of Water Right	Volume (cfs)	Priority Date
Adjudicated direct flow	43 cfs	Priority dates from 1892-1972
Supplemental	1.14 cfs	1952
Unadjudicated	0.76 cfs	1987-1993

Thus, single appropriation rights total about 45 cfs. When surplus water is available, for those rights allowed a second appropriation, diversion totals about 87 cfs. When "free water" conditions exist (when there is no limitation on the water volume available) diversion amount is limited by ditch and infrastructure capacity as long as the water is beneficially used and no injury results to downstream return flows. Average annual diversion from 1973-2009 was 17,680 ac-ft or 5.53 ac-ft/ac. During the 2016 irrigation season, 15,007 ac-ft was diverted (2015 and 2016 WSEO Hydrographer's Report District III Division 6). The irrigation season extends from late April through late September.

Crops grown in the District include irrigated pasture, alfalfa hay, grass hay, small grains and corn. Information was not available for a typical crop rotation percentage.

The Kirby Ditch Conservation Program Level II Study- WWDC (Anderson Consulting 2010) developed a comprehensive list of recommendations for the KID in four areas:

- Rehabilitation, replacement or removal of structures
- Systems operation and efficiency
- System automation
- Installation of re-regulation reservoir

The Rehabilitation Plan focused on improvements of the most critical nature that could yield the most benefit considering cost. The recommendations are listed below with those projects completed noted using WWDC Level III funding:

- Replace a culvert at Sta 25+65 (completed)
- Replace a culvert at Sta 425+36
- Reconfigure Kirby Ditch from Sta 0+00 to 49+14 (completed)
- Replace the Diversion Headgate (completed)

- Automate the Diversion Headgate
- Automate Monitoring of the WSEO Measuring Gauge
- Automate the Tail End Waste Way Gate
- Implement a Mobile Base Station and software
- Line four different ditch sections to reduce seepage loss

In addition, the diversion structure was rehabilitated (Vore 2017).

3.8.3 Upper Hanover Canal

A small area of lands in the southern portion of the Upper Hanover Irrigation District (UHID) lie within the study area for the Owl Creek Watershed Study. The entire District is composed of about 13,550 irrigated acres. The irrigated land area included in this study is approximately 1,650 acres. Review of recent aerial images indicates about 750 acres are irrigated under center pivots.

The diversion for the Upper Hanover Canal is situated on the west bank of the Big Horn River about one mile southwest of the area known as Winchester. Direct appropriation rights associated with the canal are 182.5 cfs with a flood flow right totaling 352 cfs (Nelson Engineering 1990). From 2010 to 2016 annual diversion averaged 97,314 ac-ft./year or 7.18 ac-ft./acre. Multiplying the per acre water use by the number of irrigated acres in the study area results in an estimated diversion amount of 11,847 acre –feet per year. A large proportion of cultivated land within the study area lays upslope from the canal, requiring pumped irrigation.

The canal parallels the river along its west side for a distance of three miles, then crosses the Big Horn River to the east side in an above-ground flume. The distribution system consists of the weir across the river, the main head gates, an open earth canal channel, and the flume across the Big Horn River. The canal continues in a northerly direction paralleling the Big Horn River towards the City of Worland and beyond for an overall distance of about 35 miles. Assessment for operation, maintenance and repair of the system was $16.00 per acre in 2016 (Washakie County Assessor's Office 2016).

The variety of crops raised in Washakie County is illustrated in **Table 3.8.3-1**. As further noted, although the percentages have varied over time, in recent years they have remained fairly stable. It's assumed that the composition of crops raised within this study area but situated in the UHID is the same as reported for Washakie County as referenced.

Table 3.8.3-1 Upper Hanover Crop Summary

Crop	Percent of Total Acreage in Upper Hanover Service Area
Alfalfa	20%
Beans	6%
Corn	11%
Grass Hay	13%
Spring Grains	26%
Sugar Beets	17%

Source: Wind Bighorn River Basin Plan Update (2010), Table 16

The most recent study completed for the District pertinent to the main canal and its structure is the Upper Hanover Rehabilitation Level II Study for WWDC (Nelson Engineering 1990).

That study and the associated evaluation recommended a number of improvements and rehabilitation needs. The status of those suggested improvements is unknown. No projects were identified in the Upper Hanover Irrigation District during the course of this study.

3.9 Existing Water Storage

3.9.1 Anchor Reservoir

Anchor Dam was constructed from 1957 to 1960 by the USBR. As noted in section 3.8.1 the reservoir developed sinkholes soon after filling and does not nearly hold its design capacity. It should be noted that the original Contract between the USA and Owl Creek Irrigation District for construction of Anchor Reservoir provided that water be stored for irrigation of 2,300 acres of land on Arapaho Ranch. The potential for sinkholes to develop within the reservoir basin was first documented by USBR in 1955, and subsequent investigations were completed prior to construction. However, upon initial filling in 1960/1961 sinkholes emerged and then collapsed, which precluded the possibility of filling the reservoir. Through 1971, USBR conducted soil borings, piezometer placement, radioisotope studies, gravimetric surveys, and infrared photography analysis all in attempt to more specifically identify problem areas in the reservoir floor. Through the same time frame, a number of contracts were issued to fill in emerging sinkholes. In 1970, the major sinkhole areas were diked off, with dikes rising to about elevation 6,410 feet. This completed efforts by USBR to seal the reservoir bottom. The 2008 Level II Study (Short Elliott Hendrickson 2008) concluded that operations in Anchor should not be altered and that an alternative storage facility would be more economic than attempting to investigate Anchor further. More information about Anchor Dam and reservoir is available in **Section 3.8.1.**

3.9.2 Other Storage Facilities

There are numerous other existing storage reservoirs within the project area that are adjudicated to store supplemental irrigation water. Many of these are in use, while others have fallen into disrepair. Irrigation storage is often coupled with livestock and wildlife use. All sites exhibit varied permit status and typically only serve one user with limited additional irrigation supply. These small sites are widely distributed across the project area and are generally off-channel storage structures that are filled early in the spring (**Figure 3.9.2-1**).

Analysis of WSEO reservoir data identified 75 sites as permitted for irrigation use only. Reservoir conditions such as condition (i.e. wet or dry), functionality (i.e. breeched or not breeched), and its potential as a water source were evaluated using 2017 aerial imagery. In addition to the conditions listed above, reservoir capacity was examined. Irrigation reservoirs that were classified as wet and functional were analyzed to determine if they held a quarter of, half of, or their full capacity. **Table 3.9.2-1** summarizes the findings.

Table 3.9.2-1 WSEO Irrigation Permitted Reservoirs

Total of 75			
Functional		Non-Functional	
Wet	Dry	Wet	Dry
19	13	0	43

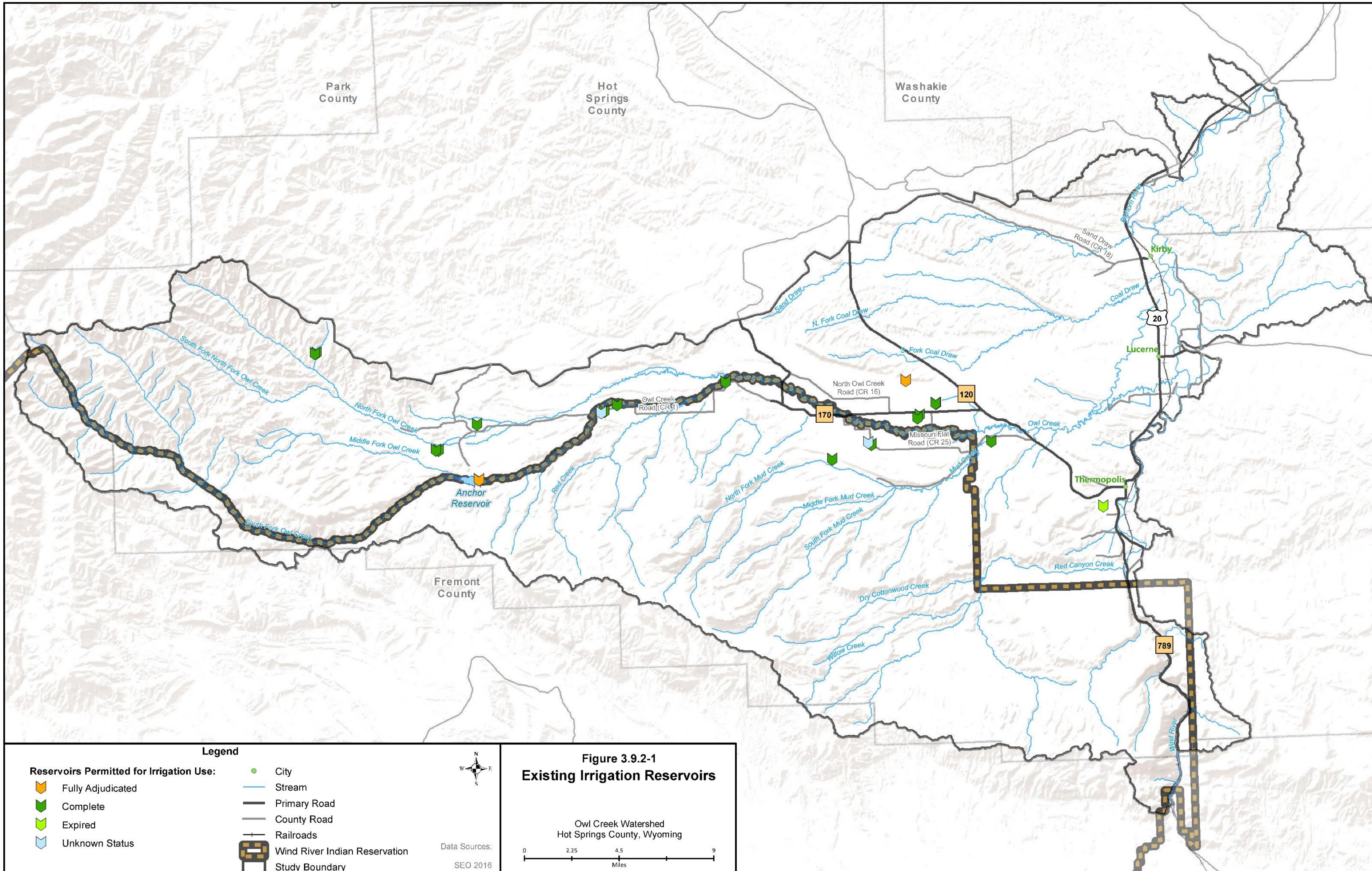

Figure 3.9.2-1
Existing Irrigation Reservoirs

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Fourteen of the nineteen reservoirs classified as Functional and Wet were determined to hold full capacity. Results of the full analysis can be found in **Appendix F**.

Numerous upland water supply sources currently exist within the study area, and varying range improvement projects have been completed which utilize these existing water sources. Typical sources include reservoirs, developed springs, and stock tanks. All water sources are utilized by livestock and/or wildlife throughout the year.

Mapping of existing water sources provides valuable information for the completion of the watershed management plan and also aids in determining placement of new water sources. Mapping efforts for this study did not create an exhaustive list, as doing so was beyond the scope and feasibility of the study., however, all BLM-permitted and SEO-permitted stock reservoirs are included in the report database, and are included in **Figure 3.9.3-1** and **Table 3.9.3-1**.

3.9.3 Wildlife and Livestock Reservoirs

Numerous upland water supply sources currently exist within the study area, and varying range improvement projects have been completed which utilize these existing water sources. Typical sources include reservoirs, developed springs, and stock tanks. All water sources are utilized by livestock and/or wildlife throughout the year.

Mapping of existing water sources provides valuable information for the completion of the watershed management plan and also aids in determining placement of new water sources. Mapping efforts for this study did not create an exhaustive list, as doing so was beyond the scope and feasibility of the study., however, all BLM-permitted and SEO-permitted stock reservoirs are included in the report database, and are included in **Figure 3.9.3-1** and **Table 3.9.3-1**.

Table 3.9.3-1 Livestock and wildlife water sources

WSEO Stock Well Data	WSEO & BLM Stock Reservoir Data	HSC Stock Tank Data
238	86	6

The following sources were used to identify wildlife and livestock reservoirs for this study:

- Stock reservoir data were obtained from the WSEO and Worland BLM Field office. Only those data pertaining to reservoirs permitted specifically for stock use were included.
- Stock well data were obtained from the WSEO. The BLM provided well data, but these data overlapped with WSEO stock well data.
- Spring data were also received but not included in the figure, due to the difficulty of confirming whether the spring is a developed, viable water source using aerial imagery. However, these data are available within the Project GIS for review, use, and analysis.
- Interviews with landowners were conducted during project meetings and in the field. During these interviews, locations of existing sources were documented when encountered and the information incorporated into the project GIS.

Analysis of the WSEO and BLM data indicate the presence of 86 reservoirs permitted for stock use. Field inspection of the sites was beyond the scope and budget of this project, however, aerial imagery using Google Earth was used to evaluate reservoir conditions. Maps of reservoir sites were overlain by multiple years of imagery using those years that provided the highest resolution aerial photography available (September 2014, September 2011, & April 2010). This was done in order to more accurately determine the status of each reservoir over time and reduce error as much as possible due to dry or wet water years. Reservoirs were then classified into three categories based on functionality. Images of reservoirs showing varying levels of functionality are shown in **Figure 3.9.3-2 a, b, c, & d**.

- **Functional** – Reservoirs that contained water in multiple years of photography or showed no signs of physical breaches or sedimentation were determined to be functional.
- **Non-Functional** – Reservoirs that showed apparent sign of physical breach or were visibly filled with sediment were determined to be non-functional.
- **Potential** - Reservoirs that contained water in one year of photography or showed no visible signs of damage were determined to be potential water sources.

Figure 3.9.3-3 displays a map of the study area showing the results of this classification for BLM and SEO reservoirs. Based upon this analysis, it appears that a minimum of 36 stock reservoirs remain “functional” water sources and 22 are “potential” water sources. The analysis also indicates that 27 stock reservoirs are “non-functional” water sources as they are either breached, sediment filled, or do not exist any longer and would require a site visit to determine their true status. **Appendix F** presents the results in a tabular format including Township, Range and Section data, and lat/long locations.

Figure 3.9.3-4 shows all functional and permitted water sources identified for this report. This includes functional stock tanks, reservoirs, and wells permitted for stock use. Note that this figure does NOT include surface water sources such as perennial streams, intermittent streams, or springs because a primary objective of this study is to evaluate opportunities that provide wildlife and livestock water in addition to these sources. Because they do not presently appear to provide sources of water to livestock or wildlife, reservoirs which appeared to be either breached, filled with sediment, or otherwise non-functioning, are not included in this figure.

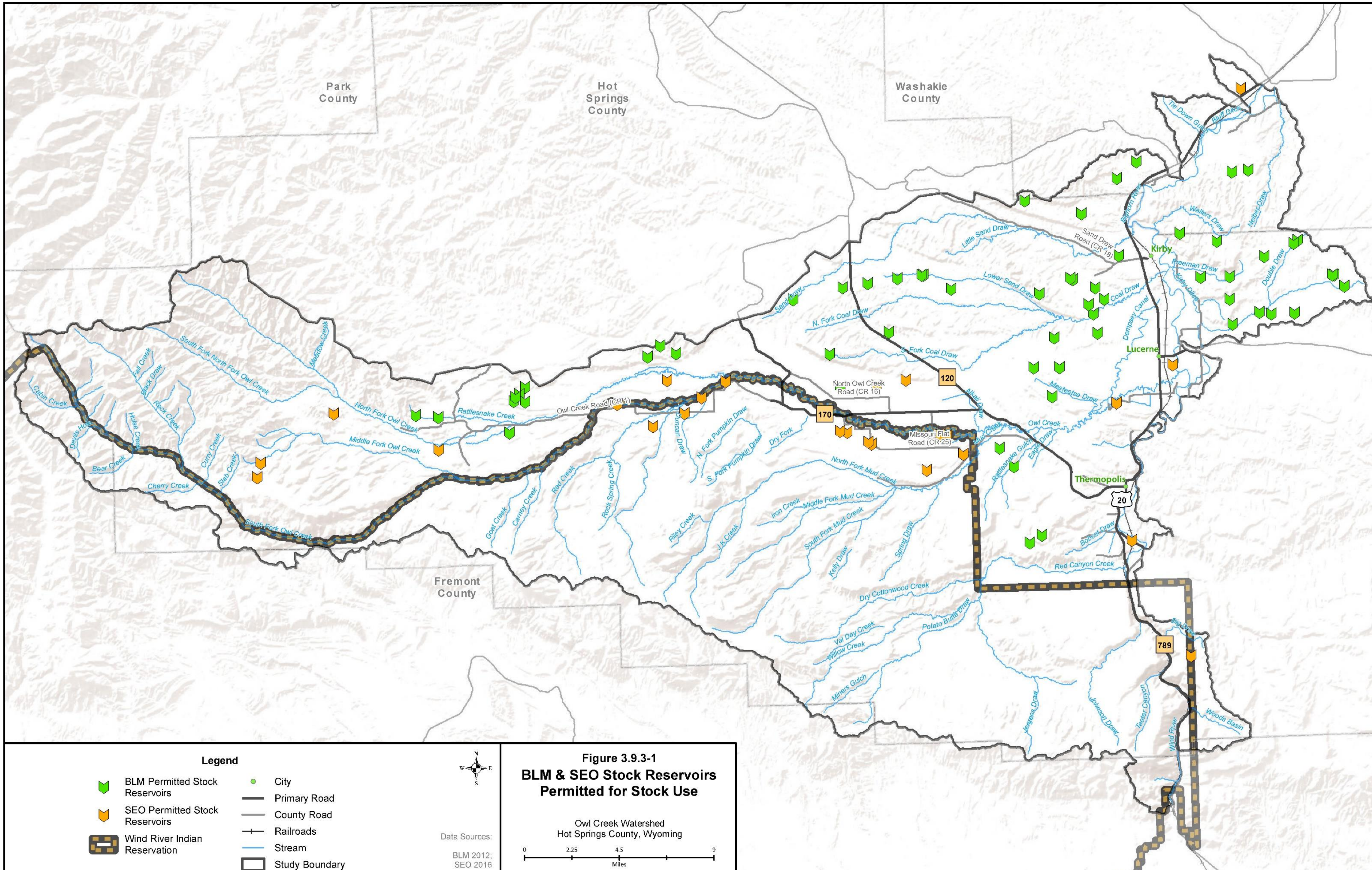

Figure 3.9.3-1
BLM & SEO Stock Reservoirs Permitted for Stock Use

Owl Creek Watershed
Hot Springs County, Wyoming

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Figure 3.9.3-2a. Example of a Functional reservoir, no physical breeches or sedimentation. (Source: NAIP Imagery 2015)

Figure 3.9.3-2b. Example of a Non-Functional reservoir. Old reservoir (on the right) breeched leaving it non-functional. (Source: NAIP Imagery 2015)

Figure 3.9.3-2c. Example of a Non-Functional Reservoir, shows evidence of sedimentation and vegetation overgrowth. (Source: NAIP Imagery 2015)

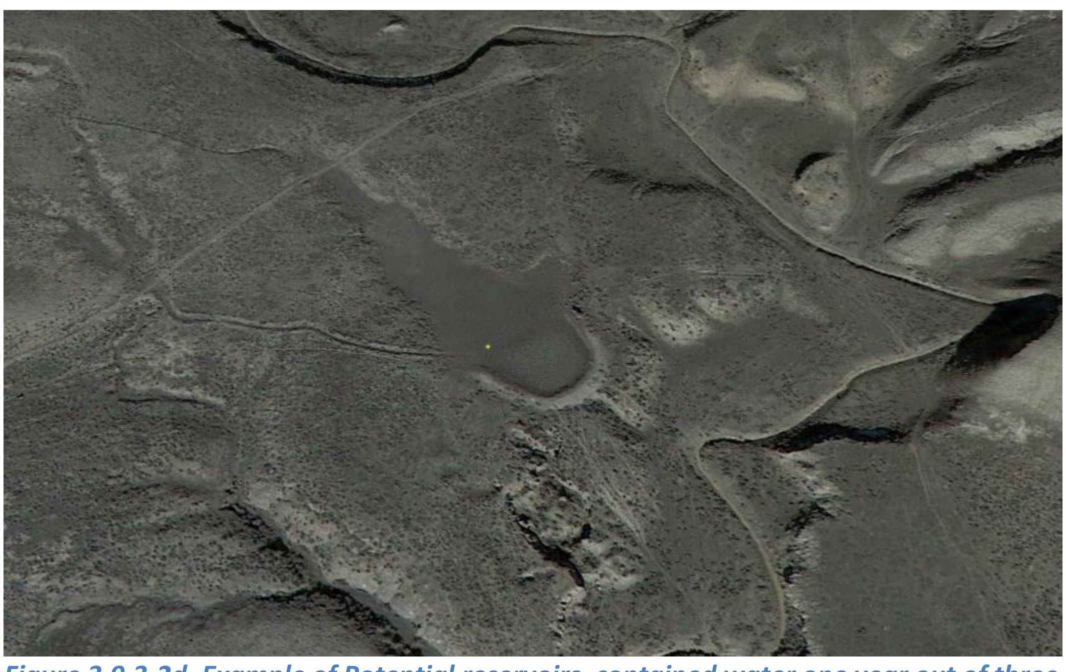

Figure 3.9.3-2d. Example of Potential reservoirs, contained water one year out of three analyzed and showed no signs of physical damage (Source: NAIP Imagery 2015).

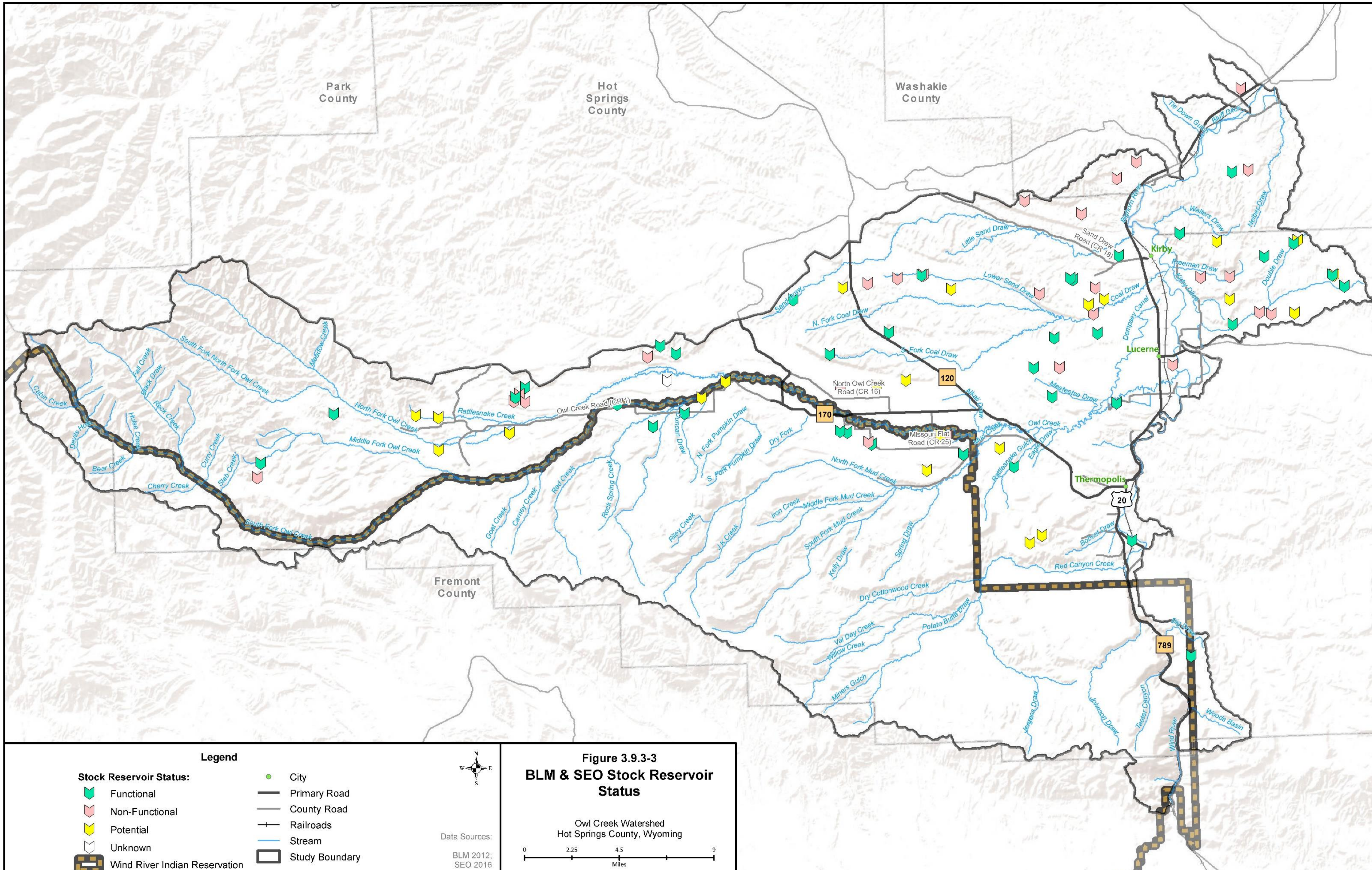

Figure 3.9.3-3
BLM & SEO Stock Reservoir Status

Owl Creek Watershed
Hot Springs County, Wyoming

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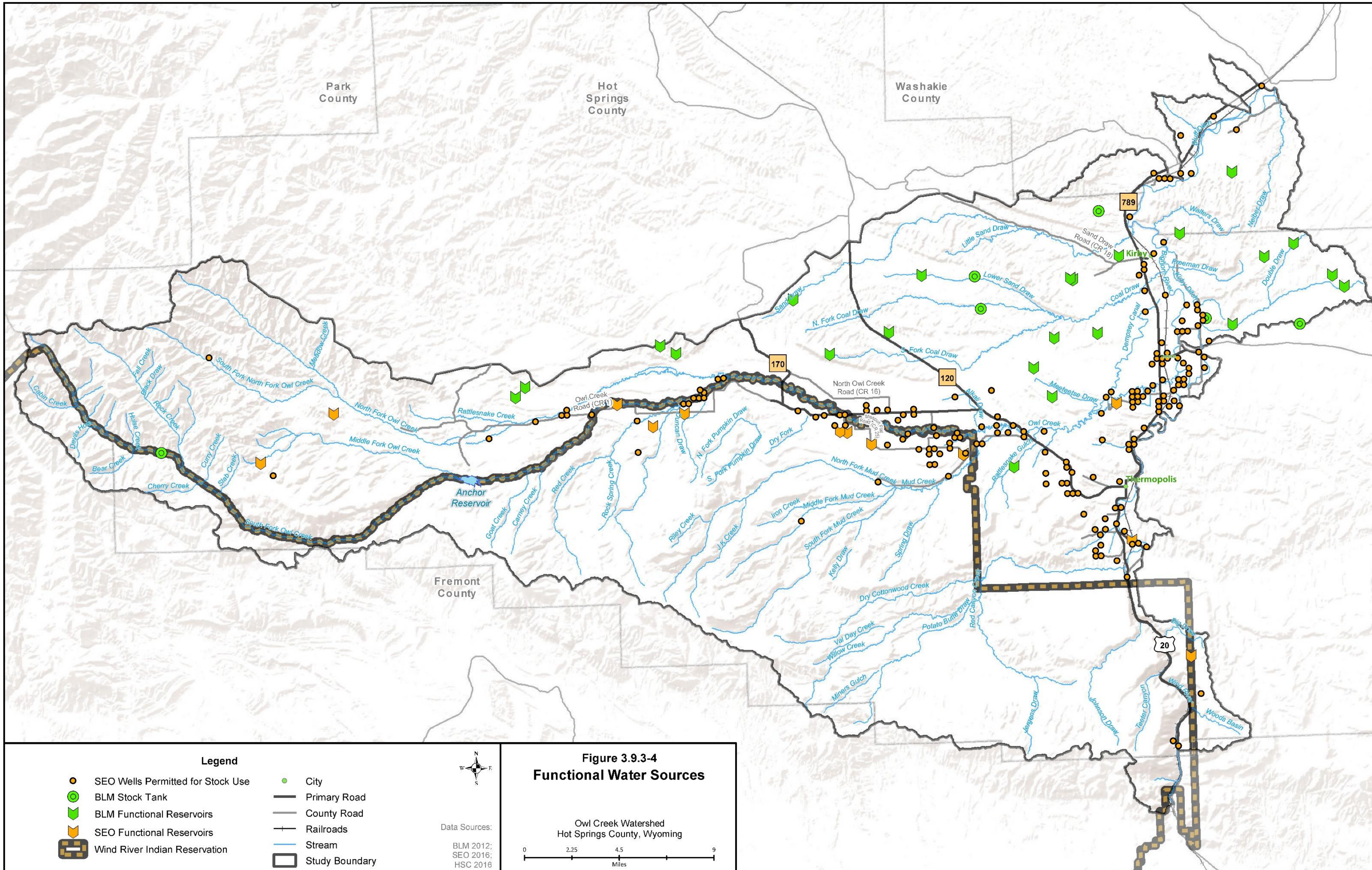

Figure 3.9.3-4
Functional Water Sources

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3.10 Existing Spring Developments

Groundwater is naturally discharged by springs and seeps, by evapotranspiration, and by discharge to streams and other aquifers. Springs and seeps occur when the water table intersects the land surface (USGS, 2016). This commonly is the result of changes in lithology, faults, fractures, and topography. Spring flows vary widely due to the nature of the aquifer/structure discharge, the amount of seasonal recharge from snowmelt and rainfall, depletion of storage during periods of drought, and even evaporation and evapotranspiration at the site of the spring. The flows can be concentrated or diffuse, again depending on the nature of the geologic conditions causing the spring (UNPRW, 2015).

There are many natural springs present within the project area. A map of developed springs based on WSEO, USGS, and BLM data is located in **Section 3.3.2.** LW was able to visit approximately four spring locations during the field inventory exercise. Of the springs visited, most had been developed with a spring box and cutoff curtain and were primarily used for stock watering. **Figure 3.3.2-2** presents a compilation of springs data for the study area gathered from WSEO, BLM, WSGS, and field inventory. The viability of these springs was difficult to note using only aerial photography. However, WSEO spring data are likely more substantial springs, as they have attracted sufficient attention to warrant establishing an explicit water right for a specific beneficial use. Smaller springs and seeps often occur as a result of local conditions such as recharge, topography, and aquifer permeability. It is important to note the micro-habitats that flourish near these sources, each supporting wildlife and livestock.

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4 WATERSHED MGMT. AND IRRIGATION SYSTEM REHABILITATION PLAN

4.1 Overview of Issues and Opportunities within the Watershed

As part of the watershed study, the LW team was tasked with developing a watershed management and irrigation system rehabilitation plan. By using information gathered from previous studies, field collected data, proposed improvements, and stakeholder meetings, LW was able to learn about and describe the major issues that affect the project area. Early on in this venture, it became evident that several of these key issues were directly related to:

1. **Failing or inadequate infrastructure:** Many diversions, headgates, and ditches are well over 30 years old and have had only rudimentary improvements made. Many diversions and headgates need to be repaired or replaced, or have been moved from their original permitted location due to headward erosion. During a meeting with WSEO on December 16, 2016, the LW team was told that many landowners are concerned that the people with the best infrastructure are often the only people to receive adjudicated flow.
2. **Poor or non-existent measurement capabilities:** There are 53 individual ditches on north and south Owl Creek. The only point of measurement is at the main headgate of each ditch where it leaves Owl Creek. The sandy soils fill Parshall flumes so that measuring is inaccurate, or the flumes are bypassed all together. Flow measurements are conducted by the SEO approximately weekly at the point of diversion; the OCID does not employ a ditch rider.
3. **Excessively long open channel ditch laterals serving limited acreage:** There are many redundant irrigation ditches that could conceivably be combined into a more centralized system. A plan was developed as part of the Anchor Dam project but when the dam failed to hold adequate water, irrigation infrastructure improvements were tabled. A modernized irrigation system for Owl Creek would require fewer diversions, which could be constructed to provide more accurate measurement and distribution of water. Upgrading open, earth-lined ditches to pipe would conserve water and in several cases, shorten the distance and time required to transport water to fields.
4. **Flashy or inadequate flows and limited water storage:** The irrigation systems within the upper and middle watershed areas have been extensively studied, yet very few improvement projects have advanced to construction. Consequently, these areas still suffer the effects of water shortages, especially in mid to late summer. Field reconnaissance confirmed that while Anchor Reservoir is not operating at its full potential, it still provides some benefit through storage and flood flow minimization. This was clearly illustrated when comparing stream bed morphology of the North Fork with that of the South Fork. The Rosgen analysis completed and shown in table 3.5.3-1 illustrates this contrast: most reaches studied on the North Fork of Owl Creek are wide or braided and cobbly, indicating significant erosion and sediment transport during common high flood flows. The South Fork of Owl Creek tends to be contained within more stable B or C channels that are commonly vegetated with grass, willows, and cottonwoods, indicating less damaging flood flows.

During an office meeting with WSEO staff on December 15, 2016, operation and maintenance issues that impact the upper and middle areas were discussed. When landowners are not under regulation they take as much water as they possibly can. A transition away from this usage pattern to one that is more sustainable would be a responsible management goal. If users would divert only their adjudicated water flow allotment when not under regulation, the excess water could be theoretically stored, effectively extending the overall irrigation season. WSEO staff stated during this meeting that this theoretical water could be easily stored within Anchor Reservoir or another location. The overutilization of high flow times coupled with failing measurement capabilities result in poor overall management capabilities. This assessment is supported by visual inspection of failing or inadequate infrastructure throughout the project area during the project inventory.

5. **Concern over water rights and distribution:** During the meeting with the WSEO, the impacts of Tribal, or Federal Reserved Rights, and Walton Rights were discussed. According to the 2016 hydrographers usage report, Provisional data suggests that a total of 9,839.8 ac-ft. were awarded to lands that exercise Tribal and Walton Rights for the 2016 water year. Of this, only 5,986.7 ac-ft. were reported to be used. This leaves a balance of 3,853.1 ac-ft. that was awarded to Tribal and Walton Right users but was never used. If owners of these water rights were to divert all of the respective adjudicated flow, then the remaining users would likely experience a decrease in available flow year to year. This aspect and the potential consequences should be carefully analyzed before any potential improvement project could proceed.

These five overarching issues are compounded by an understandable reticence of irrigation district members to support large scale projects that might address storage and distribution – or fail, as Anchor Dam did. Although several sites for other reservoirs were identified in the 2004 and 2008 studies of Owl Creek (Nelson Engineering, 2004, SEH 2008), little concerted effort has occurred within the Owl Creek Irrigation District to follow through with these projects.

During project meetings and landowner interviews for this study there was clearly more interest in individual ditch improvements or on-farm improvements that could be developed by one or a few landowners than in larger irrigation district-wide projects. In fact, the directive for this effort as requested by the sponsor (HSCD) was to focus on small, on-farm improvement projects.

4.2 How the Watershed Management Plan is Organized

This Watershed Management Plan addresses options identified by local landowners for improving watershed function and irrigation efficiency of the Owl Creek Watershed and the surrounding study area. Information contained within this management plan is based on previous studies prepared for WWDC, and landowner interviews completed during 2016 and 2017. It is the hope that this watershed study will assist the sponsor of this study, HSCD, determine which projects are most feasible and economical, and provide basic information that will assist in implementing these projects.

Section 4.3 of this report reviews the main characteristics of previously proposed water development projects.

Section 4.4 provides detailed information about projects identified during this watershed study. Each of the five sub-sections within Section 4.4 includes a list of projects identified during the study. Each project is then further described with:

- A simple written description;
- A conceptual design drawing/map. Designs were prepared for each project to a conceptual level using an aerial photo as background in order to support the cost estimates. In addition drawings showing a typical check structure, typical farm turnout (FTO) and typical stock reservoir/dam schematic can be found in **Appendix G.** Due to the number of projects inventoried and considered, some standardization of materials was necessary in the designs including but not limited to:
- 2" HDPE surface piping for stock tank supply
- stock tanks with clay bottoms and 4700 gallon size
- All ditch to pipe conversions and other buried pipe were designed with wall thickness conforming to SDR-41. In some cases the pipe wall may be thicker than what a detailed final design would require. The reasons for selecting a thicker walled pipe are:
    - Less susceptible to breakage during transportation, off-loading, construction handling, backfilling
    - More durable and resistant to backfilled rock breakage/ or rock penetrating the pipe wall
    - Rocky conditions prevalent in some project areas combined with un-inspected backfilling operations
    - Less susceptible to impact breakage as a result of agricultural equipment wheel loading during operating life
    - Overall factor of safety further insures durability during construction and operating life of the pipe
    - Normally SDR 41 pipe is readily available where some of the other specified pipe is more difficult to obtain
    - Provide a reasonable pipe thickness specification that could generally be used in conceptual designs throughout the project area even though laying conditions, terrain, and subsurface conditions vary.
- An estimated cost;
- Whether and how the project can be funded with WWDC funds, and a list of other potential sponsors/agency funding options specific to that project;
- Whether the project would be considered a new or a rehabilitation project according to WWDC guidance;
- Likely permits required (if any) from local, state, or federal agencies;
- Any challenges, fatal flaws identified (such as extreme cost), and number of landowners/users served; and
- The appropriate Net Effect Diagram (NED) to use in funding applications to show potential positive and negative effects of the project.

Section 5 of the Watershed Management Plan presents the benefits and goals of watershed planning, and provides a Net Effect Diagram, or NED, that provides information on the potential costs and benefits of a proposed project type to the surrounding watershed ecosystem. This information is particularly useful if applying for federal funds.

Section 6 provides an explanation of how project costs were estimated and provides a detailed breakdown of costing and the sources of costs.

Section 7 provides a 3-level ranking matrix of all projects identified during this watershed study. Ranking criteria are based on WDO priorities as well as priorities declared by the watershed study sponsor (HSCD). This matrix is designed to help HSCD determine what projects to support and move forward to consideration by the WDO or other funding entities. The matrix compares projects in terms of cost, each project's role in the maintenance and function of the watershed and the irrigation infrastructure, and other factors. The matrix provides a subjective evaluation of each project without regard to landowner identity, and thus provides an unbiased third party assessment (WDO 2015).

Projects that receive funding from the WWDC must be sponsored by a public entity that can legally receive state funds, incur debt, generate revenues to repay a state loan, hold title and grant a minimum of a parity position mortgage on the existing water system and improvements associated with the project, or provide other adequate security for the anticipated state construction loan. A project sponsor can be a municipality, irrigation district, joint powers board, or other approved assessment district that will realize direct benefits of the project (WDO 2015).

The project sponsor, which would be HSCD, may request funding from WWDC for **Small Watershed Projects (SWPPs)** if the total cost of a project is estimated to be less than $135,000. Applications are submitted by January 1, 2018 and construction is possible the same year (WDO 2015).

If the project cost is estimated to be more than $135,000, the project would be considered a **Conventional Project**. The sponsor may choose to apply for a WDO **Level II** study to identify alternatives and solutions to a water supply issue. If it is determined the project is technically and economically feasible and serves to meet a water supply need or alleviate a water supply problem, regardless of whether a Level II study is completed, the sponsor may request cost-share funding for a **Level III** construction project (WDO 2015). Further details about funding is found in Section 7.

Section 8 presents potential project funding sources for different types of projects and the basic requirements one needs to follow to apply for the various funds. Many options are included here and one may find that there are some creative sources of funding that one may be able to use if one "thinks outside the box" on how to make a viable project that helps one's operation and the surrounding watershed.

Section 9 presents the various types of permits that may be required for different project types and includes some less-obvious permits, such as a mining permit, that may be needed if one is considering new ways of developing a water project. The section includes some of the major points to remember when applying for these permits.

Section 10 provides a summary of the main findings of the watershed study and management plan and provides recommendations on what projects appear most fundable and what project are most important to supporting agriculture and the health of the watershed.

4.3 Storage Projects proposed in previous studies

4.3.1 Owl Creek Storage Projects

Following the Owl Creek Master Plan, a Level II study was performed in which Anchor Reservoir and six other storage alternatives were analyzed for construction or improvement (SEH 2008). No solutions were identified that would return Anchor Reservoir to its original storage status (i.e. filling to full reservoir contents). The Wind-Bighorn study identified two preferred sites for new reservoirs, but recommended that additional studies be performed to further develop more detailed hydrologic, water rights and reservoir operations modeling to refine existing irrigation needs, available flows, and storage opportunities (WBH 2010 Plan Update).

The 2010 Wind Big Horn Plan Update water supply availability and shortage analysis determined that there is not adequate available water within the Owl Creek sub-basin to fully meet existing diversion requirements, even if storage in the watershed were to be developed. However, as part of the 2013 Update to this watershed study, a more detailed water supply availability and shortage model was developed which estimated monthly flow volumes at 80 nodes throughout the watershed for wet, dry, and average year scenarios.

According to this model, both North Fork and South Fork Owl Creek above their confluence likely have available streamflow throughout the irrigation season for each of the wet, dry, and average year scenarios. Below the confluence of North Fork and South Fork Owl Creek, there is water available within the main stem of the Owl Creek sub-basin during wet and average year scenarios only. The model suggests that the lower reaches of the main stem of Owl Creek see a drastic drop in available streamflow during dry year scenarios when there is likely little to no water available. Results of this study are discussed in **Section 3.3.5.**

It is apparent that shortages do exist within the watershed as many landowners have voiced concerns of limited water availability, particularly late in the irrigation season. These reports from the landowners are supported by modeled streamflow availability analysis, which estimates that little to no streamflow is available to meet existing irrigation requirements during dry and average years in the lower reaches of the watershed. However, there does appear to be excess water available during April, May, and June coinciding with the spring melt and runoff. These times of excess flow are times when irrigators are not usually under regulation and water use is unimpeded. Based upon discussions with SEO staff and the analysis of the data provided by the model it appears that there is the potential for water storage in the upper reaches of the watershed, possibly within Anchor Reservoir, during this time. This stored water could then be used to extend the irrigation season to the benefit of the users, especially those lower in the watershed.

4.3.2 Kirby Canal Storage Projects

In the 2010 Kirby Irrigation District Conservation Program Level II, six potential reservoir sites were identified. Of these, only one site was located within the study boundary. This site was identified as site 5-Warm Springs Re-regulation Reservoir. This site was considered as an alternative to put operational waste to beneficial use within the KID. The reservoir would be located under the Kirby Canal and was estimated to hold 100 ac-ft. and benefit 775 acres of irrigated land with supplemental supply. The structure would consist of an excavated impoundment combined with a relatively short embankment (10 feet or less). The reservoir would release into abandoned portions of the Warm Springs Ditch.

Rehabilitation of approximately three miles of would be required and assumes placement of a pipeline (18 inch to 24 inch) to convey as much as 15 cfs, along with installation of turnout structures to deliver the storage water to the users located downstream. Total construction cost was estimated to be $1.4 million in the 2010 report (Anderson Consulting 2010).

4.3.3 Anchor Reservoir Upgrades

Several studies have been completed to investigate the possibility of improving Anchor Reservoir. These are discussed in **Section 3.8.1**. The 2008 Level II Study (Short Elliott Hendrickson 2008) concluded that operations in Anchor should not be altered and that an alternative storage facility would be more economic than attempting to investigate Anchor further.

4.4 Project Opportunities Currently Proposed

As described in Tasks 3 and 5 of our initial contract with WWDC, the LW team completed a watershed inventory and description. Early on, LW was advised by the HSCD that the focus of this effort should be to improve on-farm efficiencies and address landowners' individual needs. To complete this task, LW staff initiated public outreach to meet with producers and inventory projects of interest by individual landowners. LW received overwhelming public interest in this effort, and cataloged over 87 individual projects. These projects range in scale from small upland range improvements affecting only 1 user to large conveyance rehabilitation projects affecting multiple users on a given ditch lateral.

To maximize efficiency during the field effort, a landowner questionnaire was developed and used to gather all preliminary data for each producer's specific operation. This information was then cataloged separately from the project specific inventory data and used to aid in the economic analysis, the riparian health and environmental assessment, Rosgen classification, and understanding of range condition on that property. These data were collected using an integrated GPS and GIS system that facilitated desktop analyses of the background landscape and of each project identified to develop conceptual designs and costs. Project maps were developed using a combination of Hot Springs County Assessor data, WYDOT, SEO, GIS Data from existing studies, and field data collected during this study. These sources may have minor discrepancies relative to each other. All maps are for reference only and are not for construction.

Due to a high level of public interest in the watershed study, the number of landowners requesting projects for inclusion in the report exceeded the scope and budget set forth by LW's initial contract with WWDC. To accommodate all interested landowners, the LW team conducted workshop interviews at the Bighorn Federal Bank in Thermopolis on two occasions, March 9 and March 29, 2017, to identify additional projects in a "workshop" setting. These interviews did not include a field visit, photographs, or field measurements. Instead, a brief project description and cost based on other apparently similar projects was prepared for each project identified using landowner-provided estimates and approximations. When landowners prepare applications for these workshop projects, the example projects can very likely be used as models for funding applications or design work.

This section is broken down into five sub-sections that describe the five categories of projects identified. Project categories are shown in **Table 4.4-1**:

Table 4.4-1 Project Categories	***Project Type***	***# of Projects Inventoried***
Irrigation System Improvements	ISYS	52
Irrigation Storage Projects	ISTO	4
Stream Channel Stability and Rehabilitation Projects	SCS	6
Upland Range Improvements	URI	14
Other Watershed Improvements	OWI	10
Other Recommended Watershed Improvements	Level II	3
Totals		89

4.4.1 Irrigation System Improvements (ISYS)

Fifty-two (52) irrigation system improvement projects were identified. Of these, 32 projects were identified during on-site landowner interviews, and 20 projects were identified during workshop meetings. Each project is described below, numbered in sequential order from upstream to downstream. Most, but not all, of the projects identified and characterized on-site have a large-scale map illustrating conceptual project design. Workshop interviews do not have project-specific maps. **Table 4.4.1-1A and Table 4.4.1-1B** summarize each project's characteristics. **Figure 4.4.1-1** illustrates the locations of proposed ISYS projects within the study area.

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Table 4.4.1-1A ISYS Projects

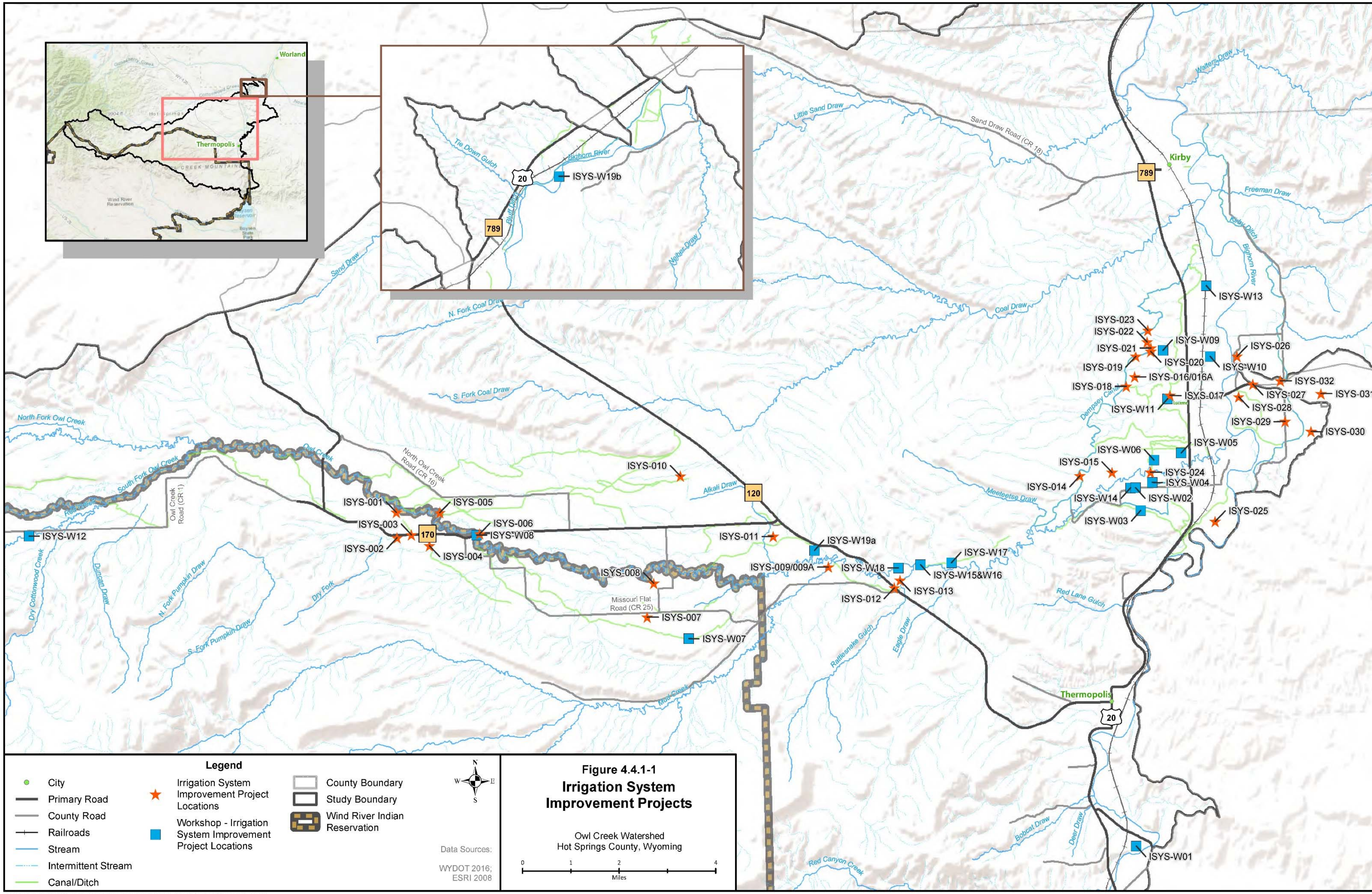
Project Number	Ditch/ Stream	Location	No. of Users	Estimated Acreage Served (Acre)	Pipeline Length, Size, & Material	New Center Pivot	New Gated Pipe	Brief Description
ISYS-001	Woodard	S34, T9N, R3E	2	30	4000' 10" PVC (PIP) SDR-41			Install buried pipeline, measuring devise, FTO, air vent
ISYS-002	Chessington-Wilson	S3, T8N, R3E	3	35	110' 10" PVC (PIP) SDR-41 520' 10" PVC Surface Pipe		X	Install new buried pipeline and new gated pipe. Update check structure
ISYS-003	Chessington-Wilson	S3, T8N, R3E	3	65	2080' 12" PVC (PIP) SDR-41			Install new buried pipeline and upgrade splitter box. Install flow measurement risers for midstream user
ISYS-004	Woodard-Johnson	S3, T8N, R3E	4	315	2300' 21" PVC (PIP) SDR-41			Install buried pipeline and reroute flow under adjacent field
ISYS-005	Winchester	S35, T9N, R3E	6	350	9500' 24" PVC (PIP) SDR-41			Convert a portion of the Winchester Ditch to buried pipeline, include sand trap, rip-rap
ISYS-006	Merrill	S11, T43N, R97W	1	50	600' 24" PVC (PIP) SDR-41			Install buried pipeline
ISYS-007	South Side	S16, T8N, R4E	1	70	1200' 10" PVC Surface Pipe		X	Permit wells for stock and irrigation use. Install windmill and construct stock reservoir. New gated pipe. 3 Existing Wells for permitting, 1 new well to be drilled
ISYS-008	Ready	S9, T8N, R4E	1	6	N/A			Install new FTO with measuring device and Pod sprinkler system
ISYS-009/009A	Martin	S13, T43N, R96W S19, T43N, R95W	3	520	7950' 21" PVC (PIP) SDR-41 1080' 10" PVC (PIP) SDR-41			Convert a portion of the Martin Ditch to buried pipeline
ISYS-010	Thompson	S9, T43N, R96W	1	60	4000' 10" PVC (PIP) SDR-41			Reconstruct a portion of the Thompson ditch and install buried pipeline
ISYS-011	Hale	S14, T43N, R96W	1	35	1700' 12" PVC (PIP) SDR-41 4870' 10" PVC Surface Pipe		X	Install new buried pipeline, measuring device and new gated pipe
ISYS-012	Martin	S19, T43N, R95W	1	30	650' 10" PVC (PIP) SDR-41	X		Install half center pivot , measuring device and buried supply line
ISYS-013	Martin	S19, T43N, R95W	1	38	270' 12" PVC (PIP) SDR-41 1200' 10" PVC Surface Pipe		X	Install new buried pipeline and new gated pipe
ISYS-014	Upper Lucerne	S11, T43N, R95W	1	5	1000' of 2'' HDPE buried pipeline. 1800' of 10'' drain tile pipeline.			Install drainage system and solar sump pump
ISYS-015	Upper Lucerne	S2, T43N, R95W	1	110	5330' 15" PVC (PIP) SDR-41			Install buried pipeline
ISYS-016/016A	Upper Lucerne	S36, T44N, R95W	2	35	1400' 10" PVC (PIP) SDR-41			Install buried pipeline, measuring device, check structure and splitter box
ISYS-017-023	Upper Lucerne Lower Lucerne	S36, T44N, R95W S30, T44N, R94W	3	495	N/A			Install/replace 7 flow measurement devices. 6 metal long throated flumes and 1 in-stream flow device
ISYS-024	Lucerne	S7, T43N, R94W	N/A	N/A	180' 42" HDPE			Rehab of Lucerne Canal siphon under Owl Creek including tube, approach and discharge aprons and walls, air vents and rip-rap
ISYS-025	Cyclone	S17, T43N, R94W	5	200	2600' 15" PVC (PIP) SDR-41			Install buried pipeline to supply 5 landonwers and install 5 new FTO
ISYS-026	Kirby Canal	S28, T44N, R94W	1	10	800' 8" Surface Pipe		X	Install new gated pipe
ISYS-027	Kirby Canal	S33, T44N, R94W	1	100	1300' 10" PVC (PIP) SDR-41	X		Install half center pivot and buried supply line with measuring device
ISYS-028	Kirby Canal	S33, T44N, R94W	1	30	3500' 10" PVC (PIP) SDR-41 1000' 10" PVC Surface Pipe			Install buried pipeline and gated pipe
ISYS-029-30	Kirby Canal	S4, T43N, R94W	1	110	1800' 10" PVC (PIP) SDR-41 1000' 10" PVC Surface Pipe	X	X	Install half center pivot and buried supply line. Install new gated pipe, 2 new FTO with measuring device's
ISYS-031	Kirby Canal	S34, T44N, R94W	1	20	1850' 10" PVC (PIP) SDR-41 900' 10" PVC Surface Pipe		X	Install new buried pipeline with measuring device, and new gated pipe
ISYS-032	Kirby Canal	S33, T44N, R94W	3	166	1680' 10" PVC (PIP) SDR-41 1250' 10" PVC Surface Pipe		X	Install new buried pipeline with measuring device, new FTO, and new gated pipe

*All values were estimated either during time of field visit or after desk top analysis. All values should be confirmed prior to processing of the project.

Table 4.4.1-1B ISYS Projects

Project Number	Ditch/ Stream	Location	No. of Users	Estimated Acreage Served (Acre)	Pipeline Length, Size, & Material	New Center Pivot	New Gated Pipe	Brief Description
ISYS-W01	Big Horn	S13, T42N, R95W	1	15	15 HP motor and high effeciency centrifugal pump			Replace existing pump and motor and install 4 inch HDPE SDR 11 laterals to sprinkler heads.
ISYS-W02	Upper Lucerne	S12, T43N, R95W	1	2	450' 10" PVC (PIP) SDR-41			Installing buried pipe in county road right-of-way, through existing culvert under the road.
ISYS-W03	Upper Lucerne	S12, T43N, R95W	12	100	Unknown			Replace aproximately 2,400' of degraded concrete lining of an open channel ditch
ISYS-W04	Lower Lucerne	S7, T43N, R94W	3	20	320' 12" PVC (PIP) SDR-41			Install new buried pipeline with measuring device
ISYS-W05	Owl Creek	S6, T43N, R94W	1	NA	7,760' of perforated drainage system. Size to be determined			Install perforated drainage system
ISYS-W06	Lucerne Canal	S7, T43N, R94W	1	40	25 HP vairiable flow pump			Replace 2 existing pumps with one larger more efficent pump
ISYS-W07	South Side	S15, T80N, 40E	2	80	1600' Buried pipe, 4 headgate structures, and 2,700' of gated pipe		X	Change POD for one landowner and replace 3 existing degraded headgates. Install gated pipe for both users
ISYS-W08	Owl Creek	S11, T43N, R97W	1	15	400' Buried pipe, 1600' gated pipe		X	Install new POD and pump system to feed proposed gated pipe
ISYS-W09	Upper Lucerne Canal	S30, T44, R94W	2	NA	1500' 12" PVC (PIP) SDR-41			Install new buried pipeline with measuring device and new FTO
ISYS-W10	Lucenre Canal	S29, T44N, R94W	1	30	Siphon size and specifications to be determined			Install siphon under drainage channel
ISYS-W11	Lower Lucerne Canal	S31, T44N, R94W	4 or 5	100	4,800' 12" PVC(PIP) SDR-41			Install buried pipeline, new FTO risers with measuring devices for each user
ISYS-W12	Red Creek	S34, T90N, R20E	2	50	1,670' 16" PVC (PIP) SDR-41			Install two separate lengths of buried pipe; starting at diversion off of Red Creek
ISYS-W13	Big Horn	S06, T44N, R94W	1	163	1,100' 15" PVC (PIP) SDR-41			Install 1,100 feet of buried pipe to supply pivot
ISYS-W14	South Side	S12, T43N, R95W	5	45	4,200' UNK" PVC (PIP) SDR-41			Install buried pipeline to supply 5-6 landonwer with irrigation water
ISYS-W15&16	McManus	S17, T43N, R95W	2	228	24" headgate			Rehabilitate 24" headgate
ISYS-W17	McManus	S17, T43N, R95W S16, T43N, R95W	1	85	Unknown			Rehabilitate or replace 6 different FTO
ISYS-W18	Hale #2	S18, T43N, R95W	1	?	Unknown			Rehabilitate or replace the 24" headgate on Hale #2 ditch
ISYS-W19	Owl Creek	S13, T43N, R96W	1	10	1,200' PVC (PIP)			Install buried pipe to feed existing open ditch
ISYS-W20	Owl Creek	S10, T80N, R40E	1	100	5000' of 18-24" PVC (PIP) SDR-41			Install 5000' of buried pipe for irrigation

*All values were estimated either during time of field visit or after desk top analysis. All values should be confirmed prior to processing of the project.



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ISYS-001

A portion of the Woodard Ditch leaks through the sidewall and floods the adjacent property, which causes erosion. The ditch sidewall is weakened over time, resulting in decreased channel stability and increasing seepage loss. The ditch currently serves two users. One of the landowners would like to convert the open channel ditch to buried pipe. Two potential starting points for the pipe were discussed. The project would be a low pressure; gravity fed system and would incorporate the following components:

- 2-3 air vents
- Riser and FTO for second user
- Screen on the intake
- Rip-rap at discharge location

Moss and nitrogen are not currently a problem in the supply ditch. Completion of this project would allow the landowner to decrease ditch loss, increase irrigation efficiency, and increase overall production.

Estimated Total Cost (See Section 6): $78,000

Feasibility / Ability to fund (See Section 8): Eligible for Small Water Project Program (SWPP) [6]funding as Priority 3, NRCS may have funding

Rehabilitation vs. New Development: Rehab

Likely Permits Required (See Section 9): Water rights permitting may be necessary through WSEO (see section 9 for details)

Challenges / Fatal Flaws Identified: None. 2 users served

Net Effects on watershed (See Section 5): Increased water use efficiency (NED 430) and decreased transmission and spread of noxious weeds

ISYS-002 & ISYS-003

The Chessington-Wilson Ditch currently serves three different users, two of which expressed interest in improvements. *Landowner A* (ISYS-003) would like to upgrade the splitter box, **located west of both landowners properties**, and install buried pipeline (starting at splitter box) to supply existing wheel line. Completion of this project would eliminate excessive erosion in the Right-of-Way (ROW) of Highway 170, decrease ditch loss, and increase irrigation efficiency. *Landowner B* (ISYS-002) would like to install a riser and new gated pipe, extending off of ISYS-003. If completed, landowner B could increase their effective irrigated acreage from 15 acres to 35 acres. Separately, landowner B would like to upgrade their check structure and install buried pipe to feed existing gated pipe.

Estimated Total Cost (See Section 6): ISYS-002: $18,000; ISYS-003: $58,000
Feasibility / Ability to fund (See Section 8): Eligible for SWPP funding as priority 4, NRCS funding
Rehabilitation vs. New Development: New development

[6] Small Water Project Program (SWPP) cover projects with a total project value of $135,000, See Section 6 for more detailed information.

Likely Permits Required (See Section 9): WBLC, Right-Of-Way, potentially WSEO
Challenges / Fatal Flaws Identified: None. 2 users served
Net Effects on watershed (See Section 5): Increase water use efficiency, reduced erosion, and decreased transmission and spread of noxious weeds (NED 430).

ISYS-004:

The Woodard-Johnson Ditch currently causes excessive erosion in the Right-of-Way (ROW) of Highway 170 and its users experience extreme water loss from the ditch. This project would involve converting the open channel ditch to buried pipe and re-routing it under an adjacent field and then onto the landowner's property. The project would be a low pressure gravity fed system and would incorporate the following components: Multiple air vents, screen on the intake, and energy dissipation structure at discharge location. The ditch currently serves three users and approximately 260 acres for one individual. There are multiple overhead powerlines, TCT fiber optic lines, and one highway crossing. If completed, ditch water loss would decrease, the landowner would receive full adjudicated flow, and overall production could be increased.

Estimated Total Cost (See Section 6): $220,000
Feasibility / Ability to fund (See Section 8): Project exceeds SWPP funding maximum, possibly eligible for WWDC Level II or III funding. If so, requires a sponsoring entity. May also be fundable by NRCS or others.
Rehabilitation vs. New Development: New development
Likely Permits Required (See Section 9): Right-of-Way, easement, WSEO (See section 9 for details)
Challenges / Fatal Flaws Identified: Highway crossing and fiber line in highway borrow ditch. 1 user served.
Net Effects on watershed (See Section 5): Increased water use efficiency, decreased erosion in county highway barrow ditch (NED 430) and decreased transmission and spread of noxious weeds.

ISYS-005:

The scale and overall impact of this project is larger in comparison to most others. This project would involve converting the Winchester Ditch from open channel to buried pipe. It currently serves six users.

The diversion off of Owl Creek is in functioning condition, but seepage loss in the ditch is significant due to the course-grained bedding material. There is no sand trap present, making operation and maintenance of the ditch difficult. This would be a gravity fed system that would benefit multiple users by decreasing ditch water loss, increasing water availability and production for all users. The project would incorporate the following components: sand-trap , flow measurement, and return flow ditch installation, rip-rap at discharge location, and air vents.

Estimated Total Cost (See Section 6): $1,001,000

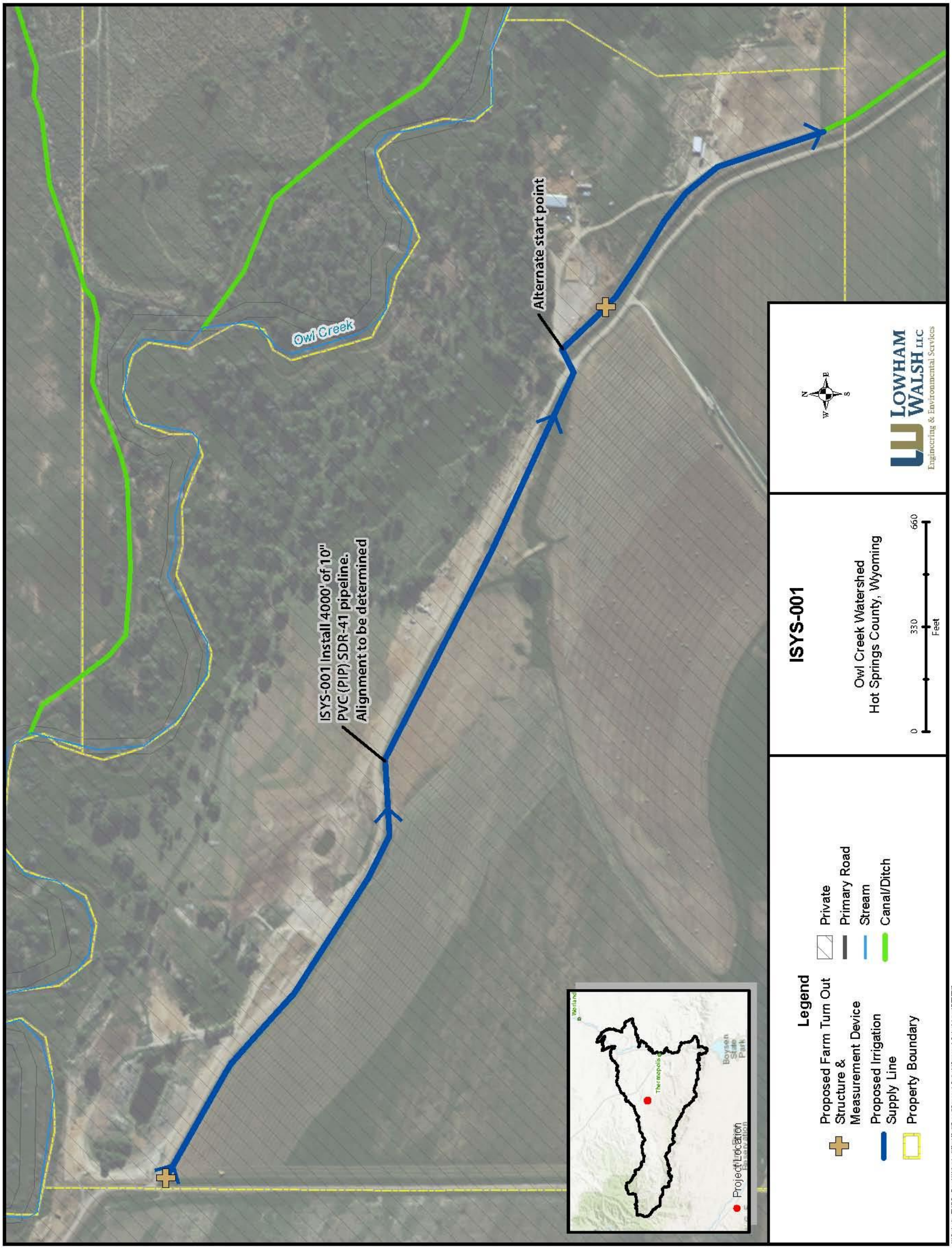
Feasibility / Ability to fund (See Section 8): Project exceeds SWPP funding maximum, possibly eligible for WWDC Level II or III funding. If so, requires a sponsoring entity.

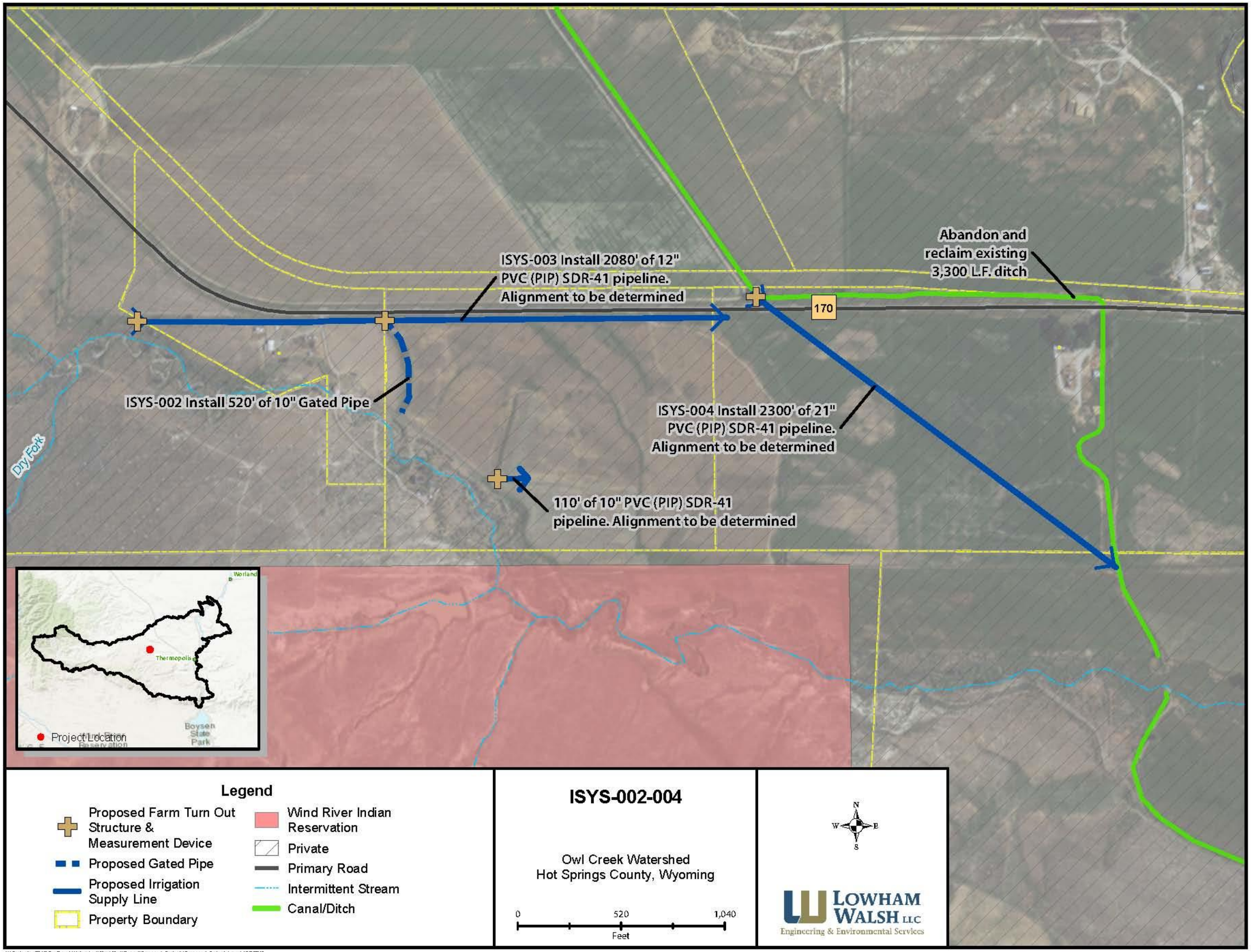
Rehabilitation vs. New Development: Rehabilitation

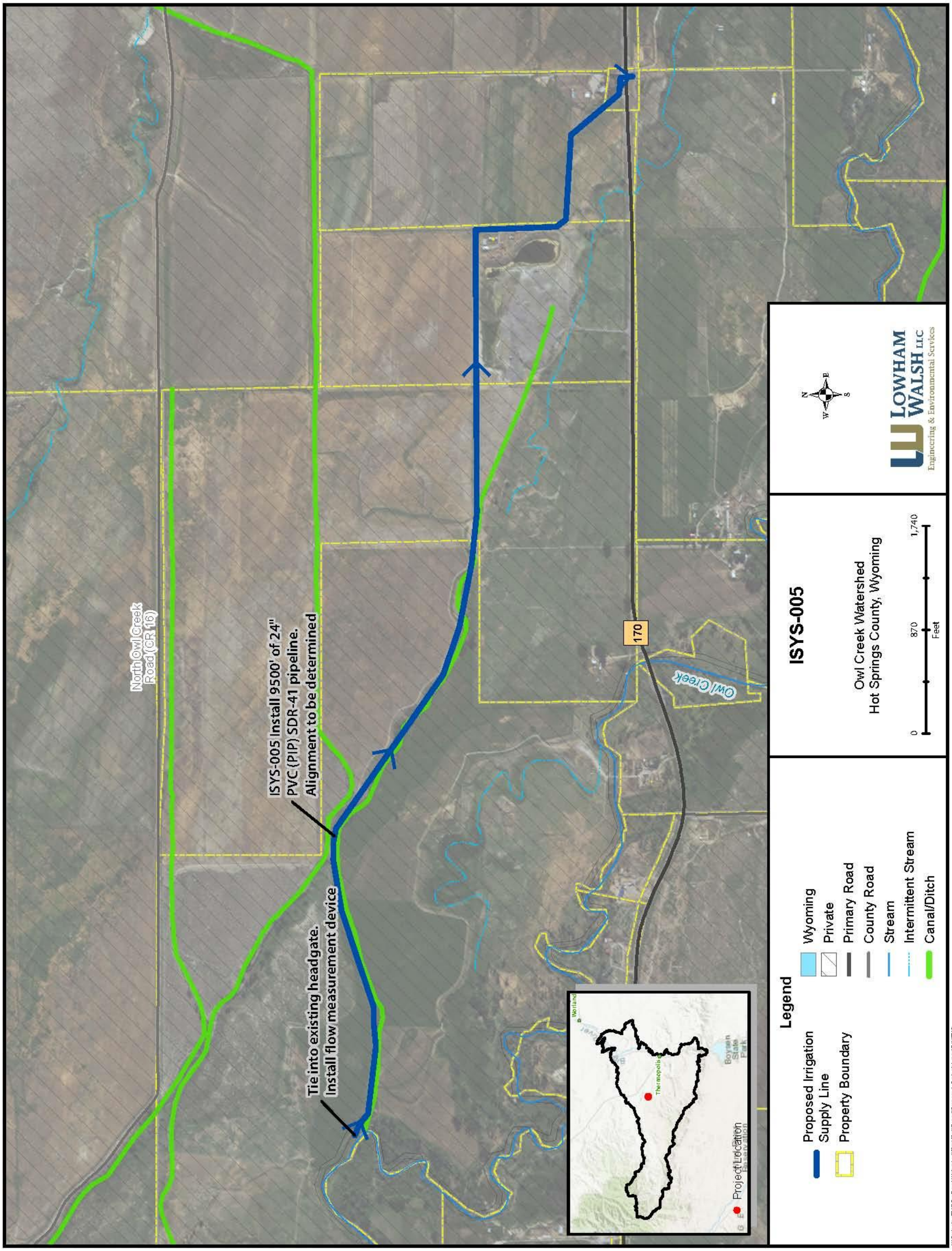
Likely Permits Required (See Section 9): WSEO, WDEQ and USACE, if wetlands and streams will be impacted

Challenges / Fatal Flaws Identified: Wetlands present, Utes' ladies tresses may be of concern. 6 users served.

Net Effects on watershed (See Section 5): Decreased ditch loss, increased water use efficiency (430) and decreased transmission and spread of noxious weeds.


ISYS-001 Install 4000' of 10" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Alternate start point
Owl Creek
ISYS-001
Owl Creek Watershed
Hot Springs County, Wyoming
0
330
660
Feet
Legend
Proposed Farm Turn Out Structure & Measurement Device
Proposed Irrigation Supply Line
Property Boundary
Private
Primary Road
Stream
Canal/Ditch
N
E
S
W
LOWHAM WALSH LLC
Engineering & Environmental Services
Worland
Thermopolis
Boysen State Park
Project Location


ISYS-003 Install 2080' of 12" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Abandon and reclaim existing 3,300 L.F. ditch
170
ISYS-002 Install 520' of 10" Gated Pipe
ISYS-004 Install 2300' of 21" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Dry Fork
110' of 10" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Worland
Thermopolis
Boysen State Park
Project Location
Legend
Proposed Farm Turn Out Structure & Measurement Device
Proposed Gated Pipe
Proposed Irrigation Supply Line
Property Boundary
Wind River Indian Reservation
Private
Primary Road
Intermittent Stream
Canal/Ditch
ISYS-002-004
Owl Creek Watershed
Hot Springs County, Wyoming
0
520
1,040
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services


North Owl Creek Road (CR 16)
ISYS-005 Install 9500' of 24" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Tie into existing headgate. Install flow measurement device
170
Owl Creek
Legend
Proposed Irrigation Supply Line
Property Boundary
Wyoming
Private
Primary Road
County Road
Stream
Intermittent Stream
Canal/Ditch
Project Location
Thermopolis
Worland
Boysen State Park
ISYS-005
Owl Creek Watershed
Hot Springs County, Wyoming
0
870
1,740
Feet
N
E
S
W
LOWHAM WALSH LLC
Engineering & Environmental Services

ISYS-006:

This project would involve converting approximately 600 ft. of the Merrill Ditch from open channel to buried pipe and re-routing it across a neighboring field along Highway 170. This is a relatively short length of pipe with the primary function of protecting irrigation water from chemical overspray. The landowner operates an organic produce farm and maintaining an herbicide free operation is critical to the business. There are fiber optic utilities present within the vicinity of the project.

Estimated Total Cost (See Section 6): $35,000

Feasibility / Ability to fund (See Section 8): Eligible for SWPP funding as a Priority 4, NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WBLC, Right-Of-Way, easement, WSEO, and/or Other

Challenges / Fatal Flaws Identified: None. Serves 1 user.

Net Effects on watershed (See Section 5): Decreased risk of contaminating irrigation waters with herbicide/pesticides (430) and decreased transmission and spread of noxious weeds.

ISYS-007:

The landowner has four existing wells that they desire to permit for irrigation and stock use. Approximately 70 acres would be regularly irrigated from these wells. Current permitting status and well depths need to be verified. A windmill and stock pond are desired. In addition, the landowner would like to install new gated pipe to irrigate an additional 35 acres; however the LW team was unable to visit this project site. These improvements would allow the landowner to increase water availability and increase farm/ranch production.

Estimated Total Cost (See Section 6): $44,000

Feasibility / Ability to fund (See Section 8): SWPP program, Priority 1, NRCS, FSA, WGFD

Rehabilitation vs. New Development: New development

Likely Permits Required (See Section 9): SEO permit for stock pond and well permitting. Note that on-channel stock ponds need to be permitted by WDEQ

Challenges / Fatal Flaws Identified: One landowner served

Net Effects on watershed (See Section 5): Provides livestock and wildlife water away from owl creek, which protects these stream banks from overgrazing (614, 642)

ISYS-008:

The landowner would like to irrigate six acres of currently fallow field to provide pasture for their livestock. The property has a water right that is not currently exercised out of the Ready Ditch, which is fed by Owl Creek. The project would include installing a stilling well and pump to feed a movable pod sprinkler system. A FTO and a buried power transmission line (approximately 300-ft) would need to be installed.

Estimated Total Cost (See Section 6): $13,000

Feasibility / Ability to fund (See Section 8): SWPP as a Priority 4, NRCS

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): None, as understood this landowner has an appropriate water right for this proposed development

Challenges / Fatal Flaws Identified: None. Serves 1 user.

Net Effects on watershed (See Section 5): Controlled irrigation will reduce the likelihood of developing alkali flats and will prevent undue soil erosion. See NED 327.

ISYS-009/009A:

This project is a conversion of the open-channel Martin Ditch to buried pipe, benefiting three different landowners. Two of the three landowners have expressed interest in improvements. The ditch is fed by both Owl Creek and Mud Creek. The ditch loses a substantial amount of water to seepage, making effective irrigation extremely difficult. If completed, two additional projects (ISYS-012 & ISYS-013) would also benefit from increased water supply. The NRCS has looked at and mapped this project. All of the users' farming and ranching operations would benefit from decreased seepage loss.

Estimated Total Cost (See Section 6): $715,000

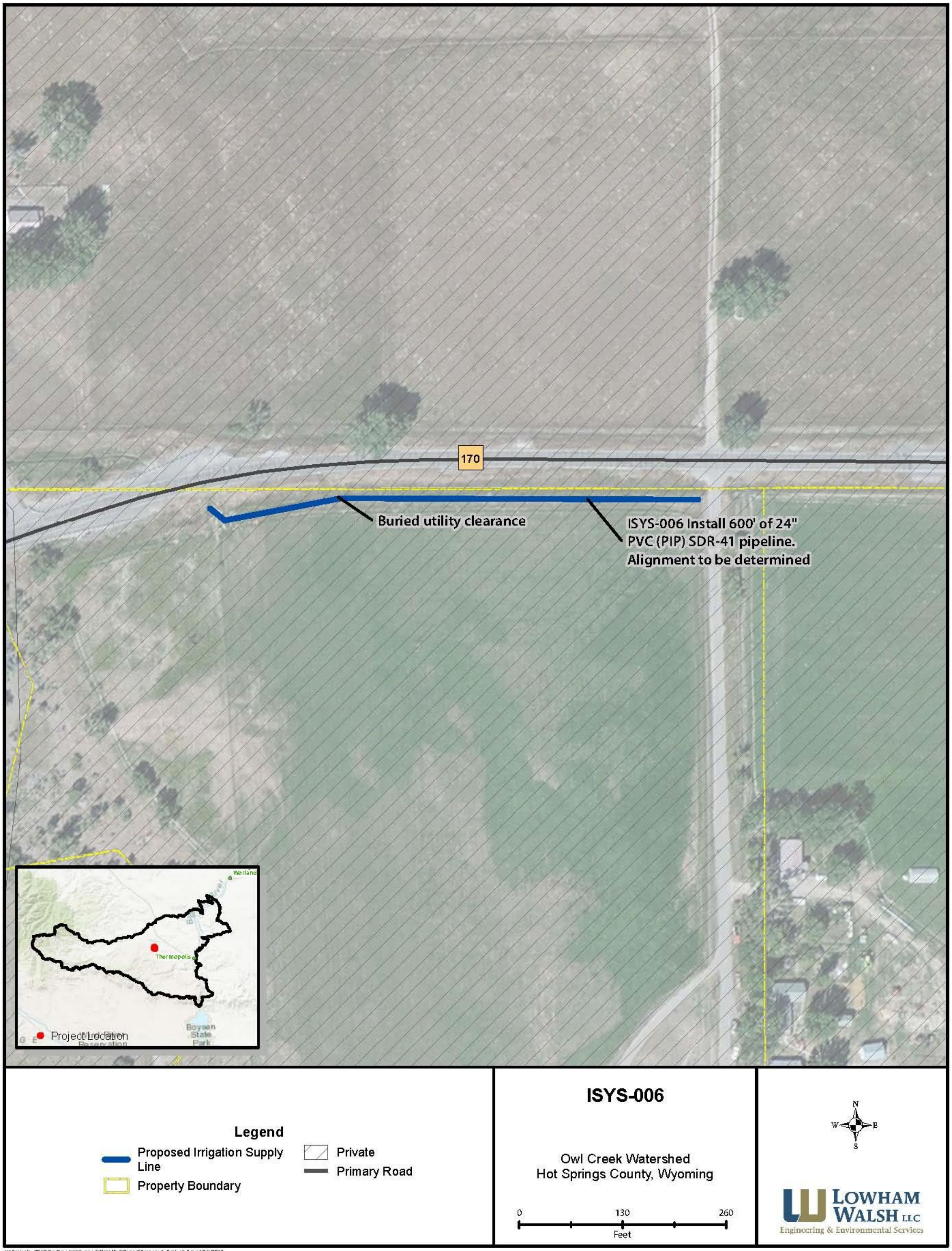
Feasibility / Ability to fund (See Section 8): Project exceeds SWPP funding maximum, possibly eligible for WWDC Level II or III funding. If so, requires a sponsoring entity. May also be fundable by NRCS NRCS, OSLI, WGFD

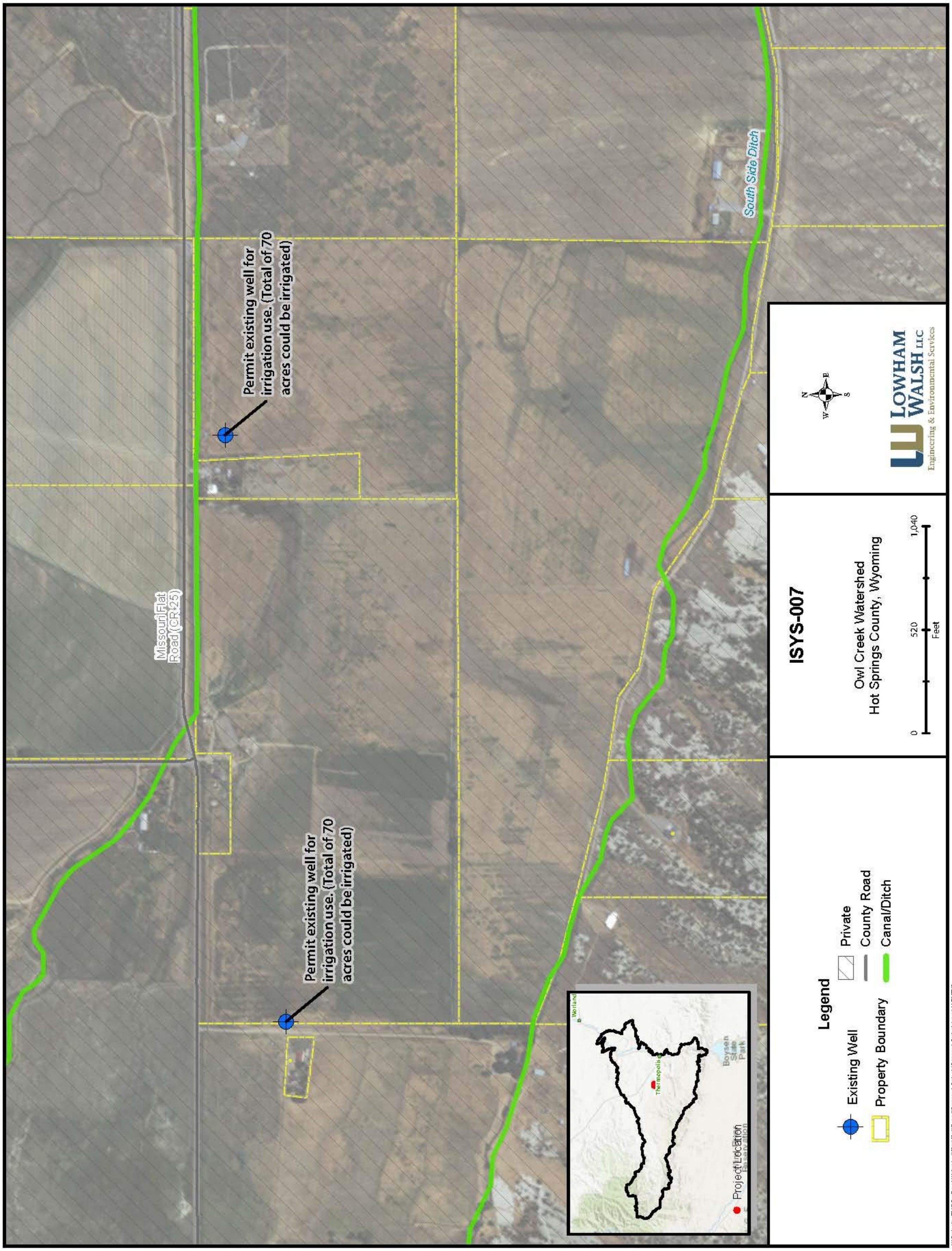
Rehabilitation vs. New Development: Rehabilitation

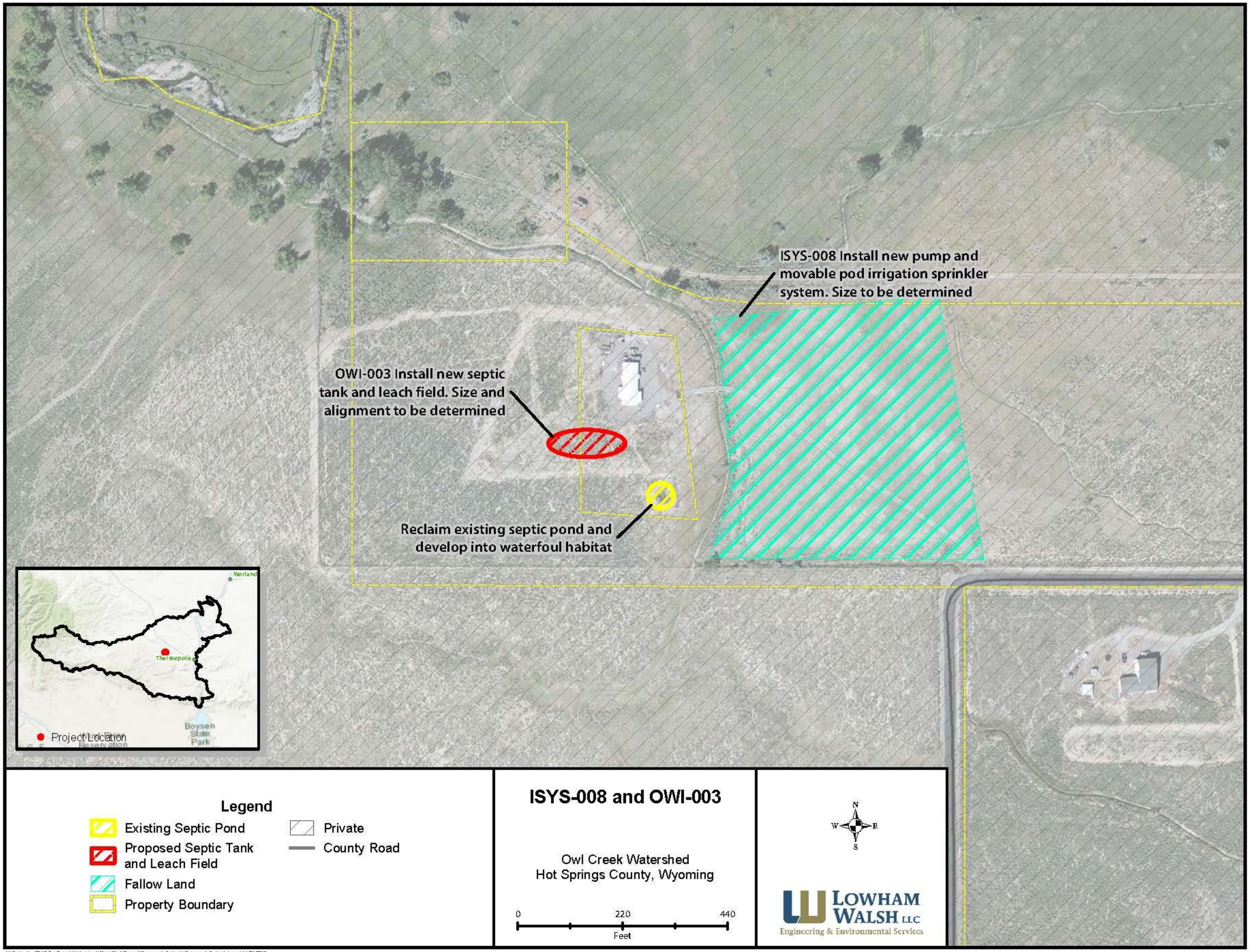
Likely Permits Required (See Section 9): ACOE, if wetlands will be disturbed

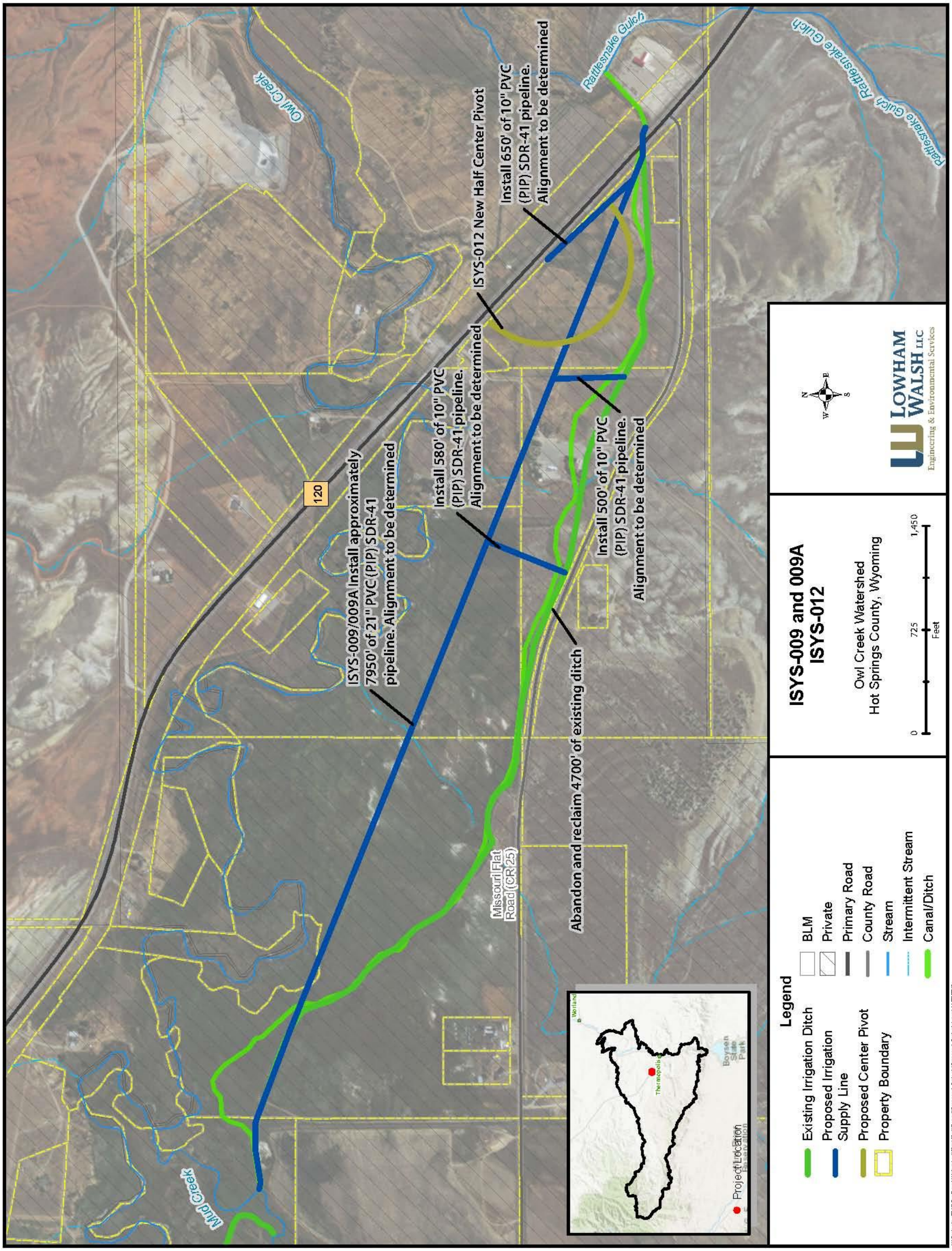
Challenges / Fatal Flaws Identified: Project is within potential Utes' ladies tresses habitat. Serves 3 users.

Net Effects on watershed (See Section 5): Increased water use efficiency, leaving more water in the creek or higher crop production levels (430) and decreased transmission and spread of noxious weeds.


170
Buried utility clearance
ISYS-006 Install 600' of 24"
PVC (PIP) SDR-41 pipeline.
Alignment to be determined
Worland
Thermopolis
Boysen State Park
Project Location
Legend
Proposed Irrigation Supply Line
Property Boundary
Private
Primary Road
ISYS-006
Owl Creek Watershed
Hot Springs County, Wyoming
0
130
260
Feet
N
W
E
S
Lowham Walsh LLC
Engineering & Environmental Services


Permit existing well for irrigation use. (Total of 70 acres could be irrigated)
Missouri Flat Road (CR 25)
South Side Ditch
Permit existing well for irrigation use. (Total of 70 acres could be irrigated)
ISYS-007
Owl Creek Watershed
Hot Springs County, Wyoming
0
520
1,040
Feet
Legend
Existing Well
Property Boundary
Private
County Road
Canal/Ditch
LOWHAM WALSH LLC
Engineering & Environmental Services
Project Location
Thermopolis
Boysen State Park
Worland


ISYS-008 Install new pump and movable pod irrigation sprinkler system. Size to be determined
OWI-003 Install new septic tank and leach field. Size and alignment to be determined
Reclaim existing septic pond and develop into waterfoul habitat
Worland
Thermopolis
Boysen State Park
Project Location
Legend
Existing Septic Pond
Proposed Septic Tank and Leach Field
Fallow Land
Property Boundary
Private
County Road
ISYS-008 and OWI-003
Owl Creek Watershed
Hot Springs County, Wyoming
0
220
440
Feet
N
E
S
W
LOWHAM WALSH LLC
Engineering & Environmental Services


Owl Creek
Rattlesnake Gulch
Mud Creek
120
Missouri Flat Road (CR 25)
ISYS-009/009A Install approximately 7950' of 21" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Install 580' of 10" PVC (PIP) SDR-41 pipeline. Alignment to be determined
ISYS-012 New Half Center Pivot
Install 650' of 10" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Install 500' of 10" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Abandon and reclaim 4700' of existing ditch
Legend
Existing Irrigation Ditch
Proposed Irrigation Supply Line
Proposed Center Pivot
Property Boundary
BLM
Private
Primary Road
County Road
Stream
Intermittent Stream
Canal/Ditch
Project Location
Thermopolis
Boysen State Park
ISYS-009 and 009A
ISYS-012
Owl Creek Watershed
Hot Springs County, Wyoming
0
725
1,450
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services

ISYS-010:

The Thompson Ditch was disrupted by the development of the Thermopolis Airport north of town. The landowner is currently unable to irrigate 60 acres historically served by this ditch. The ditch would need to be re-trenched for approximately 2300 feet upstream of the airport boundary due to residential development and a number of years of dis-use. There is a French drainage system installed under the airport that could possibly be utilized as supplemental supply to the proposed system. The WSEO needs to be consulted in regards to water adjudication. Water produced by the drainage system should be sampled for quality, due to its extremely high mineral content, indicated by the scale build up observed on the ground surface at time of field visit. Completion of this project would bring current fallow acreage into production and would prevent forfeiture of adjudicated water rights.

Estimated Total Cost (See Section 6): $97,000

Feasibility / Ability to fund (See Section 8): Rehabilitation Program, SWPP as a Priority 3, and/or New Development Program, OSLI

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): Right-Of-Way, WSEO, FAA, ACOE (if wetlands present)

Challenges / Fatal Flaws Identified: Gaining a Right-Of-Way, Wetlands may be present

Net Effects on watershed (See Section 5): Expand irrigated land to provide food and cover for livestock and wildlife (430) and decreased transmission and spread of noxious weeds

ISYS-011:

This project involves converting the landowner's irrigation ditch from open channel to pipe. Presently, the landowner receives water from a buried supply pipeline that is located adjacent to Hwy-170. A spur off of the main supply line terminates at the landowner's existing riser and Farm Turn Out (FTO). The landowner would like to continue from the FTO with buried pipeline to feed four separate lengths of new gated pipe. Benefits of this project include increased irrigation efficiency and production on approximately 35 existing irrigated acres, and reclamation of current irrigation ditches.

Estimated Total Cost (See Section 6): $94,000

Feasibility / Ability to fund (See Section 8): Eligible for SWPP funding as a Priority 4, NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): None.

Challenges / Fatal Flaws Identified: None. Serves 1 user.

Net Effects on watershed (See Section 5): Increased irrigation efficiency allows more water to stay in the creek, or water may be used to increase production on approximately 35 acres (430) and decreased transmission and spread of noxious weeds.

ISYS-012:

This project is dependent on ISYS-009/009A. The landowner would like to install approximately 650 feet of half pivot off of Hwy-120 on 30 acres of currently fallow field. This would require installing a buried irrigation supply line to the pivot center and an approximately 5-horse power pump. The supply line would be fed by ISYS-009/009A related upgrades and is dependent on its completion.

Estimated Total Cost (See Section 6): $85,000

Feasibility / Ability to fund (See Section 8): Project is eligible for SWPP funding as a Priority 4

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): None.

Challenges / Fatal Flaws Identified: None. 1 user served.

Net Effects on watershed (See Section 5): Increase water delivery to crop, better application efficiency of nutrients, pesticides, and amendments, decrease erosion, and increase plant vigor resulting in increased biomass and soil quality (430, 442, 443, 449).

ISYS-013:

The landowner would like to replace an existing, buried corrugated metal pipe (CMP) siphon with new buried pipe. The buried pipe serves as a siphon to carry water from the delivery ditch, under a drainage channel, and up to a field. This new siphon would follow the same route and would feed proposed gated pipe to increase the irrigation efficiency of approximately 38 acres. The possibility of continuing with more gated pipe to irrigate an additional 12 acres along Owl Creek was discussed, but not defined at the time of field visit. This project is dependent on the completion of ISYS-009/009A. Benefits include increased irrigation efficiency and improved forage for livestock and wildlife.

Estimated Total Cost (See Section 6): $24,000

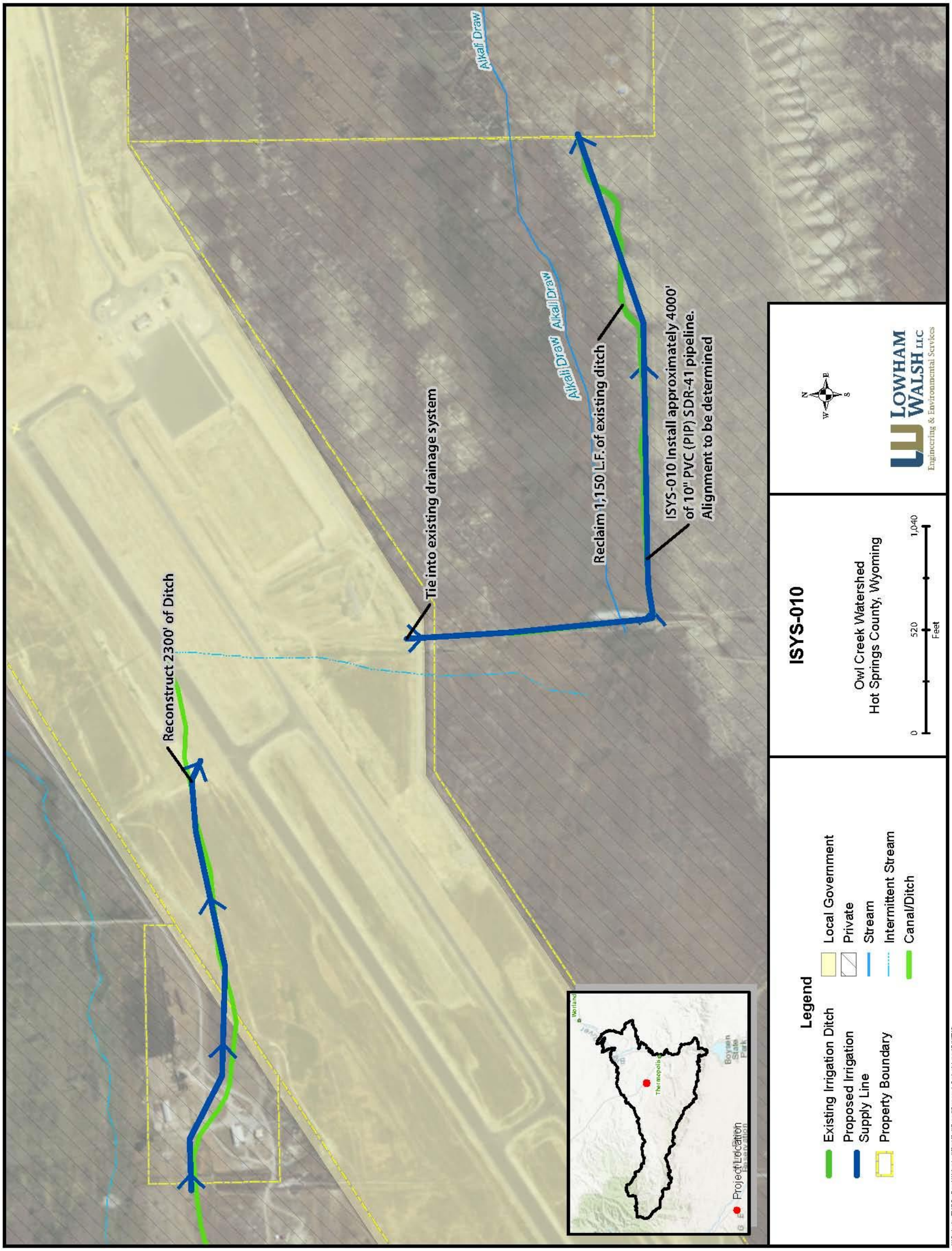
Feasibility / Ability to fund (See Section 8): Project eligible for SWPP funding as a Priority 4, Farm Bill

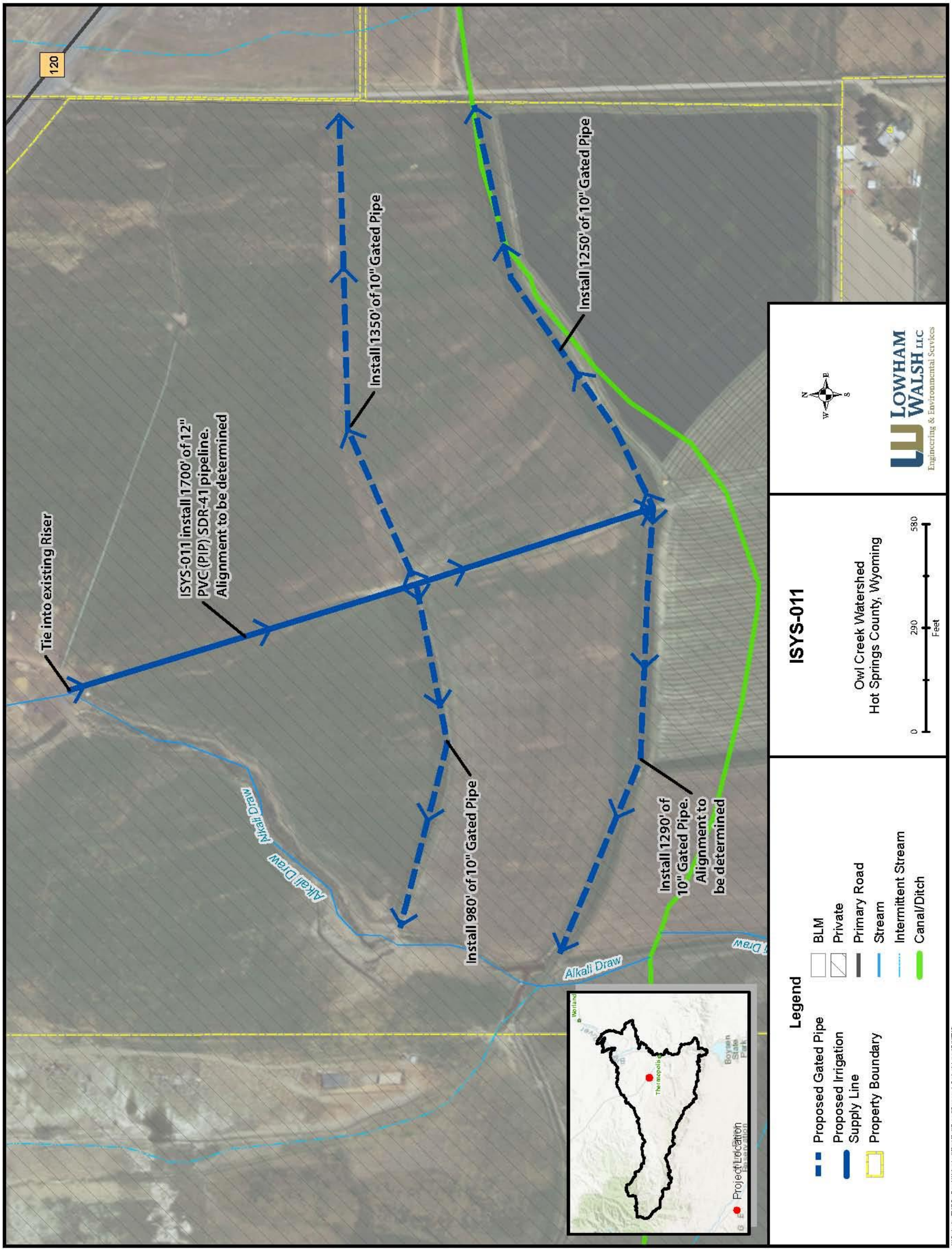
Rehabilitation vs. New Development: Rehabilitation

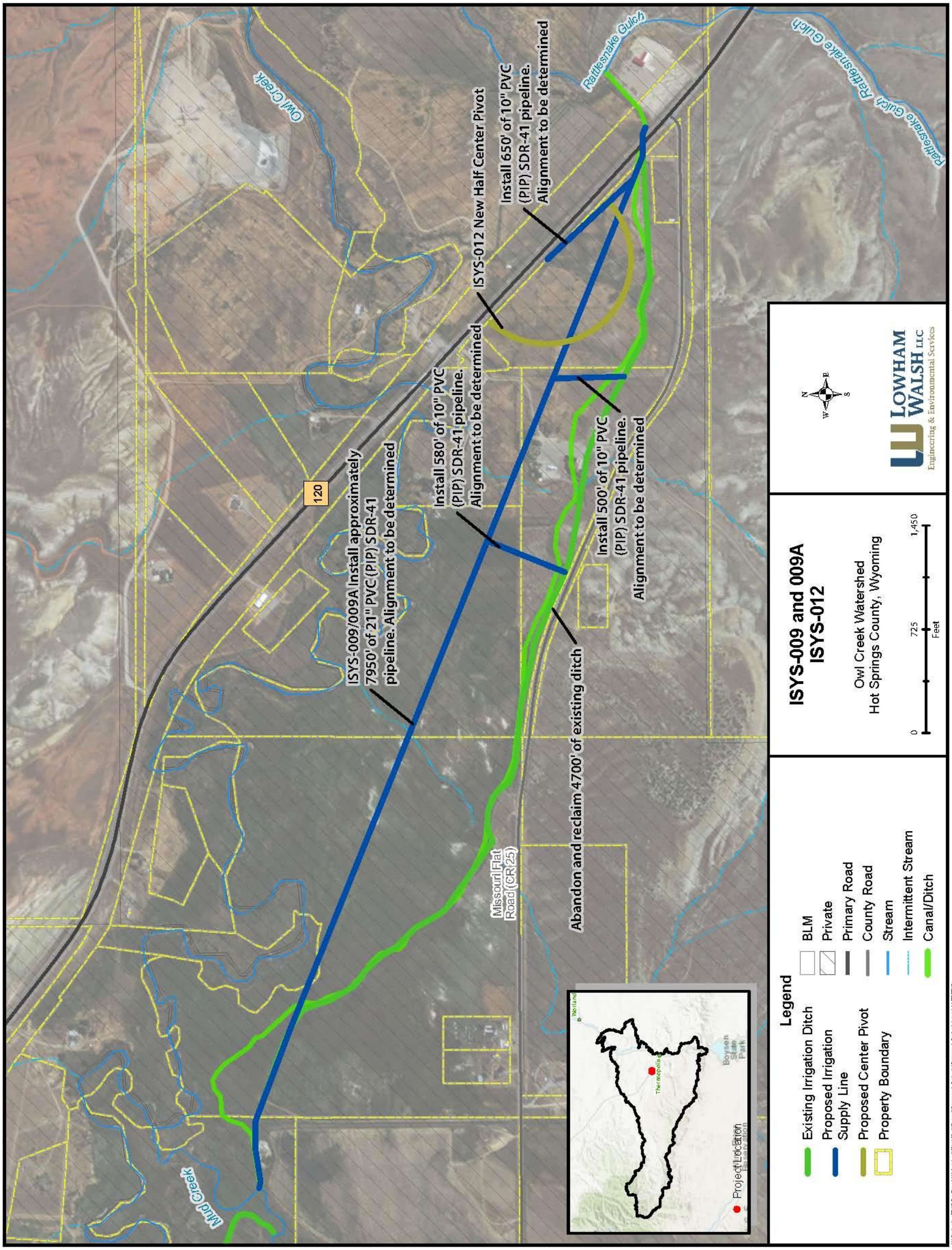
Likely Permits Required (See Section 9): None and/or Other

Challenges / Fatal Flaws Identified: None. One user served.

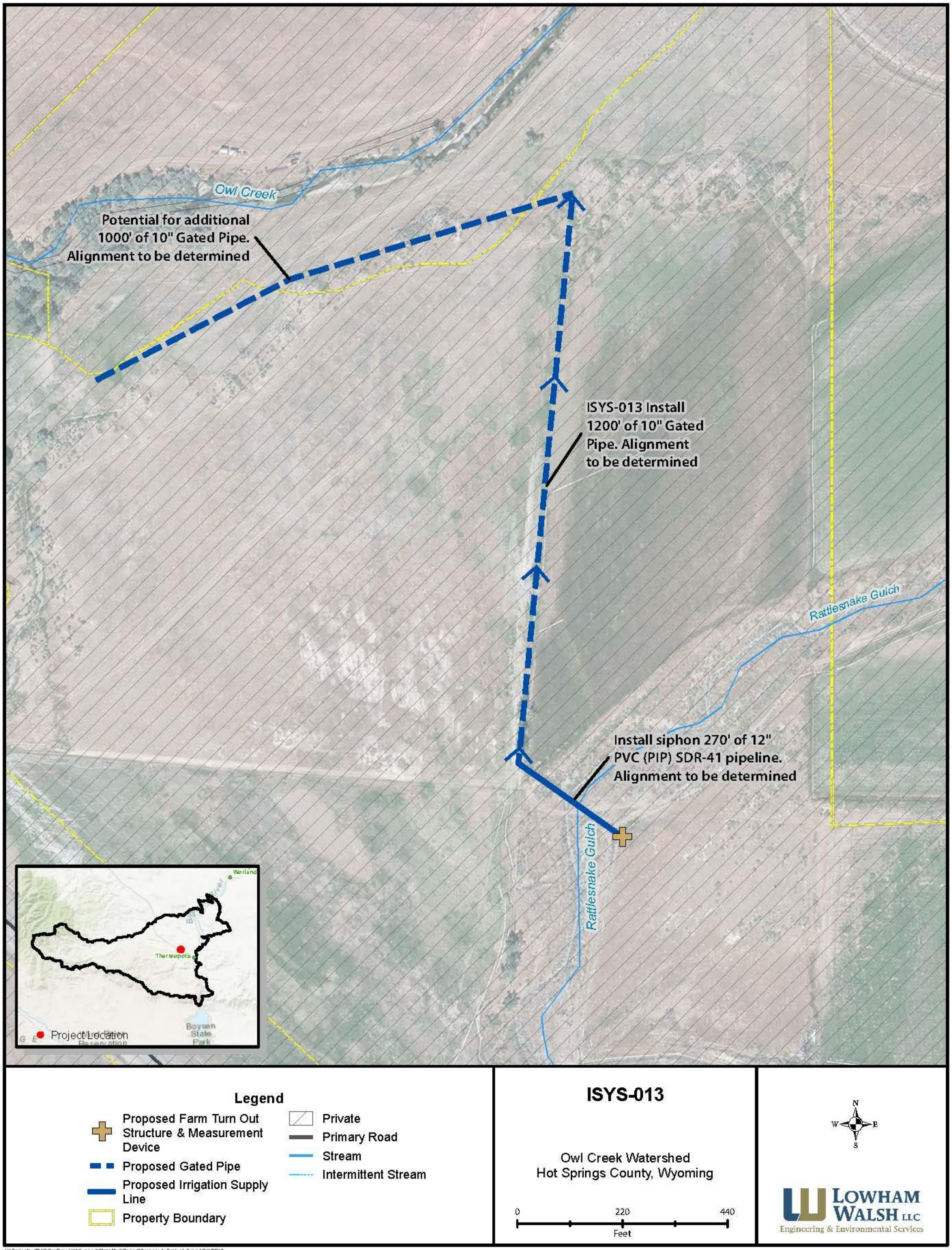
Net Effects on watershed (See Section 5): Increase water availability for irrigation, decrease evaporation losses and erosion, increase plant growth and productivity, maximize nutrient management, decrease leaching of nutrients, and decreased transmission and spread of noxious weeds (430, 590, 499).


Reconstruct 2300' of Ditch
Tie into existing drainage system
Reclaim 1,150 L.F. of existing ditch
ISYS-010 Install approximately 4000' of 10" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Alkali Draw
ISYS-010
Owl Creek Watershed
Hot Springs County, Wyoming
0
520
1,040
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services
Legend
Existing Irrigation Ditch
Proposed Irrigation Supply Line
Property Boundary
Local Government
Private
Stream
Intermittent Stream
Canal/Ditch
Project Location
Thermopolis
Boysen State Park


120
Tie into existing Riser
ISYS-011 install 1700' of 12" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Install 1350' of 10" Gated Pipe
Install 1250' of 10" Gated Pipe
Install 980' of 10" Gated Pipe
Install 1290' of 10" Gated Pipe. Alignment to be determined
Alkali Draw
ISYS-011
Owl Creek Watershed
Hot Springs County, Wyoming
0
290
580
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services
Legend
Proposed Gated Pipe
Proposed Irrigation Supply Line
Property Boundary
BLM
Private
Primary Road
Stream
Intermittent Stream
Canal/Ditch
Project Location
Thermopolis
Worland
Boysen State Park



ISYS-009 and 009A
ISYS-012
Owl Creek Watershed
Hot Springs County, Wyoming
0
725
1,450
Feet
ISYS-009/009A Install approximately 7950' of 21" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Install 580' of 10" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Install 500' of 10" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Install 650' of 10" PVC (PIP) SDR-41 pipeline. Alignment to be determined
ISYS-012 New Half Center Pivot
Abandon and reclaim 4700' of existing ditch
Missouri Flat Road (CR 25)
120
Owl Creek
Mud Creek
Rattlesnake Gulch
Legend
Existing Irrigation Ditch
Proposed Irrigation Supply Line
Proposed Center Pivot
Property Boundary
BLM
Private
Primary Road
County Road
Stream
Intermittent Stream
Canal/Ditch
Project Location
Thermopolis
Worland
Boysen State Park
LOWHAM WALSH LLC
Engineering & Environmental Services


Owl Creek
Potential for additional 1000' of 10" Gated Pipe. Alignment to be determined
ISYS-013 Install 1200' of 10" Gated Pipe. Alignment to be determined
Rattlesnake Gulch
Install siphon 270' of 12" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Rattlesnake Gulch
Worland
Thermopolis
Boysen State Park
Project Location
Legend
Proposed Farm Turn Out Structure & Measurement Device
Proposed Gated Pipe
Proposed Irrigation Supply Line
Property Boundary
Private
Primary Road
Stream
Intermittent Stream
ISYS-013
Owl Creek Watershed
Hot Springs County, Wyoming
0
220
440
Feet
N
W
E
S
LOWHAM WALSH LLC
Engineering & Environmental Services

ISYS-014:

This project would involve properly draining approximately five acres of potential farm ground. The landowner states that there is a significant loss in crop revenue annually because the area remains too wet to farm properly. The landowner suspects a high ground water table and possible seepage from the Upper Lucerne Canal are potential sources. The possibility of installing a French drain and solar pump, combined with lining the adjacent portion of the Upper Lucerne Canal was discussed. The possibility of coupling this project with URI-008 as a supplemental water source should also be considered.

Estimated Total Cost (See Section 6): $34,000

Feasibility / Ability to fund (See Section 8): SWPP Level 2 or 4

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): ACOE, WDEQ permit if wetlands & springs present, WSEO

Challenges / Fatal Flaws Identified: Wetlands could be present, spring development if not just high groundwater table

Net Effects on watershed (See Section 5): Decrease subsurface water level, decrease soil compaction, increase crop forage production, decrease operation and maintenance, and increase soil quality (606).

ISYS-015:

The landowner would like to convert open channel ditch to buried pipe in several places. The landowner currently does not have enough water to irrigate more than 50 acres due to ditch loss. There are 60 acres that are currently fallow. This project would completely enclose an existing ditch which has, over time, been replaced by buried pipe. The landowner has lost six to ten calves annually in the steep earthen ditches that would be able to be reclaimed if the irrigation supply was buried. These improvements would allow the landowner to increase water availability and increase farm and ranch production.

Estimated Total Cost (See Section 6): $210,000

Feasibility / Ability to fund (See Section 8): Project exceeds SWPP funding maximum, possibly eligible for WWDC Level II or III funding. If so, requires a sponsoring entity.

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): None.

Challenges / Fatal Flaws Identified: None. 1 user served.

Net Effects on watershed (See Section 5): Increased water use efficiency, decreased leaching of nutrients and sediment delivery to receiving waters, decreased opportunity to spread noxious weeds (430).

ISYS-016/016A:

This project would be an open channel to pipe conversion that would pass across State land on an abandoned irrigation ditch fed by the Upper Lucerne Canal. It would benefit two different landowners - both have expressed interest in improvements. The project would be a gravity fed system and would incorporate the following components:

- Measuring device
- Check structure
- 2 to 3 air vents

The buried pipe would begin at the existing 12 inch FTO and terminate at a proposed splitter. The splitter would then supply both landowners. Approximately 110 acres would be served. Completion of this project would allow for increased crop production and would prevent forfeit of adjudicated water for one landowner.

Estimated Total Cost (See Section 6): $36,000

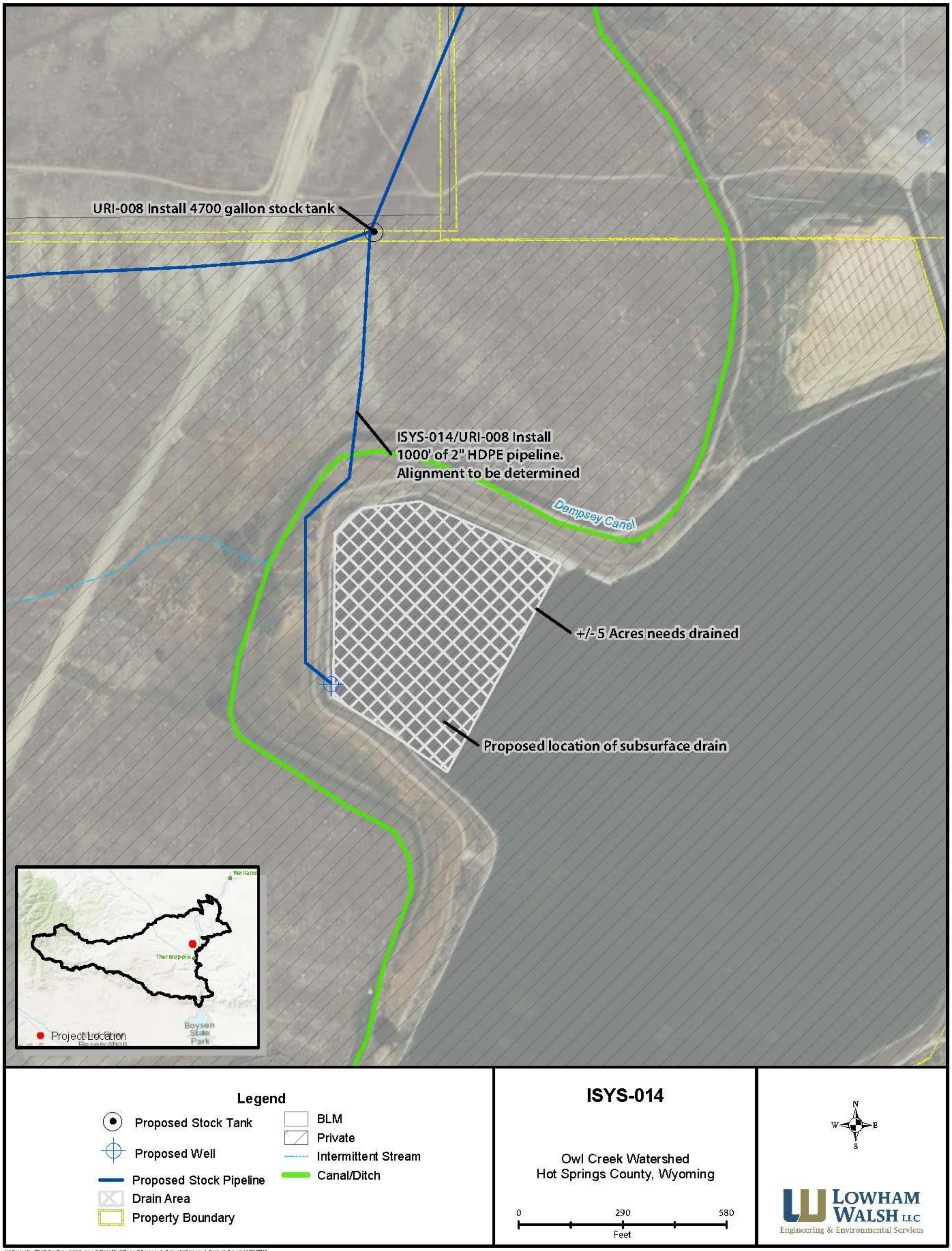
Feasibility / Ability to fund (See Section 8): Eligible for SWPP as Priority 4, OSLI

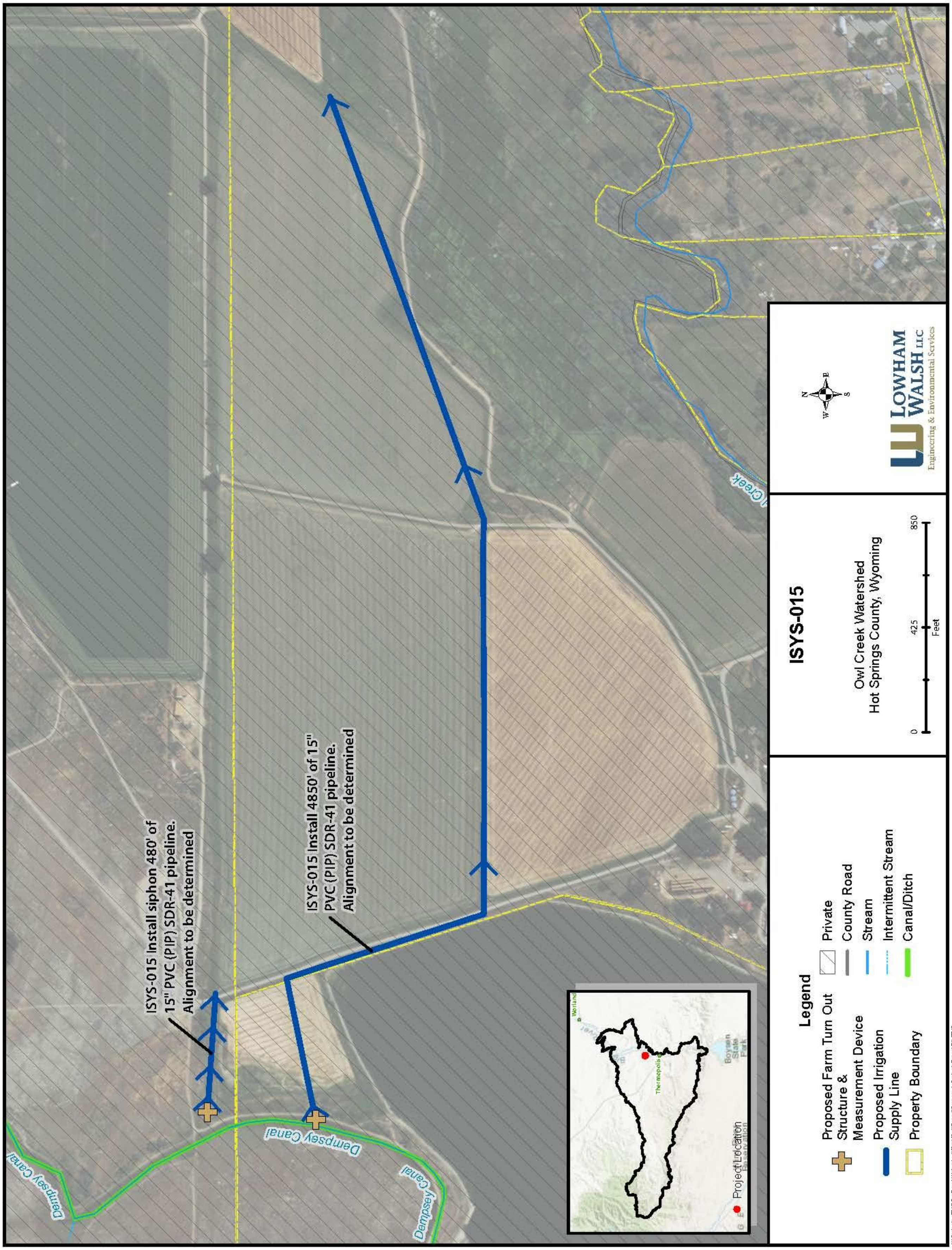
Rehabilitation vs. New Development: New Development

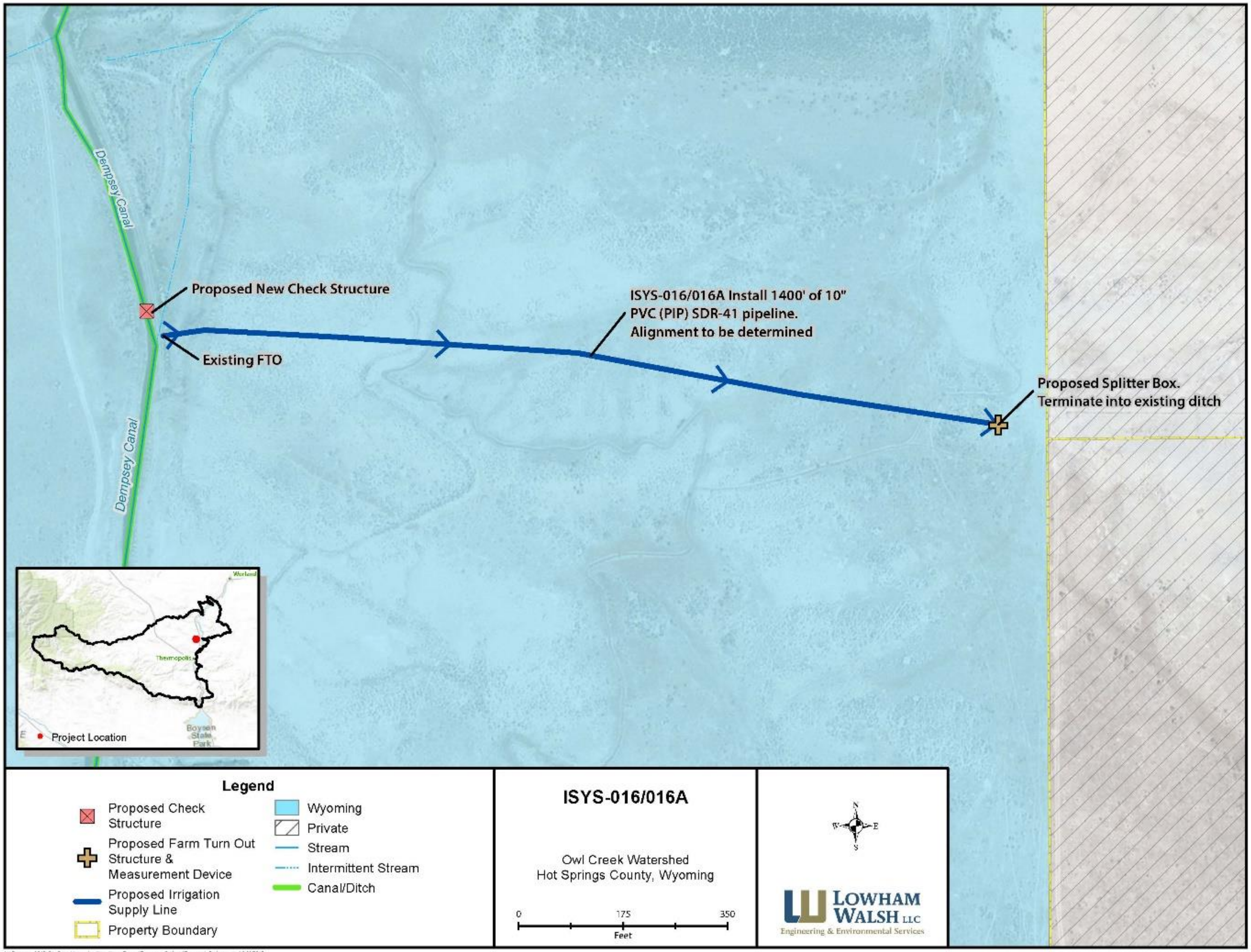
Likely Permits Required (See Section 9): WSEO and WDEQ, maybe even OSLI

Challenges / Fatal Flaws Identified: Crosses state land. 2 users served.

Net Effects on watershed (See Section 5): Increase water availability, decrease infiltration and evaporation losses, decrease erosion, and decreased transmission and spread of noxious weeds (430).


URI-008 Install 4700 gallon stock tank
ISYS-014/URI-008 Install 1000' of 2" HDPE pipeline. Alignment to be determined
Dempsey Canal
+/- 5 Acres needs drained
Proposed location of subsurface drain
Worland
Thermopolis
Boysen State Park
Project Location
Legend
Proposed Stock Tank
Proposed Well
Proposed Stock Pipeline
Drain Area
Property Boundary
BLM
Private
Intermittent Stream
Canal/Ditch
ISYS-014
Owl Creek Watershed
Hot Springs County, Wyoming
0
290
580
Feet
N
S
E
W
LOWHAM WALSH LLC
Engineering & Environmental Services


ISYS-015 Install siphon 480' of 15" PVC (PIP) SDR-41 pipeline. Alignment to be determined
ISYS-015 Install 4850' of 15" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Dempsey Canal
Dempsey Canal
Dempsey Canal
Creek
ISYS-015
Owl Creek Watershed
Hot Springs County, Wyoming
0
425
850
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services
Legend
Proposed Farm Turn Out Structure & Measurement Device
Proposed Irrigation Supply Line
Property Boundary
Private
County Road
Stream
Intermittent Stream
Canal/Ditch
Project Location
Thermopolis
Worland
Boysen State Park


Proposed New Check Structure
Existing FTO
ISYS-016/016A Install 1400' of 10"
PVC (PIP) SDR-41 pipeline.
Alignment to be determined
Proposed Splitter Box.
Terminate into existing ditch
Dempsey Canal
Dempsey Canal
Project Location
Thermopolis
Worland
Boysen State Park
Legend
Proposed Check Structure
Proposed Farm Turn Out Structure & Measurement Device
Proposed Irrigation Supply Line
Property Boundary
Wyoming
Private
Stream
Intermittent Stream
Canal/Ditch
ISYS-016/016A
Owl Creek Watershed
Hot Springs County, Wyoming
0
175
350
Feet
N
S
E
W
LOWHAM WALSH LLC
Engineering & Environmental Services

ISYS-017 thru 023:

The landowner would like to install or repair flow measurement devices at seven different locations. ISYS-0017 requires an in-stream flow measurement device for an existing 10 inch buried pipeline that comes off of the Lower Lucerne Canal. Several types of measurement devices for such applications exist. One is offered by Greyline Instruments. The remaining six locations (ISYS-018 thru 023) require new metal measuring flumes to be installed in existing open channel ditches near each diversion point off of the Upper Lucerne Canal. One flume location would require extensive erosion repair prior to placement. The landowner was aware of the erosion and intended to repair wash-out prior to the beginning of irrigation season.

Estimated Total Cost (See Section 6): $30,000

Feasibility / Ability to fund (See Section 8): Eligible for SWPP as Priority 4, NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): None

Challenges / Fatal Flaws Identified: None. 2 users served.

Net Effects on watershed (See Section 5): Increase water use efficiency, increase application efficiency, increase plant growth and productivity, and could increase water quantity (449).

ISYS-024:

This project would involve rehabilitation of a siphon on the Lucerne Canal that delivers water under Owl Creek. Presently the siphon is suspected to leak, resulting in a loss of irrigation water for downstream users. Video filming the siphon interior and using a high density polyethylene (HDPE) slip lining were discussed as possible rehabilitation methods. There was also evidence of scour occurring on the wing wall approach.

Estimated Total Cost (See Section 6): $44,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 3 project

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): None

Challenges / Fatal Flaws Identified: None. Multiple users served.

Net Effects on watershed (See Section 5): Increase water use efficiency, decrease water loss, increase water conservation, increase water available for other uses/users (587, 582).

ISYS-025:

This project would involve converting open channel ditch to buried pipe on an irrigation lateral supplied by the Cyclone Ditch. This irrigation lateral serves five different landowners and approximately 200 total irrigated acres. This would be a gravity fed system and would incorporate the following components:

- Five different risers and FTOs, two of which would extend under the private road the pipeline parallels.
- 2 to3 air vents

- Rip-rap at discharge locations
- Fiber optic utility within vicinity

Only one water user has expressed interest in improvements to date. If completed, this project would significantly decrease seepage loss, increase water delivery effectiveness and efficiency, and result in increased farm and ranch production.

Estimated Total Cost (See Section 6): $129,000

Feasibility / Ability to fund (See Section 8): Eligible for SWPP as Priority 4, NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): Potential Right of Way under road, WSEO

Challenges / Fatal Flaws Identified: Fiber cable. 5 users served.

Net Effects on watershed (See Section 5): Decrease seepage loss, increase water use efficiency, increase farm and ranch production, and decreased transmission and spread of noxious weeds (430).

ISYS-026:

The landowner would like to install 750 ft. of gated pipe to farm approximately 10 acres of fallow ground. The landowner has successfully been awarded NRCS funds to install a pipeline from the Kirby Canal that will terminate at the FTO just inside property boundary. Construction is scheduled for fall of 2017.

Estimated Total Cost (See Section 6): $7,000

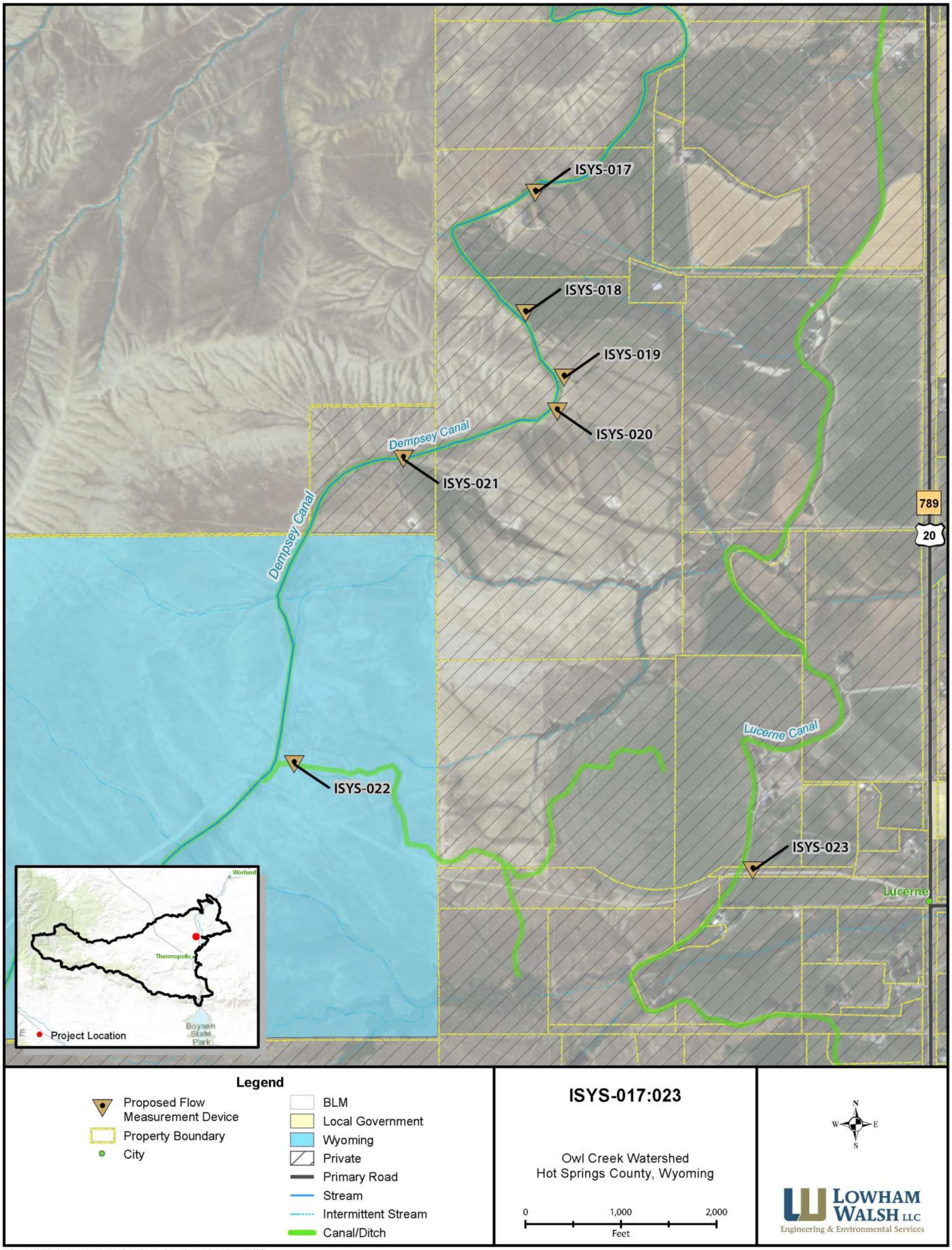
Feasibility / Ability to fund (See Section 8): Project eligible for SWPP funding as a Level 4, Farm Bill (already funded)

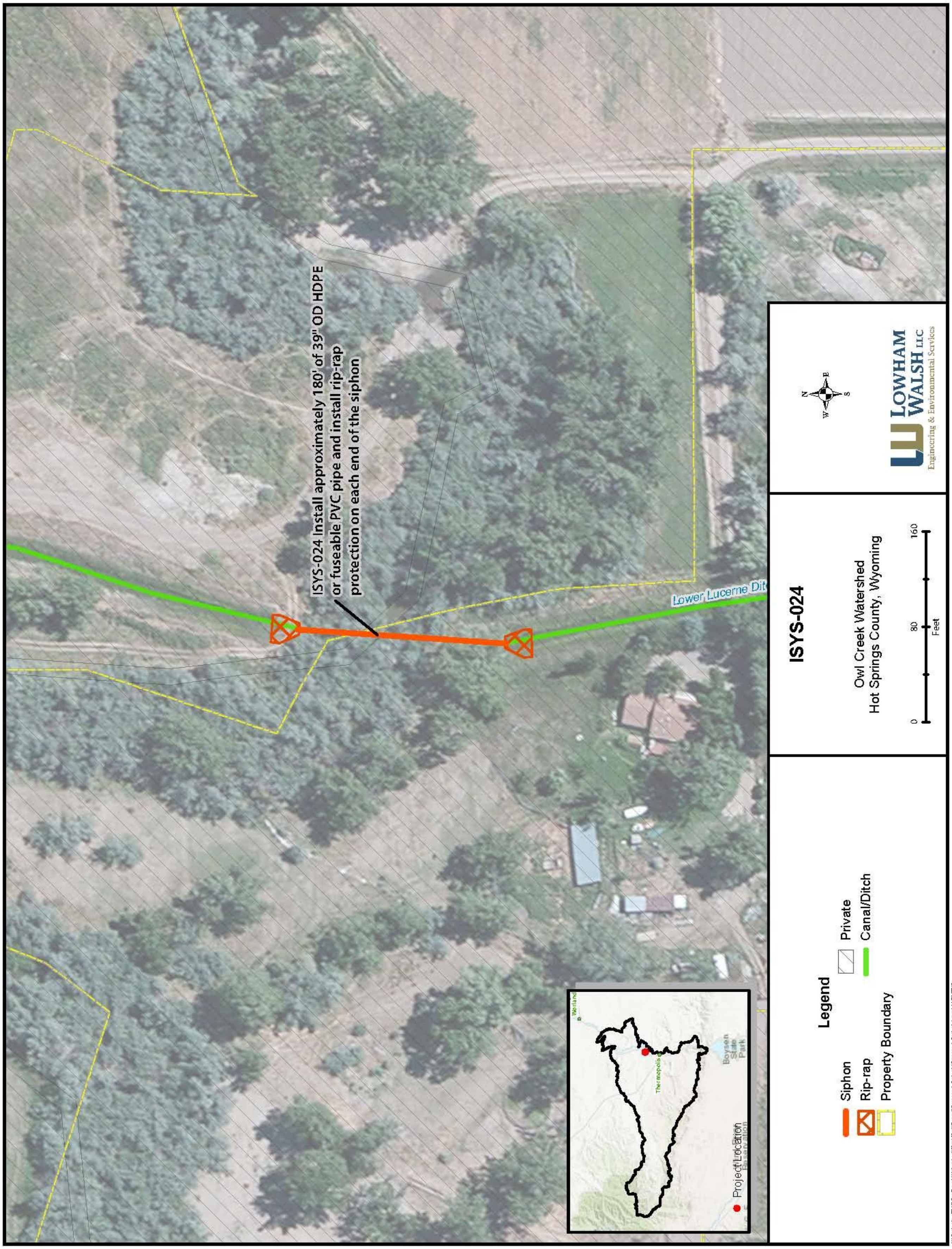
Rehabilitation vs. New Development: New Development

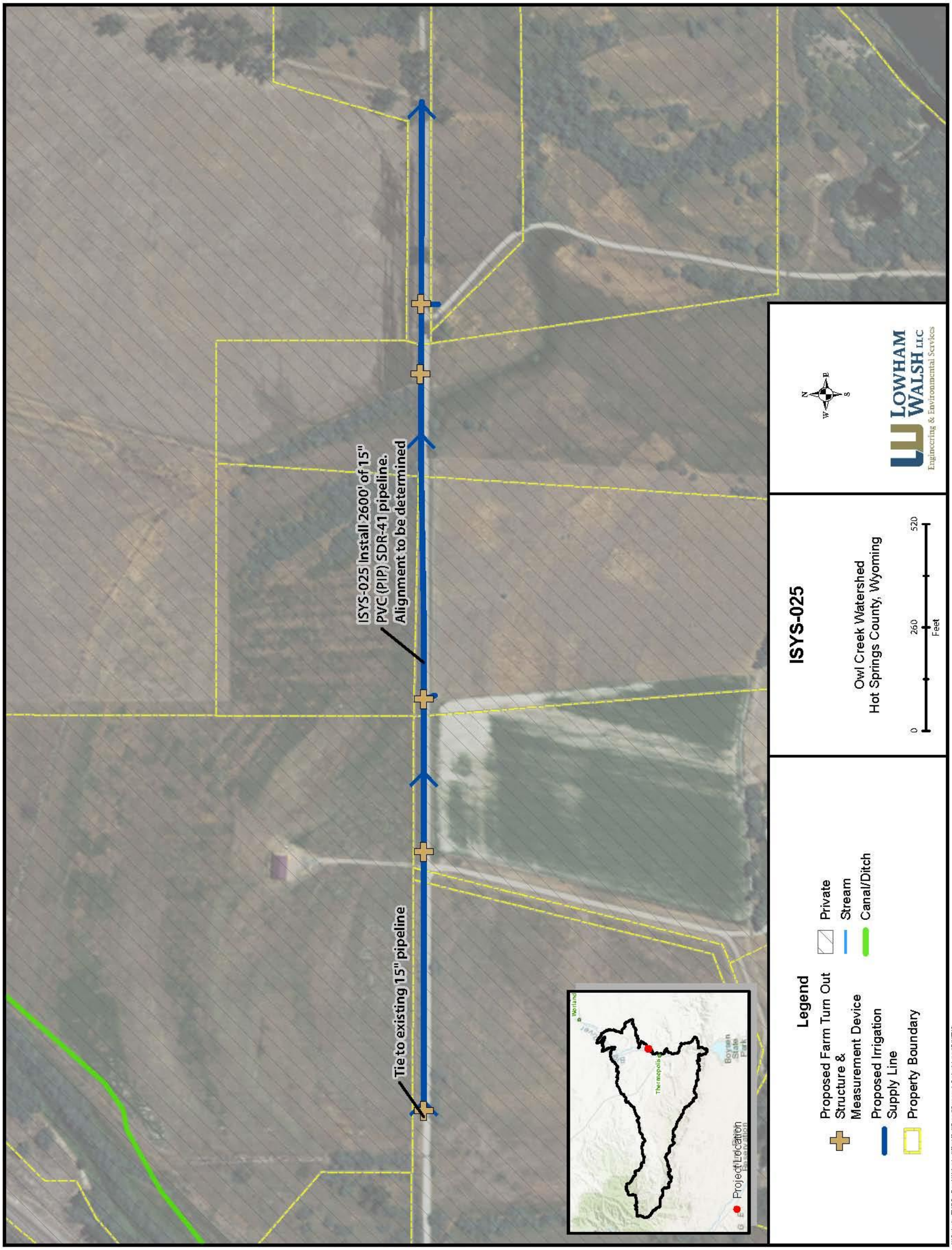
Likely Permits Required (See Section 9):

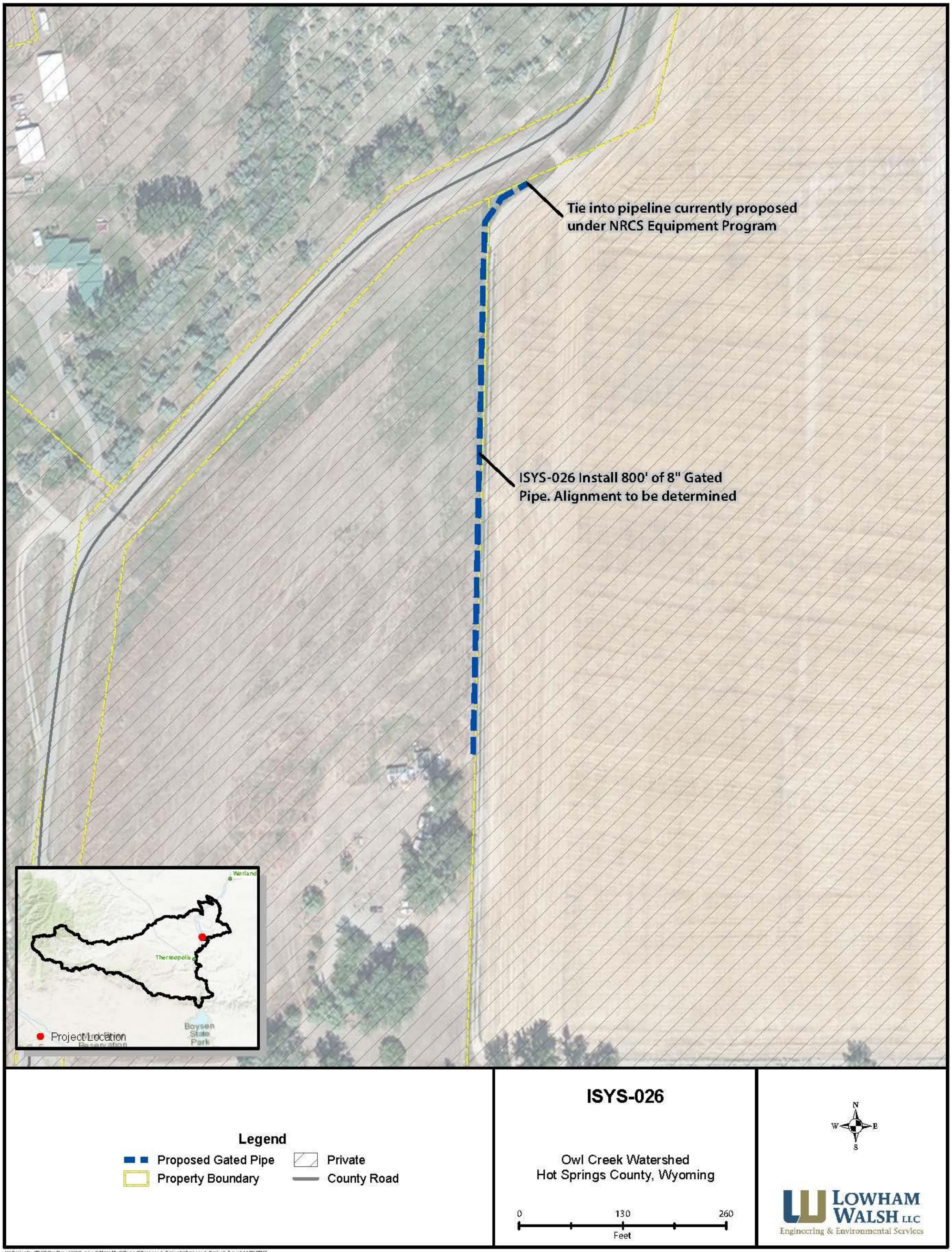
Challenges / Fatal Flaws Identified: None. 1 user served.

Net Effects on watershed (See Section 5): Increased water use efficiency, decreased leaching of nutrients and sediment delivery to receiving waters, decreased opportunity to spread noxious weeds (430).


ISYS-017
ISYS-018
ISYS-019
ISYS-020
Dempsey Canal
ISYS-021
Dempsey Canal
789
20
Lucerne Canal
ISYS-022
ISYS-023
Lucerne
Worland
Thermopolis
Boysen State Park
Project Location
Legend
Proposed Flow Measurement Device
Property Boundary
City
BLM
Local Government
Wyoming
Private
Primary Road
Stream
Intermittent Stream
Canal/Ditch
ISYS-017:023
Owl Creek Watershed
Hot Springs County, Wyoming
0
1,000
2,000
Feet
N
W
E
S
Lowham Walsh LLC
Engineering & Environmental Services


ISYS-024 Install approximately 180' of 39" OD HDPE
or fuseable PVC pipe and install rip-rap
protection on each end of the siphon
Lower Lucerne Dit
ISYS-024
Owl Creek Watershed
Hot Springs County, Wyoming
0
80
160
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services
Legend
Siphon
Rip-rap
Property Boundary
Private
Canal/Ditch
Worland
Thermopolis
Boysen State Park
Project Location


ISYS-025 Install 2600' of 15" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Tie to existing 15" pipeline
ISYS-025
Owl Creek Watershed
Hot Springs County, Wyoming
0
260
520
Feet
Legend
Proposed Farm Turn Out Structure & Measurement Device
Proposed Irrigation Supply Line
Property Boundary
Private
Stream
Canal/Ditch
LOWHAM WALSH LLC
Engineering & Environmental Services
Project Location
Thermopolis
Worland
Boysen State Park



Tie into pipeline currently proposed under NRCS Equipment Program
ISYS-026 Install 800' of 8" Gated Pipe. Alignment to be determined
Worland
Thermopolis
Boysen State Park
Project Location
Legend
Proposed Gated Pipe
Property Boundary
Private
County Road
ISYS-026
Owl Creek Watershed
Hot Springs County, Wyoming
0
130
260
Feet
N
S
E
W
LOWHAM WALSH LLC
Engineering & Environmental Services

ISYS-027:

The landowner would like to install approximately 1,000 feet of half pivot to the south of Black Mountain Road on deeded ground. Buried pipe and a farm turn out will be required. The length of the pivot and size of pump should be verified. Installation of the pivot would improve water use efficiency.

Estimated Total Cost (See Section 6): $134,000

Feasibility / Ability to fund (See Section 8): Buried pipe and FTO project portion eligible for SWPP funding as Level 4, NRCS

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): WSEO

Challenges / Fatal Flaws Identified: None.

Net Effects on watershed (See Section 5): Increase plant growth and productivity, decrease water quantity used, and decrease erosion (see NED 449)

No map was prepared for this project as the location of the FTO and pivot center were not known at the time of the field visit. The general location of this project is shown on Figure 4.4.1-1.

ISYS-028:

The landowner would like to install a section of buried pipe and a section of gated pipe to irrigate fallow acreage that is currently used for horse pasture. The gravity operated system would consist of buried pipeline that would begin at Kirby Canal and end approximately 3/8 of a mile to the east. The gated pipe would serve approximately 30 acres and could produce enough pasture to support an estimated ten head of horses.

Estimated Total Cost (See Section 6): $71,000

Feasibility / Ability to fund (See Section 8): Project eligible for SWPP funding as Level 4, NRCS

Rehabilitation vs. New Development: New development

Likely Permits Required (See Section 9): None

Challenges / Fatal Flaws Identified: None

Net Effects on watershed (See Section 5): Increase water use efficiency; provide additional irrigated lands for use by livestock and wildlife, and decreased transmission and spread of noxious weeds (430).

ISYS-029 & 030:

This project involves installing approximately 1500 ft. of buried pipe and a new FTO to supply a half pivot. The pivot would be located to the east side of East River Road (County road 19) and would serve approximately 110 acres. The land is currently flood irrigated and requires approximately three to four CFS to cover the field per irrigation cycle, a center pivot could use up to 33 percent less water. Land leveling and contouring would be required for the pivot to function properly. The landowner also would like to install a new FTO to irrigate a field corner that is currently vegetated by greasewood.

Estimated Total Cost (See Section 6): $248,000

Feasibility / Ability to fund (See Section 8): Project exceeds SWPP funding maximum, possibly eligible for WWDC Level II or III funding. If so, requires a sponsoring entity.

Rehabilitation vs. New Development: New development

Likely Permits Required (See Section 9): None

Challenges / Fatal Flaws Identified: May not be fundable by WWDC because the project as planned only serves 1 user.

Net Effects on watershed (See Section 5): Decrease water quantity lost through evaporation, decreased erosion and leaching of nutrients into stream (see NED 449, section 5).

ISYS-031:

The landowner would like to install buried pipe from Kirby Canal, under south Kirby Road and tie that into a proposed section of gated pipe. Presently, a full pivot irrigates the majority of the field; however, the landowner would like to use gated pipe to irrigate the field corner. It is estimated that an additional 18 to 20 acres could be put into production.

Estimated Total Cost (See Section 6): $52,000

Feasibility / Ability to fund (See Section 8): Project eligible for SWPP funding as Level 4, NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): Possible Right-Of-Way under county road, WSEO?

Challenges / Fatal Flaws Identified: None

Net Effects on watershed (See Section 5): Decrease water quantity lost through evaporation, decreased erosion, leaching of nutrients into stream, and decreased transmission and spread of noxious weeds (449).

ISYS-032:

The landowner would like to convert open channel to buried pipe from Kirby Canal and tie into proposed gated pipe. The ditch currently serves three users. Existing 18 inch head gate needs to be replaced. The possibility of extending buried line to serve remaining users should be reviewed. Installing buried pipe would prevent excessive erosion and mitigate expanding alkali deposits presently observed. The landowner's home is in danger of being undercut by the irrigation ditch and poor drainage is reducing the amount of productive land.

Estimated Total Cost (See Section 6): $57,000

Feasibility / Ability to fund (See Section 8): Project eligible for SWPP funding as Level 4, NRCS, FSA

Rehabilitation vs. New Development: Rehabilitation

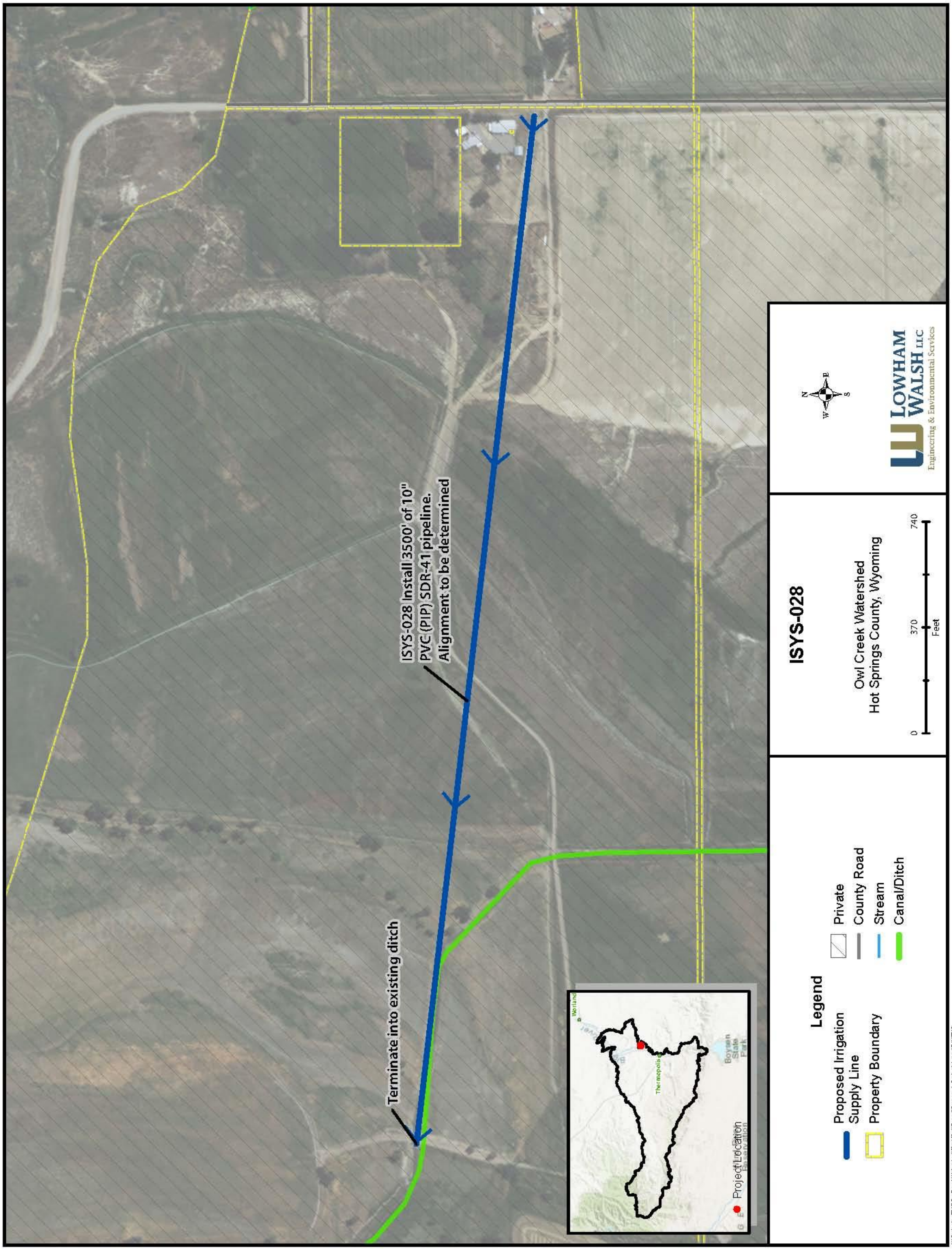
Likely Permits Required (See Section 9): WSEO permit

Challenges / Fatal Flaws Identified: None

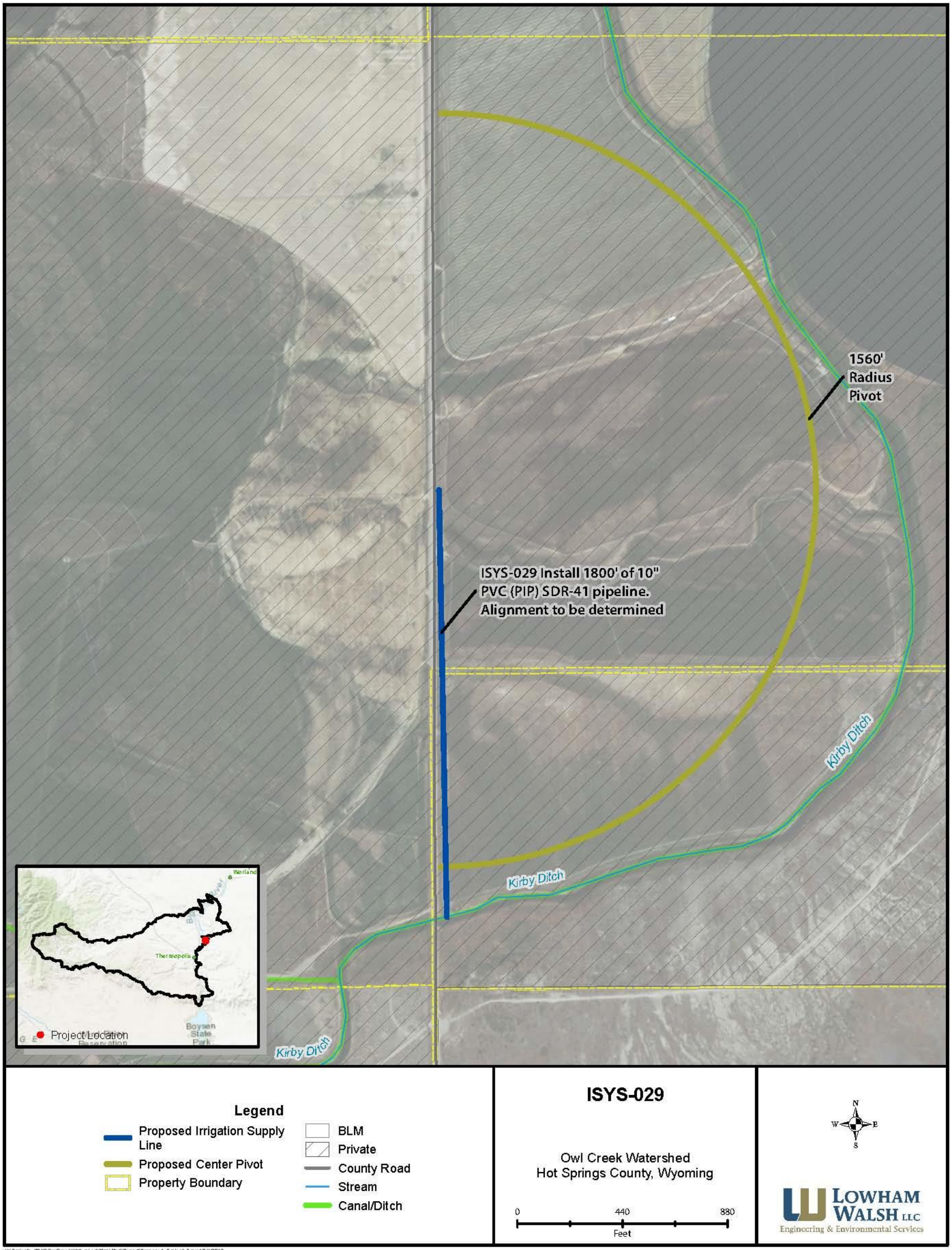
Net Effects on watershed (See Section 5): Decrease water quantity lost through evaporation, decreased erosion and leaching of nutrients and alkali, which currently re-deposits on ground. Addresses safety hazards at landowner's house and decreases transmission and spread of noxious weeds (449).

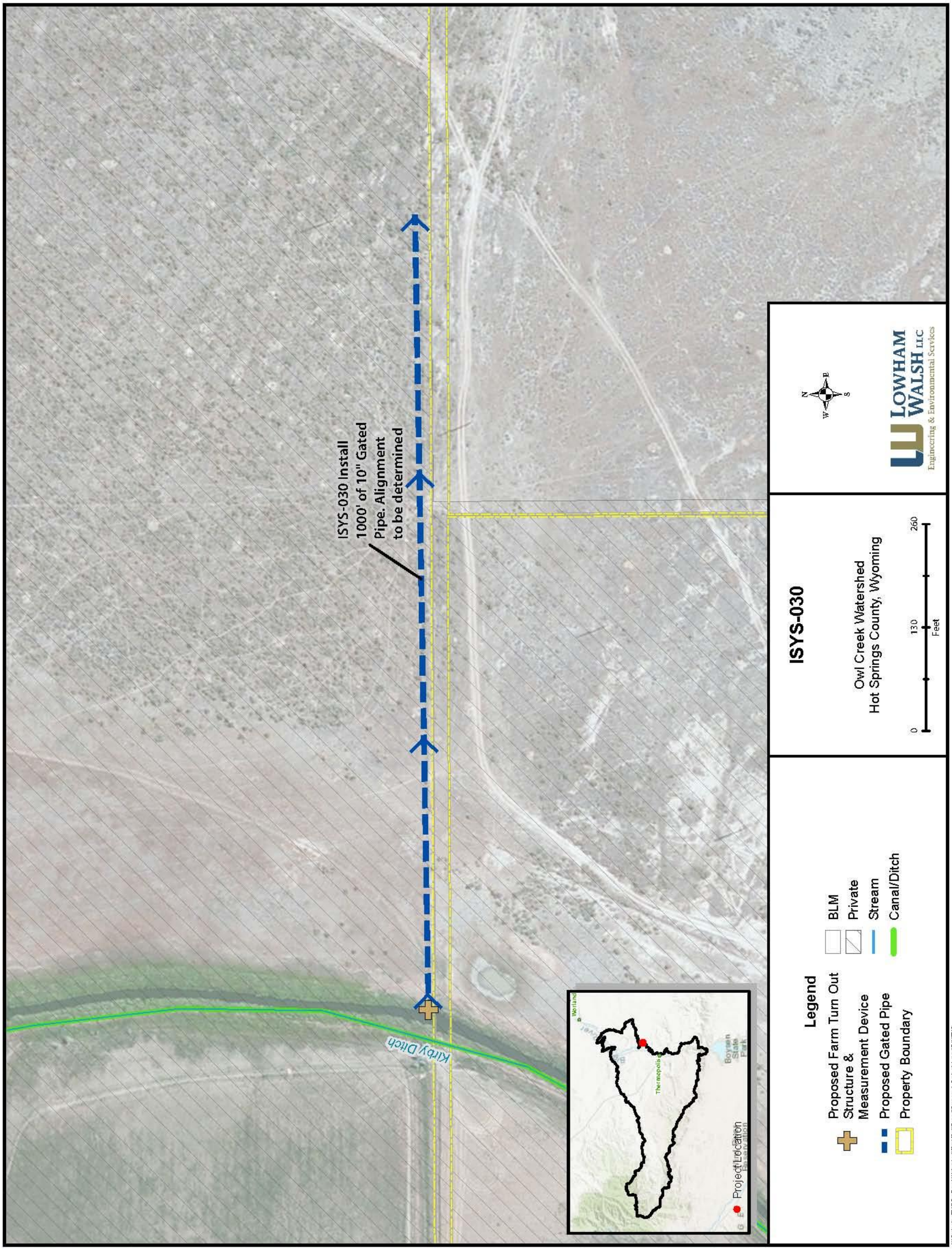
Figure ISYS-027

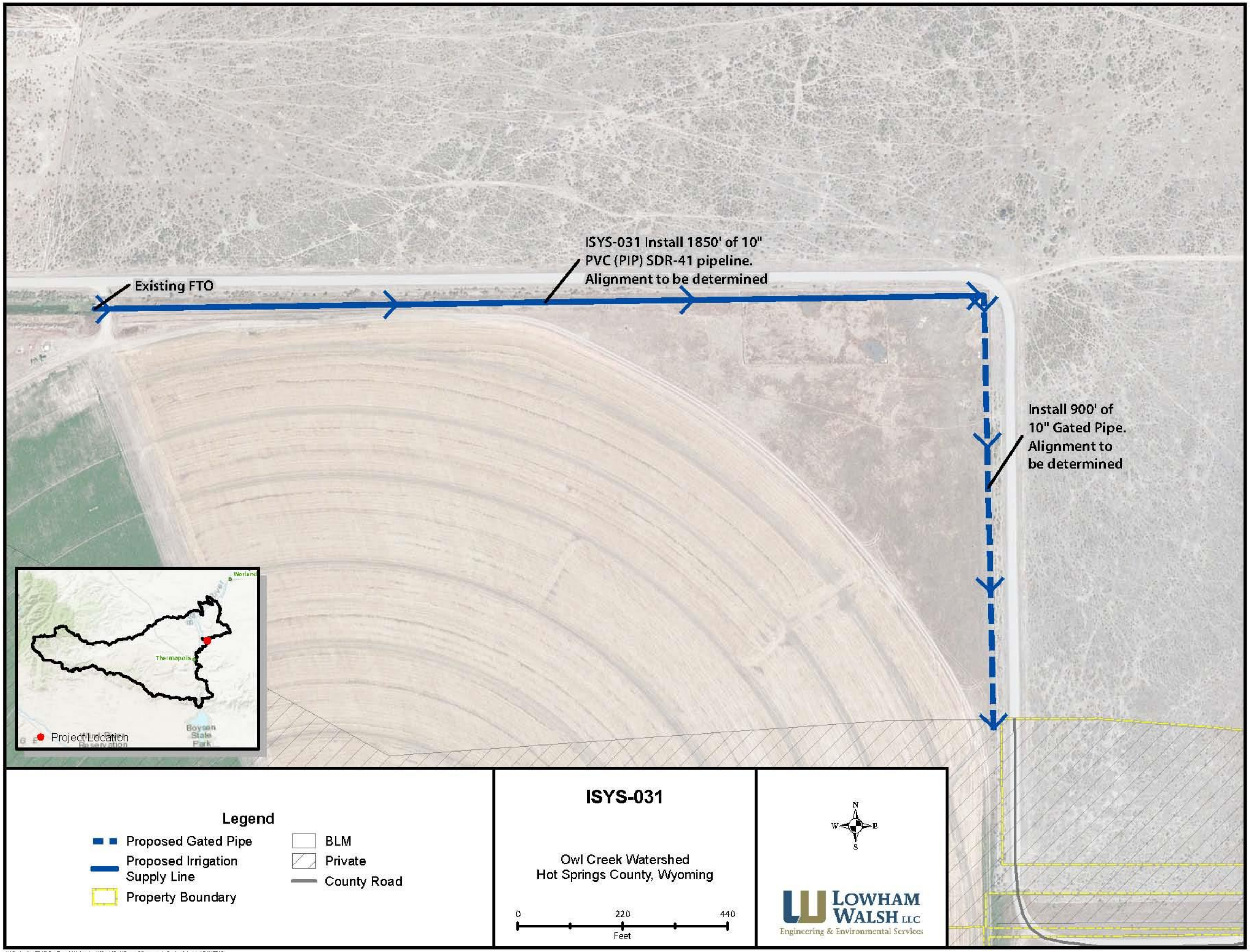
Map not available.



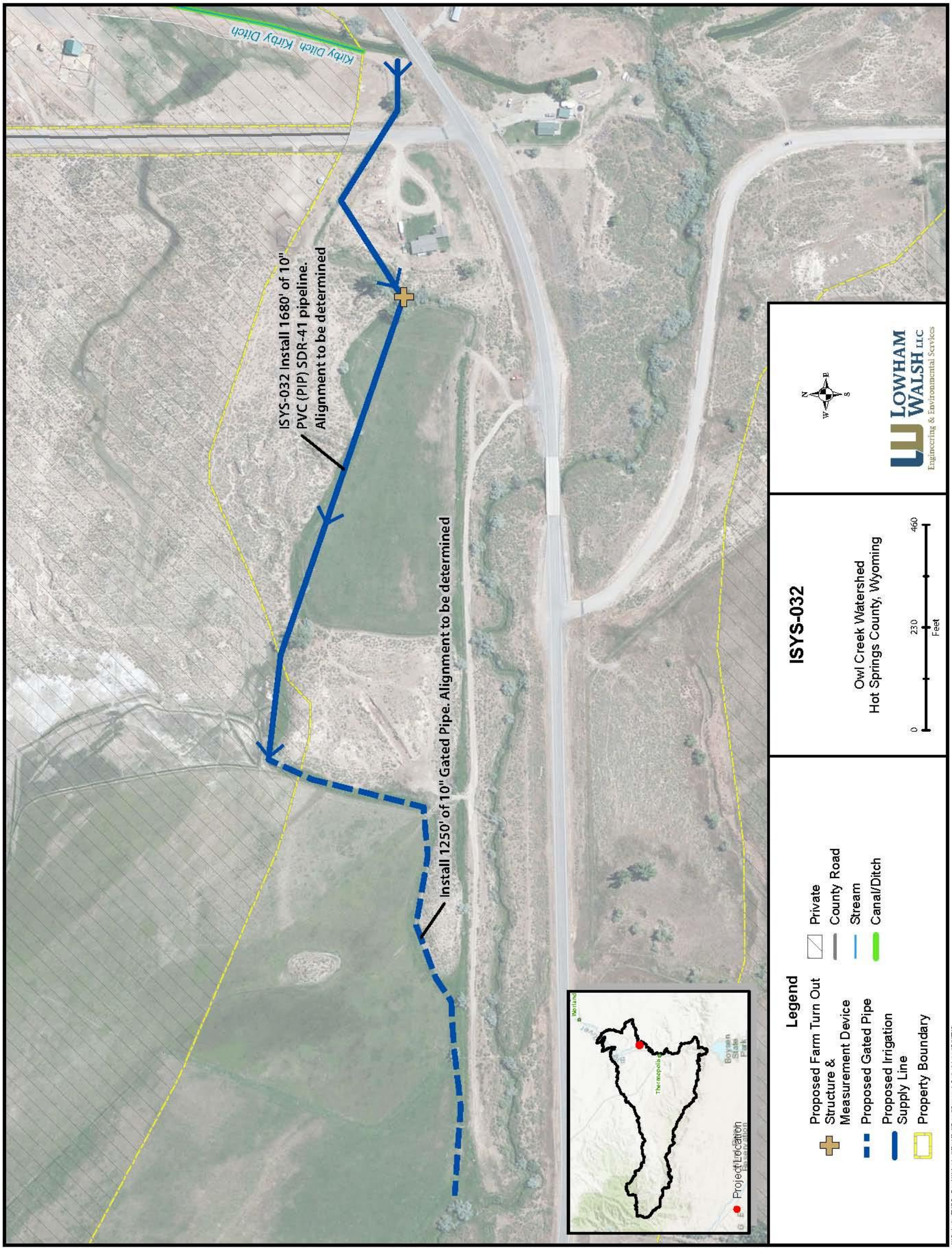
ISYS-028 Install 3500' of 10" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Terminate into existing ditch
ISYS-028
Owl Creek Watershed
Hot Springs County, Wyoming
0
370
740
Feet
Legend
Proposed Irrigation Supply Line
Property Boundary
Private
County Road
Stream
Canal/Ditch
Worland
Thermopolis
Boysen State Park
Project Location
LOWHAM WALSH LLC
Engineering & Environmental Services


1560' Radius Pivot
ISYS-029 Install 1800' of 10" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Kirby Ditch
Kirby Ditch
Kirby Ditch
Worland
Thermopolis
Boysen State Park
Project Location
Legend
Proposed Irrigation Supply Line
Proposed Center Pivot
Property Boundary
BLM
Private
County Road
Stream
Canal/Ditch
ISYS-029
Owl Creek Watershed
Hot Springs County, Wyoming
0
440
880
Feet
N
W
E
S
LOWHAM WALSH LLC
Engineering & Environmental Services


ISYS-030 Install 1000' of 10" Gated Pipe. Alignment to be determined
Kirby Ditch
Project Location
Thermopolis
Boysen State Park
Legend
Proposed Farm Turn Out Structure & Measurement Device
Proposed Gated Pipe
Property Boundary
BLM
Private
Stream
Canal/Ditch
ISYS-030
Owl Creek Watershed
Hot Springs County, Wyoming
0
130
260
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services



ISYS-031 Install 1850' of 10"
PVC (PIP) SDR-41 pipeline.
Alignment to be determined
Existing FTO
Install 900' of
10" Gated Pipe.
Alignment to
be determined
Worland
Thermopolis
Boysen
State
Park
Project Location
Legend
Proposed Gated Pipe
Proposed Irrigation
Supply Line
Property Boundary
BLM
Private
County Road
ISYS-031
Owl Creek Watershed
Hot Springs County, Wyoming
0
220
440
Feet
N
E
S
W
LOWHAM
WALSH LLC
Engineering & Environmental Services


Kirby Ditch
Kirby Ditch
Kirby Ditch
ISYS-032 Install 1680' of 10" PVC (PIP) SDR-41 pipeline. Alignment to be determined
Install 1250' of 10" Gated Pipe. Alignment to be determined
Worland
Thermopolis
Boysen State Park
Project Location
Legend
Proposed Farm Turn Out Structure & Measurement Device
Proposed Gated Pipe
Proposed Irrigation Supply Line
Property Boundary
Private
County Road
Stream
Canal/Ditch
ISYS-032
Owl Creek Watershed
Hot Springs County, Wyoming
0
230
460
Feet
N
E
S
W
LOWHAM WALSH LLC
Engineering & Environmental Services

4.4.2 Additional ISYS Projects Identified During Workshop Meetings

ISYS-W01:

The landowner would like to replace an existing 1950's era irrigation pump and electric motor that pulls water directly from the Bighorn River. Excessive moss is a major problem affecting the intake of the pump and plugging the impact sprinkler heads. The existing pump is 15 HP and provides an estimated 130 gpm at 150 feet of total dynamic head (TDH). The main line is 6 inch PVC rated at 100 pounds per square inch (psi). The landowner would like to install additional 4 inch HDPE SDR11 laterals from the existing mainline to supply more sprinkler heads. The pump upgrade would include a new three phase 15 HP electrical motor and high efficiency centrifugal pump and water filter. This improvement would promote better crop production for two users, more efficient use of irrigation water, savings of electrical costs and less down time due to plugged intakes and nozzles. Because the project site was not visited, nor was any level of survey performed, the projected cost is presented as a range.

Estimated Total Cost Range (See Section 6): $10,000 - $15,000

Feasibility / Ability to fund (See Section 8): Eligible for SWPP funding as Priority 3: Pipelines, Conveyance facilities

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO? None

Challenges / Fatal Flaws Identified: None. 2 users served.

Net Effects on watershed (See Section 5): Increased water use efficiency, less field runoff to river (430).

ISYS-W02:

The landowner has expressed interest in piping an existing drainage ditch that runs parallel to Sunny Side Lane for approximately 390 ft. then turns north for 60 ft. and crosses under the road through an existing culvert. Presently, the water backs up into the landowner's adjacent field and is causing excessive erosion in the county ROW and borrow ditch. The new pipe would be 10 inch PVC. Replacing the drainage ditch with pipe will benefit the county road by minimizing current maintenance costs and allowing for proper drainage of irrigated land, which will allow increased production on the landowner's field. This project would also improve the means of conveyance for 4 additional landowners who utilize the waste flow. Because the project site was not visited, nor was any level of survey performed, the projected cost is presented as a range.

Estimated Total Cost Range (See Section 6): $25,000 - $35,000

Feasibility / Ability to fund (See Section 8): Eligible for SWPP funding as Priority 4, NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): ROW for county road crossing, WSEO

Challenges / Fatal Flaws Identified: The backed-up water may be considered a wetland, although it is not mapped as such on the NWI Wetland Map. Wetlands are protected under the Clean Water Act. More than "incidental" impacts to wetlands must be permitted and compensatory mitigation must be conducted.

Net Effects on watershed (See Section 5): Decrease flooding resulting in an increase in plant productivity and soil quality, increase water quantity available to users, and decrease erosion and spread of noxious weeds(449, 590).

ISYS-W03:

Currently there is a concrete ditch paralleling Valley Vista Dr. that serves 12 different landowners and approximately 100 acres. The ditch is fed by a headgate located on the Upper Lucerne Canal and is approximately 2400 ft. in length. The concrete has degraded and is due for upgrade as the ditch leaks between the joints in the concrete. The landowner expressed concern that the ditch would not be able to be piped as there is heavy sediment and algal growth present during the irrigation season. The ditch should be evaluated for re-lining and/or replacing the damaged sections of concrete. This would increase conveyance efficiency for all affected users. For this project, because the project site was not visited, nor was any level of survey performed, the projected cost range was too broad to estimate.

Estimated Total Cost Range (See Section 6): Cost estimate to be developed during design phase.

Feasibility / Ability to fund (See Section 8): NRCS, OSLI, Irrigation District

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): None

Challenges / Fatal Flaws Identified:

Net Effects on watershed (See Section 5): Increase water use efficiency; provide additional irrigated lands for use by livestock and wildlife and reduce spread of noxious weeds (430).

ISYS-W04:

The landowner would like to replace an existing open channel ditch with pipe that runs from an existing head gate on the Lower Lucerne Canal. The pipeline would tie into an existing 12" pipe stub that terminates just after the headgate. The proposed 12" pipe would then extend for 320 ft. under the adjacent road and end at a proposed splitter box. This project would increase delivery efficiency for 3 land owners irrigating a total of approximately 20 acres. This transmission line would alleviate ditch erosion and decrease the spread of noxious weeds. Flow measurement would need to be installed on both sides of the splitter box. Because the project site was not visited, nor was any level of survey performed, the projected cost is presented as a range.

Estimated Total Cost Range (See Section 6): $8,000 - $15,000

Feasibility / Ability to fund (See Section 8): Eligible for SWPPP funding as priority 4, NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): ROW, WSEO

Challenges / Fatal Flaws Identified: 3 users served.

Net Effects on watershed (See Section 5): Increased water use efficiency, decreased leaching of nutrients and sediment delivery to receiving waters, and decreased transmission and spread of noxious weeds (430).

ISYS-W05:

The landowner has three separate drainage ditches that exist on their property that are no longer efficient due to vegetation growth and sediment deposition. The landowner would like to re-excavate the ditch lines, install perforated drainage pipe and gravel, and then backfill and compact. A survey would be required and permission from the OCID would be required to upgrade the waste ways. The three separate ditches measure approximately 7,760 ft. in total. Current cross sectional dimensions are unknown. The drainage pipelines would ensure that more waste water would return to Owl Creek. The idea of using the waste water to create a wetland area away from the irrigated land was also discussed. This would benefit two landowners and potentially increase flow transmitted to Owl Creek. Development of a wetland could increase wildlife habitat and could be used to offset other wetlands that may be affected by drainage projects elsewhere in the watershed study area. For this project, because the project site was not visited, nor was any level of survey performed, the projected cost range was too broad to estimate.

Estimated Total Cost Range (See Section 6): Cost estimate to be developed during design phase.

Feasibility / Ability to fund (See Section 8): DU, USFWS, WGFD, Wyoming Wildlife Natural Resources Trust (WWNRT), FSA, NRCS, WDEQ

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WDEQ WYPDES

Challenges / Fatal Flaws Identified:

Net Effects on watershed (See Section 5): Return flow to Owl Creek. Potential mitigation wetlands would create wildlife habitat, store water in alluvial aquifer, increase carbon sequestration, and improve quality of receiving waters, (See Section 5 and NED #656).

ISYS-W06:

Currently the landowner uses two 5 HP, gasoline powered pumps to lift water from their delivery ditch that is fed by the Lucerne Canal to flood irrigate approximately 40 acres. The landowner would like to replace the two pumps with one 25 HP, variable speed pump. A new pumping pond would be excavated at the end of the existing ditch to pump from. The total lift and design flow is estimated to be 8 ft. and 5 cfs respectively. The pump would be AC powered and a trench would need to be excavated for approximately 250 ft. to bring power from the nearest power pole. This project would decrease the landowners operations and maintenance (O&M) costs, increase delivery efficiency, and would allow the landowner to transition to gated pipe irrigation at a later date. The pumping pond would provide seasonal wildlife habitat. For this project, because the project site was not visited, nor was any level of survey performed, the projected cost range was too broad to estimate.

Estimated Total Cost Range (See Section 6): Cost estimate to be developed during design phase.

Feasibility / Ability to fund (See Section 8): NRCS, WGFD

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO

Challenges / Fatal Flaws Identified: None

Net Effects on watershed (See Section 5): Increase water use efficiency, pond may provide seasonal wildlife habitat and increase vegetation diversity (NED 378).

ISYS-W07:

This project would require collaboration between two different landowners operating off of the South Side Ditch. *Landowner A* currently receives water from approximately one mile of ditch fed by the South Side Ditch and regularly receives little to no water. *Landowner A* would like to move their point of diversion (POD) upstream to the same headgate as their neighbors, *Landowner B*. Both landowners would then benefit from the installation of a buried supply line off of one head gate. The supply line could be used to operate independent runs of gated pipe serving a combined 80 acres. This would require a new headgate and check structure, two risers, and flow measuring devices, and would be approximately 1,600 ft. long. *Landowner B* was also interested in rehabilitating three additional headgates on their property that no longer function adequately. *Landowner A* would need to follow the appropriate permitting procedures with the WSEO for changing his Point of Diversion (POD). Because the project site was not visited, nor was any level of survey performed, the projected cost is presented as a range.

Estimated Total Cost Range (See Section 6): $45,000 - $55,000

Feasibility / Ability to fund (See Section 8): NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO

Challenges / Fatal Flaws Identified: 2 users served.

Net Effects on watershed (See Section 5): Increased water use efficiency, decreased leaching of nutrients and sediment delivery to receiving waters, decreased opportunity to spread noxious weeds, (NED 430).

ISYS-W08:

The landowner would like to change their Point of Diversion (POD) in order to better receive adjudicated flow. Currently the landowner is believed to be served off of the Winchester Ditch, but does not receive any flow due to poor ditch conveyance due to down-cutting. The landowner would like to change their POD to be located closer to their property and install a pump and pumping pond to pull water directly out of Owl Creek. Doing so would allow the user to fully irrigate 15 acres. A powerline would need to be trenched in for approximately 370 ft. The pump will need to be sized according to the total head and flow requirements. Water would be pumped from the pond, to a high point in the adjacent field via a buried pipeline approximately 400 ft. in length. The pipeline would terminate in existing surface ditches that the landowner would eventually like to replace with gated pipe. The landowner would need to follow the appropriate permitting procedures with the WSEO to change their POD as well as permit the excavation within the riparian area through the Corp of Engineers (USACE). For this project, because the project site was not visited, nor was any level of survey performed, the projected cost range was too broad to estimate.

Estimated Total Cost Range (See Section 6): Cost estimate to be developed during design phase.

Feasibility / Ability to fund (See Section 8): NRCS, WGFD, WWNRT, FSA

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): WSEO, USACE

Challenges / Fatal Flaws Identified: Change in POD cannot be funded by WWDC. If a wetland or moist riparian area exists in the area to be disturbed by headgate reconstruction, the area may contain habitat for Ute ladies' tresses, a protected species. Surveys may be required.

Net Effects on watershed (See Section 5): Pond would provide seasonal wildlife habitat and vegetation diversity. Bring irrigated lands back into production using water efficiently (NED 378 and NED 430).

ISYS-W09:

Landowner would like to replace an open channel ditch off of the Upper Lucerne Canal with a buried pipeline. This project would be directly related to the flow measurement device described in project ISYS-021. The 12 inch pipeline would be approximately 1,500 ft. long and serve 2 users. The total acreage served was not specified. Project would greatly improve water delivery efficiency and would allow the current ditch to be reclaimed. Pipeline will terminate into a riser and splitter box. Survey would be required to determine alignment and design flow will need to be verified.

Estimated Total Cost (See Section 6): \$30,000-\$50,000

Feasibility / Ability to fund (See Section 8): SWPP, NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO

Challenges / Fatal Flaws Identified: None.

Net Effects on watershed (See Section 5): Increased water use efficiency, decreased leaching of nutrients and sediment delivery to receiving waters, decreased opportunity to spread noxious weeds (NED430).

ISYS-W10:

The landowner has a field with an existing irrigation right, but has no means of conveyance. Landowner would need to install a siphon to cross under a drainage ditch. This siphon would collect waste water near the bottom of the landowner's irrigated field and deliver water to the dry parcel. It is estimated that there is 5 ft. of elevation difference between the beginning and termination of the proposed siphon. Survey would be required to verify elevations and to properly size the structure to accommodate the flow. It is estimated to be approximately 450 ft. in length. This improvement would serve 30 acres and one landowner. For this project, because the project site was not visited, nor was any level of survey performed, the projected cost range was too broad to estimate.

Estimated Total Cost (See Section 6): Cost estimate to be developed during design phase.

Feasibility / Ability to fund (See Section 8): SWPP Priority 4, NRCS

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): WSEO, USACE at drainage ditch crossing, depending on nature of drainage ditch

Challenges / Fatal Flaws Identified: Quality of used irrigation water may be an issue

Net Effects on watershed (See Section 5): Conserves irrigation water supplies and improves offsite water availability without requiring additional water from Owl Creek, which may help maintain Owl Creek in-stream flow, quality, and species diversity (NED 447).

ISYS-W11:

The landowner would like to replace an existing open channel ditch that runs from an existing head gate off of the Lower Lucerne Canal with pipe. The pipeline would tie into an existing 12 inch pipe stub that terminates just after headgate. The proposed 12 inch pipe would then extend for 4,800 ft. This pipeline would benefit 4 to 5 users and serve approximately 100 acres. The current ditch is very sandy and the conveyance losses are suspected to be high. A survey to verify all sizes would be required. For this project, because the project site was not visited, nor was any level of survey performed, the projected cost range was too broad to estimate.

Estimated Total Cost (See Section 6): Cost estimate to be developed during design phase.

Feasibility / Ability to fund (See Section 8): NRCS, SWPP

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO

Challenges / Fatal Flaws Identified: 4 to 5 users served.

Net Effects on watershed (See Section 5): Increased water use efficiency, decreased leaching of nutrients and sediment delivery to receiving waters, decreased opportunity to spread noxious weeds, (NED 430).

ISYS-W12:

The landowner would like to install two separate lengths of buried pipe in the irrigation conveyance ditch that is diverted off of Red Creek. The first length is located on deeded land and the second is located on Tribal land. The landowner has expressed his interest to improve the ditch to both parties, with no objections. The irrigation ditch is severely eroded and near the point of washing out due to the migration of Red Creek and seepage from the irrigation ditch. The first length will require approximately 470 ft. of buried pipe; the second length will require roughly 1,200 ft. A measurement device is also recommended. Required materials will include; 16 inch PVC pipe and back-fill material. The ditch supplies two different users with irrigation water and would greatly reduce erosion, resulting in water conservation.

Estimated Total Cost (See Section 6): $50,000-$75,000

Feasibility / Ability to fund (See Section 8): NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): Tribal permit, WSEO

Challenges / Fatal Flaws Identified: Tribal permit may be difficult to acquire.

Net Effects on watershed (See Section 5): Continued functionality of ditch, increased water use efficiency, decreased leaching of nutrients and sediment delivery to Red Creek, decrease opportunity to spread noxious weeds, (NED 430).

ISYS-W13: The landowner would like to replace a portion of their open channel ditch with buried pipe, extending it from an existing length of pipe. It is used to supply irrigation water for barley, corn, beans, and alfalfa production. Approximately 1,100 ft. of 15 inch buried pipe would be required and a 21'' x 15'' reducer to join to existing pipe. There is roughly 2 to 4 ft. in elevation change with a flow rate of approximately 4 cfs. The landowner would like to leave the pipe open ended. A concrete structure would be necessary at the end of the pipeline to dissipate flow. Installation would benefit one user and would eliminate ditch seepage and erosion.

Estimated Total Cost (See Section 6): $40,000-$60,000

Feasibility / Ability to fund (See Section 8): NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO

Challenges / Fatal Flaws Identified: None

Net Effects on watershed (See Section 5): Increased water use efficiency, decreased leaching of nutrients and erosion and decreased transmission and spread of noxious weeds (NED 430).

ISYS-W14:

The landowner does not have access to irrigation water, but currently pays for the water right. There is an existing, open channel ditch diverted off of South Side Ditch that could transport water along West Sunnyside Road, but no laterals to individual properties exist. This project could potentially include 6 to 8 users and could put approximately 45 acres +/- into production. The landowners would like to install approximately 4,200 ft. of buried pipe with 6 to 8 Farm Turn Outs (FTO). The size of the pipe will depend on the number of users. Consultation with the Lucerne Pumping & Pipeline Company and the State Engineers Office will be required to determine the water right situation. Individual landowner agreement will be necessary as well. For this project, because the project site was not visited, nor was any level of survey performed, the projected cost range was too broad to estimate.

Estimated Total Cost (See Section 6): Cost estimate to be developed during design phase.

Feasibility / Ability to fund (See Section 8): NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO, road ROW

Challenges / Fatal Flaws Identified: Water rights issues

Net Effects on watershed (See Section 5): Increased water use efficiency, decreased leaching of nutrients and erosion, and decreased transmission and spread of noxious weeds (NED 430).

ISYS-W15 & 16:

The landowner would like to coordinate with the adjacent neighbor to rehabilitate the headgate on the McManus diversion off of Owl Creek. Currently, the two water users cannot regulate their irrigation water due to a rusted and failing headgate that will not seal properly. Presently they are using the sand trap gate to regulate water which requires rehabilitation as well, both landowners wish to restore the headgate and sand trap. Flooding of their fields is an issue in the spring when runoff is high. The water users would like to install a 24 in. culvert that would fit into the present concrete box to help rehabilitate the 5’x8 ’x12’ Waterman headgate. There are roughly 230 irrigated acres served by the McManus Ditch between the two users and rehabilitation of the headgate would greatly reduce water loss and erosion and would lead to increased production. For this project, because the project site was not visited, nor was any level of survey performed, the projected cost range was too broad to estimate.

Estimated Total Cost (See Section 6): Cost estimate to be developed during design phase.

Feasibility / Ability to fund (See Section 8): NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO, WDEQ or USACE

Challenges / Fatal Flaws Identified: If a wetland or moist riparian area exists in the area to be disturbed by headgate reconstruction, the area may contain habitat for Ute ladies’ tresses, a protected species. Surveys may be required.

Net Effects on watershed (See Section 5): Decreased flooding issues, increased efficiency of irrigation water application conserves water (NED 449)

ISYS-W17:

The landowner irrigates approximately 85 acres off of the McManus Ditch and would like to rehabilitate 6 separate diversion points. The headgates at these diversions are old and degraded and eroded areas have started to form, resulting in water loss. Dirt work will be required to rehabilitate the existing ditches and to properly install new headgates. The dimensions of the current headgates is unknown, however the landowner estimates approximately $1500 per point of diversion. For this project, because the project site was not visited, nor was any level of survey performed, the projected cost range was too broad to estimate.

Estimated Total Cost (See Section 6): Cost estimate to be developed during design phase.

Feasibility / Ability to fund (See Section 8): NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): USACE or WDEQ

Challenges / Fatal Flaws Identified: If a wetland or moist riparian area exists in the area to be disturbed by headgate reconstruction, the area may contain habitat for Ute ladies' tresses, a protected species. Surveys may be required.

Net Effects on watershed (See Section 5): Decreased flooding issues, increased efficiency of irrigation water application conserves water (NED 449).

ISYS-W18:

The landowner irrigates approximately 60 acres off of Hale #2 Ditch and is the only user at this point of diversion. The 24 in. headgate is in disrepair and the landowner would like to replace it. The landowner believes that a similar design will be sufficient to suit current and future needs. Replacing the headgate will result in reduced water loss and increased irrigation efficiency, leading to increased crop production. A flow measurement device is also required.

Estimated Total Cost (See Section 6): $7,000-$12,000

Feasibility / Ability to fund (See Section 8): NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WDEQ or USACE

Challenges / Fatal Flaws Identified: None.

Net Effects on watershed (See Section 5): Increased efficiency of irrigation water application conserves water (NED 449).

ISYS-W19:

This project involves two smaller projects, involving rehabilitation of irrigated land and installation of buried pipe for irrigation use. The projects are located in different areas, both are on deeded ground. The center of the landowner's field is not well drained, resulting in a loss of crop production at times. The landowner would like to install approximately 380 ft. of perforated pipe near the center of the field, allowing the excess water to drain into the Big Horn River. There is approximately 500 ft. of drop between the center of the field and the river. In addition, the landowner would like to install an estimated 400 ft. of buried pipe that would lead to an open ditch. This would allow them to cultivate approximately 10 acres of currently fallow agricultural land. One user would benefit from this project. Completion of each of the projects would allow the landowner to increase crop production. For this project, because the project site was not visited, nor was any level of survey performed, the projected cost range was too broad to estimate.

Estimated Total Cost (See Section 6): Cost estimate to be developed during design phase.

Feasibility / Ability to fund (See Section 8): NRCS

Rehabilitation vs. New Development: Rehabilitation and New Development

Likely Permits Required (See Section 9): WSEO, WDEQ, USACE

Challenges / Fatal Flaws Identified: Permitting

Net Effects on watershed (See Section 5): Drainage of the center of the field may decrease soil compaction and increase soil quality (NED 606). Utilizing drainage water in a second field conserves irrigation water supplies and improves offsite water availability (NED 447) and decreases transmission and spread of noxious weeds.

ISYS-W20:

The landowner owns 62 acres and currently irrigates 25 acres. Historically, additional acreage could be irrigated, but extreme ditch loss on the Ready Ditch restricts the amount of water the landowner is able to receive. The landowner would like to install an 18-24 inch buried pipeline that could tie into existing gated pipe to irrigate alfalfa. The pipeline would begin at the splitter box approximately 900 ft. downstream of the diversion off of Owl Creek, extend under Jones road, and terminate approximately 5000 ft. downstream. Completion would enable the landowner to eventually install gated pipe or even a pivot in the future. Installation would benefit one landowner and would allow for increased crop production. For this project, because the project site was not visited, nor was any level of survey performed, the projected cost range was too broad to estimate.

Estimated Total Cost (See Section 6): Cost estimate to be developed during design phase.

Feasibility / Ability to fund (See Section 8): NRCS, SWPP

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): None.

Challenges / Fatal Flaws Identified: None.

Net Effects on watershed (See Section 5): Increase water availability for irrigation, increase plant growth productivity, decrease infiltration and evaporation losses, decrease erosion and transmission of weeds, and decrease sediment delivery to surface waters (NED 430).

4.4.3 Irrigation Storage Improvements (ISTO)

Introduction

Four Irrigation Storage Improvement projects were identified during on-site landowner interviews. Each project is described below, numbered in sequential order from upstream to downstream. **Table 4.4.3-1** summarizes the characteristics of each project. **Figure 4.4.3-1** illustrates the locations of proposed ISTO projects within the study area.

Table 4.4.3-1 ISTO Projects

Project Number	Ditch/Stream	Location	Estimated Capacity (Acre-Ft)	Estimated Acreage Served (Acre)	Brief Description
ISTO-001	Woodard Johnson/Natural Runoff	S7, T8N, R4E	40	135+/-	Rehabilitate existing reservoir and repair wash out upstream of reservoir; repair low level outlet
ISTO-002	Natural Runoff	S8, T8N, R4E	20<	30+/-	Construct new reservoir with low level outlet . The reservoir would serve as flood control and irrigation use
ISTO-003	Natural Runoff Alkali Draw	S10, T43N, R96W	20<	10+/-	Drill new well, install solar array and pump, and rehabilitate existing reservoir
ISTO-004	Proposed Diversion off of Owl Creek	S17, T43N, R95W	50	60+/-	Convert an existing gravel pit into a reservoir; include lining as necessary. Install outlet works and pumping station for irrigation.
*All values were estimated either during time of field visit or after desk top analysis. All values shall be confirmed prior to advancing the project.					

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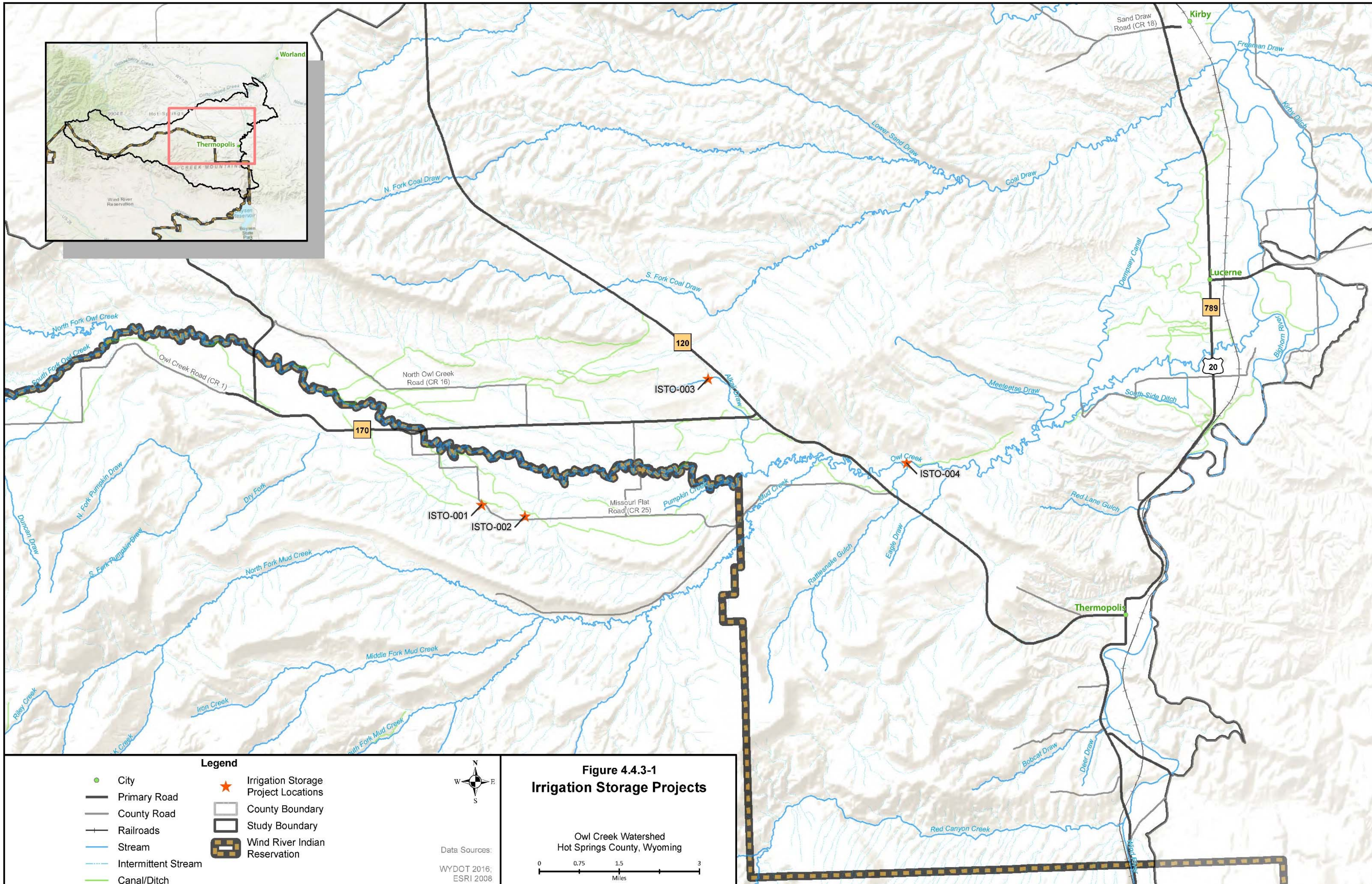

Figure 4.4.3-1
Irrigation Storage Projects

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ISTO-001:

The landowner would like to rehabilitate an existing, permitted reservoir (Skinner P3363R). The reservoir is permitted for 40 ac-ft capacity with livestock and irrigation use but no longer holds water. The landowner suspects that natural flow into the reservoir has been disrupted upstream due to wash-out. LW was unable to verify the status of the supply ditch because the wash-out is located on the Wind River Indian Reservation (WRIR). The reservoir requires rehabilitation of the existing controllable low-level outlet. The benefit of upgrading the reservoir to functional condition includes enhanced livestock watering availability for the Arapaho Ranch and irrigation storage for the landowner. If water were stored in this reservoir, it would supplement the water supply available to approximately 135 acres of land. Other benefits would be enhanced wildlife water availability (mule deer and antelope) along with habitat benefits for waterfowl and sage grouse. Coordination with the tribe would be required to complete improvements.

Estimated Total Cost (See Section 6): $30,000

Feasibility / Ability to fund (See Section 8): WWDC SWPP Priority 2, Wyoming Wildlife and Natural Resource Trust (WWNRT), Wyoming Game and Fish Department (WGFD), NRCS, FSA, USFWS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO, Tribal Permit

Challenges / Fatal Flaws Identified: Landowner coordination

Net Effects on watershed (See Section 5): Increase water storage and availability for irrigation, livestock, and wildlife, improved wildlife and aquatic habitat (NED 378).

ISTO-001 site: Skinner Reservoir (P3363R)

ISTO-002:

The landowner has no adjudicated water right for their property. They would like to develop an impoundment to capture storm water runoff from an ephemeral drainage that ties into the South Side Ditch. The proposed reservoir would provide irrigation water for approximately 30 acres and serve as flood control for the landowner's residence. The reservoir would be designed with a storage capacity of less than 20 ac-ft and would require a controllable low level outlet. The landowner would be required to apply for an irrigation and reservoir application right through WSEO. Project benefits include future utilization of runoff water, improved wildlife and waterfowl habitat, and placement of additional land into agricultural production. Surveys would be required for permitting, design, and construction.

Estimated Total Cost (See Section 6): $16,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 2, WGFD, WWNRT, NRCS, FSA, USFWS

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): WSEO, WDEQ, USACE

Challenges / Fatal Flaws Identified: WSEO

Net Effects on watershed (See Section 5): Provides improved wildlife habitat, vegetation diversity, and controls flood flows into South Side Ditch (NED 378, 640).

ISTO-002 Site: Native erosion channel that leads to South Side Ditch, Potential Reservoir Site

ISTO-003:

There is an existing well that has gone dry. It no longer feeds a reservoir on landowner's deeded acreage and therefore no longer supplies irrigation water to a nearby pasture. The landowner wants to drill a new well, install a solar array and pump, and rehabilitate the existing reservoir. The reservoir would be designed with a storage capacity less than 20 ac-ft and require a controllable low level outlet. The landowner would be required to apply for an irrigation right through WSEO in addition to a reservoir application. Benefits of the project include restoring irrigation to the land thereby increasing productivity and providing habitat improvement for water fowl and wildlife. Surveys would be required for permitting, design, and construction.

Estimated Total Cost (See Section 6): $42,000

Feasibility / Ability to fund (See Section 8): WWDC SWPP Priority 2, Wyoming Wildlife and Natural Resource Trust (WWNRT), Wyoming Game and Fish Department (WGFD), USFWS, FSA, Farm Bill programs

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO

Challenges / Fatal Flaws Identified: Drilling viable well

Net Effects on watershed (See Section 5): Increase water storage and availability for irrigation and provides livestock, wildlife, and aquatic habitat (NED 378).

ISTO-003 Site: Existing Dry Reservoir, Existing Dry Well

ISTO-004:

The landowner wants to rehabilitate the reclaimed Dave Jones gravel pit for water storage purposes. The reservoir would be filled with excess flow from Owl Creek during runoff. The reservoir is estimated at 50 ac-ft. in capacity and would require permitting by WSEO-Board of Control. Sealing the reservoir to prevent leakage may be an issue and needs to be addressed. The landowner plans to eventually pump water under Owl Creek through an 8" diameter pipeline for approximately 650 ft. to a field for supplemental irrigation. The project area has been surveyed by a local surveyor and a WSEO permit is currently being pursued. Potential benefits include improved wildlife and water fowl habitat, recreation, increased stock watering access and improving irrigation for approximately 60 irrigated acres.

Estimated Total Cost (See Section 6): $147,000

Feasibility / Ability to fund (See Section 8): Project exceeds SWPP funding maximum, possibly eligible for WWDC Level II or III funding. If so, requires a sponsoring entity. May also be fundable by WWNRT, WGFD, FSA, NRCS, USFWS

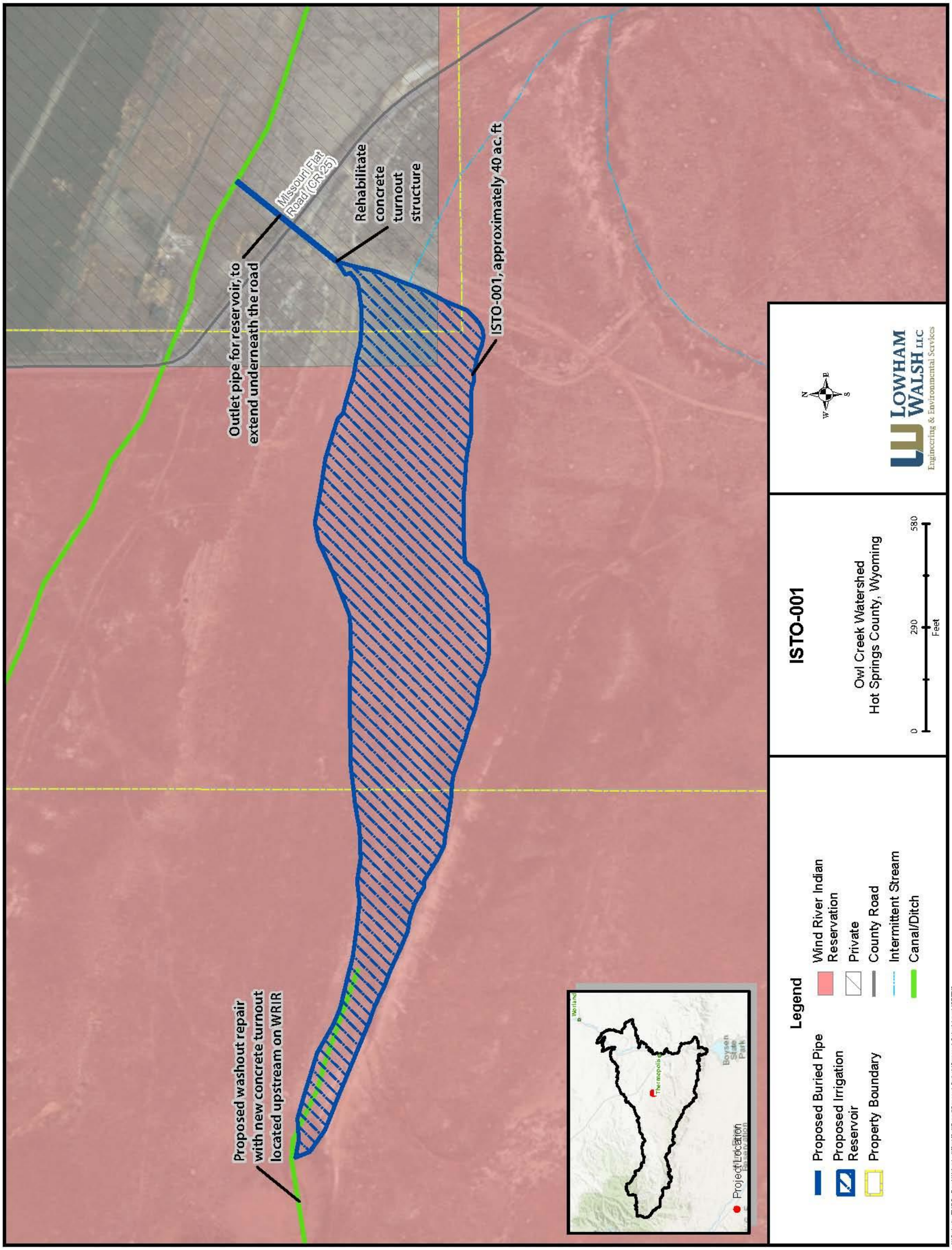
Rehabilitation vs. New Development: New Development

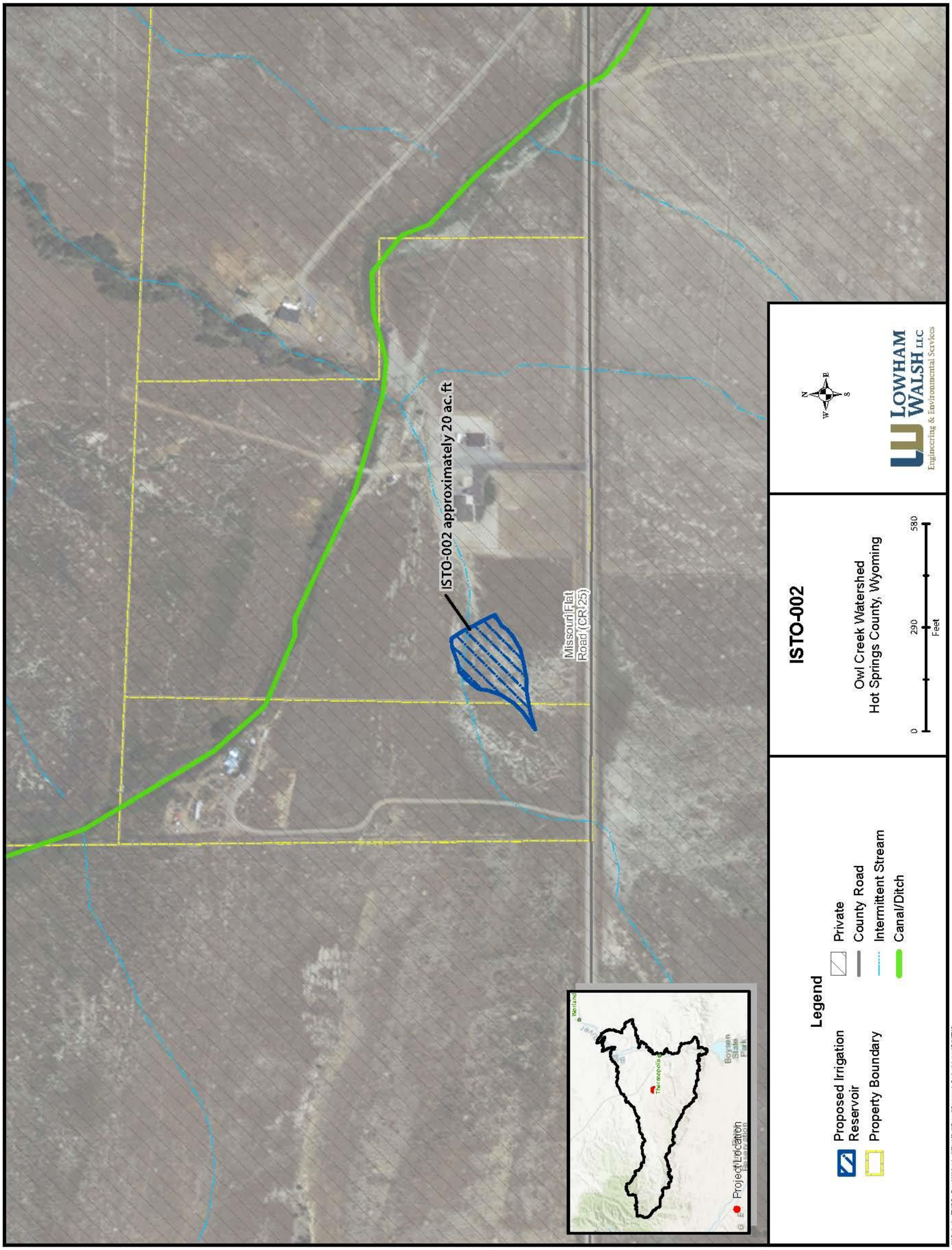
Likely Permits Required (See Section 9): WSEO-Board of Control as it is over 20 ac-ft, WDEQ

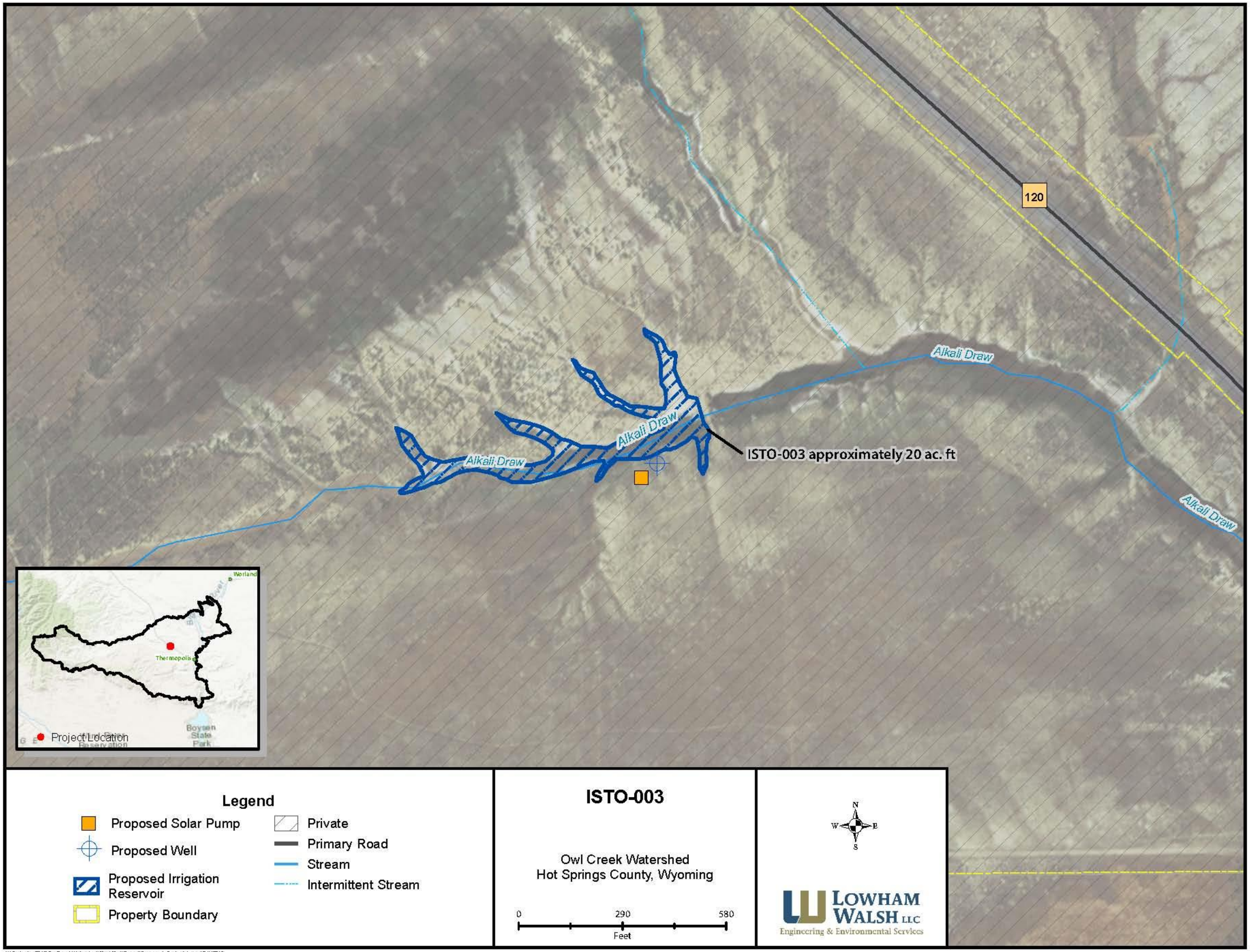
Challenges / Fatal Flaws Identified: Sizing pond to match available water, acquiring the water right, and sealing the reservoir may be issues.

Net Effects on watershed (See Section 5): Improved wildlife habitat, stock watering access, increased length of irrigation season (NED 520, 378).

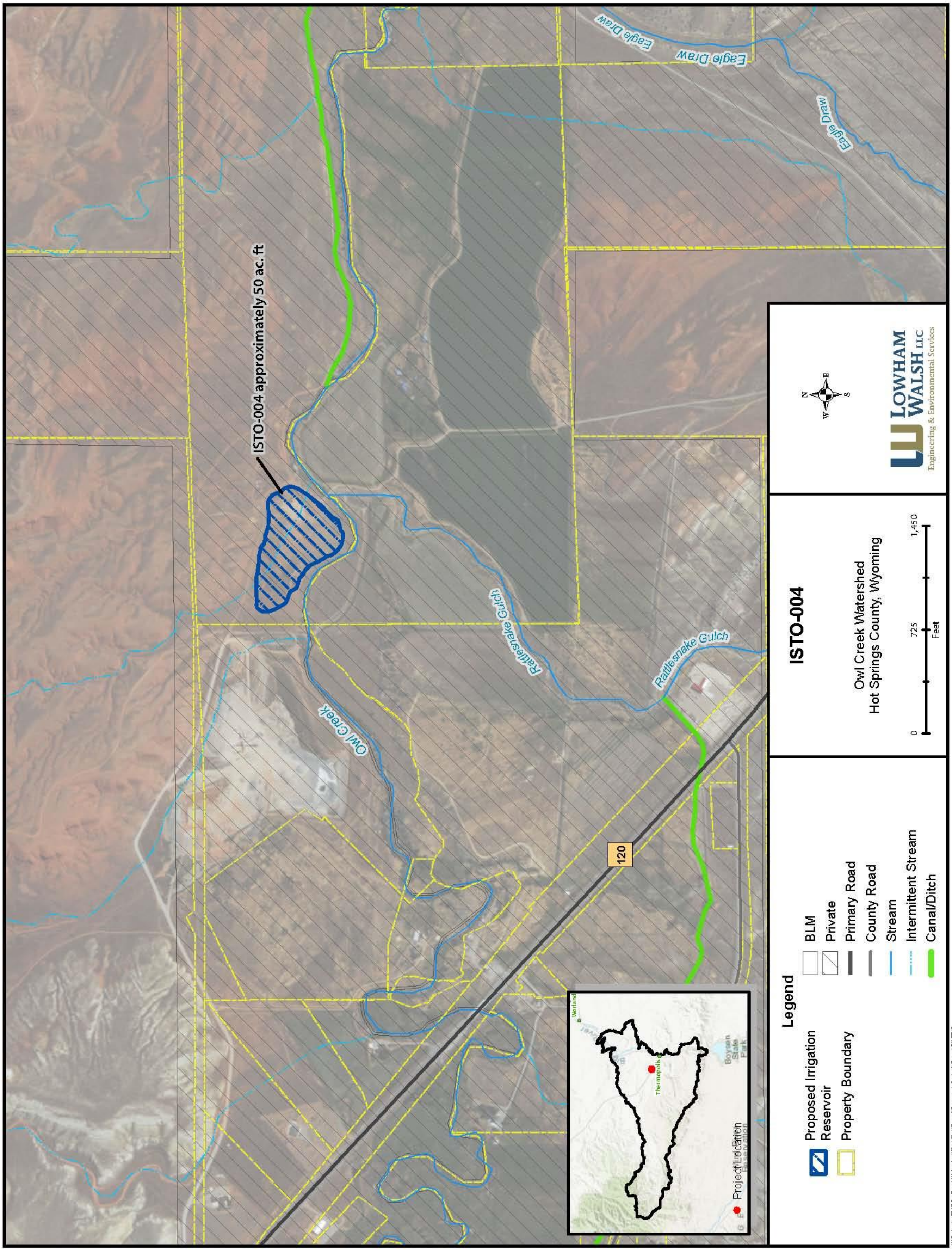
ISTO-004 Site: Dave Jones Gravel Pit


Missouri Flat Road (CR 25)
Rehabilitate concrete turnout structure
Outlet pipe for reservoir, to extend underneath the road
ISTO-001, approximately 40 ac. ft
Proposed washout repair with new concrete turnout located upstream on WRIR
ISTO-001
Owl Creek Watershed
Hot Springs County, Wyoming
0
290
580
Feet
N
E
S
W
LOWHAM WALSH LLC
Engineering & Environmental Services
Legend
Proposed Buried Pipe
Proposed Irrigation Reservoir
Property Boundary
Wind River Indian Reservation
Private
County Road
Intermittent Stream
Canal/Ditch
Thermopolis
Boysen State Park
Project Location


ISTO-002 approximately 20 ac.ft
Missouri Flat Road (CR 25)
ISTO-002
Owl Creek Watershed
Hot Springs County, Wyoming
0
290
580
Feet
N
E
S
W
LOWHAM WALSH LLC
Engineering & Environmental Services
Legend
Proposed Irrigation Reservoir
Property Boundary
Private
County Road
Intermittent Stream
Canal/Ditch
Worland
Thermopolis
Boysen State Park
Project Location



120
Alkali Draw
Alkali Draw
Alkali Draw
Alkali Draw
ISTO-003 approximately 20 ac. ft
Worland
Thermopolis
Boysen State Park
Project Location
Legend
Proposed Solar Pump
Proposed Well
Proposed Irrigation Reservoir
Property Boundary
Private
Primary Road
Stream
Intermittent Stream
ISTO-003
Owl Creek Watershed
Hot Springs County, Wyoming
0
290
580
Feet
N
W
E
S
LOWHAM WALSH LLC
Engineering & Environmental Services


ISTO-004 approximately 50 ac. ft
Eagle Draw
Eagle Draw
Eagle Draw
Rattlesnake Gulch
Rattlesnake Gulch
Owl Creek
120
Thermopolis
Boysen State Park
Project Location
Legend
Proposed Irrigation Reservoir
Property Boundary
BLM
Private
Primary Road
County Road
Stream
Intermittent Stream
Canal/Ditch
ISTO-004
Owl Creek Watershed
Hot Springs County, Wyoming
0
725
1,450
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services

4.4.4 Additional ISTO Projects Identified in Meeting Room Setting

No additional ISTO projects were identified in the meeting room setting.

4.4.5 Stream Channel Stability and Rehabilitation Projects (SCS)

The scope of this Level I investigation precludes an in-depth evaluation of stream channel conditions. Locations where stability issues exist were documented largely through project workshops and word of mouth. Consequently, only a limited number of specific locations where stream channel or bank stabilization projects may be beneficial were noted. However, four sites were visited and on-site notes, measurements, and photos were taken to document conditions. Given the magnitude of the extent of the study area, the complexity of the stream system, and the variety of land uses encompassed within it, there are certainly additional locations where further investigation may be warranted. Seven projects were identified. Each project is described below, numbered in sequential order from upstream to downstream. Most, but not all, of the projects identified and characterized on-site have a large-scale map illustrating general project design. Workshop interviews do not have project-specific maps. **Figure 4.4.5-1** illustrates the locations of proposed SCS projects within the study area and **Table 4.4.5-1** summarizes the general characteristics of each project.

Table 4.4.5-1 SCS Projects

Project Number	Stream	Location	Earth Work Required (CY)	Channel Structures	Miscellaneous Construction	Miscellaneous Structures	Brief Description
SCS-001	N Fork Owl Creek	S8, T43N, R99W	110	Rock Channel Stabilization Structures(3)	Bank Reinforcement Structures(3)		Repair erosion resulting in down cutting
SCS-002	Red Creek	S4, T8N, R2E	33	New concrete check structure	New FTO w/25'-24" CMP, new measurement device	New Sand Trap	Diversion in disrepair. Requires replacement to prevent down cutting
SCS-003	Red Creek	S4, T8N, R2E	75		60'-24"dia. CMP, 25 ton 12"L.D. Rip-Rap		Repair erosion threatening to compromise irrigation ditch parallel to Red Creek
SCS-004	Owl Creek	S7, T43N, R94W	40	New concrete check structure	New FTO , 15 Ton 12" L.D. Rip-Rap, measurement device	New Sand Trap	Diversion in disrepair. Requires replacement to prevent down cutting
SCS-W01	N Fork Owl Creek	S13, T43N, R100W	Unknown	Unknown	Unknown	Unknown	Rehabilitation of irrigation diversion
SCS-W02	Red Creek	S34, T90N, R20E	Unknown	Unknown	Unknown	Unknown	Repair erosion on Red Creek with new diversion structure
*All values were estimated either during time of field visit or after desk top analysis. All values should be confirmed prior to processing of the project.							

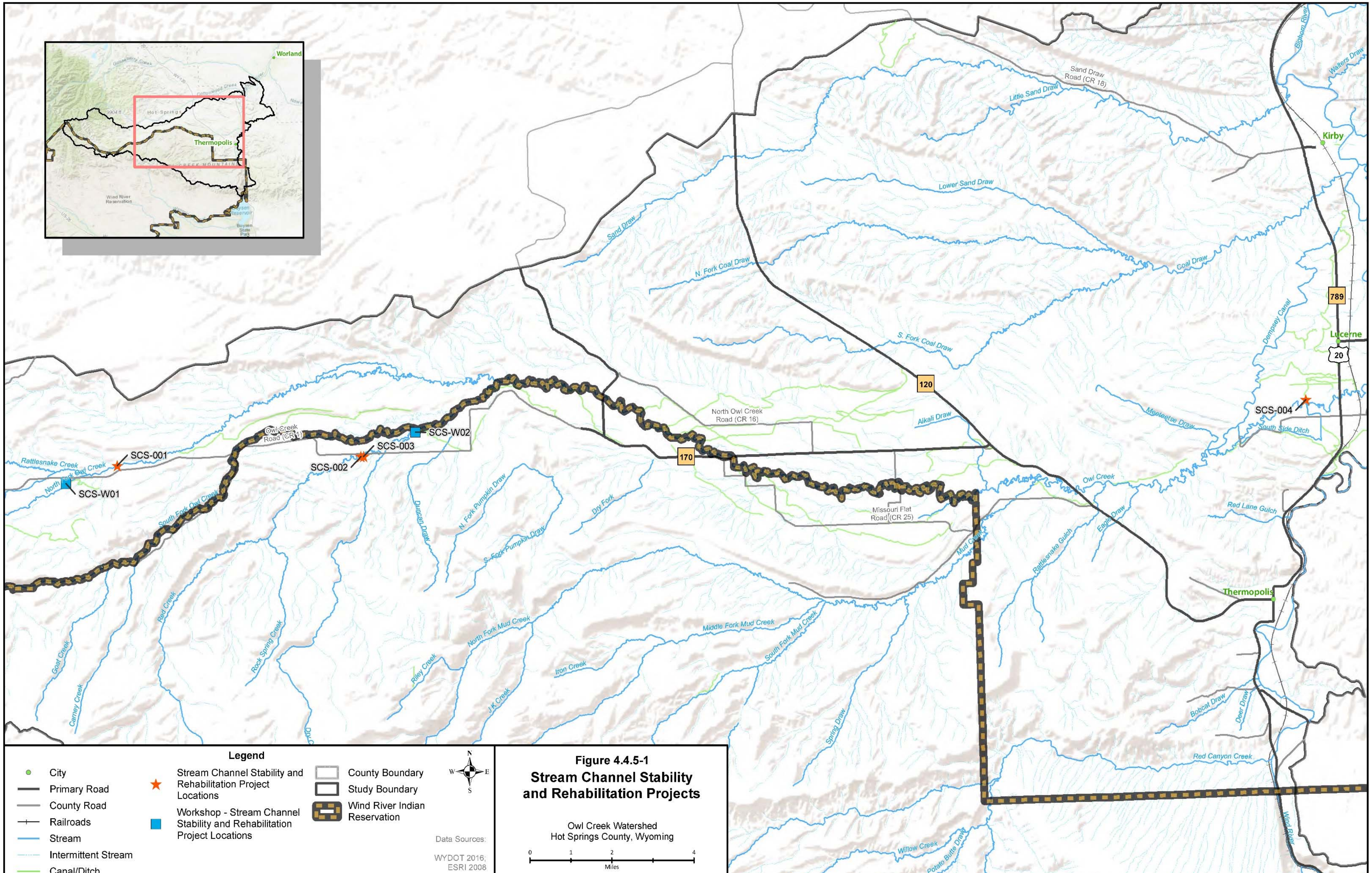


Figure 4.4.5-1
Stream Channel Stability and Rehabilitation Projects

U:\Projects_2015\OwlCreekWatershed\Map\Mxd\Report\Fig_4_4_5-1_Projects_SCS.mxd 12/14/2017

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SCS-001: The North Fork of Owl Creek is highly susceptible to erosion during times of high flow. This project would involve completing stream bank restoration on approximately a half mile of the North Fork. The landowner estimates that erosion has been most severe in the previous two or three years, likely due to larger runoff events in those years. An estimated 2 to 3-foot head-cut has developed on the outside bend of the creek directly behind the landowner's home, exposing the buried potable water line to the house. The excessive down-cutting has made it difficult for the landowner to operate irrigation head gates. Placing appropriate sized boulders, J-hooks, cross vein weirs, installing root balls, and revegetation were discussed as potential best management practices (BMPs). Benefits of this project include reducing scour and erosion in this local reach of the stream, reducing sediment migration downstream, stabilization of the channel and stream banks, restoration of irrigation system efficacy, and prevention of damage occurring to the landowner's water line and well. Photos of the eroded bank area are located below.

This project would require permitting by WDEQ and USACE to work within the 100 year floodplain of Owl Creek. Surveys would be required for permitting, design and construction. Other options include:

- Constructing a stable, fish-passable drop structure at the potable water pipe crossing to provide a hard point to prevent upward migration of the headcut. This would need to be sized for a significant flood flow to remain stable.
- Drilling a new potable water well on the same side of the river as the house. This would be considered a New Source and Priority 1 project.

Estimated Total Cost (See Section 6): $54,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 5, Trout Unlimited (TU), WGFD, USFWS, FSA, WWNRT, OSLI

Rehabilitation vs. New Development: Rehabilitation or New Development, depending on option selected

Likely Permits Required (See Section 9): USACE, WDEQ, WSEO

Challenges / Fatal Flaws Identified: Length of disturbance may exceed that allowed in the applicable USACE Nationwide permit and an Individual permit may be required.

Net Effects on watershed (See Section 5): Project as proposed may reduce scour and erosion in local reach of the stream, reduce sediment migration downstream, stabilize downstream channel and stream banks, improve irrigation system efficacy (NED 436, NED 378).

SCS-001 - Stream bank looking southeast

SCS-001: Close-up of stream bank on North Fork

SCS-002: This project would involve the repair and replacement of a 24 inch CMP diversion and contrived check structure off of Red Creek that currently serves two users. Personnel safety is a concern when operating the system during high flow. Both users have expressed interest in upgrading the structure and installing a measurement device. A photo of the project area is shown below.

This project would incorporate the following components:

- New FTO and check structure
- Measurement device
- Rip-rap above and below check structure
- Sand Trap with return ditch to Red Creek

Benefits of this project include increasing efficiency and effectiveness of water delivery to both users, measurement of water delivery, and improving safety conditions. The diversion/headgate is shown in Figure SCS-002, below.

Estimated Total Cost (See Section 6): $50,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 4, NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): USACE or WDEQ, WSEO?

Challenges / Fatal Flaws Identified:

Net Effects on watershed (See Section 5): A properly functioning diversion and check structure would be safer for landowners/the public and would limit stream bank erosion. Could be used to limit upstream head cutting (NED 348).

SCS-002: Diversion off of Red Creek

SCS-003: This project is located directly downstream of the SCS-002 diversion. The outside stream bank has been severely eroded leaving a 12-foot-high unstable bank. The steep bank is about to wash out due to the upward migration of a headcut on Red Creek and seepage from the adjacent irrigation lateral. It is estimated that 75 yards of fill material would be required to re-construct the stream bank and prevent further damage. Fill would need to be protected with appropriately sized rip-rap and revegetation. The limited access to the site and confining work area needs to be considered. Benefits of the project include stream bank stabilization, preservation of the irrigation lateral bank, and reduction in downstream sediment discharge. Permitting by WDEQ and USACE would be required. Surveys would be required for permitting, design and construction.

Estimated Total Cost (See Section 6): $28,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 4,TU, WGFD, USFWS, FSA, WWNRT

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WDEQ, USACE

Challenges / Fatal Flaws Identified: Access for heavy equipment would be difficult.

Net Effects on watershed (See Section 5): The project would stabilize the stream bank, preserve the function of the irrigation lateral, and reduce downstream sediment discharge (NED 348).

SCS-003 Erosion on right streambank on Red Creek

SCS-003 Same location showing erosion on Red Creek

SCS-004: Currently, the landowner has a home-made check structure on Owl Creek that is aging and requires repair. Due to the location and elevation drop at the site, should the structure fail, a headcut would move rapidly upstream and would impacts water users both up and downstream. The check structure presently consists of railroad ties, large pipes, and car bodies to dissipate energy. Photos of this diversion are shown below. The landowner has expressed interest in creating a more permanent structure as it requires repair annually. Two photos of the project area is shown below.

The following components would be required to complete this project:

- New reinforced concrete check structure and FTO head gate
- Measurement device
- A sand trap with return ditch to Owl Creek
- Approximately 40 cubic yards of eight-inch rip-rap

Benefits of this project include reduction in annual maintenance and repair, increased water distribution efficiency and measurement, prevention of a head cut migrating upstream, and reduced discharge of sediment downstream. Permitting by WDEQ and USACE would be required. Surveys would be required for permitting, design and construction.

Estimated Total Cost (See Section 6): $67,000

Feasibility / Ability to fund (See Section 8): WWDC SWPP Priority 4, NCRCS, TU, WGFD, USFWS

Rehabilitation vs. New Development: Rehabilitation

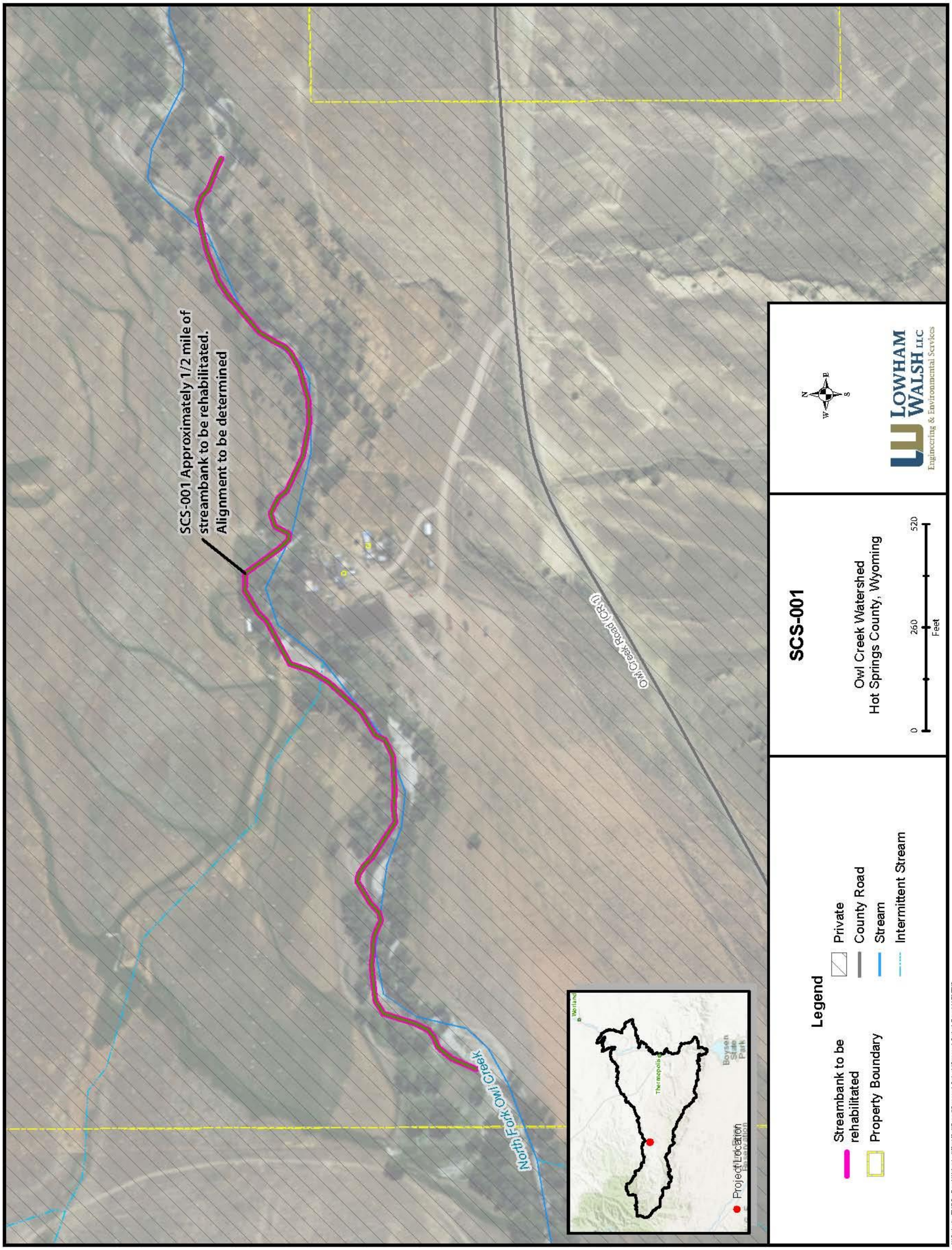
Likely Permits Required (See Section 9): WSEO, USACE, WDEQ

Challenges / Fatal Flaws Identified: The check structure should utilize natural design elements to allow fish passage

Net Effects on watershed (See Section 5): A new structure will prevent head cutting upstream, will stabilize the drainage, and will reduce discharge of sediment downstream (NED 348).

SCS-004: Check structure on Owl Creek

SCS-004: Check structure and diversion


SCS-001 Approximately 1/2 mile of streambank to be rehabilitated. Alignment to be determined
North Fork Owl Creek
Owl Creek Road (CR 1)
Project Location
Thermopolis
Boysen State Park
Legend
Streambank to be rehabilitated
Property Boundary
Private
County Road
Stream
Intermittent Stream
SCS-001
Owl Creek Watershed
Hot Springs County, Wyoming
0
260
520
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services


Owl Creek Road (CR1)
Red Creek
SCS-003 Install approximately
75 cubic yards of rip-rap
SCS-002 Rehabilitate existing FTO
SCS-002 and SCS-003
Owl Creek Watershed
Hot Springs County, Wyoming
0
70
140
Feet
Legend
Existing Farm Turn Out Structure
Rip-rap
Property Boundary
Private
County Road
Stream
Worland
Thermopolis
Boysen State Park
Project Location
LOWHAM WALSH LLC
Engineering & Environmental Services


SCS-004 Rehabilitate existing FTO
Owl Creek
SCS-004
Owl Creek Watershed
Hot Springs County, Wyoming
0
70
140
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services
Legend
Existing Farm Turn Out Structure
Property Boundary
Private
Stream
Canal/Ditch
Project Location
Thermopolis
Boysen State Park
Worland

4.4.6 Additional SCS Projects identified in Workshops

SCS-W01: A diversion on the North Fork of Owl Creek requires rehabilitation. The diversion serves one landowner who irrigates approximately 80 acres. The diversion and check structure have degraded over time and can no longer deliver sufficient water. This project is similar in nature to SCS-002 and SCS-003.

Estimated Total Cost (See Section 6): $30,000-$50,000 depending on required flow, current condition of existing infrastructure, access to project area, and material quantity.

Feasibility / Ability to fund (See Section 8): Eligible for SWPP funding as Priority 3: Pipelines, Conveyance facilities (See section 8 for details)

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): None

Challenges / Fatal Flaws Identified: WDEQ and USACE will be required. Surveying will be required for permitting, design and construction.

Net Effects on watershed (See Section 5): Reduction in annual maintenance and repair, increased water distribution efficiency and measurement, prevention of a head cut migrating upstream, and reduced discharge of sediment downstream (NED 430).

SCS-W02: Red Creek is highly vulnerable to erosion due to silty soils. It has migrated from its channel near the landowner's two existing ponds. The ponds are designed with an inlet and outlet to and from the creek but due to extreme down-cutting, Red Creek no longer has sufficient elevation to fill the ponds. The landowner would like to restore the channel of Red Creek to facilitate stream flow into the ponds which historically were used for wildlife habitat. It is proposed that a dam be installed either upstream of the ponds or at the confluence of Red Creek and the South Fork of Owl Creek to raise its elevation. Cement ditch pieces have been placed in the creek in an attempt to raise it, but have been washed out. Any structure installed will require wing-walls built into the stream bank. For this project, because the project site was not visited, nor was any level of survey performed, the projected cost range was too broad to estimate.

Estimated Total Cost (See Section 6): Cost estimate to be developed during design phase.

Feasibility / Ability to fund (See Section 8): SWPP Priority 2, WWLFI, WGFD, USFWS, DU, WWNRT

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): USACE, WSEO, WDEQ

Challenges / Fatal Flaws Identified:

Net Effects on watershed (See Section 5): Reduce head-cutting upstream, increase stream stabilization (NED 348).

4.4.7 Upland Range Improvement Projects (URI)

Fourteen Upland Range Improvement projects were identified. Nine projects were identified during on-site landowner interviews and five projects were identified during workshop meetings. Each project is described below, numbered in sequential order from upstream to downstream. All but one of the on-site identified projects have a large-scale map illustrating conceptual project design. Workshop interviews do not have project-specific maps. **Table 4.4.7-1** summarizes each project's characteristics. **Figure 4.4.7-1** illustrates the locations of proposed URI projects within the study area.

Table 4.4.7-1 URI Projects

Project Number	Land Ownership	Location	Estimated AUM Served	Δ Elevation (Ft)	2" HDPE Pipeline Length (Ft)	Energy Source	New Stock Tank	Brief Description
URI-001	Private	S19, T43N, R101W	200	240	3550' DR-41 HDPE Buried Pipe	Solar	X	Install DR-41 buried pipeline and solar powered pump from developed spring to new stock tank, install buried gravity pipeline from stock tank to existing pipeline
URI-002	Private	S8, T43N, R99W	200	257	2900' DR-41 HDPE Buried Pipe	Commercial 110/230 V	X	Install buried pipeline and new pump from existing well up to new stock tank. Existing well requires rehabilitation and testing
URI-003	State, BLM	S16, T44N, R96W	300	160	4600' DR-41 HDPE Buried Pipe	Solar	X	Install buried pipeline and solar powered pump from existing well up to new stock tank
URI-004	Private	S8, T8N, R4E	40	N/A	Unknown	Solar	X	Drill new well, install solar powered pump, and buried pipeline to new stock tank
URI-005	Private, BLM	S19, T43N, R95W	81	120	1800' DR-41 HDPE Buried Pipe	Solar	X	Install buried pipeline and solar powered pump from existing well up to new stock tank
URI-006	Private	S2, T42N, R96W	100	600	4700' DR-41 HDPE Buried Pipe	Solar	X	Install buried pipeline and solar powered pump from existing well up to proposed stock tank and existing reservoir; may require a solar powered relift pump due to elevation requirement
URI -007	Private	S12, T43N, R95W		N/A	N/A	N/A		Rehabilitate existing stock reservoir which is washing out. Install outlet structure.
URI-008	Private,State, BLM	S3, T43N, R95W		N/A	10,000' DR-41 HDPE Buried Pipe	Solar	X(3)	Drill new well, install solar powered pump, and buried pipeline to multiple new stock tanks*
URI-008A	Private	S26, T44N, R95W		230	8150' DR-41 HDPE Buried Pipe	Commercial 110/230 V	X(3)	Install buried pipeline and pump from oil field discharge pond up to new stock tanks*
URI-009	Private	S2, T43N, R95W		24	1200' DR-41 HDPE Buried Pipe	N/A	X	Install a buried pipeline from an existing stock reservoir to proposed geothermal watering devices for livestock
URI-W01	Private	S10, T43N, R100W			7,000' HDPE 2" Buried Pipe	Solar		Install buried pipeline and solar powered pump from spring to three existing stock tanks
URI-W02	Private	S7, T43N, R99W	188	Uknown	Uknown	Solar	X	Rehabilitate three existing wells, install solar powered pumps and stock tanks for livestock and wildlife
URI-W03	Private	S7, T43N, R99W	188	Uknown	Uknown	Solar		Develop an existing spring, install solar powered pump for livestock and wildlife
URI-W04	Private	S7, T43N, R99W	188	Uknown	Uknown	Solar		Develop an existing spring and install solar powered pump to distribute livestock watering locations
URI-W05	Private	S7, T43N, R99W	188	Uknown	Uknown	UNK	X	Install buried pipeline from well referenced in URI-W02 to proposed livestock tank

*Project is broken into two independent alternatives. Only one is to be completed.

*All values were estimated either durring time of field visit or after desk top analysis. All values should be confirmed prior to processing of the project.

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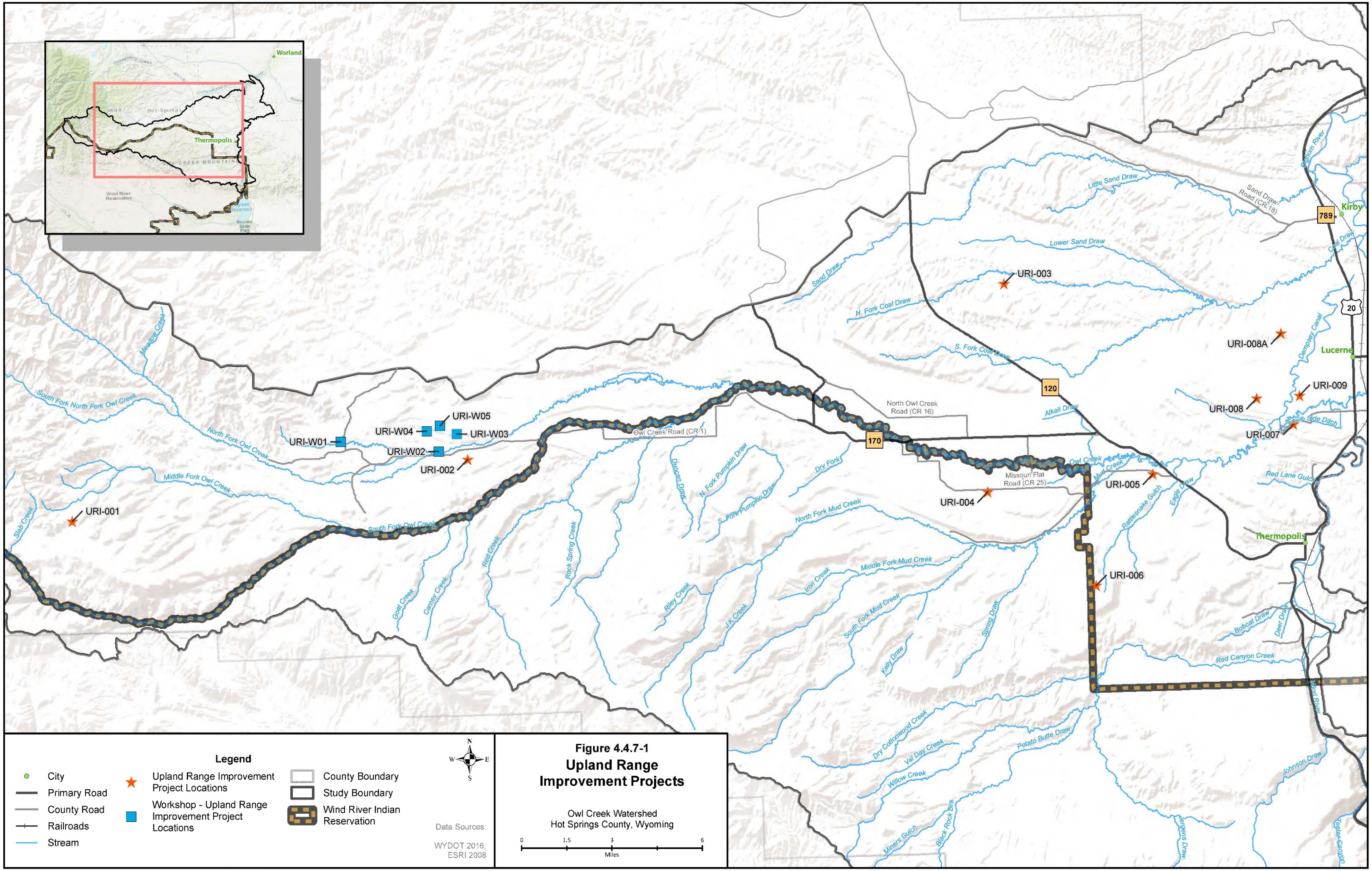

Legend
City
Primary Road
County Road
Railroads
Stream
Upland Range Improvement Project Locations
Workshop - Upland Range Improvement Project Locations
County Boundary
Study Boundary
Wind River Indian Reservation
Data Sources:
WYDOT 2016;
ESRI 2008
Figure 4.4.7-1
Upland Range Improvement Projects
Owl Creek Watershed
Hot Springs County, Wyoming
Miles
URI-001
URI-002
URI-003
URI-004
URI-005
URI-006
URI-007
URI-008
URI-008A
URI-009
URI-W01
URI-W02
URI-W03
URI-W04
URI-W05
Thermopolis
Kirby
Lucerne
Worland
Owl Creek Road (CR 1)
North Owl Creek Road (CR 16)
Missouri Flat Road (CR 25)
Sand Draw Road (CR 18)
U:\Projects_2015\OwlCreekWatershed\Map\Mxd\Report\Fig_4_4_7-1_Projects_URI.mxd 12/14/2017

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URI-001: There is a developed spring on deeded ground near Lime Ridge that supplies an on-channel stock reservoir. The landowner would like to install a solar array, pump, and pipeline from the spring to a proposed stock tank located on a high intervening ridge, then gravity feed via buried pipeline into a reservoir in the bottom of the adjacent draw. The spring and top of the ridge above the proposed reservoir is shown in the photos below. The buried pipe would tie into existing piping that continues down the adjacent draw to fill additional existing stock tanks. Design flow of the spring was estimated to be 10 gpm (based on flow measurement in Sept. 2016). Necessary materials would consist of solar panels, pump, valves, quick-crete, several air relief valves, 200 to 300 gallon stock tank, and 3,550 feet of 2-inch diameter HDPE pipe. A survey would be required to confirm elevations and material specifications. Permitting through the WSEO would also be required. Approximately 2,600 acres of deeded upland grazing land would benefit from better utilization by 200 cow/calf pairs from July to October. Wildlife, including mule deer, elk, ducks, and other water fowl, would also benefit.

Estimated Total Cost (See Section 6): $32,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 1, WWNRT, WGFD, NRCS

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): WSEO and potentially USACE, WDEQ

Challenges / Fatal Flaws Identified: None

Net Effects on watershed (See Section 5): Increased water supply to livestock and wildlife, potential increased aquatic vegetation and species present, ecological integrity of spring is maintained (NED 378, 574).

URI-001 Developed Spring

URI-001 Highpoint Looking down toward spring

URI-002: The landowner would like to rehabilitate an existing well on the property and install 2,900 feet of 2-inch diameter pipeline to a proposed stock tank located on an adjacent hill in a grazing allotment. The tank would then overflow to fill a reservoir below. The reservoir may require bentonite to seal the bottom. The existing non-permitted well is stone and mortar with an 8-inch casing cut off below grade Two photos of the project area are shown below. The well would need to be flow tested before pursuing the project. The pump would be powered from nearby 110 or 220 volt electrical power. Design flow is estimated to be 8 gpm in order to serve the 550 acre pasture and 200 cow/calf pairs. Rocky bedding material would be encountered. The pipeline crosses County Road 170, and could be pulled through an existing storm culvert under the road; however, there is also an existing telephone utility ROW to cross which would require a survey to be completed This project would decrease livestock dependency on the riparian area or enhance range utilization, as well as benefit wildlife. The project would require permitting through WSEO for the well and the reservoir. A permit for the road crossing would also be required from the Hot Springs County Road Department. An alternative approach may include drilling a well closer to the elevation of the existing stock reservoir.

Estimated Total Cost (See Section 6): $31,000

Feasibility / Ability to fund (See Section 8): WWDC SWPP Priority 1, WWNRT, WGFD, NRCS

Rehabilitation vs. New Development: Rehabilitation or New Development, depending on final plan

Likely Permits Required (See Section 9): WSEO, ROW, WDEQ?

Challenges / Fatal Flaws Identified: None

Net Effects on watershed (See Section 5): Decrease livestock dependency on the riparian area and increase range utilization, as well as benefit wildlife (NED 574, 614, 378).

URI-002: Existing Well, Highpoint looking at Reservoir

URI-003: The grazing lessee would like to install a pipeline from an existing solar powered pump and stock tank to a proposed stock tank. Two photos of the project area are shown below. The solar powered well is located on state land and the pipeline crosses BLM ground, ending on deeded land. The existing solar array and pump produces approximately 20 gpm and is 45 feet deep, according to the lessee. Additional solar panels and an upgraded pump would be required to compensate for the elevation changes. Rocky bedding material would be encountered during pipeline installation. The project would need to be permitted through the BLM and Wyoming State Land Board. The project would serve approximately 150 to 300 head of cattle from October to January. Benefits include enhanced range utilization by livestock and increased watering opportunities for wildlife.

Estimated Total Cost (See Section 6): $34,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 1, WWNRT, OSLI, WGFD, NRCS, BLM

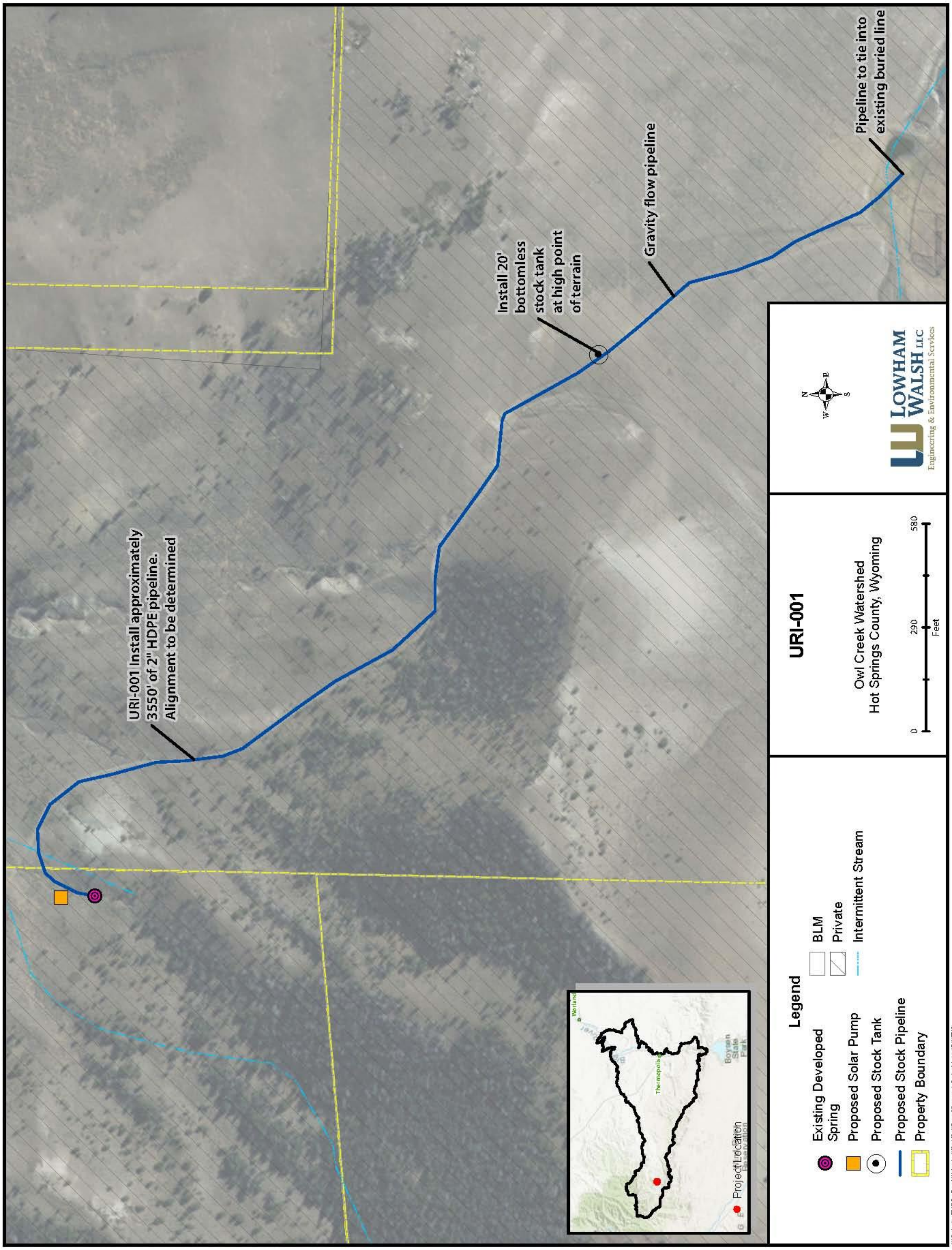
Rehabilitation vs. New Development: Rehabilitation and New Development

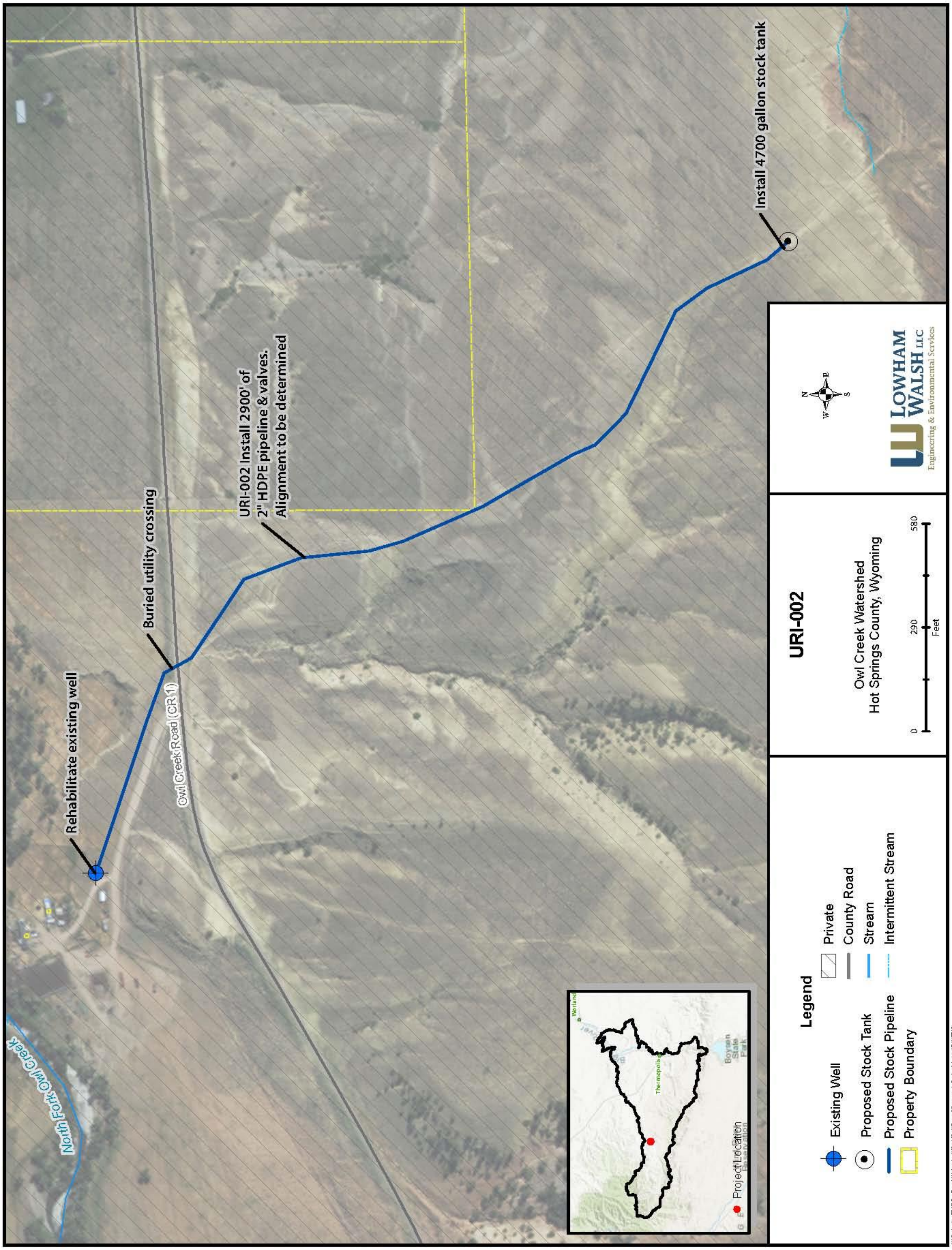
Likely Permits Required (See Section 9): WSEO, WBLC, BLM "Cat-Ex" likely applies if under 1600 linear feet, or "EA" if over.

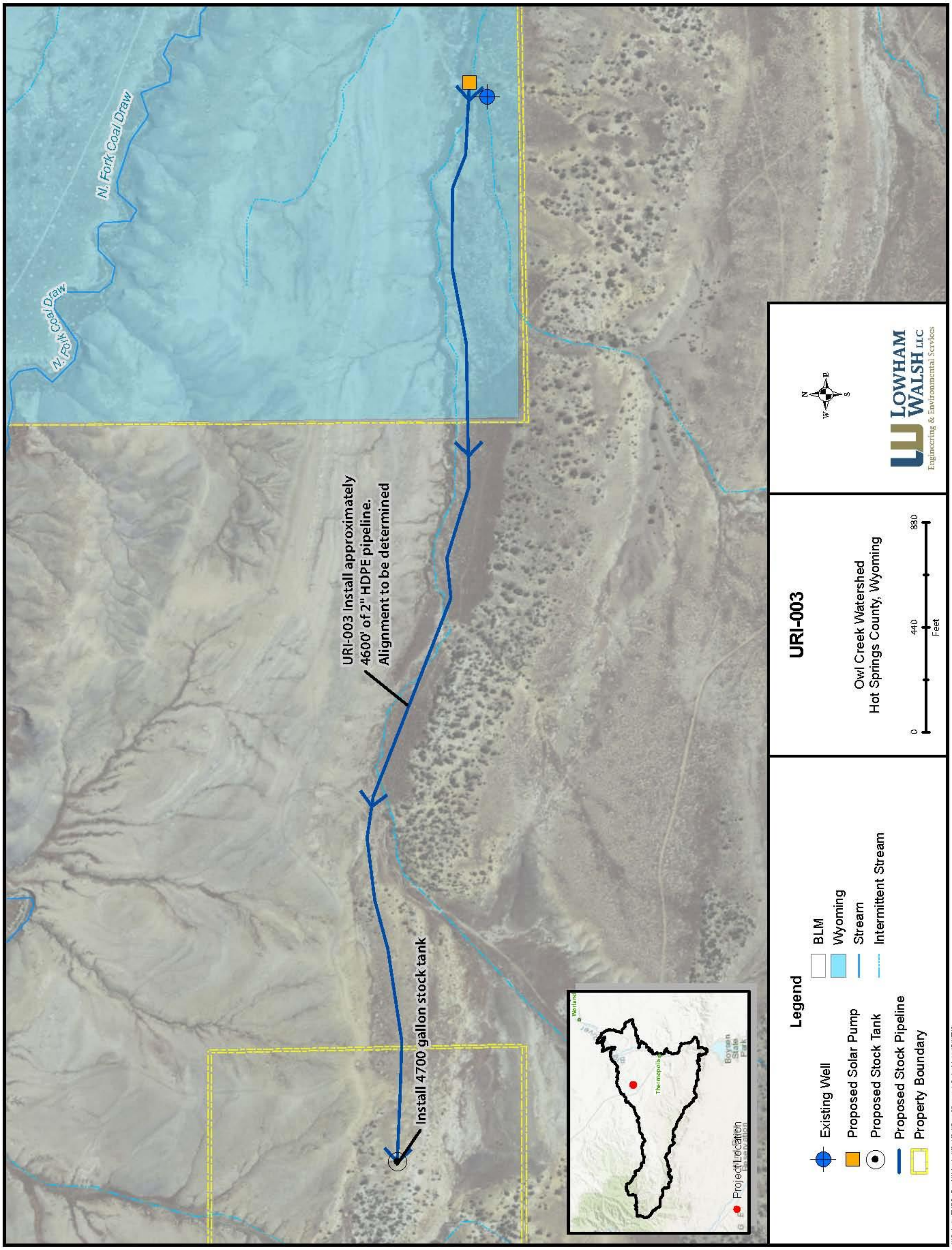
Challenges / Fatal Flaws Identified: Rocky ground may be costly to work in. If EA required, BLM will prepare but this may take a long time. Can hire consultant to conduct EA, this can be costly.

Net Effects on watershed (See Section 5): Benefits include opportunities for better range utilization by livestock and increased watering opportunities for wildlife (NED 574, 614, 645).

URI-003: Existing Solar Array, Highpoint that must be gained, looking northwest


URI-001 Install approximately
3550' of 2" HDPE pipeline.
Alignment to be determined
Install 20'
bottomless
stock tank
at high point
of terrain
Gravity flow pipeline
Pipeline to tie into
existing buried line
Legend
Existing Developed Spring
Proposed Solar Pump
Proposed Stock Tank
Proposed Stock Pipeline
Property Boundary
BLM
Private
Intermittent Stream
Project Location
Thermopolis
Worland
Boysen State Park
URI-001
Owl Creek Watershed
Hot Springs County, Wyoming
0
290
580
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services


Rehabilitate existing well
Buried utility crossing
URI-002 Install 2900' of
2" HDPE pipeline & valves.
Alignment to be determined
Install 4700 gallon stock tank
Owl Creek Road (CR 1)
North Fork Owl Creek
URI-002
Owl Creek Watershed
Hot Springs County, Wyoming
0
290
580
Feet
Lowham Walsh LLC
Engineering & Environmental Services
Legend
Existing Well
Proposed Stock Tank
Proposed Stock Pipeline
Property Boundary
Private
County Road
Stream
Intermittent Stream
Project Location
Thermopolis
Boysen State Park
Worland


N. Fork Coal Draw
N. Fork Coal Draw
URI-003 Install approximately 4600' of 2" HDPE pipeline. Alignment to be determined
Install 4700 gallon stock tank
Worland
Thermopolis
Boysen State Park
Project Location
Legend
Existing Well
Proposed Solar Pump
Proposed Stock Tank
Proposed Stock Pipeline
Property Boundary
BLM
Wyoming
Stream
Intermittent Stream
URI-003
Owl Creek Watershed
Hot Springs County, Wyoming
0
440
880
Feet
N
E
S
W
LOWHAM WALSH LLC
Engineering & Environmental Services

URI-004: The landowner and grazing lessee would like to drill a new stock well and install a solar array with stock tank on approximately 40 acres of deeded dryland pasture. This project could decrease livestock dependency on a riparian area or enhance grazing opportunities in the pasture by providing a reliable water source. Wildlife could benefit from establishing a reliable water source in the area. Permitting through the WSEO would be required.

Estimated Total Cost (See Section 6): $24,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 1, WWNRT, WGFD may also be available

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): WSEO

Challenges / Fatal Flaws Identified: None. 1 user served.

Net Effects on watershed (See Section 5): Benefits include opportunities for better range utilization by livestock and increased watering opportunities for wildlife (NED 574, 614).

URI-005: The grazing lessee would like to install a solar powered pump in an existing well and 1,800 feet of 2-inch diameter HDPE pipeline to fill a proposed stock tank located on BLM land (see photo below). The existing well is on deeded property owned by the lessee and produces approximately 3 gpm. Water should be tested for quality as mineral deposits are present at the well. The water would serve 81 AUMs on a 950 acre pasture. Permitting would be required by BLM and a survey would be necessary for design.

Estimated Total Cost (See Section 6): $26,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 1, WWNRT, WGFD, BLM

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO, BLM “Cat-Ex” or “EA”

Challenges / Fatal Flaws Identified: None. 1 user served.

Net Effects on watershed (See Section 5): Benefits include opportunities for better range utilization by livestock and increased watering opportunities for wildlife (NED 574, 614).

URI-005: At well looking up towards BLM land.

URI-006: The landowner wants to extend 4,700 ft. of 2-inch pipeline from an existing solar powered well uphill to a proposed stock tank, overflow water would drain via a second pipe into an existing dry reservoir. The design flow of the existing system is estimated to be 8 gpm at peak output. The project would serve 80 to 100 cow/calf pairs. A survey would be required for design. This project would enhance range utilization, benefit terrestrial wildlife, water fowl and one landowner. A review of permitting status on the reservoir would be required.

Estimated Total Cost (See Section 6): $42,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 1, WWNRT, WGFD, NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO

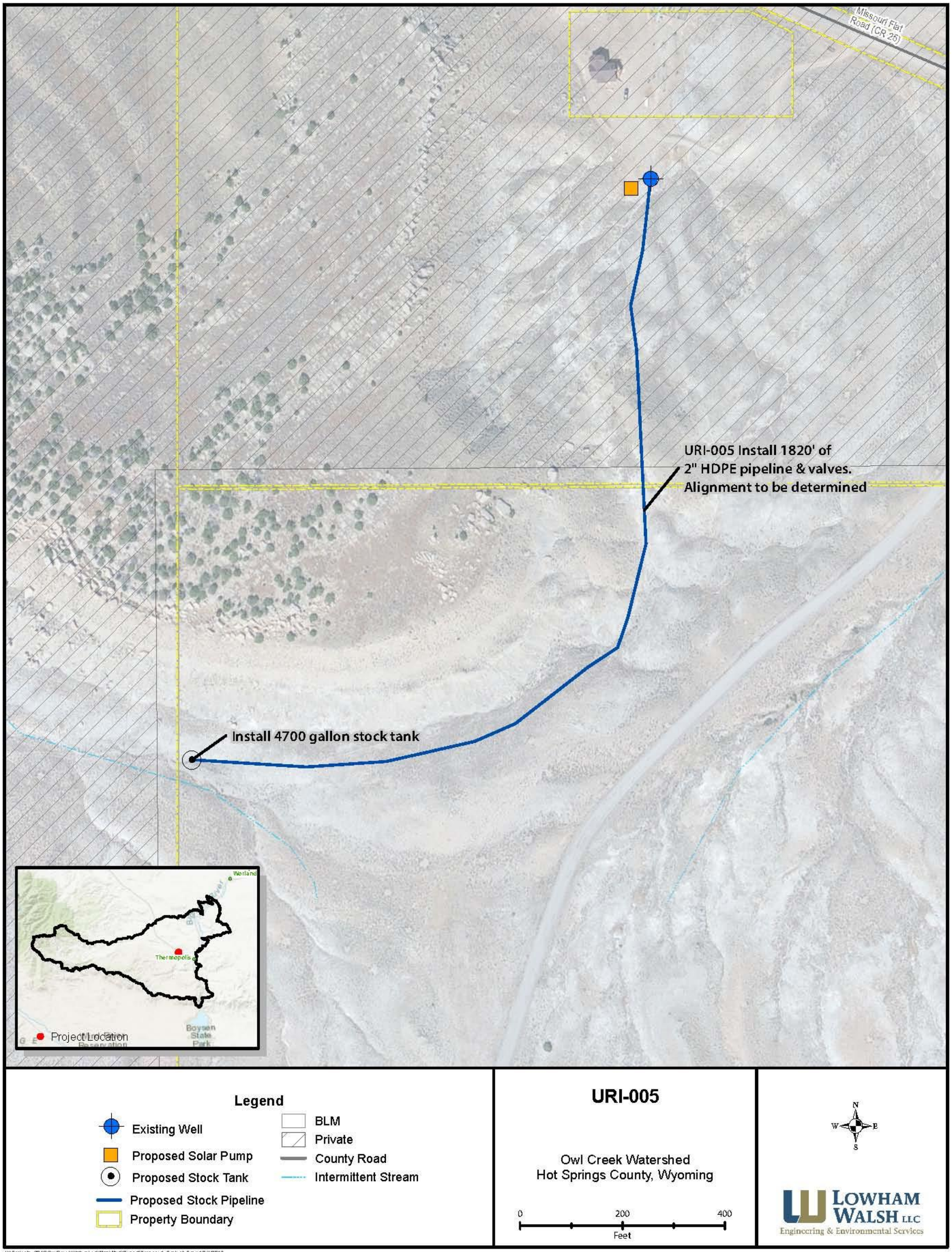
Challenges / Fatal Flaws Identified: None. 1 user served.

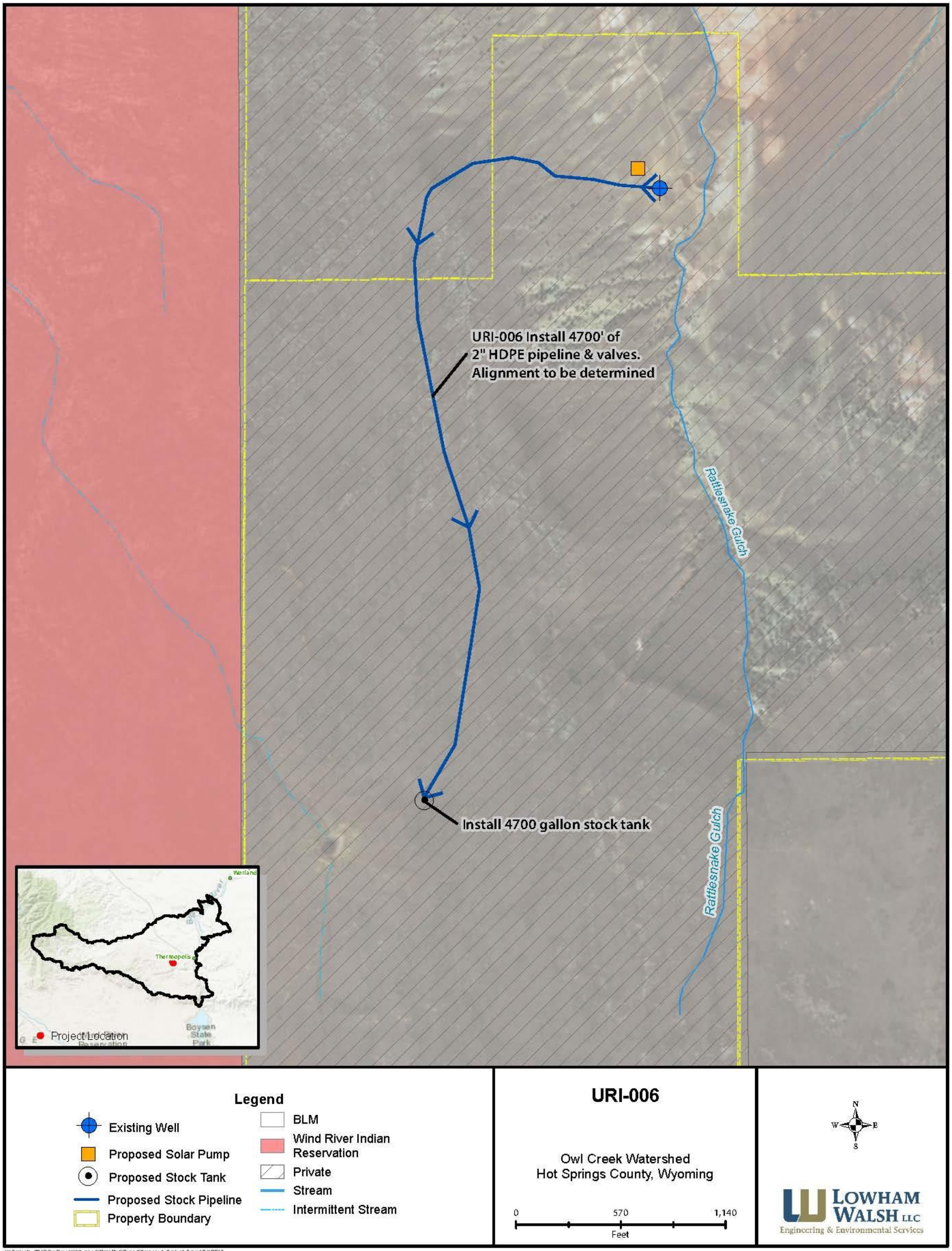
Net Effects on watershed (See Section 5): Benefits include opportunities for better range utilization by livestock and increased watering opportunities for wildlife (NED 574, 614).

URI-006 Existing Stock Tank at Solar Array

URI-006 Highpoint looking down to dry Reservoir


URI-004 Install 4700 gallon stock tank, 2" HDPE pipe, valves
South Side Ditch
Worland
Thermopolis
Boysen State Park
Project Location
Legend
Proposed Solar Pump
Proposed Stock Tank
Proposed Well
Proposed Stock Pipeline
Property Boundary
Private
Canal/Ditch
URI-004
Owl Creek Watershed
Hot Springs County, Wyoming
0
80
160
Feet
N
E
S
W
LOWHAM WALSH LLC
Engineering & Environmental Services


Missouri Flat Road (CR 25)
URI-005 Install 1820' of
2" HDPE pipeline & valves.
Alignment to be determined
Install 4700 gallon stock tank
Worland
Thermopolis
Project Location
Boysen State Park
Legend
Existing Well
Proposed Solar Pump
Proposed Stock Tank
Proposed Stock Pipeline
Property Boundary
BLM
Private
County Road
Intermittent Stream
URI-005
Owl Creek Watershed
Hot Springs County, Wyoming
0
200
400
Feet
N
S
E
W
LOWHAM WALSH LLC
Engineering & Environmental Services


URI-006 Install 4700' of
2" HDPE pipeline & valves.
Alignment to be determined
Install 4700 gallon stock tank
Rattlesnake Gulch
Rattlesnake Gulch
Worland
Thermopolis
Project Location
Boysen State Park
Legend
Existing Well
Proposed Solar Pump
Proposed Stock Tank
Proposed Stock Pipeline
Property Boundary
BLM
Wind River Indian Reservation
Private
Stream
Intermittent Stream
URI-006
Owl Creek Watershed
Hot Springs County, Wyoming
0
570
1,140
Feet
N
S
E
W
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URI-007: The existing stock reservoir on deeded property is threatened by erosion in the spillway. There is no existing outlet piping at the reservoir. The spillway is likely undersized for the drainage area. The stock reservoir would require permitting through the WSEO. Erosion in the spillway would need to be addressed and repaired including possible rip-rap placement. Proper outlet piping with valving would need to be placed in the embankment with rip rap protection at the toe. The landowner uses the reservoir to support 25 to 50 cow/calf pairs. Maintaining this reservoir in working order is important to keep livestock off a nearby riparian area and has allowed the rancher to increase the stocking rate in a nearby dryland pasture. Benefits include better utilization of the pasture, elimination of sediment discharge downstream, and a maintained water resource for wildlife.

Estimated Total Cost (See Section 6): $5,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 2, WWNRT, WGFD, NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO

Challenges / Fatal Flaws Identified: None. 1 user served.

Net Effects on watershed (See Section 5): Benefits include better utilization of the pasture, elimination of sediment discharge downstream, and a maintained water resource for wildlife (NED 574, 614).

URI-007 Spillway Erosion

URI-008/008A: This project could potentially require collaboration between three or four different landowners depending on layout. The proposed project would provide water to a large tract of State, BLM, and deeded property serving multiple grazing allotments. Two different alternatives were discussed by the LW team. Either one or the other of these alternatives should be persued but not both.

Alternative 1(URI-008):

This alternative considers drilling a new well and installing a solar array and pump on a Wyoming State School Section leased by one interested party. Multiple stock tanks could then be sequentially installed in a gravity system. The system would cross approximately ¼ mile of BLM land before entering deeded property. There is the possibility of incorporating ISYS-014 as a supplemental water supply to the system. This alternative would require a new well capable of producing 12 gpm, a 0.5 HP pump and solar array, 7,200 feet of 2 in. diameter HDPE pipeline, 3 stock tanks with 4,700 gallon capacity, and associated valves and fittings. Permitting through the WSEO, BLM, and Wyoming State Land Board is required. Surveys would be required for design, permitting and construction. Benefits include better utilization of grazing allotments on 1,000 acres for multiple lessees and providing multiple water resources for livestock and wildlife.

URI-008 From school section looking downstream

Alternative 2(URI-008A):

This alternative explores the possibility of accessing produced water from nearby Gebo oilfield operations. This alternative has the potential to serve additional users and acreage. An agreement would need to be made between users served to prorate operation and maintenance costs incurred by project. The produced water should be tested for quality and WSEO permit status needs reviewed. This alternative has been pursued previously and was unsuccessful due to loss of interest. This alternative requires 1.5 Horse power pump producing 12 gpm, 8150 feet of 2" diameter HDPE pipeline, 3 stock tanks of 4700 gallon capacity, and associated valves and fittings. Permitting through the WSEO, BLM, and Wyoming Board of Land Commissioners is required. Additionally based on legal status of the produced water, an agreement with owners of the oil wells may be required. Surveys would be required for design, permitting and construction. Benefits of the project include managed utilization of an existing but unused water supply, improvements for multiple users, better utilization of 1000 acres of grazing allotment and providing multiple water resources for wildlife.


URI-008A Highpoint looking south *URI-008A Highpoint looking towards Gebo Field*

The summary below applies to both alternatives to project URI-008.

Estimated Total Cost (See Section 6): URI-008 - $75,000 & URI-008A - $71,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 1, WWNRT, WGFD, OSLI, BLM

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): WSEO, WYPDES, WDEQ, WBLC. OSLI, BLM "Cat-Ex" or "EA"

Challenges / Fatal Flaws Identified: None. Multiple users served.

Net Effects on watershed (See Section 5): Benefits include better utilization of grazing allotments on 1,000 acres for multiple lessees and providing multiple water resources for livestock and wildlife (NED 516, 533, 574, 614).

URI-009: The landowner would like to install 1,200 feet of 2-inch HDPE pipeline and associated valving, from an existing reservoir which is gravity fed by the Upper Lucerne Canal. Piping would supply winter water to two proposed geothermal watering devices for livestock. There is evidence of accelerated erosion to the Upper Lucerne canal banks and installing watering devices would allow the landowner to restrict livestock access to the canal. Benefits include managed use of wastewater, reduced OM&R costs on canal, and better distribution of livestock. An access permit from Owl Creek Irrigation District (OCID) may be required.

Estimated Total Cost (See Section 6): $8,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 3, NRCS

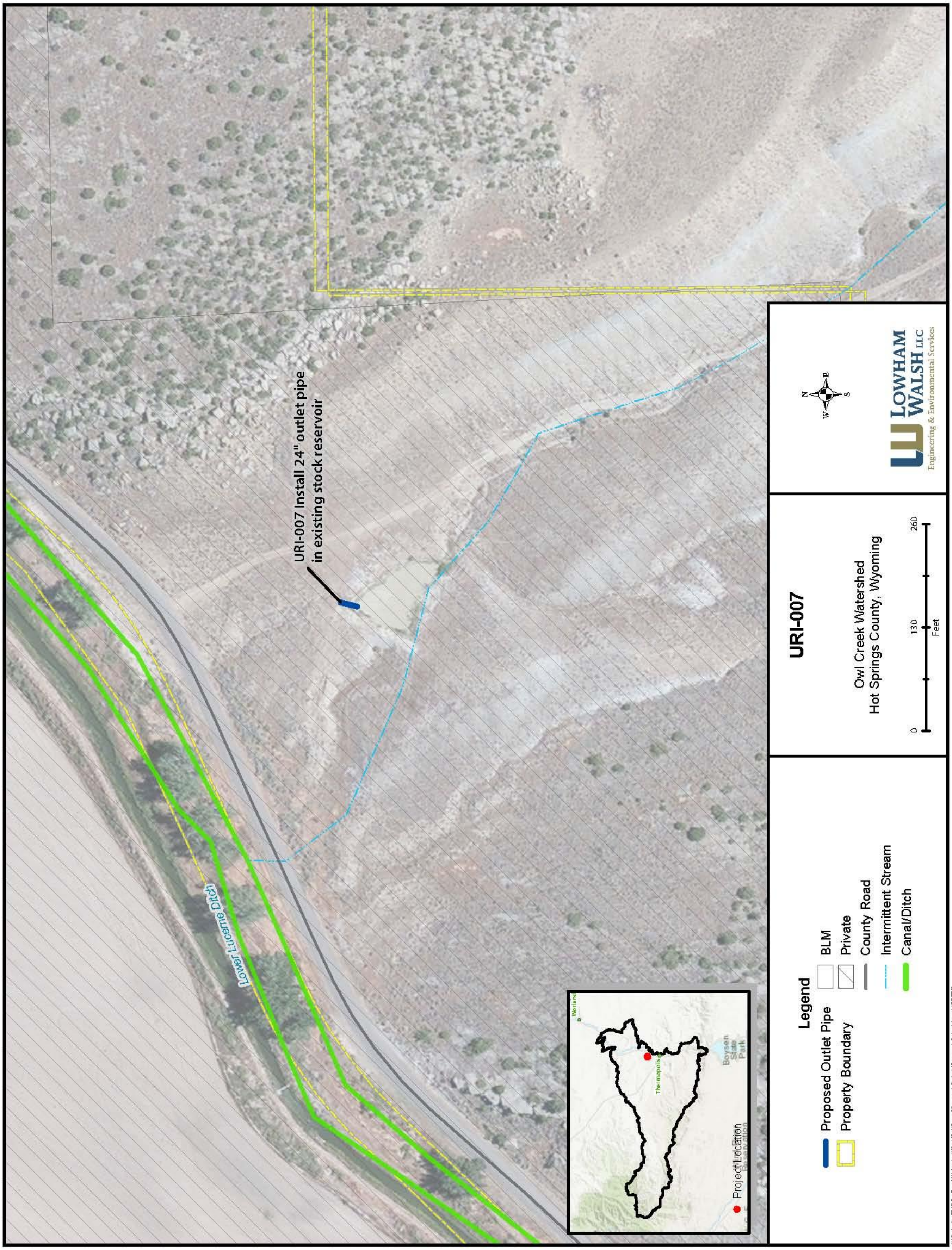
Rehabilitation vs. New Development: New Development

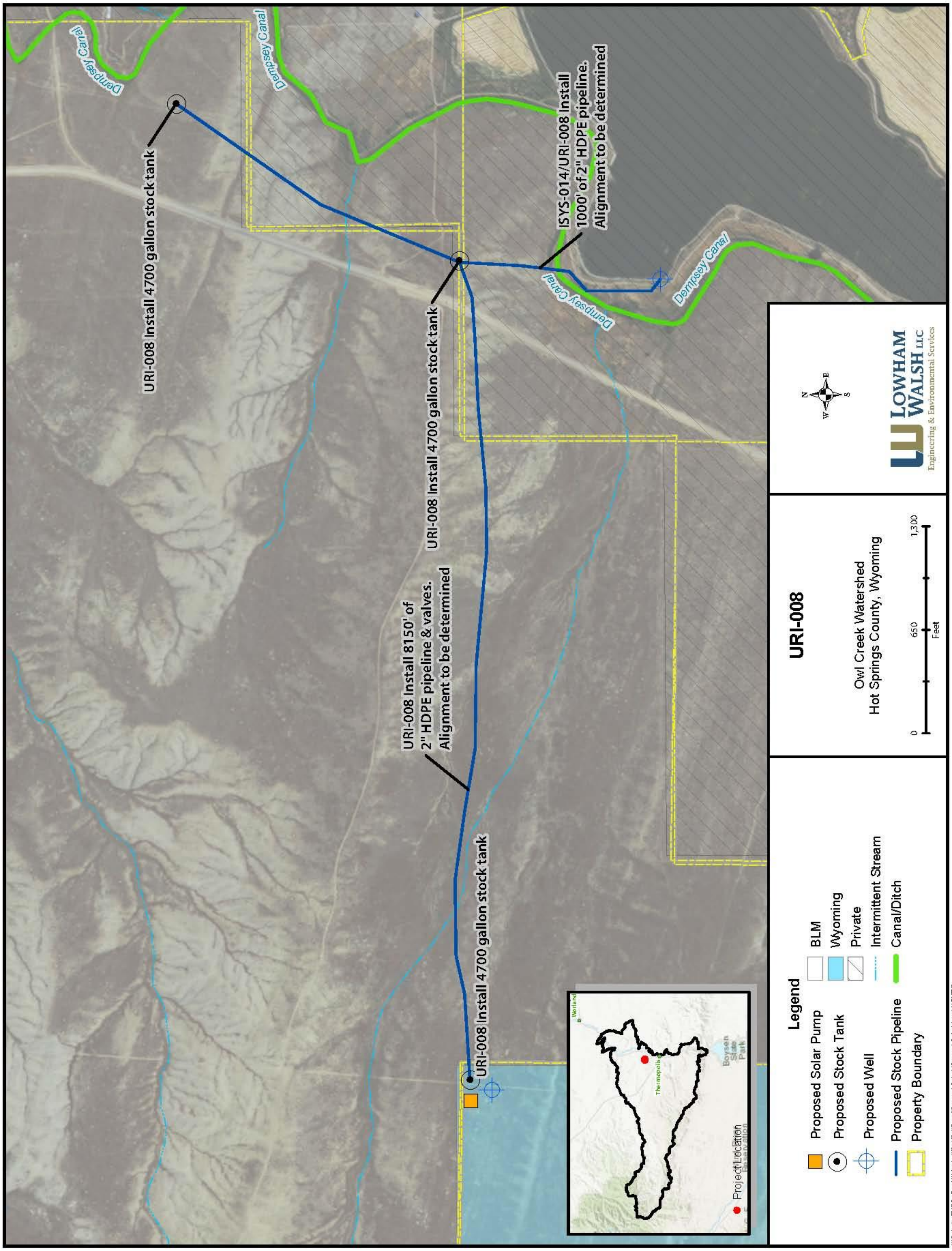
Likely Permits Required (See Section 9): OCID, WSEO

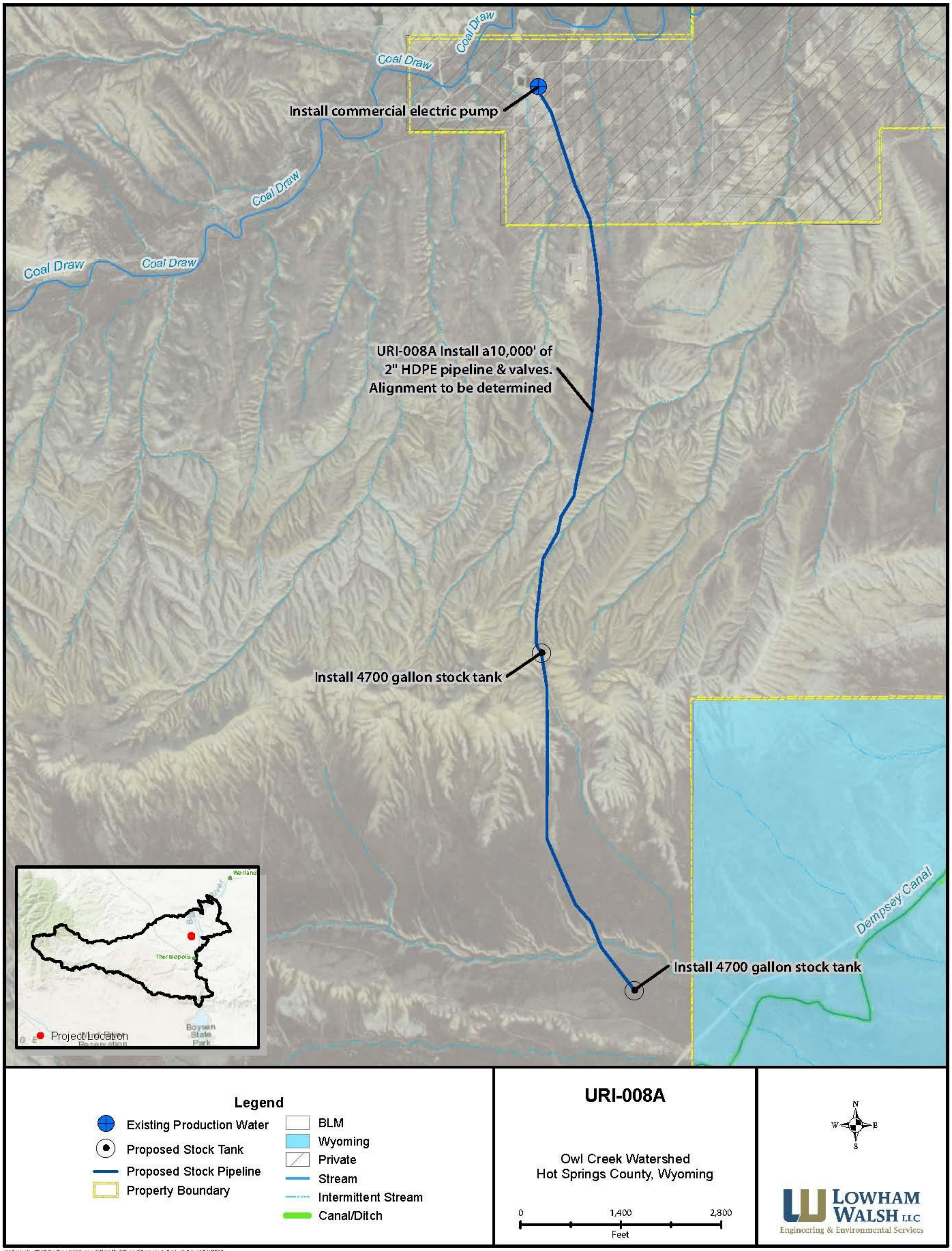
Challenges / Fatal Flaws Identified: Obtaining appropriate permits

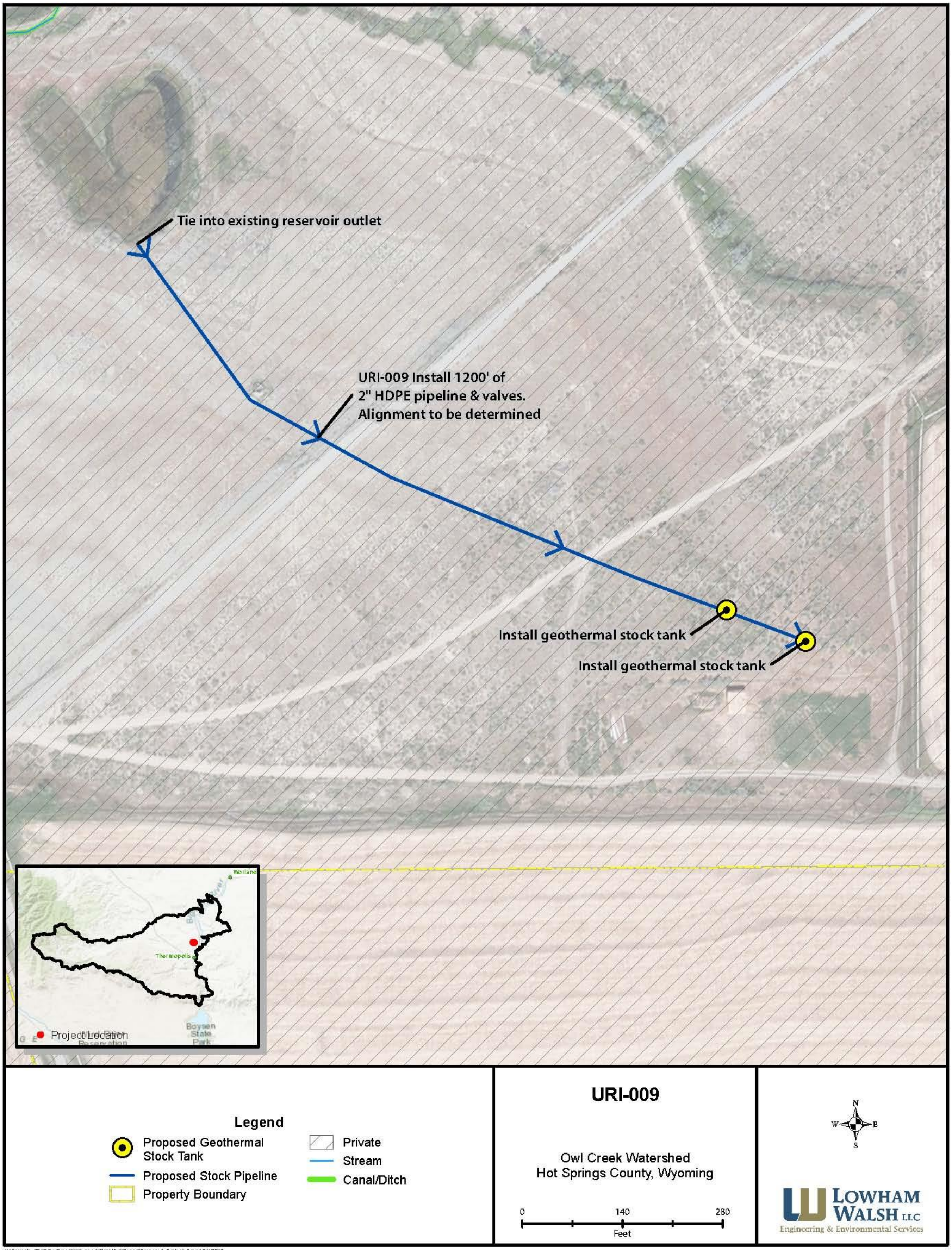
Net Effects on watershed (See Section 5): Benefits include managed use of wastewater, reduced OM&R costs on canal, and better dispersion of livestock. (NED 516, 614).

URI-009 Stock Reservoir to fill Stock Watering Devices


URI-007 Install 24" outlet pipe
in existing stock reservoir
Lower Lucerne Ditch
Worland
Thermopolis
Boysen
State
Park
Project Location
Legend
Proposed Outlet Pipe
Property Boundary
BLM
Private
County Road
Intermittent Stream
Canal/Ditch
URI-007
Owl Creek Watershed
Hot Springs County, Wyoming
0
130
260
Feet
LOWHAM
WALSH LLC
Engineering & Environmental Services


URI-008 Install 4700 gallon stock tank
URI-008 Install 4700 gallon stock tank
URI-008 Install 4700 gallon stock tank
URI-008 Install 8150' of
2" HDPE pipeline & valves.
Alignment to be determined
ISYS-014/URI-008 Install
1000' of 2" HDPE pipeline.
Alignment to be determined
Dempsey Canal
Dempsey Canal
Dempsey Canal
Dempsey Canal
URI-008
Owl Creek Watershed
Hot Springs County, Wyoming
0
650
1,300
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services
Legend
Proposed Solar Pump
Proposed Stock Tank
Proposed Well
Proposed Stock Pipeline
Property Boundary
BLM
Wyoming
Private
Intermittent Stream
Canal/Ditch
Project Location
Thermopolis
Boysen State Park


Coal Draw
Coal Draw
Coal Draw
Coal Draw
Coal Draw
Install commercial electric pump
URI-008A Install a10,000' of
2" HDPE pipeline & valves.
Alignment to be determined
Install 4700 gallon stock tank
Install 4700 gallon stock tank
Dempsey Canal
Project Location
Thermopolis
Worland
Boysen State Park
Legend
Existing Production Water
Proposed Stock Tank
Proposed Stock Pipeline
Property Boundary
BLM
Wyoming
Private
Stream
Intermittent Stream
Canal/Ditch
URI-008A
Owl Creek Watershed
Hot Springs County, Wyoming
0
1,400
2,800
Feet
N
W
E
S
LOWHAM WALSH LLC
Engineering & Environmental Services


Tie into existing reservoir outlet
URI-009 Install 1200' of
2" HDPE pipeline & valves.
Alignment to be determined
Install geothermal stock tank
Install geothermal stock tank
Worland
Thermopolis
Boysen
State
Park
Project Location
Legend
Proposed Geothermal
Stock Tank
Proposed Stock Pipeline
Property Boundary
Private
Stream
Canal/Ditch
URI-009
Owl Creek Watershed
Hot Springs County, Wyoming
0
140
280
Feet
N
S
E
W
LOWHAM
WALSH LLC
Engineering & Environmental Services

4.4.8 Additional URI Projects Identified in Workshops

Due to an increase in public interest in the study, additional landowners had requested projects for inclusion in the report. These additional projects and inventory had stretched beyond the scoping and budget set forth by the initial contract with WWDC. However, in an effort to accommodate all interested landowners, The LW team conducted workshop interviews to define the scope of each respective project. These interviews were conducted in a workshop setting and do not include a field visit, photographs, or field measurements. Instead, a brief project description and cost to scale were prepared using landowner provided estimates and approximations. These projects should use similar described projects as models for use in further analysis such as funding applications or design work.

URI-W01: The landowner wants to develop an existing unimproved spring on their private property. According to the landowner's estimate and visual inspection using aerial imagery, approximately 6,000-7,000 feet of 2-inch HDPE pipeline and associated valves would be required to feed a series of three 500 gal stock tanks stretching across deeded rangeland. A solar powered pump delivering approximately 3-4 gpm is desired. The producers herd size was not specified. A survey would be required for design, permitting and construction. This project could enhance range utilization, benefit terrestrial wildlife, water fowl, and one landowner. Given the similar nature of this project to URI-001, URI-002, URI-003, URI-006, and URI-008A it can be estimated that the project cost will be between $30,000-$45,000.

Estimated Total Cost (See Section 6): $30,000 to $45,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 1, WWNRT, WGFD, NRCS

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): WSEO

Challenges / Fatal Flaws Identified: None. 1 user served.

Net Effects on watershed (See Section 5): Benefits include opportunities for better range utilization by livestock and increased watering opportunities for wildlife (NED 642, 614).

URI-W02: The landowner has three existing wells near their home. Currently none of the three wells are in use. The landowner would like to rehabilitate each of the wells and install a solar pump and stock tank at each location. A survey would be required for design, permitting and construction. This project could enhance range utilization and benefit terrestrial wildlife on 640 acres of deeded property. This project is similar in nature to projects URI-004, or ISYS-007. It is estimated that the project will cost between $35,000-$50,000.

Estimated Total Cost (See Section 6): $35,000 - $50,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 1, WWNRT, WGFD, NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO

Challenges / Fatal Flaws Identified: 1 user served.

Net Effects on watershed (See Section 5): Increase access to and use of groundwater for livestock production purposes and decrease use of existing surface water sources (614, 642).

URI-W03: The landowner wants to develop an existing un-improved spring on their private property. The water could then be used to fill an existing un-permitted stock reservoir. A survey would be required for design, permitting and construction. This project could enhance range utilization, benefit terrestrial wildlife, and one landowner. It is estimated that the project cost would be between $5,000-$20,000, depending on condition of existing embankment and rehabilitation required.

Estimated Total Cost (See Section 6): $5,000-$20,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 1, WWNRT, WGFD, NRCS

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): WSEO

Challenges / Fatal Flaws Identified: 1 user served.

Net Effects on watershed (See Section 5): Increase water quantity, quality, and distribution for livestock and wildlife, increase plant productivity, and increase upland wildlife habitat (574).

URI-W04: There is an existing spring near the parcel boundary between two landowners. If the spring were developed, than both the incumbent and the downstream landowner user would benefit from the surface flow. This project could enhance range utilization, benefit terrestrial wildlife, and two landowners. It is estimated that the project cost would be between $5,000-$10,000. The project was proposed to the LW team by the downstream landowner. The landowner whose property the actual improvement would occur on would need to be consulted.

Estimated Total Cost (See Section 6): $5,000-$10,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 1, WWNRT, WGFD, NRCS

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): WSEO

Challenges / Fatal Flaws Identified: 2 users served.

Net Effects on watershed (See Section 5): Increase water quantity, quality, and distribution for livestock and wildlife, increase plant productivity, and increase upland wildlife habitat (574).

URI-W05

This project is dependent onURI-W02. The landowner would like to pump water from one of the wells referenced in URI-W02 to a proposed upland stock tank. A pump would be required, as the wells are located below the proposed tank. The elevation change is unknown. The required length of pipe is approximately 5,772 ft. following an existing two track road. The proposed stock tank is located on an adjacent BLM grazing allotment leased by the landowner. The wells are located on deeded ground. The allotment is roughly 1,177 acres and currently has three additional reservoirs within it. One of which was classified as functional and the remaining two were classified as non-functional. Development of this proposed stock tank would allow the landowner to utilize the allotment more effectively by distributing livestock more evenly.

Estimated Total Cost (See Section 6): $35,000 - $45,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 2, NRCS, BLM

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): NEPA, WSEO

Challenges / Fatal Flaws Identified: NEPA

Net Effects on watershed (See Section 5): Increase access to difficult areas and increase distribution for livestock and wildlife resulting in an increase in plant productivity and condition and less soil erosion and more stable soil (614, 642).

4.4.9 Other Watershed Improvements (OWI)

Ten (10) watershed improvements were identified that did not fit into other project categories. Of these, seven were identified during on-site interviews and three were identified during workshop interviews. Each project is described below, numbered in sequential order from upstream to downstream. Most, but not all, of the projects identified and characterized on-site have a large-scale map illustrating conceptual project design. Workshop interviews do not have project-specific maps. **Table 4.4.9-1** summarizes each project's characteristics. **Figure 4.4.9-1** illustrates the locations of proposed OWI projects within the study area.

Table 4.4.9-1 OWI Projects

Project Number	Ditch/Stream	Location	Primary Uses	Earthwork (units as indicated)	Miscellaneous Construction	Piping(LF)	Brief Description
OWI-001	Red Creek, Natural Runoff	S3, T8N, R2E	Stock, Recreation, Flood Control	25 Cyds Bentonite		50' -6"diameter DR-32 PVC Discharge Pipe with valve	Rehabilitation of existing reservoir. Install Bentonite lining and outlet infrastructure.
OWI-002	Merrill Ditch	S11, T43N, R97W	Irrigation, Stock, Tilapia Farming, Recreation, Wildlife	25,500 Cyds exc. to embankment	Low head irrigation pump		Construct new reservoir. May require re-pumping some water for irrigation.
OWI-003	N/A	S9, T8N, R4E	Stock, Recreation, Wildlife	40 Ton Gravel, 50 Cyds excavatiton	25 Infiltrators		Construct new septic system to replace non-functioning evaporative septic pond. Rehabilitate septic pond into stock reservoir.
OWI-004	Irrigation runoff	S12, T43N, R95W	Stock, Recreation, Wildlife			50' -6"diameter DR-32 PVC Discharge Pipe w/Valve	Develop an existing gravel pit into a reservoir. Install outlet structure.
OWI-005	Upper Lucerne Canal Natural Runoff	S1, T43N, R95W	Stock, Recreation, Wildlife, Flood Control	4,100 Cyds. Embankment, 825 Cyds Excavation	150 Ton 12"L.D. Rip-Rap	100'- 8" dia. DR-32 PVC Discharge Pipe w/Valve	Rehabilitate existing reservoir embankment. Install outlet structure.
OWI-006	Irrigation runoff	S6, T43N, R94W	Stock, Recreation, Wildlife	25,500 Cyds exc. to embankment		50' -6"diameterDR-32 PVC Discharge Pipe w/Valve	Construct new reservoir.
OWI-007	N/A	S32, T44N, R94W	Flood Control	950 Cyds. Embankment, 250 Cyds Excavation	310 Ton 12"L.D. Rip-Rap		Construct berm to prevent residential flooding at the confluence of Kirby Creek and the Big Horn River.
OWI-W01	N/A	S32, T44N, R94W	Flood Control				Capture excess water to control flooding and minimize erosion.
OWI-W02	UNK	S14, T43N, R96W S15, T43N, R96W	Livestock and irrigation				Install buried pipe in two locations to feed livestock tank and irrigation ditch.
OWI-W03	N/A	S5, T44N, R94W	Irrigation				Conduct land leveling to install center pivot.
*All values were estimated either during time of field visit or after desk top analysis. All values should be confirmed prior to continuation of the project.							

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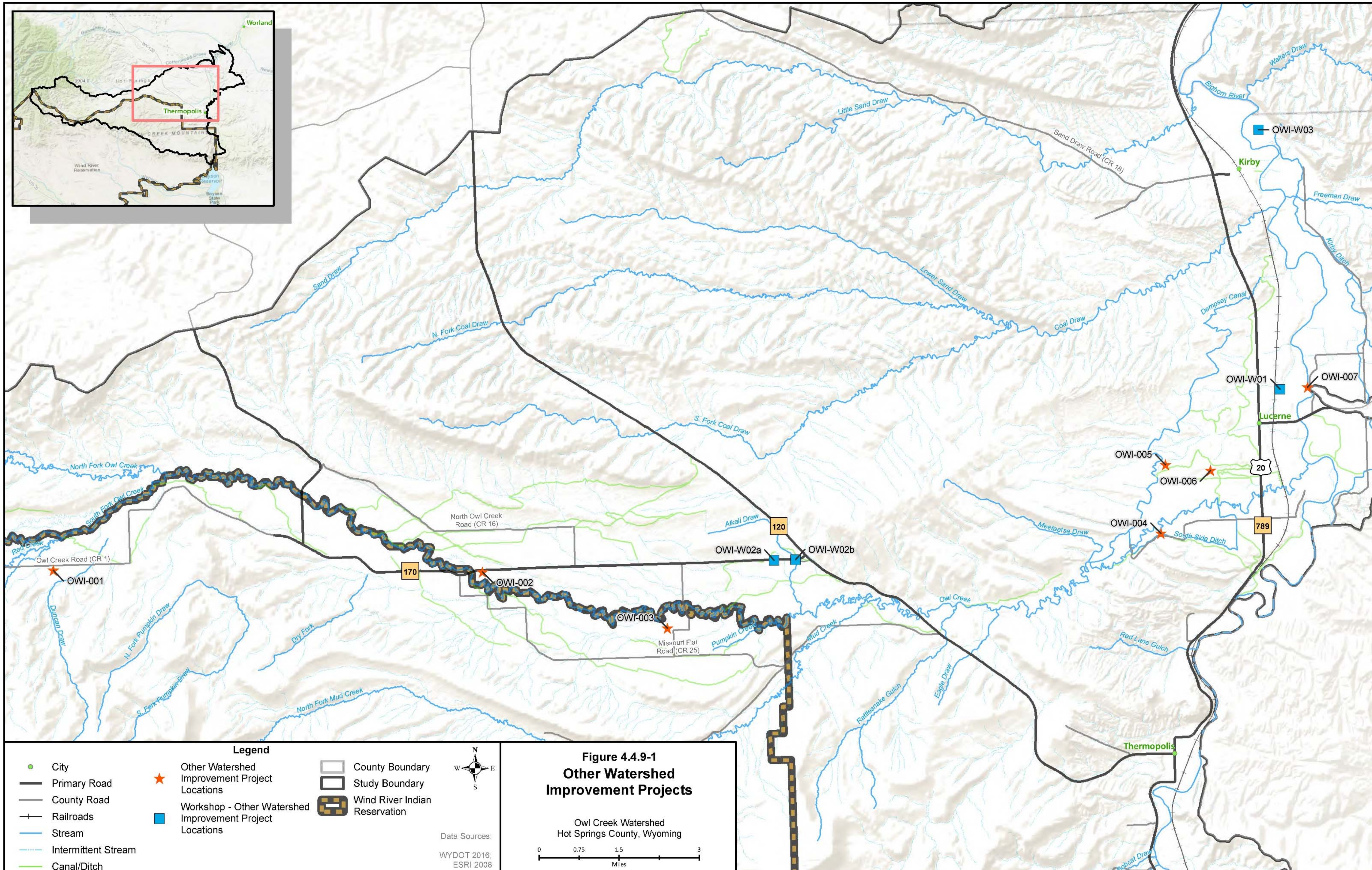

U:\Projects_2015\OwlCreekWatershed\Map\Mxd\Report\Fig_4_4_9-1_Projects_OWI.mxd 12/14/2017

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OWI-001:

The landowner would like to rehabilitate an existing stock reservoir (ENL of Curtis P11646S). Currently, the stock reservoir has a capacity of 3.58 ac-ft. which is filled from a diversion off of Red Creek, however, the reservoir is inefficient at impounding water and excessive leakage is suspected due to soil porosity. The possibility of using bentonite matting to seal the reservoir was discussed as well as filing an enlargement permit with the WSEO to increase capacity. The landowner expressed interest in diverting additional runoff water into the basin to mitigate annual flooding of nearby out-buildings. Benefits would include development of grazing management options in the pasture, wildlife use, and recreation. This project may require surveying for permitting, design, and construction.

Estimated Total Cost (See Section 6): $68,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 2, NRCS, WWDC

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO, WDEQ, USACE

Challenges / Fatal Flaws Identified: 1 user served.

Net Effects on watershed (See Section 5): Increase usable water supply, decrease erosion, provide and/or improve water quality and quantity for livestock and wildlife, and increase flexibility and efficiency of management (378, 636).

OWI-001: Curtis SR, proposed for enlargement

OWI-002:

This landowner would like to create a reservoir for irrigating their existing produce farm and potentially diversifying into tilapia farming. The reservoir would be designed with a storage capacity less than 20 ac-ft. and would be supplied out of the Merrell Ditch. The project would require permitting through the WSEO. Completion of this project would allow the landowner to diversify their operation, provide wetland habitat, water stock, and recreation. This project would require surveys for permitting, design, and construction.

Estimated Total Cost (See Section 6): $43,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 2, NRCS, WWNT, WGFD (if plan is revised), WWDC

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): WSEO, WDEQ, USACE

Challenges / Fatal Flaws Identified: WGFD regulations do not allow introduction of non-native fish in any body of water. The project would need to be developed for native fish. 1 user served.

Net Effects on watershed (See Section 5): Increase useable water supply, increase nutrients and organics, and potentially increase production of aquatic organisms (378, 397,399)

OWI-002 :Approximate location of Reservoir

OWI-002: Supply Ditch

OWI-003:

This landowner suspects that ground water is seeping into their septic pond (Permit Number 01-358). The existing pond is approximately 40 ft. in diameter and eight to 10 ft. deep. They would like to install a leach field to mitigate excessive pumping currently required. If completed, the landowner expressed interest in altering the old pond for wildlife use. Permitting through WDEQ and WSEO would be required. There may by funding assistance through WDEQ and county outreach programs.

Estimated Total Cost (See Section 6): $28,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 5, NRCS, WDEQ, WWDC, WGFD

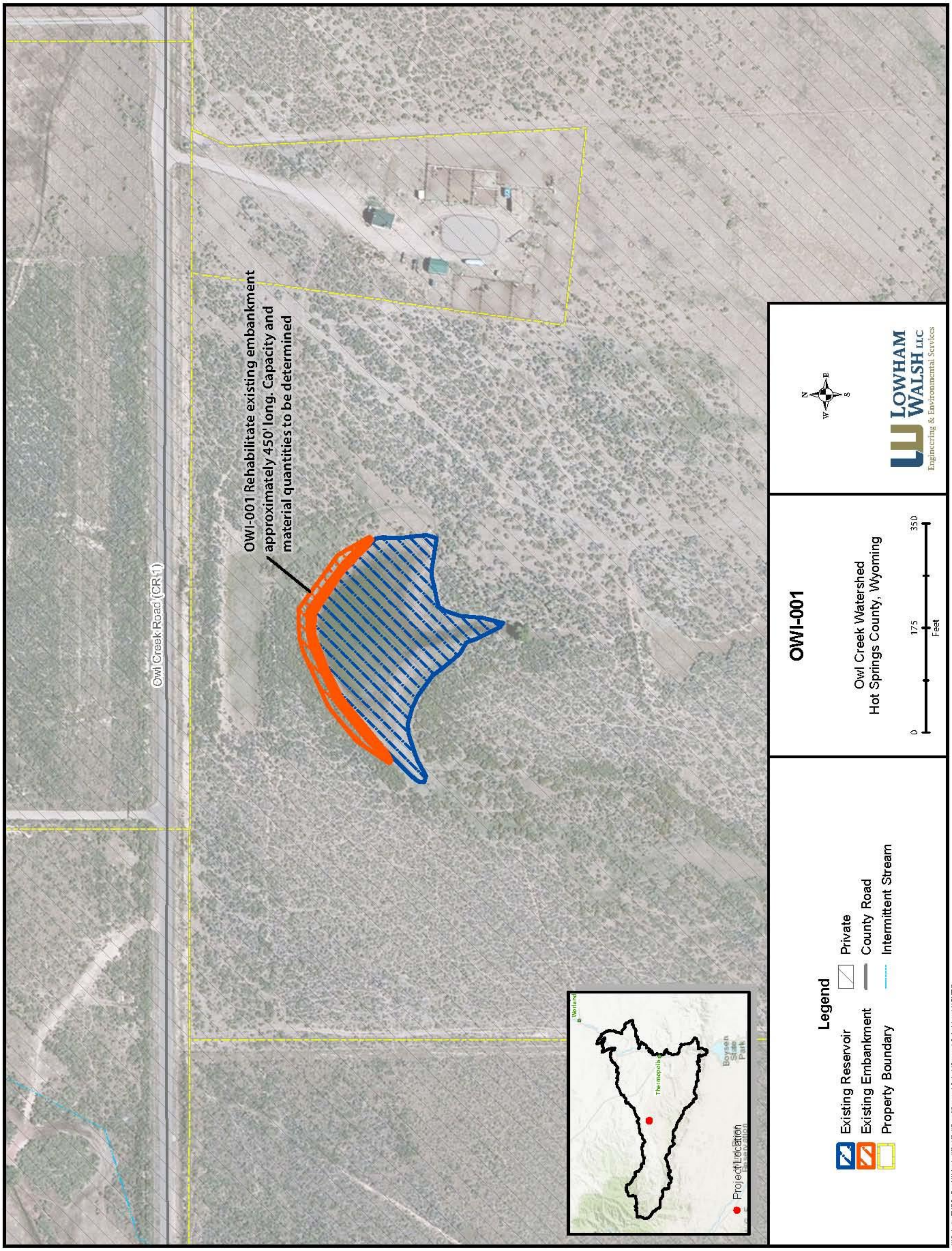
Rehabilitation vs. New Development: Rehabilitation

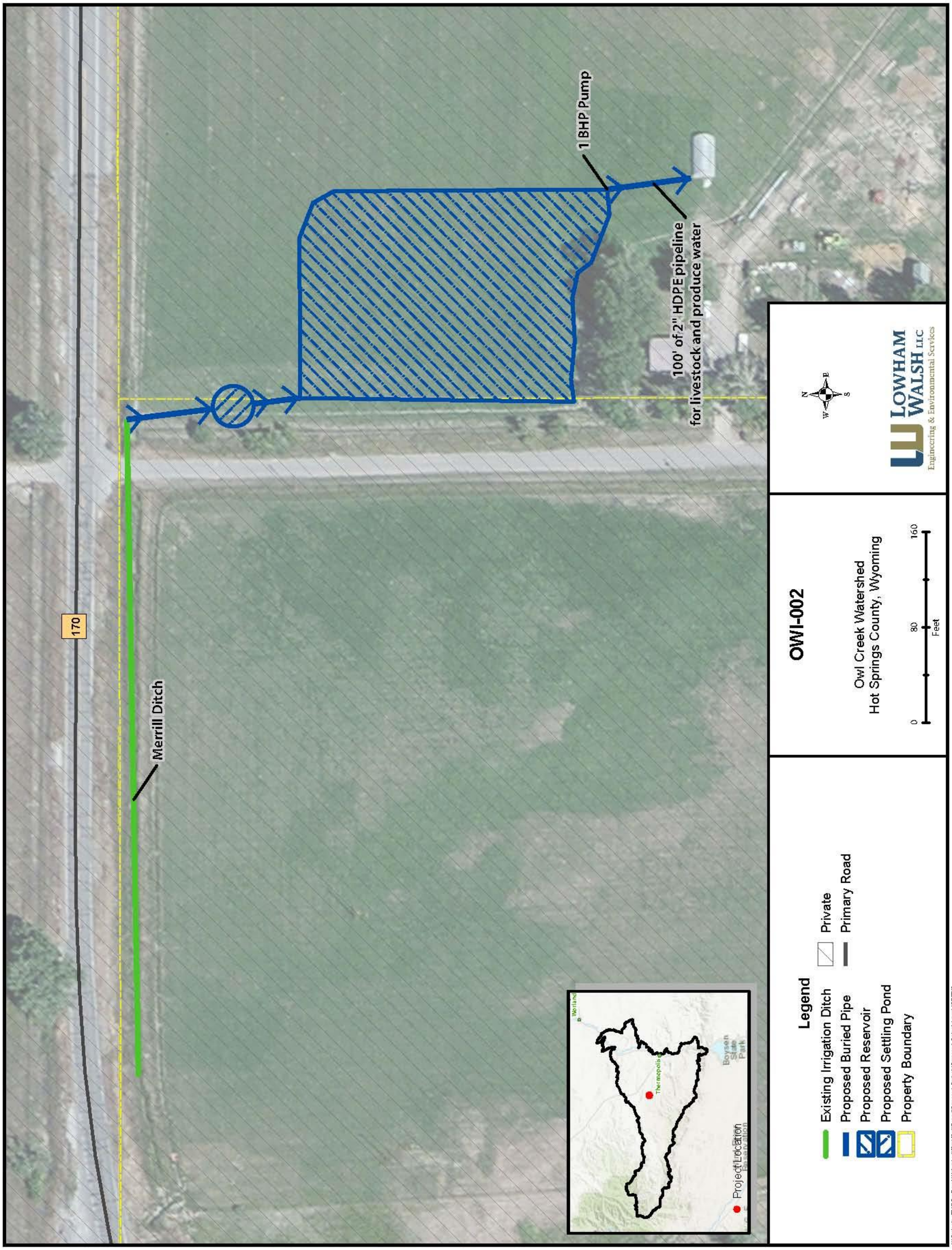
Likely Permits Required (See Section 9): WDEQ, WSEO

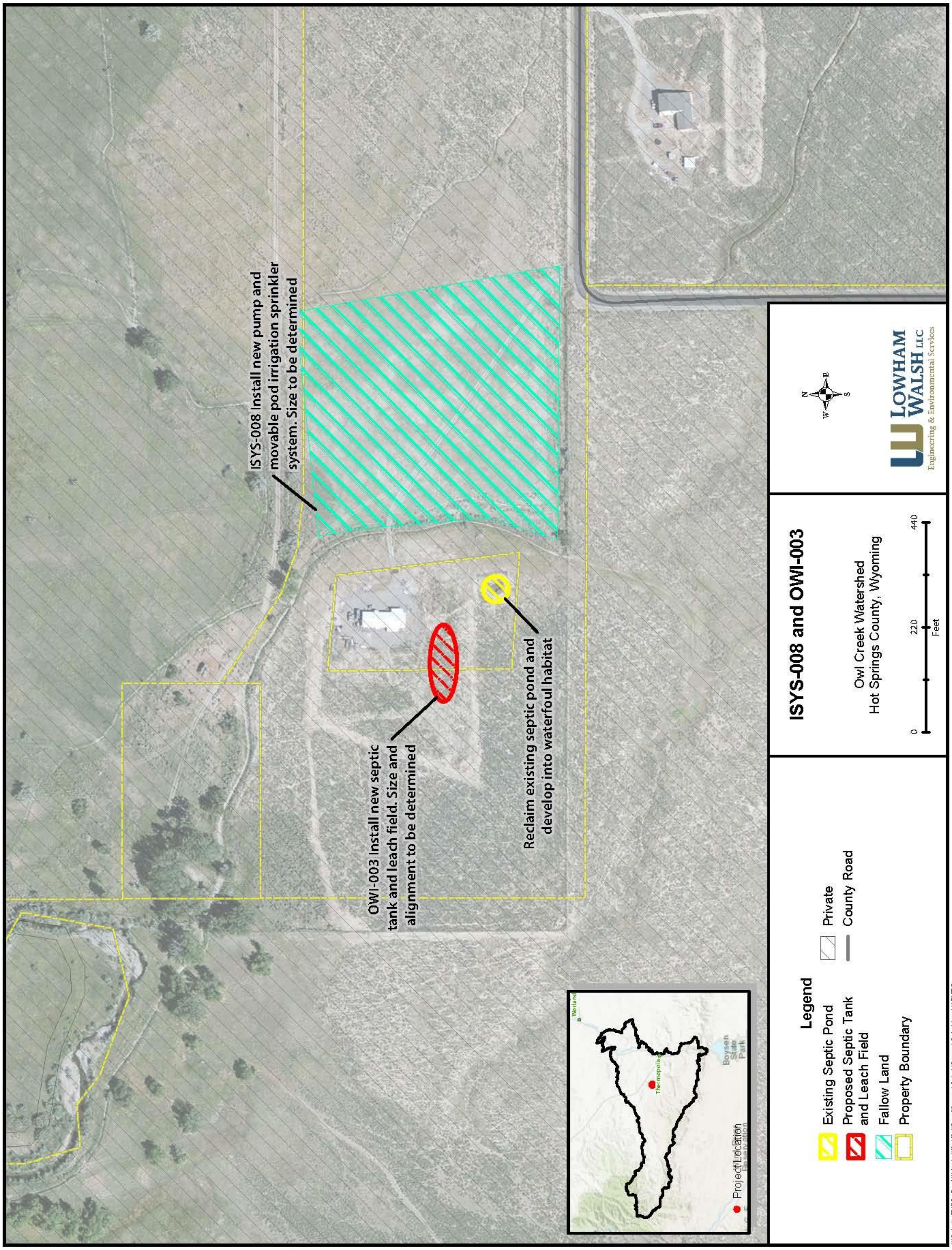
Challenges / Fatal Flaws Identified: 1 user served.

Net Effects on watershed (See Section 5): Increase water quantity for wildlife and improve area water quality and increase wildlife habitat (378).

OWI-003: Existing Septic Pond


OWI-001 Rehabilitate existing embankment approximately 450' long. Capacity and material quantities to be determined
Owl Creek Road (CR 1)
OWI-001
Owl Creek Watershed
Hot Springs County, Wyoming
0
175
350
Feet
N
E
S
W
LOWHAM WALSH LLC
Engineering & Environmental Services
Legend
Existing Reservoir
Existing Embankment
Property Boundary
Private
County Road
Intermittent Stream
Project Location
Thermopolis
Boysen State Park


1 BHP Pump
100' of 2" HDPE pipeline
for livestock and produce water
Merrill Ditch
170
OWI-002
Owl Creek Watershed
Hot Springs County, Wyoming
0
80
160
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services
Legend
Existing Irrigation Ditch
Proposed Buried Pipe
Proposed Reservoir
Proposed Settling Pond
Property Boundary
Private
Primary Road
Project Location
Thermopolis
Worland
Boysen State Park


ISYS-008 Install new pump and movable pod irrigation sprinkler system. Size to be determined
OWI-003 Install new septic tank and leach field. Size and alignment to be determined
Reclaim existing septic pond and develop into waterfoul habitat
ISYS-008 and OWI-003
Owl Creek Watershed
Hot Springs County, Wyoming
0
220
440
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services
Legend
Existing Septic Pond
Proposed Septic Tank and Leach Field
Fallow Land
Property Boundary
Private
County Road
Project Location
Worland
Thermopolis
Boysen State Park

OWI-004:

This landowner would like to convert an abandoned gravel pit into a stock reservoir and permit for livestock use. The reservoir would be designed with a storage capacity less than 20 ac-ft. and would be filled by irrigation runoff. This project would require a standard stock reservoir permit through the WSEO. The design would include a controllable low level outlet to ensure proper drainage prior to harvesting an adjacent field. Benefits include development of grazing management, wildlife use, and recreation. This project would require surveying for permitting, design, and construction.

Estimated Total Cost (See Section 6): $25,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 2, NRCS, WGFD, WWDC

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO, WDEQ

Challenges / Fatal Flaws Identified: Permitting would be required but likely would not be onerous.

Net Effects on watershed (See Section 5): Increase water availability, increase plant productivity and condition, and increase wildlife habitat (378)

OWI-004: Abandoned Gravel Pit inundated with water

OWI-005:

Presently, there is a natural drainage channel that is used by the Lucerne Irrigation District to transfer water from the Upper to Lower Canal in times of high flow. This project would involve re-building an earthen embankment across the draw to store water to use for livestock and wildlife use. The drainage is approximately 120 feet wide and 12 feet deep and it is estimated to carry 35 to 40 cfs during a storm event. The project would need to be permitted as an SW-4 standard stock reservoir through the WSEO. The design would include a controllable low level outlet and emergency spillway. Rip-rap would be required at the outlet for erosion control. This project would require surveying for WSEO permitting, design, and construction.

Estimated Total Cost (See Section 6): $37,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 2, NRCS, WDEQ, WWDC

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO, WDEQ, USACE

Challenges / Fatal Flaws Identified: Permitting would be required with WSEO and USACE, although depending on the size of the project this may not be difficult. 1 user served.

Net Effects on watershed (See Section 5): Increase water depth (seasonal), increase water retention (seasonal), increase water use efficiency and water conservation, increase habitat, and decrease contaminants to downstream discharge (356, 587).

OWI-005: Drainage Channel and Historic Embankment

OWI-006:

This landowner would like to excavate an existing low spot to capture spring runoff and irrigation waste water. It would be permitted with WSEO and used as a winter water source for livestock and would also benefit wildlife. The reservoir would be designed with a storage capacity less than 20 ac-ft. and would require to be permitted as a standard stock reservoir. If completed, the landowner could develop grazing management options, provide wetland habitat, and recreation. This project would require surveying for permitting, design, and construction.

Estimated Total Cost (See Section 6): $30,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 2, NRCS, WDEQ, WGFD, WWDC

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): WSEO, WDEQ, potentially USACE

Challenges / Fatal Flaws Identified: Permitting required. 1 user served.

Net Effects on watershed (See Section 5): Increase useable water supply, increase biodiversity/habitat, and decrease sediment and nutrient transport (636).

OWI-006: Potential development area

OWI-006: Low spot

OWI-007:

This project would involve developing a berm approximately 200 feet in length on the east bank of Kirby Creek at the confluence with the Big Horn River to protect the landowner's home from flooding during times of high flow. The house is approximately five feet above the bank edge of the Big Horn River. There is currently no infrastructure in place to stop water from flooding the home. Removing approximately one acre of vegetation (Russian Olives and woody debris) on the opposite bank was discussed to allow the water to move in another direction. Survey and runoff hydrology would be required to determine exact size and dimension needed for berm. Permitting through WDEQ and USACE would also be required.

Estimated Total Cost (See Section 6): $30,000

Feasibility / Ability to fund (See Section 8): NRCS, EPA, USACE, WDEQ

Rehabilitation vs. New Development: New Development

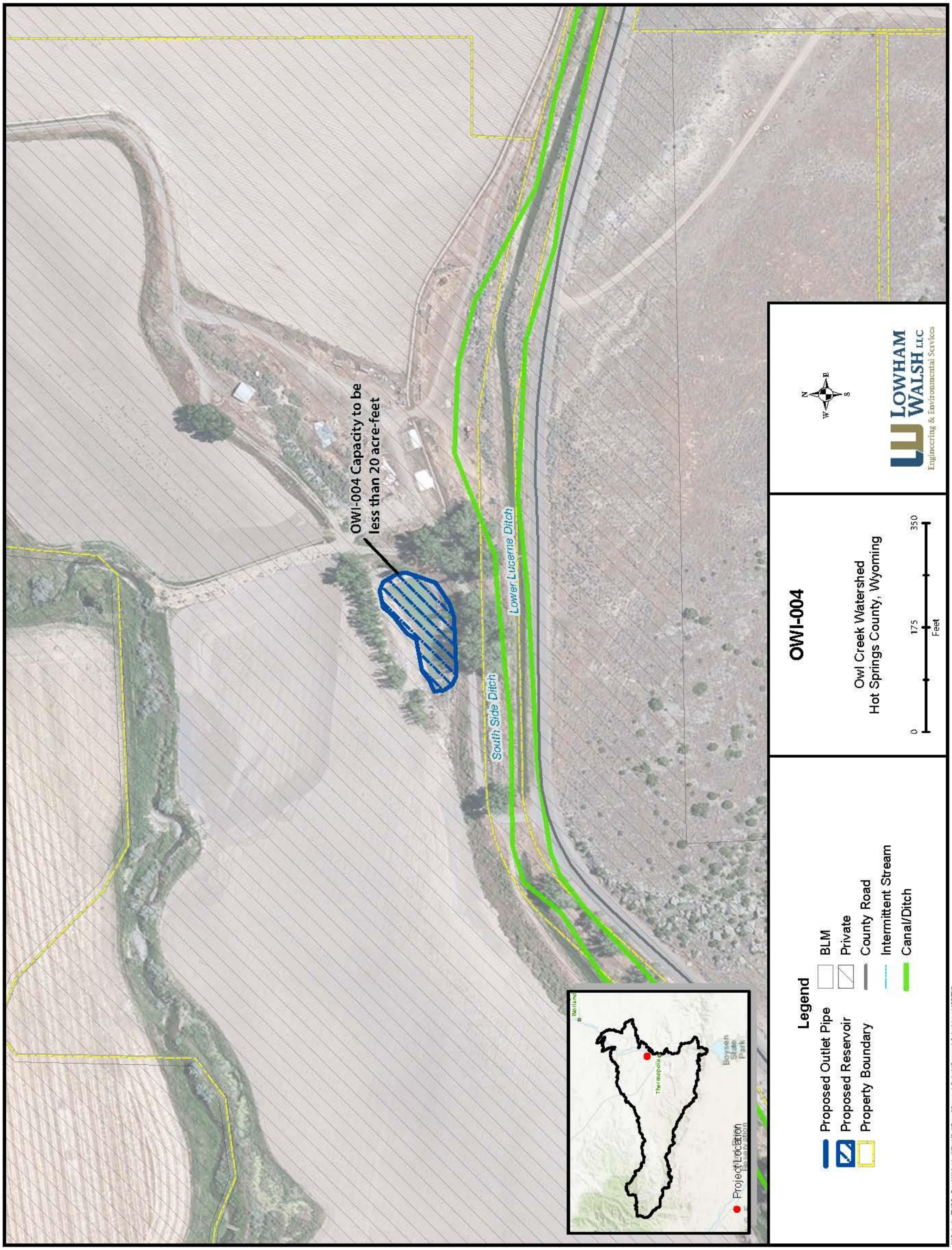
Likely Permits Required (See Section 9): WSEO, WDEQ, USACE

Challenges / Fatal Flaws Identified: May not meet WWDC water development criteria.

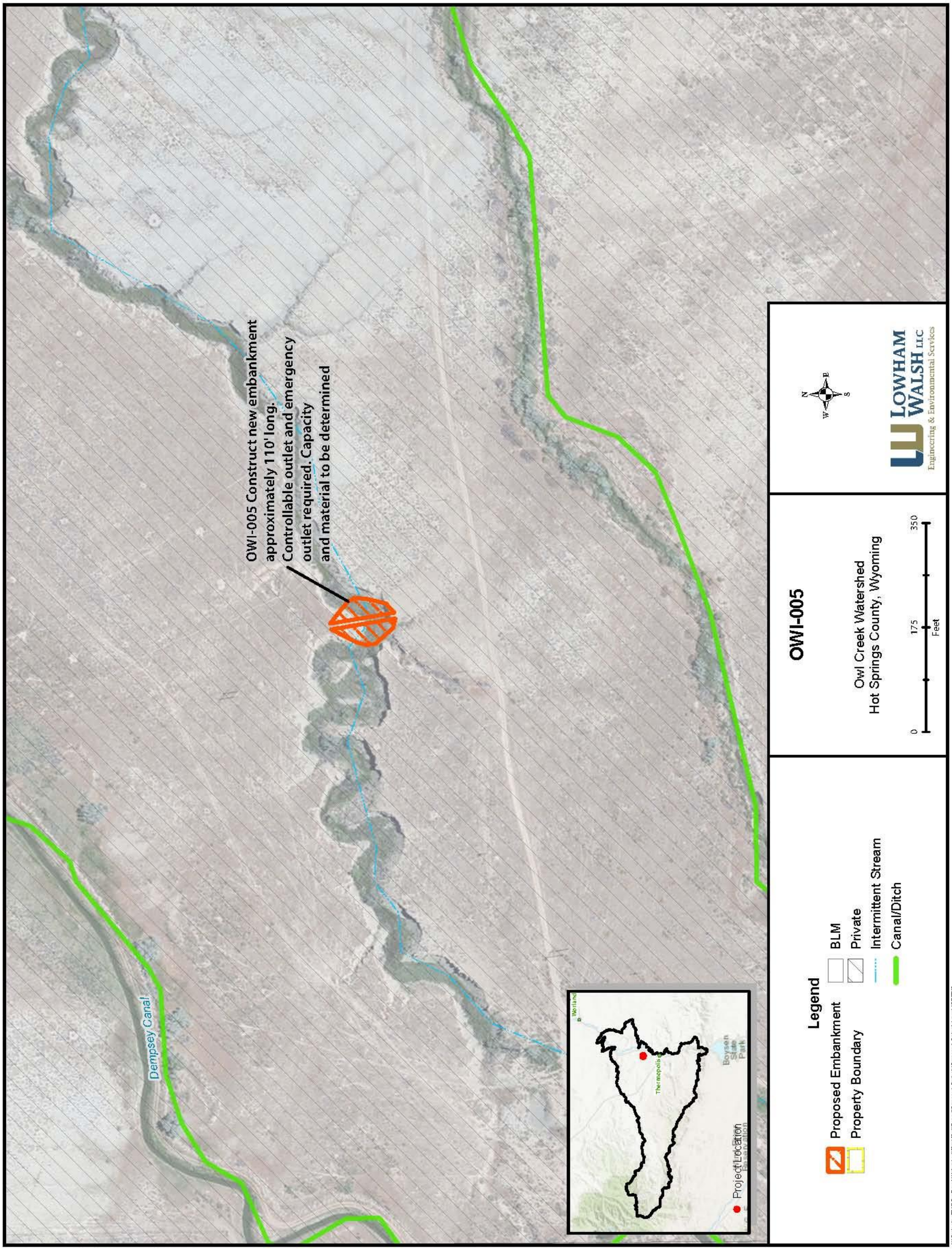
Net Effects on watershed (See Section 5): Decrease river floodplain, increase water retention, decrease contaminants downstream, and potentially increase shoreline habitat (348, 356).

OWI-007: At house looking at confluence

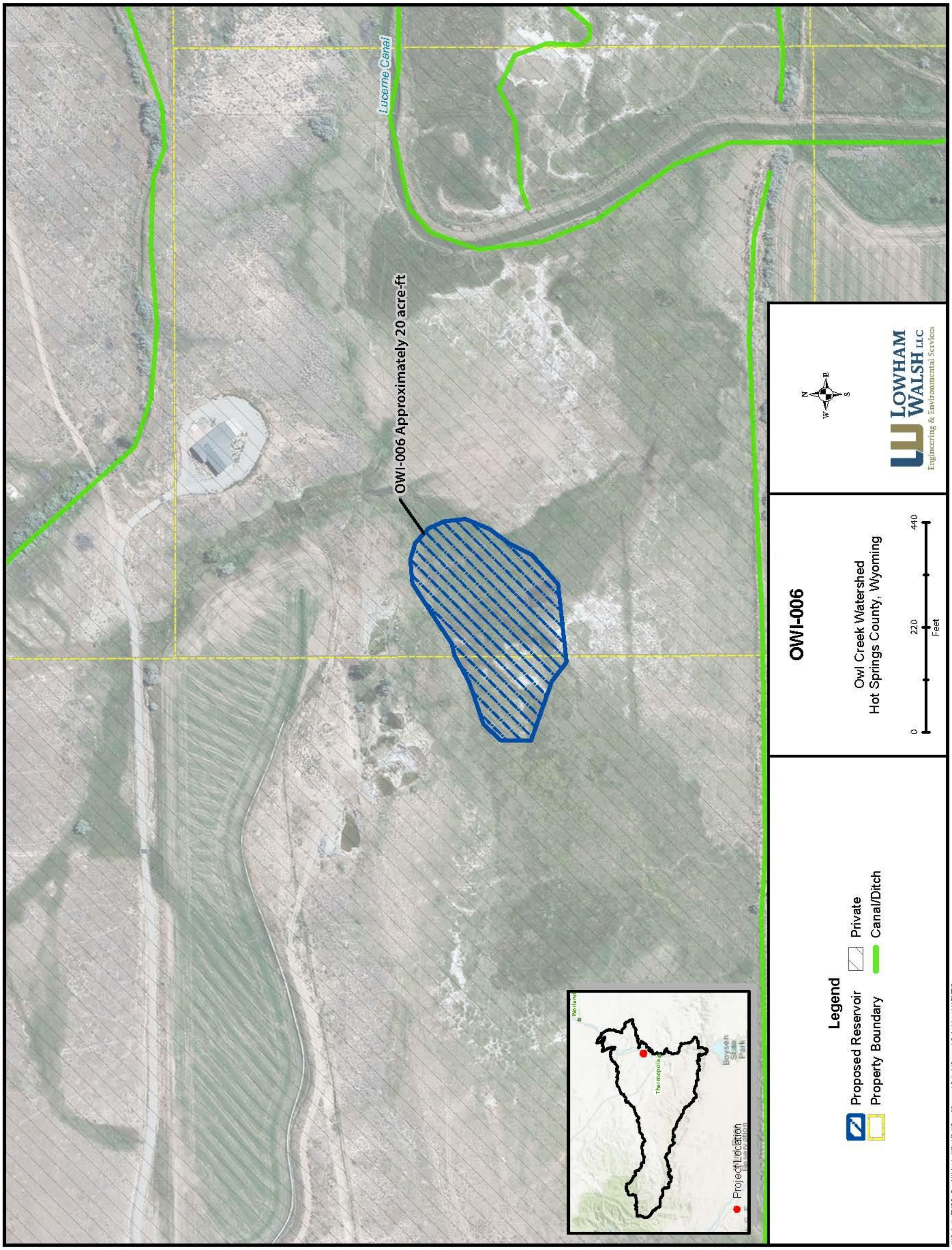
OWI-007: At river's edge looking up to house

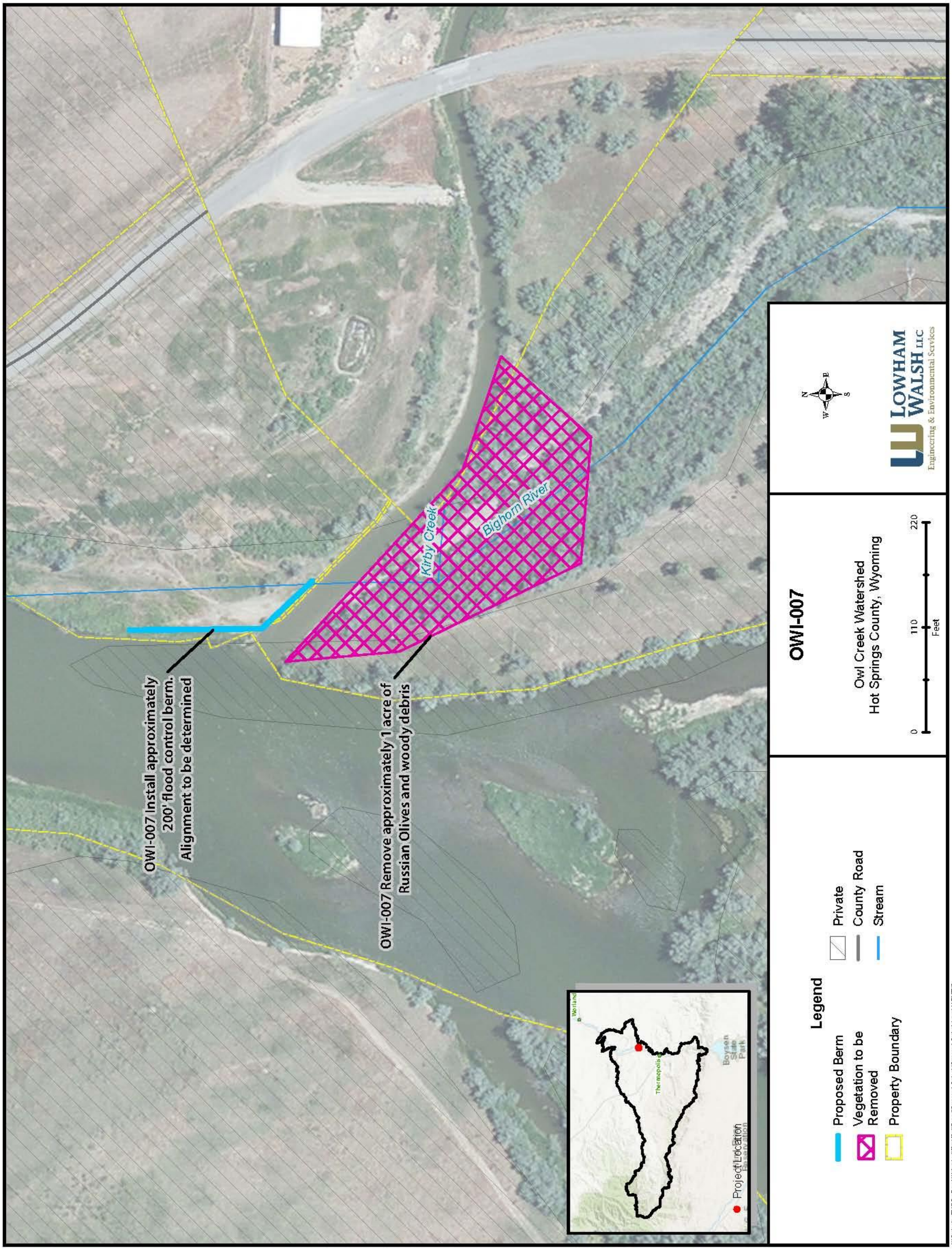


OWI-004 Capacity to be less than 20 acre-feet
Lower Lucerne Ditch
South Side Ditch
OWI-004
Owl Creek Watershed
Hot Springs County, Wyoming
0
175
350
Feet
Lowham Walsh LLC
Engineering & Environmental Services
Legend
Proposed Outlet Pipe
Proposed Reservoir
Property Boundary
BLM
Private
County Road
Intermittent Stream
Canal/Ditch
Worland
Thermopolis
Boysen State Park
Project Location



OWI-005 Construct new embankment
approximately 110' long.
Controllable outlet and emergency
outlet required. Capacity
and material to be determined
Dempsey Canal
Worland
Thermopolis
Boysen
State
Park
Project Location
Legend
Proposed Embankment
Property Boundary
BLM
Private
Intermittent Stream
Canal/Ditch
OWI-005
Owl Creek Watershed
Hot Springs County, Wyoming
0
175
350
Feet
N
E
S
W
LOWHAM
WALSH LLC
Engineering & Environmental Services


Lucerne Canal
OWI-006 Approximately 20 acre-ft
OWI-006
Owl Creek Watershed
Hot Springs County, Wyoming
0
220
440
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services
Legend
Proposed Reservoir
Property Boundary
Private
Canal/Ditch
Worland
Thermopolis
Boysen State Park
Project Location


OWI-007 Install approximately
200' flood control berm.
Alignment to be determined
OWI-007 Remove approximately 1 acre of
Russian Olives and woody debris
Kirby Creek
Bighorn River
OWI-007
Owl Creek Watershed
Hot Springs County, Wyoming
0
110
220
Feet
LOWHAM WALSH LLC
Engineering & Environmental Services
Legend
Proposed Berm
Vegetation to be Removed
Property Boundary
Private
County Road
Stream
Worland
Thermopolis
Boysen State Park
Project Location

4.4.10 Additional OWI Projects Identified in Workshops

OWI-W01:

The landowner owns 11.57 acres within the Lucerne Irrigation District. There is a slough that flows along the southern edge of the property boundary. At times there is a large amount of water that flows through the property, damaging the landowner's fences and bridges. The water eventually returns to the Big Horn River, however, it is not waste water. The source of the water is a headgate on the Lower Lucerne Ditch. It is believed that this slough protects the canal from washing out, acting as an emergency spill way. The landowner does not desire to capture the water for personal irrigation or watering source. The landowner suggested that perhaps there is a way to capture this water and control its release and allow surrounding landowners to use it before it is returned to the river. Controlling the release of this water would make more efficient use of water and stop significant amounts of erosion.

Estimated Total Cost (See Section 6): Further evaluation required to develop a cost estimate

Feasibility / Ability to fund (See Section 8): WDEQ, NRCS

Rehabilitation vs. New Development: Rehabilitation

Likely Permits Required (See Section 9): WSEO, USACE, WDEQ

Challenges / Fatal Flaws Identified: Potentially multiple users affected

Net Effects on watershed (See Section 5): Impound water, trap sediment, decrease erosion, runoff velocity, flooding, and down slope deposition, increase wildlife habitat (638).

OWI-W02:

This project combines two smaller projects, involving installation of two separate lengths of buried pipe. One would supply a livestock tank and the other would supply an existing open ditch for irrigation use. Both projects will originate from an existing 12 inch buried pipeline located along the south side of the highway right-of-way and are located roughly 1,750 ft. from one another. The landowner would like to install a 2 inch buried pipeline starting at the existing 12 inch line and terminating at a livestock tank in the landowner's corrals. Required length of pipe is approximately 680 ft. The landowner would be the only user of the proposed buried pipe. Installation would allow them to water livestock closer to their home and distribute livestock more evenly. The second project involves installing a 4 inch buried pipeline to supply an existing open ditch with irrigation water. Doing so would enable the landowner to irrigate approximately 11 acres of currently fallow land. The proposed 4 inch buried pipe would start at the above mentioned existing 12 inch line and terminate at the existing open ditch. Required length of pipe is approximately 315 ft. The landowner would benefit from increased crop production.

Estimated Total Cost (See Section 6): $4,000 - $6,000

Feasibility / Ability to fund (See Section 8): SWPP Priority 3, NRCS

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): WSEO

Challenges / Fatal Flaws Identified: 1 user served.

Net Effects on watershed (See Section 5): Livestock pipeline: Increase water quantity and quality and increase health of domestic and wild animals (516). Irrigation pipeline: Increase water available for irrigation, decrease evaporation losses, and decrease erosion (430).

OWI-W03:

The landowner would like to install a center pivot on a portion of shrub ground that borders the Big Horn River to the west. The area would require extensive development such as tree and shrub removal, land leveling, and dirt work. Trees and shrubs would have to be removed with a dozer and buried pipe would have to be installed to supply the pivot. The landowner does pay for water out of the Big Horn, but does not currently use it. The project is on deeded ground and would benefit one individual.

Estimated Total Cost (See Section 6): Further evaluation required to develop a cost estimate

Feasibility / Ability to fund (See Section 8): NRCS

Rehabilitation vs. New Development: New Development

Likely Permits Required (See Section 9): WSEO, WDEQ, County permits

Challenges / Fatal Flaws Identified: May not meet WWDC water development criteria.

Net Effects on watershed (See Section 5): Land leveling would: increase surface drainage, decrease ponding, increase winter freeze production, increase crop vigor and production; installing a pivot would: increase water availability for irrigation, decrease evaporation losses, decrease erosion, and increase plant growth and productivity (430, 466).

4.4.11 Projects Recommended for Level II Study

Lucerne Level II Project

The LW team completed a field visit with representatives of OCID and the Lucerne Pumping Plant and Canal Company (LPPC) to assess infrastructure concerns within the Lucerne area, which encompasses the Upper, Lower, and Dempsey Canal systems. Physical location and components of the canal system are discussed in more detail in Section 3.8, Irrigation Delivery Systems. A summary of projects identified is included below using an "LUC" before the project number, starting at 001.

LUC-001: The main pump station, containing four pumps, ranging from 175 horse power to 300 horse power each, feed both the Upper and Lower Canal systems. They are in excess of 60 years old and have been rebuilt numerous times. The OCID maintenance man reported that the wall thickness of all associated piping has worn extremely thin and replacement should be evaluated. The four 20" automated valves no longer seal properly thereby allowing the impellers to rotate backwards when pumps are shut down. The electrical control panels for each of the four motors are outdated and upgrading should be evaluated including installation of Variable Frequency Drive's (VFD).

LUC-002: A review and detailed evaluation of the Re-lift Pump Station electrical and mechanical systems should be completed to assure proper and safe operation.

LUC-003: An engineering review and evaluation of condition and operation of siphons, and culverts on the delivery system should be completed.

LUC-004: According to the Level II study completed in 2006 (Owl Creek Irrigation District Conservation Study, Aqua Engineering, Ft. Collins, CO), seepage analysis was completed on several reaches along the upper and lower canals. As a result of that study, several seepage loss mitigation practices were discussed and recommended. Minimal upgrades have been made, however, due to budget constraints. This project would consist of a re-evaluation of those recommended methods for reducing seepage and updating project costs for implementing the recommendations.

LUC-005: In response to the request of the OCID and LPPC representatives, this project would include updating the field inventory of all infrastructure previously completed as part of the Owl Creek Masterplan Level I Study completed in 2004.

Based upon the field visitation, visual inspection, and conversation with OCID and LPPC representatives, it is recommended that the Lucerne Area projects be grouped into one OCID sponsored project. In order to address all needs of the project, it is recommended that an application be submitted to WWDC for a Level II study. The scope and extent of the study include revisiting the seepage issues, updating the LPPC infrastructure inventory, addressing installation of safety features; developing detailed plans to rehabilitate all major infrastructure within the system including the diversion, pump station, siphons, culverts, re-lift station, and sections of the canals. Appropriate construction and project cost estimates would also be required.

Level II Project: Lucerne Pumps

Level II Project: Lucerne Pump Motor Control Center

Level II: Lucerne Canal

Cyclone Ditch Level I Project

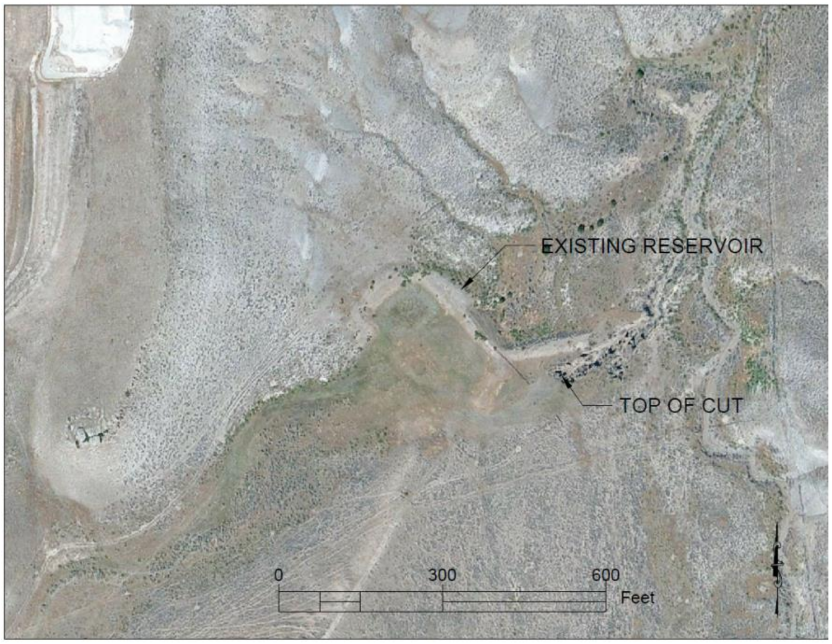
The LW team was approached during a workshop meeting by a representative user of the Cyclone Ditch system. The user indicated that it would be necessary to review failing infrastructure through the entire system, which is independent of other irrigation districts and canal companies in the area. Some of the issues identified were failing infrastructure, lack of flow measurement, seepage loss in sandy soil, and other delivery inefficiencies. It was discussed that the ditch company would need to become a public entity in order to be eligible to sponsor a Level II project.

Large Headcuts on BLM Land Level II Project

The grazing lessee would like to conduct repairs on three large headcuts located to the northwest of Thermopolis. One headcut has a spring emanating from it that the lessee would like to develop as a livestock water source. The lessee has a water right to this spring. LW staff attended a site visit on March 17, 2017 with representatives of the BLM, HSCD, and the lessee to review the three project locations. These are located on two BLM allotments south of Missouri Flats road. An aerial image of the sites visited is included below to show their relative locations to known landmarks. Numbers on the aerial photo below correspond to the site descriptions shown below. Aerial photos of the first two headcuts are shown below the first image. Following this are representative photographs of these locations taken from the ground. The third headcut is shown with a photo taken from the ground: this location has the spring noted above that the landowner would like to develop as a stock water source.

Headcuts on unnamed draw NW of Thermopolis. Source imagery: XXX

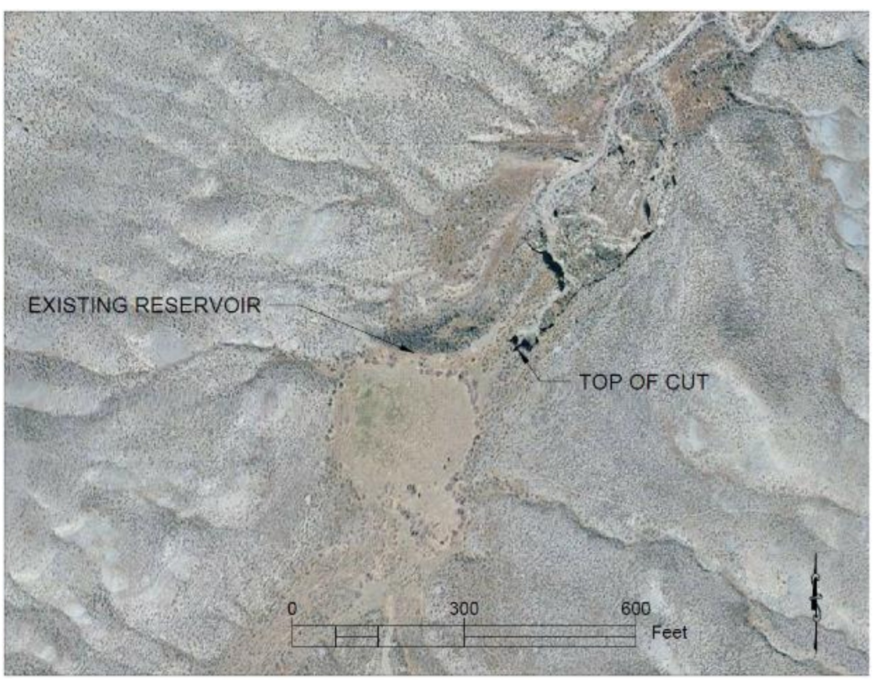
Site 1: Head Cut 1 – (Lat: 43.66 Long: -108.32): The first head cut we visited was just downstream of a reservoir embankment. The embankment itself appeared in good condition for its age and looked to be approximately SW-4 size. The basin has silted in level to the spillway and a substantial head cut has formed just downstream of the spillway dike. The reservoir, according to the SEO is permitted (P5150) and is listed as complete/current. It is called the Sanford Stock Reservoir. It is permitted for stock use only and is located within the Red Canyon BLM allotment. At the time of visitation the headcut was estimated to be 50' across and 15' deep. It is located within a sage grouse core area.



Site 1: Aerial view of headcut area. Source imagery: XX

Site 2: Head Cut 2 – (Lat: 43.67 Long: -108.31):

The second head cut is on the same drainage and is approximately 0.5 miles downstream of the first, with an almost identical relation to an existing reservoir. Similar to the first, the basin has silted level to the spillway and the head cut has formed in the old spillway channel. The dam height is over 20' tall with approximately 1:1 downstream slope. This reservoir, according to the SEO is not permitted. This head cut is slightly larger and is approximately 50' wide and 25' deep. This head cut is located within the Eagle Draw allotment, on the west edge of a Sage-grouse core area.



Site 2: Aerial view of headcut. Source imagery: xx

Headcut 1 looking NE at top of cut

Headcut 1 looking Downstream

Silted reservoir pool level with spillway looking NW 50' upstream of top of cut.

Headcut 2 looking downstream

Site 3: Spring Development – (Lat: 43.67 Long: -108.30):

The third project visited was the location of a proposed spring development. At time of visitation the spring was not flowing but water was pooled at the surface. Based on prior visitations, Jim Mischke estimated that the spring will produce no less that 1gpm all summer long. This spring is located in the BLM Eagle Draw allotment adjacent to the South Owl Creek allotment, leased by Mr. Don McCumber. Development of this spring could potentially serve each allotment and provide a more reliable water source. The spring could be fenced off to restrict heavy livestock use, protecting water quality and vegetation growing in and around the spring. It was discussed that this would be considered a new source of water and the permitting effort would be extensive due to BLM requirements and its location within Sage-grouse core area.

Site 3: Spring location, looking upstream

4.4.12 Other Recommended Watershed Improvements

After reviewing all of the collected data, the rehabilitation and management plan was completed. In review, it is highly recommended that the following improvements be completed in order to maximize efficient use of water resources within the project area.

1. Replace failing or inadequate infrastructure
2. Replace poor or non-existent measurement capabilities
3. Eliminate excessively long open channel ditch laterals serving limited acreage.

By improving these three core areas, particularly in the Owl Creek Watershed itself, water delivery, consumption, and loss mitigation will all be greatly improved.

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5 POTENTIAL EFFECTS AND BENEFITS OF PROPOSED PROJECTS

5.1 Benefits of Watershed Management Planning

The Wyoming Water Development Commission's (WWDC) Level I Watershed Study provides a landscape level analysis of a hydrologically connected watershed and nearby, associated, smaller watersheds that are within Hot Springs County. It focuses on two primary components. The first component is identification of the physical attributes of the analysis area. This is accomplished by conducting a comprehensive inventory of the natural resources and using that inventory to describe current natural resource conditions.

The second component is a long range plan outlining management and/or rehabilitation opportunities and activities that address irrigation efficiency, watershed function, and ecological enhancement. Carefully thought out land and water development systems and improvements are commonly called Best Management Practices (BMPs) or conservation practices. These BMPs and conservation practices are eligible for grant funding assistance through the WWDC's Small Water Project Program (SWPP) for projects with a total value of $135,000 or less, or the Conventional program for projects with a total value over $135,000. The WWDC's SWPP funds are mainly used to help landowners pay for the design and installation of irrigation diversion and conveyance improvements such as buried water delivery pipelines, water well development, spring developments, solar platforms and pumps, stock tanks, restoring wetlands, and installing other BMPs that promote land and water conservation. Conventional program projects can be larger versions of the same projects mentioned above, or they can be major infrastructure improvements such the construction of major irrigation system improvements.

There can be one or multiple benefits that occur with the implementation of BMPs and conservation practices. Benefits can be measurable or visible or both. Benefits can be localized or system-wide and direct to the landowner or land, or to the community and ecosystem, depending on multiple factors such as the BMPs used, ecological sites or watershed affected, or region of the state.

BMPs and conservation practices can also be used to relieve grazing pressure on riparian areas and create the potential to improve soil health, plant community diversity, and forage production. They can provide an opportunity to rest rangelands and allow control of invasive species, which are often associated with increased sedimentation or water use.

Ecosystem functions and landscape health benefit from improved soil health, water infiltration / percolation, and other water cycle improvements. Expected project benefits can be related to watershed function including collection and storage of water along with ecological enhancements such as plant and animal habitat and stream corridor or riverine stability as well as societal values including economic stability and open space maintenance. Multiple benefits can result from improvement opportunities for water resources, which are critical to meet the daily water demands of the resident population of humans and animals; develop, increase or extend irrigation water availability; and improve fish habitat and potential recreational benefits.

5.1.1 Natural Resources Conservation Service Conservation Effects Assessment

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

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

5.1.2 Watershed Function

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

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

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

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

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

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

As discussed in the Belle Fourche WWDC watershed study (RESPEC 2015), during the 1950s and 1960s, ranchers and landowners on five ranches, covering about one half of the watershed, began conservation work including root-plowing, reseeding, tree-dozing, aerial spraying, and chaining of mainly mesquite and juniper brush within theWest Rock Creek Watershed in West Texas. These species limited water availability for native grasses such as sideoats grama, buffalograss, curly mesquite, and tobosa (Moseley, 1983). Approximately 30,000 acres (70 percent) of the mesquite was removed from the watershed, and the original prairie was restored (Moseley, 1983; Wiedenfeld, 1986). In the mid to late-1960s, one of the five ranchers noticed that a spring, which was dry since 1935, had started flowing again, and by replacing the water-hungry brush with a good grass cover, more rainfall soaked into the aquifer and recharged the dormant springs and flow began on all five ranches by 1970 (Moseley, 1983). Ongoing grazing management on each ranch enhanced the cover of grasses in the watershed with soils producing an estimated 2,000 to 2,500 pounds of forage per acre, which helps retard brush succession; the ranchers periodically must maintain and control brush to keep the preferred vegetation balance (Moseley, 1983). Grassland ecosystems are more water-use efficient because they produce more plant material than shrublands with close to the same amount of precipitation input (USDA, 2013).

5.1.3 Ecological Enhancement

An ecological enhancement is any activity that improves an ecosystem, such as stabilizing erosive soils; increasing soil quality; planting or maintaining native grasses, shrubs, or trees; removing and controlling invasive species; and improving or maintaining riparian/wetland areas. Ecological sites are complex and varied within the study area as described in Section 3.1.6. The potential benefits achieved from project activities and implementations that influence the condition of those ecological sites and characteristics are also just as complex and varied. Conjunctive to soil function is plant community diversity, health and productivity and subsequent forage diversity, production and wildlife habitat. Benefits accrued to water quality are significant because improvements to the chemical, physical, and biological constituents of a waterbody produce both local site enhancements and those transferred downstream. Wetland enhancement and restoration provides benefits to ecological stabilization and contributions to water quality and quantity. Ecologically, watersheds function by providing diverse sites and pathways along which vital chemical reactions occur and furnishing habitat for the flora and fauna that constitute the biological elements of ecosystems (Black, 1997).

5.1.4 Plant and Animal Habitat

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

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

5.1.5 Stream Corridors and Riparian/Wetland Areas

Reducing the impact to riparian plant communities by developing upland water resources can result in in-stream corridor benefits. Riparian plant community diversity and regeneration of preferred important woody species can help restore local water tables, trap sediments, increase wildlife habitat and migration corridors, and stabilize stream banks (which can affect localized land loss). In addition, aquatic population benefits can accrue and recreation potential can be realized. Livestock distribution practices such as water developments, supplement placement, and herding are effective means of managing the intensity and season of livestock grazing in riparian areas (NRCS, 2011). The season of grazing also determines livestock grazing effects on riparian plant communities, particularly woody plants, and can be managed to conserve riparian habitats and their associated services (NRCS, 2011). Sufficient evidence exists in peer reviewed studies to suggest that NRCS riparian grazing management would maintain or enhance key riparian vegetation attributes (i.e., species composition, root mass and root density, cover, and biomass). It would also enhance stream channel and riparian soil stability, which will in turn support ecosystem services, such as flood and pollutant attenuation and high-quality riparian habitat (NRCS, 2011). Peer-reviewed literature generally supports the effectiveness of water developments, supplement placement, and herding for reducing riparian vegetation utilization, or time spent in riparian areas (NRCS, 2011).

5.1.6 Increased water availability for agriculture

Agricultural water users can conserve water through improved irrigation efficiency and improved tracking of water use. These efforts will increase the water available for irrigation use, particularly for lands located on middle Owl Creek, and for those who hold junior rights. Increased water use efficiency could alter the finding in Section 3.3.5 that there is not enough excess water to make its storage worthwhile.

Canal lining and other conveyance system conservation measures can decrease water loss to seepage and evaporation. The WWDC prepared an Irrigation System Survey Report in 2008 that evaluated losses and other issues associated with water consumption, such as whether conservation measures affected water loss and whether such measures had a habitat benefit associated with them. Not all conveyance loss issues can be addressed through conservation measures, but many are related to seepage and ditch and equipment maintenance. Conveyance losses can be very high and seepage issues were a common problem listed in the 2008 report. However, reducing conveyance losses in irrigation canals and improving irrigation application efficiencies can impact aquifers, wildlife habitat and other environmental resources. Often another use is dependent on the return flows produced from such inefficiencies. Producers need to consider the impact of agricultural conservation measures on other resources (Wind-Bighorn Plan Update 2010).

Improving the accuracy of water use measurement on each diversion and turn-out can improve the equity of water distribution and increase understanding of where water losses occur for future planned improvements. New head gates, turn-outs, parshall flumes, weirs or electronic measuring devices (e.g., SCADA) that are properly installed, maintained, and utilized to measure flows would allow Owl Creek irrigators to much more accurately measure and distribute water, and would provide data that could be used to update and simplify the ditch system.

Using efficient on-field irrigation methods can increase water use efficiency dramatically. Sub-surface drip irrigation is the most efficient in water usage (95 percent to 98 percent efficiency), followed by micro-sprinklers (85 percent to 95 percent), pivot sprinkler systems (75 percent to 85 percent), and then furrow and flood irrigation (60 percent to 75 percent) (Doll 2009 in Wind-Bighorn Plan Update 2010).

Where sprinklers are used, it is important to assure the system's ability to uniformly distribute water across all plants in the field. This may involve replacing nozzles, ensuring the irrigation pump is in good working condition and not irrigating in high winds. Irrigation scheduling (when and how much to irrigate) can also help achieve maximum water use efficiency. Monitoring the soil moisture in the field is an important part of determining proper irrigation timing. One method used for monitoring soil moisture is the burial of gypsum blocks in the field. Measurement of water in gypsum blocks reflects the amount of water in the soil (Wind-Bighorn Plan Update 2010).

Many of the gages and diversion structures used to measure water use are outdated or in failing condition (for example, see Section 4, ISYS-006, ISYS-17 through 23). Currently, excess flows are flushed through and lost to the Bighorn River. The Wind-Bighorn Plan Update (2010) referenced at the end of Section 3.5.5 did not evaluate how water storage might affect water distribution and water availability for junior water right holders on Owl Creek, or whether such changes would be a significant change for these rights holders. Therefore, there may be value in further study of small-scale water storage within the Owl Creek drainage.

5.1.7 Societal Value

Natural resource stewardship not only has economic value in terms of forage, livestock, and wildlife production relationships, but also can have noneconomic value placed on those conservation practices by society. Those values can even influence the perception of those implementing conservation practices and can be as much of an influence in the decision process to implement conservation as is an economic value. Additionally, a BMP or conservation practice can possibly provide an ecological service to accrue more value to society in general than to a local landowner. Ecosystem services are defined as those things or experiences produced by natural systems on which humans place value (NRCS, 2011). Ecosystem services benefit society in diverse ways while each of the conservation practices can potentially produce different kinds, qualities, and amounts of these goods and services, depending on location, natural potentials, current states, and other factors. Noneconomic values can and should be considered in determining watershed enhancement programs, particularly when considering public investment in conservation. NRCS (2011) found little to no research exists showing the direct noneconomic effects of BMPs and conservation practices on individuals, households, or social systems but acknowledged that producers likely realize psychological benefits from conservation because stewardship typically ranks high among the management goals of livestock producers (Huntsinger and Fortmann, 1990; Sayre, 2004). Moreover, producers who believe strongly in a responsibility to society are more likely to engage in environmentally sound management practices, such as invasive weed control and riparian protection (Kreuter et al., 2005). In 2012, in cooperation with the Wyoming Stock Growers Association (WGSA), University of Wyoming, and University of California-Davis, research scientists with the USDA's ARS Rangeland Resources Research Unit in Cheyenne, Wyoming, who were investigating the effects of rangeland management decision making, asked WGSA producer members about their goals, ranching operations, and management practices via a mail survey. A total of 307 ranchers responded to the survey (Kachergis et al., 2013; Mealor, 2013). Livestock production and forage production were the top management goals, with ecosystem characteristics that support these goals (e.g., soil health and water quality) second (Kacheris et al., 2013; Mealor, 2013).

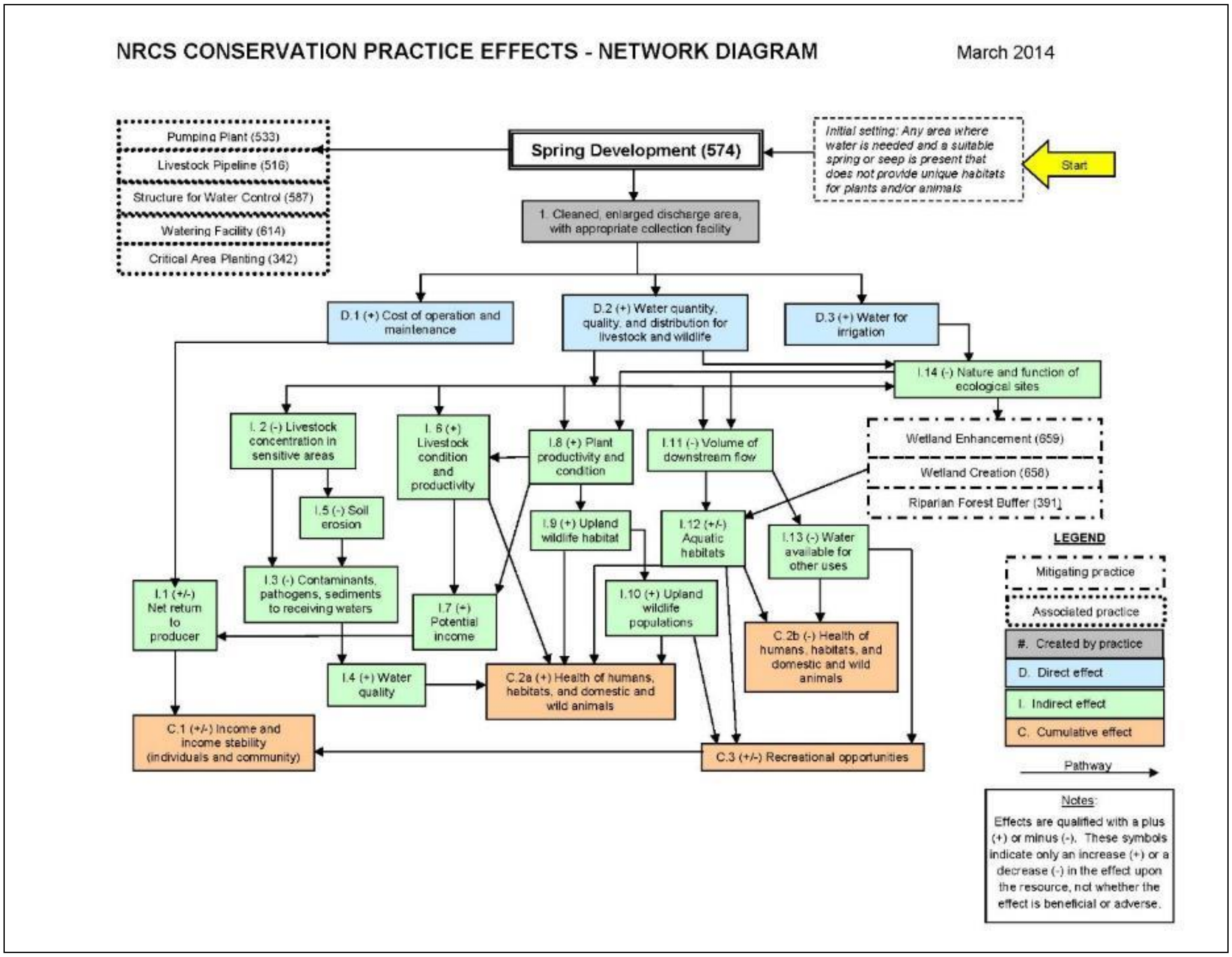
In addition to other social values and ecological enhancements, open spaces have long been held with high value to Wyoming and other western region states. From a ranching industry perspective, tourism interest, outdoor recreationist activity, or a real-estate value, open space is significant. Preservation of our custom and culture has been and continues to be a focal point of consideration. Open spaces are critical for upland/riparian conductivity, wildlife migrations and habitat, and recreational opportunity. Open space is valued for preservation of cultural resources and for reducing or preventing of land conversion to a condition that can be stewarded to an improved ecological condition (Respec 2015).

5.2 NED diagrams

The NRCS prepares Net Effect Diagrams (NEDs) of conservation practices or BMPs which act together to achieve desired purposes. The NEDs "are flow charts of direct, indirect and cumulative effects resulting from installation of the (improvement) 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" (Natural Resources Conservation Service, 2014).

Benefits associated with a particular conservation practice or BMP can be classified as direct, indirect or cumulative. Direct and indirect benefits would be considered measureable or tangible benefits. For example, construction of a reservoir designed to augment late season irrigation water supplies provides the direct or measurable benefit of providing a supply of water commensurate with its storage capacity. An indirect benefit could be the habitat provided to wildlife. Likewise, the same reservoir could provide the cumulative benefit of increased income to producers and improved health of the local economy. Project benefits can be related to ecological enhancement, water quantity, economic stability, stream corridor or riverine stability, or maintenance of open spaces (Anderson Consulting Engineers 2015).

An example NED for spring developments is shown below. All NEDs applicable to the projects proposed in this report are listed after the diagram and the actual diagrams are included in ***Appendix H***. Other NEDS for other types of projects can be found at:
https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/cp/ncps/?cid=nrcs143_026849.



A list of NEDs included in **Appendix H** is shown in **Table 5.2-1.**

Table 5.2-1 NEDS included in Appendix H of this document

NED	NRCS Conservation Practice Effects	NED	NRCS Conservation Practice Effects
327	Conservation Cover	554	Drainage Water Management
348	Dam, Diversion	574	Spring Development
356	Dike	582	Open Channel
378	Pond	587	Structure for Water Control
397	Aquaculture Ponds	606	Subsurface Drain
399	Fishpond Management	610	Salinity and Sodic Soil Management
430	Irrigation Pipeline	614	Watering Facility
436	Irrigation Reservoir	636	Water Harvesting Catchment
442	Sprinkler System	638	Water and Sediment Control Basin
443	Irrigation System, Surface and Subsurface	640	Water spreading
447	Irrigation System, Tail-water Recovery	642	Water Well
449	Irrigation Water Management	645	Upland Wildlife Habitat Management
466	Land Smoothing	656	Constructed Wetland
516	Livestock Pipeline	520	Pond Sealing or Lining, Compacted Soil Treatment
533	Pumping Plant		

6 COST ESTIMATES EXPLANATION

6.1 Introduction to cost estimating methods

Project costs for proposed improvements, where field visits were possible, have been estimated based on quantity estimates for each project and prevailing pricing for similar work in similar setting. The quantity estimates are based on nominal dimensioning as illustrated in the applicable conceptual design drawings; basic measurements, surveys, data procured during field visits, and the proposed extent of improvement.

For the Owl Creek Study, NRCS Practice Standards/Codes and corresponding unit costs were used as a data base. Utilizing the Practice Standards provided an expedient and efficient way to generally characterize the work components involved in a project. Recognizing that only NRCS employees are familiar with the subtleties and constraints of their system, it is not intended to characterize the work in strict conformance with the Practice Standard. Modification to the published costs was necessary to 1) produce estimates in compliance with the WDO contractual requirements 2) include costs not recognized in the NRCS system such as Mobilization, and 3) develop project costs representative of the work required, based on in-house experience. It's also recognized that published costs represent values the agency will reimburse for the work, not necessarily the total cost of the work.

It's noted that, a project owner may seek funding from a variety of agencies/entities other than NRCS. Those agencies/entities may use different task descriptors and costing methods. If a project owner does seek funding through NRCS, then the local DC may modify a project cost estimate and re-define the work using strictly conforming NRCS Practice Codes and corresponding unit prices to arrive at the reimbursement amounts allowable.

Unit Costs for construction materials and labor include a base unit cost derived from the NRCS 2014 Cost Estimating Guide, Historically Underserved (HU) line items. Based on consultation with the local NRCS District Conservationist, Jim Mischke, in October 2016, HU line items represent a straight 90% cost share regardless of project type. As a result, the listed HU cost has been inflated 10% to obtain an expected construction cost. That cost has been inflated an additional 4% to account for contractor mobilization which is not included in NRCS unit costs according to Mr. Mischke, and 6% for local and state sales tax. The foregoing cost is presented in the individual Detailed Project Cost Estimates, in **Appendix I**.

In the Cost Summary Tables presented in this section of the report, the Detailed Project Cost Estimate value is entered as the Total Component Cost. That cost is added to the Construction Engineering cost, calculated at 10% of Construction Cost, as prescribed by WDO cost estimating requirements. The latter cost is then increased by 15 % for Contingency to arrive at Total Construction Cost, again as prescribed by the WDO. Lastly, the Total Construction Cost is increased due to inflation, as calculated from Engineering News Record CCI[7] indices from July 2014 to July 2016 then projected to 2017 for a total inflation rate of 7.53%. The inflation amount along with all the Preconstruction Costs are added to the Total Construction Cost to arrive at a Total Project Cost.

In order to evaluate the applicability of this cost estimating method, materials and installation costs were obtained from regional material suppliers and local contractors. Portions of project costs for two

[7] Construction Cost Index

different projects were estimated using these unit costs and then compared to project costs using the modified NRCS unit costs. The project costs compared favorably and were within 10-15% regardless of method. Consequently, it is felt using the modified NRCS costs as described above results in projected 2017 costs acceptable for a Level I Reconnaissance Study.

Projects identified at the Workshops and noted in the Report with a “w” designator did not benefit from a field visit. The scope of work and complexity of the project was described by landowner to the interviewing consulting team member. Based on the Landowner description, the project was compared to a similar project that had benefited from a field visit and a detailed cost estimate. Subsequent to the comparative evaluation, a range of expected cost was assigned to the project. In a few cases, due to size, extent or project complexity, no estimate is provided. A notice for such a project is included which states “Cost estimate to be developed during design phase.”

6.2 Cost Estimate tables by project type

6.2.1 Irrigation System Improvements

On-site Interviews

Table 6.2.1-1 ISYS On-site Interviews

Project Number	Final Design and Specifications	Permitting and Mitigation Fees	Legal Fees	Access and Right of Way	Pre-Construction Costs	Total Component Cost *Reference Appendix I	Construction Engineering (10%)	Construction & Engineering Subtotal	Contingency (15%)	Total Construction Cost	ENR Inflation From 2014-2017 (7.53%)	Total Project Cost
ISYS-001	$ 3,800	$ -	$ -	$ -	$ 3,800	$ 54,503	$ 5,450	$ 59,953	$ 8,993	$ 68,946	$ 5,192	**$ 78,000**
ISYS-002	$ 2,000	$ -	$ -	$ -	$ 2,000	$ 11,936	$ 1,194	$ 13,130	$ 1,970	$ 15,100	$ 1,137	**$ 18,000**
ISYS-003	$ 2,000	$ 1,000	$ -	$ -	$ 3,000	$ 40,609	$ 4,061	$ 44,670	$ 6,701	$ 51,371	$ 3,868	**$ 58,000**
ISYS-004	$ 9,800	$ 1,000	$ 1,000	$ 1,000	$ 12,800	$ 152,265	$ 15,227	$ 167,492	$ 25,124	$ 192,616	$ 14,504	**$ 220,000**
ISYS-005	$ 48,700	$ 1,000	$ 4,000	$ 1,000	$ 54,700	$ 695,574	$ 69,557	$ 765,131	$ 114,770	$ 879,901	$ 66,257	**$ 1,001,000**
ISYS-006	$ 2,000	$ 1,000	$ -	$ 1,000	$ 4,000	$ 23,038	$ 2,304	$ 25,342	$ 3,801	$ 29,143	$ 2,194	**$ 35,000**
ISYS-007	$ 2,000	$ 8,000	$ -	$ -	$ 10,000	$ 24,887	$ 2,489	$ 27,376	$ 4,106	$ 31,482	$ 2,371	**$ 44,000**
ISYS-008	$ 1,000	$ -	$ -	$ -	$ 1,000	$ 8,494	$ 849	$ 9,343	$ 1,401	$ 10,744	$ 809	**$ 13,000**
ISYS-009/009A	$ 33,600	$ 2,000	$ 4,000	$ -	$ 39,600	$ 496,422	$ 49,642	$ 546,064	$ 81,910	$ 627,974	$ 47,286	**$ 715,000**
ISYS-010	$ 4,000	$ 10,000	$ 1,000	$ -	$ 15,000	$ 60,029	$ 6,003	$ 66,032	$ 9,905	$ 75,937	$ 5,718	**$ 97,000**
ISYS-011	$ -	$ -	$ -	$ -	$ -	$ 69,236	$ 6,924	$ 76,160	$ 11,424	$ 87,584	$ 6,595	**$ 94,000**
ISYS-012	$ 2,000	$ -	$ -	$ -	$ 2,000	$ 60,851	$ 6,085	$ 66,936	$ 10,040	$ 76,976	$ 5,796	**$ 85,000**
ISYS-013	$ 2,000	$ -	$ -	$ -	$ 2,000	$ 15,844	$ 1,584	$ 17,428	$ 2,614	$ 20,042	$ 1,509	**$ 24,000**
ISYS-014	$ 2,000	$ -	$ -	$ -	$ 2,000	$ 23,280	$ 2,328	$ 25,608	$ 3,841	$ 29,449	$ 2,218	**$ 34,000**
ISYS-015	$ 3,000	$ -	$ -	$ -	$ 3,000	$ 152,324	$ 15,232	$ 167,556	$ 25,133	$ 192,689	$ 14,509	**$ 210,000**
ISYS-016/016A	$ 2,000	$ -	$ -	$ 2,000	$ 4,000	$ 23,653	$ 2,365	$ 26,018	$ 3,903	$ 29,921	$ 2,253	**$ 36,000**
ISYS-017-023	$ 2,000	$ -	$ -	$ -	$ 2,000	$ 20,580	$ 2,058	$ 22,638	$ 3,396	$ 26,034	$ 1,960	**$ 30,000**
ISYS-024	$ 4,000	$ -	$ -	$ -	$ 4,000	$ 29,278	$ 2,928	$ 32,206	$ 4,831	$ 37,037	$ 2,789	**$ 44,000**
ISYS-025	$ 6,000	$ 2,000	$ 2,000	$ 1,000	$ 11,000	$ 86,650	$ 8,665	$ 95,315	$ 14,297	$ 109,612	$ 8,254	**$ 129,000**
ISYS-026	$ -	$ -	$ -	$ -	$ -	$ 5,477	$ 548	$ 6,025	$ 904	$ 6,929	$ 522	**$ 7,000**
ISYS-027	$ 4,000	$ -	$ -	$ -	$ 4,000	$ 95,745	$ 9,575	$ 105,320	$ 15,798	$ 121,118	$ 9,120	**$ 134,000**
ISYS-028	$ 1,000	$ -	$ -	$ -	$ 1,000	$ 51,733	$ 5,173	$ 56,906	$ 8,536	$ 65,442	$ 4,928	**$ 71,000**
ISYS-029&30	$ 2,000	$ -	$ -	$ -	$ 2,000	$ 180,822	$ 18,082	$ 198,904	$ 29,836	$ 228,740	$ 17,224	**$ 248,000**
ISYS-031	$ 1,000	$ -	$ -	$ 1,000	$ 2,000	$ 36,722	$ 3,672	$ 40,394	$ 6,059	$ 46,453	$ 3,498	**$ 52,000**
ISYS-032	$ 2,000	$ -	$ -	$ -	$ 2,000	$ 40,283	$ 4,028	$ 44,311	$ 6,647	$ 50,958	$ 3,837	**$ 57,000**

Workshop Interviews

Table 6.2.1-2 ISYS Workshop Interviews

Project Number	Estimated Cost Range
ISYS-W01	$10,000 - $15,000
ISYS-W02	$25,000 - $35,000
ISYS-W03	Further Evaluation Required
ISYS-W04	$8,000 - $15,000
ISYS-W05	Further Evaluation Required
ISYS-W06	Further Evaluation Required
ISYS-W07	$45,000 - $55,000
ISYS-W08	Further Evaluation Required
ISYS-W09	$30,000 - $50,000
ISYS-W10	Further Evaluation Required
ISYS-W11	Further Evaluation Required
ISYS-W12	$50,000 - $75,000
ISYS-W13	$40,000 - $60,000
ISYS-W14	Further Evaluation Required
ISYS-W15&W16	Further Evaluation Required
ISYS-W17	Further Evaluation Required
ISYS-W18	$7,000 - $12,000
ISYS-W19	Further Evaluation Required
ISYS-W20	Further Evaluation Required

6.2.2 Irrigation Supply Storage Projects

On-site Interviews

Table 6.2.2-1 ISTO On-site Interviews

Project Number	Final Design and Specifications	Permitting and Mitigation Fees	Legal Fees	Access and Right of Way	Pre-Construction Costs	Construction Subtotal	Construction Engineering (10%)	Construction & Engineering Subtotal	Contingency (15%)	Total Construction Cost	ENR Inflation From 2014-2017 (7.53%)	Total Project Cost
ISTO-001	$ 2,000	$ 3,000	$ 2,000	$ 1,000.00	$ 8,000.00	$ 16,364	$ 1,636	$ 18,000	$ 2,700	$ 20,700	$ 1,559	**$ 30,000**
ISTO-002	$ 3,000	$ 3,000	$ -	$ -	$ 6,000.00	$ 7,106	$ 711	$ 7,817	$ 1,173	$ 8,990	$ 677	**$ 16,000**
ISTO-003	$ 2,000	$ 4,000	$ -	$ -	$ 6,000.00	$ 26,539	$ 2,654	$ 29,193	$ 4,379	$ 33,572	$ 2,528	**$ 42,000**
ISTO-004	$ 5,000	$ 3,000			$ 8,000.00	$ 101,893	$ 10,189	$ 112,082	$ 16,812	$ 128,894	$ 9,706	**$ 147,000**

6.2.3 Stream Channel Stability and Rehabilitation Projects

On-site Interviews

Table 6.2.3-1 SCS On-site Interviews

Project Number	Final Design and Specifications	Permitting and Mitigation Fees	Legal Fees	Access and Right of Way	Pre-Construction Costs	Construction Subtotal	Construction Engineering (10%)	Construction & Engineering Subtotal	Contingency (15%)	Total Construction Cost	ENR Inflation From 2014-2017 (7.53%)	Total Project Cost
SCS-001	$6,000	$2,000	$0	$0	$8,000	$ 33,803	$ 3,380	$ 37,183	$ 5,577	$ 42,760	$ 3,220	**$ 54,000.00**
SCS-002	$4,000	$2,000	$1,000	$2,000	$9,000	$ 30,413	$ 3,041	$ 33,454	$ 5,018	$ 38,472	$ 2,897	**$ 50,000.00**
SCS-003	$2,000	$2,000	$1,000	$1,000	$6,000	$ 15,933	$ 1,593	$ 17,526	$ 2,629	$ 20,155	$ 1,518	**$ 28,000.00**
SCS-004	$6,000	$2,000	$0	$0	$8,000	$ 43,091	$ 4,309	$ 47,400	$ 7,110	$ 54,510	$ 4,105	**$ 67,000.00**

Workshop Interviews

Table 6.2.3-2 SCS Workshop Interviews

Project Number	Estimated Cost Range
SCS-W01	$35,000-$50,000
SCS-W02	Further Evaluation Required

6.2.4 Upland Range Improvement Projects

On-site Interviews

Table 6.2.4-1 URI On-site Interviews

Project Number	Final Design and Specifications	Permitting and Mitigation Fees	Legal Fees	Access and Right of Way	Pre-Construction Costs	Total Component Cost	Construction Engineering (10%)	Construction & Engineering Subtotal	Contingency (15%)	Total Construction Cost	ENR Inflation From 2014-2017 (7.53%)	Total Project Cost
URI-001	$ 4,000				$ 4,000	$ 20,614	$ 2,061	$ 22,675	$ 3,401	$ 26,076	$ 1,964	**$ 32,000**
URI-002	$ 2,000		$ 1,000	$ 1,000	$ 4,000	$ 20,101	$ 2,010	$ 22,111	$ 3,317	$ 25,428	$ 1,915	**$ 31,000**
URI-003	$ 1,000	$ 1,000		$ 1,000	$ 3,000	$ 23,142	$ 2,314	$ 25,456	$ 3,818	$ 29,274	$ 2,204	**$ 34,000**
URI-004	$ 1,000	$ 1,000			$ 2,000	$ 16,456	$ 1,646	$ 18,102	$ 2,715	$ 20,817	$ 1,568	**$ 24,000**
URI-005	$ 1,000	$ 1,000		$ 2,000	$ 4,000	$ 16,400	$ 1,640	$ 18,040	$ 2,706	$ 20,746	$ 1,562	**$ 26,000**
URI-006	$ 2,000	$ 2,000			$ 4,000	$ 28,069	$ 2,807	$ 30,876	$ 4,631	$ 35,507	$ 2,674	**$ 42,000**
URI -007	$ 3,000	$ 1,000	$ -	$ -	$ 4,000	$ 1,025	$ 103	$ 1,128	$ 169	$ 1,297	$ 98	**$ 5,000**
URI-008	$ 2,000	$ 1,000	$ 1,000	$ 2,000	$ 6,000	$ 50,653	$ 5,065	$ 55,718	$ 8,358	$ 64,076	$ 4,825	**$ 75,000**
URI-008A	$ 3,000	$ 2,000	$ 1,000	$ 1,000	$ 7,000	$ 46,930	$ 4,693	$ 51,623	$ 7,743	$ 59,366	$ 4,470	**$ 71,000**
URI-009	$ -	$ -	$ -	$ -	$ -	$ 5,606	$ 561	$ 6,167	$ 925	$ 7,092	$ 534	**$ 8,000**

Workshop Interviews

Table 6.2.4-2 URI Workshop Interviews

Project Number	Estimated Cost Range
URI-W01	$30,000-$45,000
URI-W02	$35,000-$50,000
URI-W03	$5,000-$20,000
URI-W04	$5,000-$10,000
URI-W05	$35,000-$45,000

6.2.5 Other Watershed Improvements

On-site Interviews

Table 6.2.5-1 OWI On-site Interviews

Project Number	Final Design and Specifications	Permitting and Mitigation Fees	Legal Fees	Access and Right of Way	Pre-Construction Costs	Construction Subtotal	Construction Engineering (10%)	Construction & Engineering Subtotal	Contingency (15%)	Total Construction Cost	ENR Inflation From 2014-2017 (7.53%)	Total Project Cost
OWI-001	$4,000	$1,000	$0	$0	$5,000	$ 46,071	$ 4,607	$ 50,678	$ 7,602	$ 58,280	$ 4,388	$ 68,000
OWI-002	$2,000	$1,000	$0	$0	$3,000	$ 29,569	$ 2,957	$ 32,526	$ 4,879	$ 37,405	$ 2,817	$ 43,000
OWI-003	$4,000	$2,000	$0	$0	$6,000	$ 16,213	$ 1,621	$ 17,834	$ 2,675	$ 20,509	$ 1,544	$ 28,000
OWI-004	$3,000	$1,000	$0	$0	$4,000	$ 15,592	$ 1,559	$ 17,151	$ 2,573	$ 19,724	$ 1,485	$ 25,000
OWI-005	$4,000	$1,000	$2,000	$0	$7,000	$ 22,034	$ 2,203	$ 24,237	$ 3,636	$ 27,873	$ 2,099	$ 37,000
OWI-006	$1,000	$2,000	$0	$0	$3,000	$ 19,883	$ 1,988	$ 21,871	$ 3,281	$ 25,152	$ 1,894	$ 30,000
OWI-007	$3,000	$4,000	$0	$0	$7,000	$ 17,181	$ 1,718	$ 18,899	$ 2,835	$ 21,734	$ 1,637	$ 30,000

Workshop Interviews

Table 6.2.5-2 OWI Workshop Interviews

Project Number	Estimated Cost Range
OWI-W01	Further Evaluation Required
OWI-W02	$4,000-$6,000
OWI-W03	Further Evaluation Required

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7 METHODS – EVALUATION CRITERIA AND HOW CRITERIA WERE UTILIZED

7.1 Matrix Development and Ranking Criteria

For the Rehabilitation Management Plan for Owl Creek, LW developed a matrix table listing all projects by project type. The goal of these matrices is to allow HSCD to quickly evaluate projects based on standard criteria and use that information to determine what projects HSCD will support for WWDC or other funding. The matrix table includes 11 rating criteria. These criteria were developed using past watershed study project rating criteria. The HSCD reviewed the criteria at a regularly scheduled meeting and suggested minor changes, which were incorporated into the final version.

The matrix also includes a section listing WWDC project priorities for both the SWPP and the Conventional Program, and states whether each project is a “rehabilitation” or “new” by WDO definition. The WDO operating criteria for SWPP projects and Conventional Program projects are included in **Appendix J.** *The WDO criteria numbers are not included in the final composite project score*.

Elements included in the matrix are:

1. Project is practical to Implement.
2. Project is cost effective compared to other, similar projects.
3. Project is economically feasible and eligible for funding via WWDC or other entities.
4. Project has no fatal flaws, can be permitted without undue hardship or effort.
5. Project is critical to maintain the continued diversion, storage, or delivery of water.
6. Project will improve water use efficiency for landowner.
7. Project positively affects water availability for other area water users and does not affect existing water compacts.
8. Project will improve the measurement and management of water flow.
9. Project supports or improves area hydrologic and ecological functioning.
10. Project is sustainable - can withstand the rigors of weather and water impacts.
11. Project is likely to have a positive effect on Owl Creek water quality, specifically E. coli levels.

Elements 3, 5, 8, and 9 were considered top-priority factors to the LW team. Matrix elements were given a number from 1 to 3, with 1 being “most favorable” and 3 being “least favorable”. Therefore in the composite score, a low number is “best”. Because the composite scores are so close numerically, we have ranked each project in order of its composite score at the bottom of each table. We have shaded the composite score cells to show more clearly the projects that rated most favorable in green and least favorable in red. In addition, “1” values and “3” values in the tables are highlighted to further help the reader see the “most favorable” and “least favorable” factors for each project in the matrix.

7.2 Matrix Table(s) by project type

The results of the matrix analysis are listed on the following pages by project type.

Table 7.2.1 On-Site ISYS Projects Matrix

Criteria (RED = WWDC Criteria, Black = Cons District Criteria)	More Favorable Projects				Less Favorable Projects																					
Project Criteria	**Project Rating**																									**Notes**
	ISYS-001	ISYS-002	ISYS-003	ISYS-004	ISYS-005	ISYS-006	ISYS-007	ISYS-008	ISYS-009/009A	ISYS-010	ISYS-011	ISYS-012	ISYS-013	ISYS-014	ISYS-015	ISYS-016/016A	ISYS-017-023	ISYS-024	ISYS-025	ISYS-026	ISYS-027	ISYS-028	ISYS-029/030	ISYS-031	ISYS-032	
Estimated Cost of Project	$78,000	$18,000	$58,000	$220,000	$1,001,000	$35,000	$44,000	$13,000	$715,000	$97,000	$94,000	$85,000	$24,000	$34,000	$210,000	$36,000	$30,000	$44,000	$129,000	$7,000	$134,000	$71,000	$248,000	$52,000	$57,000	Explanations
WWDC PROJECT SELECTION CRITERIA																										
Applicable WWDC Program Type	SWPP	SWPP	SWPP	Conven-tional	Conven-tional	SWPP	SWPP	SWPP	Conven-tional	SWPP	SWPP	SWPP	SWPP	SWPP	Conven-tional	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	Conven-tional	SWPP	SWPP	SWPP or Conventional funding
SWPP Project Priority*	3	4	3			3	4	4		3	4	4	4	4	3	3	4	4	4	4	4	4		4	3	
Conventional Project Priority**				4	4				4														3			
Rehabilitation vs New Development	Rehab	Both	Rehab	Both	Both	Rehab	Both	New	New	Both	New	New	Both	New	Both	New	Rehab	Rehab	Rehab	New	New	New	New	New	New	Rehabilitation project, new project, or both?
HOT SPRINGS CONSERVATION DISTRICT PROJECT SELECTION CRITERIA																										
1 Project is practical to Implement	2	2	2	2	3	3	2	1	2	3	1	1	2	3	2	1	1	1	1	2	2	3	2	3	2	Project has few issues with distance/ease of mobilization, availability of equipment/supplies , or need for specialized skills to build or install system.
2 Project is cost effective compared to other, similar projects	2	1	2	3	3	2	2	2	3	2	2	2	2	3	3	1	1	1	2	2	1	3	3	3	1	Relative to other similar projects, low cost per acre irrigated and/or large number of landowners benefitting from project.
3 Project is ecnomically feasible and eiligible for funding via WWDC or other entities	2	2	2	1	3	2	2	2	3	3	2	3	2	2	3	1	1	1	2	2	2	3	3	2	2	Self expanatory
4 Project has no fatal flaws, can be permitted without undue hardship or effort	2	2	2	2	3	2	2	1	2	3	1	2	2	2	1	2	1	1	1	1	2	2	2	2	2	Self expanatory
5 Project is critical to maintain the continued diversion, storage, or delivery of water	1	1	2	2	1	3	3	2	1	2	2	2	1	3	1	1	1	1	1	3	2	2	2	3	2	Self explanatory
6 Project will improve water use efficiency for landowner	1	2	1	1	2	2	2	1	1	1	1	1	1	2	1	1	1	2	1	1	1	2	1	2	1	Self explanatory
7 Project positively effects water availability for other area water users and does not affect existing water compacts	1	2	1	1	1	2	2	1	1	2	2	1	2	2	2	2	1	2	1	3	3	3	2	3	3	Self explanatory
8 Project will improve the measurement and management of water flow	2	2	2	2	1	2	2	2	1	1	2	1	2	1	2	1	1	1	1	2	2	2	1	2	2	Self explanatory
9 Project supports or improves area hydrologic and ecological functioning	2	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	Protects springs, streambanks, improves water storage in riparian zones around streams, improves wildlife habitat, range condition, etc.
10 Project is sustainable - can withstand the rigors of weather and water impacts	1	1	1	1	2	1	2	2	2	3	2	3	2	3	2	2	3	1	2	2	3	2	3	2	2	Does the project require frequent maintenance? Will the project remain serviceable > 30 years?
11. Project is likely to have a positive effect on Owl Creek water quality, specifically E. coli levels	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Self explanatory
Composite Score (Average) for Factors 1 through 10 (Lower score is "better")	1.64	1.73	1.73	1.73	2.09	2.18	2.09	1.55	1.73	2.18	1.73	1.82	1.82	2.27	1.91	1.45	1.36	1.18	1.40	2.00	2.00	2.40	2.10	2.40	1.90	
PROJECT RANKING	**6**	**7**	**7**	**7**	**18**	**21**	**18**	**5**	**7**	**21**	**7**	**12**	**12**	**23**	**15**	**4**	**2**	**1**	**3**	**16**	**16**	**24**	**20**	**24**	**14**	

*SWPP Project Criteria: 1-Source water devel, 2 - Storage, 3 - Pipelines, Conveyance, Solar, Windmill, 4 - Irrigation, 5 - Environment

**Conventional Project Criteria: 1 - Multipurpose, 2 - Storage, 3- New irrigation & municipal, 4 - Water transmission facilities, 5 - Rural domestic I, 6 - Rural domestic II, 7 - Hydropower, 8 - Purchase of existing storage, 9 - Raw water wells for towns & lawns

NOTE: Not all numbers are represented in Ranking. If there are duplicates of the same rank, the rank number defaults to the higher (less desirable) rank in the pair.

Table 7.2.2 Workshop ISYS Projects Matrix

Criteria (RED = WWDC Criteria, Black = Cons District Criteria)	More Favorable Projects				Less Favorable Projects															
Project Criteria	**Project Rating**																			**Notes**
	ISYS-W01	ISYS-W02	ISYS-W03	ISYS-W04	ISYS-W05	ISYS-W06	ISYS-W07	ISYS-W08	ISYS-W09	ISYS-W10	ISYS-W11	ISYS-W12	ISYS-W13	ISYS-W14	ISYS-W15/W16	ISYS-W17	ISYS-W18	ISYS-W19	ISYS-W20	
Estimated Cost of Project	$ 10,000-15,000	$25,000-$35,000	N/A	$8,000-$15,000	N/A	N/A	$45,000-$55,000	N/A	$30,000-$50,000	N/A	N/A	$50,000-$75,000	$40,000-$60,000	N/A	N/A	N/A	$7,000-$12,000	N/A	N/A	Explanations
WWDC PROJECT SELECTION CRITERIA																				
Applicable WWDC Program Type	SWPP	SWPP	N/A	SWPP	N/A	N/A	SWPP	N/A	SWPP	N/A	N/A	SWPP	SWPP	N/A	N/A	N/A	SWPP	N/A	N/A	SWPP or Conventional funding
SWPP Project Priority*	4	4		4			4		4			4	4				4			
Conventional Project Priority**																				
Rehabilitation vs New Development	Rehab	Rehab	Rehab	Rehab	Rehab	Rehab	Rehab	New	Rehab	New	Rehab	Rehab	Rehab	Rehab	Rehab	Rehab	Rehab	Both	Rehab	Rehabilitation project, new project, or both?
HOT SPRINGS CONSERVATION DISTRICT PROJECT SELECTION CRITERIA																				
1 Project is practical to Implement	1	2	1	1	2	2	1	2	1	2	2	1	1	2	1	1	1	2	1	Project has few issues with distance/ease of mobilization, availability of equipment/supplies , or need for specialized skills to build or install system.
2 Project is cost effective compared to other, similar projects	1	2	3	2	3	3	1	3	1	3	3	2	2	3	2	3	1	2	3	Relative to other similar projects, low cost per acre irrigated and/or large number of landowners benefitting from project.
3 Project is ecnomically feasible and eiligible for funding via WWDC or other entities	1	1	2	1	2	2	1	2	1	2	2	1	1	2	1	2	1	3	2	Self expanatory
4 Project has no fatal flaws, can be permitted without undue hardship or effort	2	1	2	3	3	3	2	3	2	3	2	2	1	2	1	2	2	2	2	Self expanatory
5 Project is critical to maintain the continued diversion, storage, or delivery of water	1	2	1	2	3	2	2	2	2	3	2	1	2	2	1	1	2	3	2	Self explanatory
6 Project will improve water use efficiency for landowner	1	1	1	1	2	1	1	1	1	1	1	1	1	2	1	1	1	2	1	Self explanatory
7 Project positively effects water availability for other area water users and does not affect existing water compacts	1	1	1	2	2	3	1	3	3	3	1	1	3	1	1	3	3	3	3	Self explanatory
8 Project will improve the measurement and management of water flow	2	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	2	Self explanatory
9 Project supports or improves area hydrologic and ecological functioning	2	2	2	3	2	2	1	3	2	3	2	2	3	3	2	3	3	3	3	Protects springs, streambanks, improves water storage in riparian zones around streams, improves wildlife habitat, range condition, etc.
10 Project is sustainable - can withstand the rigors of weather and water impacts	1	1	1	1	1	1	1	1	1	2	2	2	2	1	2	2	1	1	1	Does the project require frequent maintenance? Will the project remain serviceable > 30 years?
11. Project is likely to have a positive effect on Owl Creek water quality, specifically E. coli levels	N/A	N/A	N/A	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Self explanatory
Composite Score (Average) for Factors 1 through 10 (Lower score is "better")	1.30	1.40	1.50	1.70	2.09	2.00	1.20	2.10	1.50	2.30	1.80	1.40	1.80	2.00	1.30	1.90	1.60	2.20	2.00	
PROJECT RANKING	**2**	**4**	**6**	**9**	**16**	**13**	**1**	**17**	**6**	**19**	**10**	**4**	**10**	**13**	**2**	**12**	**8**	**18**	**13**	

*SWPP Project Criteria: 1-Source water devel, 2 - Storage, 3 - Pipelines, Conveyance, Solar, Windmill, 4 - Irrigation, 5 - Environment

**Conventional Project Criteria: 1 - Multipurpose, 2 - Storage, 3- New irrigation & municipal, 4 - Water transmission facilities, 5 - Rural domestic I, 6 - Rural domestic II, 7 - Hydropower, 8 - Purchase of existing storage, 9 - Raw water wells for towns & lawns

NOTE: Not all numbers are represented in Ranking. If there are duplicates of the same rank, the rank number defaults to the higher (less desirable) rank in the pair.

Table 7.2.3 ISTO On-site Project Matrix

Criteria (RED = WWDC Criteria, Black = Cons District Criteria)	More Favorable Projects				Less Favorable Projects
Project Criteria	**Project Rating**				**Notes**
	ISTO-001	ISTO-002	ISTO-003	ISTO-004	
Estimated Cost of Project	$26,000	$16,000	$42,000	$147,000	Explanations
WWDC PROJECT SELECTION CRITERIA					
Applicable WWDC Program Type	SWPP	SWPP	SWPP	Conventional	
SWPP Project Priority	2	2	2		
Conventional Project Priority				2	
Rehabilitation vs New Development	Rehab	New	Rehab	New	
HOT SPRINGS CONSERVATION DISTRICT PROJECT SELECTION CRITERIA					
1 Project is practical to Implement	2	2	1	3	Project has few issues with distance/ease of mobilization, availability of equipment/supplies , or need for specialized skills to build or install system.
2 Project is cost effective compared to other, similar projects	2	1	2	2	Relative to other similar projects, low cost per acre irrigated and/or large number of landowners benefitting from project.
3 Project is ecnomically feasible and eiligible for funding via WWDC or other entities	2	2	1	2	Self expanatory
4 Project has no fatal flaws, can be permitted without undue hardship or effort	3	3	1	3	Self expanatory
5 Project is critical to maintain the continued diversion, storage, or delivery of water	1	1	3	2	Self explanatory
6 Project will improve water use efficiency for landowner	1	1	1	1	Self explanatory
7 Project positively effects water availability for other area water users and does not affect existing water compacts	3	3	3	2	Self explanatory
8 Project will improve the measurement and management of water flow	1	1	1	2	Self explanatory
9 Project supports or improves area hydrologic and ecological functioning	2	2	2	3	Protects springs, streambanks, improves water storage in riparian zones around streams, improves wildlife habitat, range condition, etc.
10 Project is sustainable - can withstand the rigors of weather and water impacts	1	1	2	2	Does the project require frequent maintenance? Will the project remain serviceable > 30 years?
11. Project is likely to have a positive effect on Owl Creek water quality, specifically E. coli levels	1	N/A	N/A	N/A	Self explanatory
Composite Score (Average) for Factors 1 through 10 (Lower score is "better")	1.73	1.70	1.70	2.20	
PROJECT RANKING	3	1	1	4	

*SWPP Project Criteria: 1-Source water devel, 2 - Storage, 3 - Pipelines, Conveyance, Solar, Windmill, 4 - Irrigation, 5 - Environment

**Conventional Project Criteria: 1 - Multipurpose, 2 - Storage, 3- New irrigation & municipal, 4 - Water transmission facilities, 5 - Rural domestic I, 6 - Rural domestic II, 7 - Hydropower, 8 - Purchase of existing storage, 9 - Raw water wells for towns & lawns

NOTE: Not all numbers are represented in Ranking. If there are duplicates of the same rank, the rank number defaults to the higher (less desirable) rank in the pair.

Table 7.2.4 SCS On-site & Workshop Project Matrix

Criteria (RED = WWDC Criteria, Black = Cons District Criteria)	More Favorable Projects			Less Favorable Projects			
Project Criteria	**Project Rating**						**Notes**
	SCS-001	SCS-002	SCS-003	SCS-004	SCS-W01	SCS-W02	
Estimated Cost of Project	$54,000	$50,000	$28,000	$61,000	$35,000-$50,000	N/A	Explanations
WWDC PROJECT SELECTION CRITERIA							
Applicable WWDC Program Type	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	
SWPP Project Priority	5	4	5	4	4	5	
Conventional Project Priority							
Rehabilitation vs New Development	New or Rehab	Rehab	Rehab	Rehab	Rehab	Rehab	
HOT SPRINGS CONSERVATION DISTRICT PROJECT SELECTION CRITERIA							
1 Project is practical to Implement	1	1	1	1	1	1	Project has few issues with distance/ease of mobilization, availability of equipment/supplies , or need for specialized skills to build or install system.
2 Project is cost effective compared to other, similar projects	1	1	2	3	3	2	Relative to other similar projects, low cost per acre irrigated and/or large number of landowners benefitting from project.
3 Project is ecnomically feasible and eiligible for funding via WWDC or other entities	1	1	2	2	3	3	Self expanatory
4 Project has no fatal flaws, can be permitted without undue hardship or effort	2	1	2	2	3	2	Self expanatory
5 Project is critical to maintain the continued diversion, storage, or delivery of water	2	1	1	1	2	2	Self explanatory
6 Project will improve water use efficiency for landowner	3	1	1	1	1	1	Self explanatory
7 Project positively effects water availability for other area water users and does not affect existing water compacts	1	1	1	1	3	3	Self explanatory
8 Project will improve the measurement and management of water flow	3	1	1	1	1	2	Self explanatory
9 Project supports or improves area hydrologic and ecological functioning	1	1	1	1	2	1	Protects springs, streambanks, improves water storage in riparian zones around streams, improves wildlife habitat, range condition, etc.
10 Project is sustainable - can withstand the rigors of weather and water impacts	1	1	1	1	1	1	Does the project require frequent maintenance? Will the project remain serviceable > 30 years?
11. Project is likely to have a positive effect on Owl Creek water quality, specifically E. coli levels	N/A	N/A	N/A	N/A	N/A	N/A	Self explanatory
Composite Score (Average) for Factors 1 through 10 (Lower score is "better")	1.60	1.00	1.30	1.40	2.00	1.80	
PROJECT RANKING	4	1	2	3	2	1	

*SWPP Project Criteria: 1-Source water devel, 2 - Storage, 3 - Pipelines, Conveyance, Solar, Windmill, 4 - Irrigation, 5 - Environment

**Conventional Project Criteria: 1 - Multipurpose, 2 - Storage, 3- New irrigation & municipal, 4 - Water transmission facilities, 5 - Rural domestic I, 6 - Rural domestic II, 7 - Hydropower, 8 - Purchase of existing storage, 9 - Raw water wells for towns & lawns

NOTE: Not all numbers are represented in Ranking. If there are duplicates of the same rank, the rank number defaults to the higher (less desirable) rank in the pair.

Table 7.2.5 URI On-Site & Workshop Project Matrix

Criteria (RED = WWDC Criteria, Black = Cons District Criteria)	More Favorable Projects				Less Favorable Projects											
Project Criteria	**Project Rating**															
	URI-001	URI-002	URI-003	URI-004	URI-005	URI-006	URI-007	URI-008	URI-008A	URI-009	URI-W01	URI-W02	URI-W03	URI-W04	URI-W05	
Estimated Cost of Project	$32,000	$31,000	$34,000	$24,000	$26,000	$42,000	$5,000	$75,000	$71,000	$8,000	$30,000-$45,000	$35,000-$50,000	$5,000-$20,000	$5,000-$10,000	$35,000-$45,000	Explanations
WWDC PROJECT SELECTION CRITERIA																
Applicable WWDC Program Type	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP or Conventional funding
SWPP Project Priority	3	3	3	1	3	3	2	1	1	3	1	1	1	1	3	1-Source water devel, 2 - Storage, 3 - Pipelines, Conveyance, Solar, Windmill, 4 - Irrigation, 5 - Environment
Conventional Project Priority																1 - Multipurpose, 2 - Storage, 3- New irrigation & municipal, 4 - Water transmission facilities, 5 - Rural domestic I, 6 - Rural domestic II, 7 - Hydropower, 8 - Purchase of existing storage, 9 - Raw water wells for towns & lawns
Rehabilitation vs New Development	New	Both	New	New	New	New	Rehab	New	New	New	New	Rehab	New	New	New	Rehabilitation project, new project, or both?
HOT SPRINGS CONSERVATION DISTRICT PROJECT SELECTION CRITERIA																
1 Project is practical to Implement	1	1	2	2	2	3	1	2	2	2	2	2	1	2	2	Project has few issues with distance/ease of mobilization, availability of equipment/supplies , or need for specialized skills to build or install system.
2 Project is cost effective compared to other, similar projects	2	2	2	1	2	2	1	2	2	1	2	2	2	1	2	Relative to other similar projects, low cost per acre irrigated and/or large number of landowners benefitting from project.
3 Project is ecnomically feasible and eiligible for funding via WWDC or other entities	2	2	3	1	2	2	1	3	3	1	3	2	2	2	2	Self expanatory
4 Project has no fatal flaws, can be permitted without undue hardship or effort	1	2	3	2	3	2	1	2	2	1	2	1	1	3	3	Self expanatory
5 Project is critical to maintain the continued diversion, storage, or delivery of water	2	2	2	2	2	2	1	1	1	3	3	2	2	3	2	Self explanatory
6 Project will improve water use efficiency for landowner	2	2	2	1	1	1	2	1	1	2	2	1	1	1	1	Self explanatory
7 Project positively effects water availability for other area water users and does not affect existing water compacts	2	2	2	2	2	2	2	1	1	2	2	3	3	2	2	Self explanatory
8 Project will improve the measurement and management of water flow	2	2	2	1	2	2	2	2	3	2	1	1	2	2	1	Self explanatory
9 Project supports or improves area hydrologic and ecological functioning	1	1	1	2	2	2	2	1	1	2	1	1	1	1	1	Protects springs, streambanks, improves water storage in riparian zones around streams, improves wildlife habitat, range condition, etc.
10 Project is sustainable - can withstand the rigors of weather and water impacts	2	2	2	2	2	2	2	2	3	2	1	1	1	1	1	Does the project require frequent maintenance? Will the project remain serviceable > 30 years?
11. Project is likely to have a positive effect on Owl Creek water quality, specifically E. coli levels	1	1	2	1	2	2	1	1	1	1	1	1	1	1	1	Self explanatory
Composite Score (Average) for Factors 1 through 10 (Lower score is "better")	1.64	1.73	2.09	1.55	2.00	2.00	1.45	1.64	1.82	1.73	1.82	1.55	1.55	1.73	1.64	
PROJECT RANKING	3	5	10	2	8	8	1	3	7	5	5	1	1	4	3	

*SWPP Project Criteria: 1-Source water devel, 2 - Storage, 3 - Pipelines, Conveyance, Solar, Windmill, 4 - Irrigation, 5 - Environment

**Conventional Project Criteria: 1 - Multipurpose, 2 - Storage, 3- New irrigation & municipal, 4 - Water transmission facilities, 5 - Rural domestic I, 6 - Rural domestic II, 7 - Hydropower, 8 - Purchase of existing storage, 9 - Raw water wells for towns & lawns

NOTE: Not all numbers are represented in Ranking. If there are duplicates of the same rank, the rank number defaults to the higher (less desirable) rank in the pair.

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Table 7.2.6 OWI On-site & Workshop Project Matrix											
Criteria (RED = WWDC Criteria, Black = Cons District Criteria)	More Favorable Projects				Less Favorable Projects						
PROJECT CRITERIA	**PROJECT RATING**										**Explanations**
	OWI-001	**OWI-002**	**OWI-003**	**OWI-004**	**OWI-005**	**OWI-006**	**OWI-007**	**OWI-W01**	**OWI-W02**	**OWI-W03**	
Estimated Cost of Project	$68,000	$41,000	$28,000	$25,000	$38,000	$30,000	$30,000	N/A	$4,000-$6,000	N/A	
WWDC PROJECT SELECTION CRITERIA											
Applicable WWDC Program Type	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	SWPP	N/A	SWPP	N/A	
SWPP Project Priority	2	1	5	2	2	1	5		4	4	
Conventional Project Priority											
Rehabilitation vs New Development	Rehab	New	Rehab	Rehab	Rehab	New	New	Rehab	New	New	
HOT SPRINGS CONSERVATION DISTRICT PROJECT SELECTION CRITERIA											
1 Project is practical to Implement	1	2	2	2	2	1	3	3	2	3	Project has few issues with distance/ease of mobilization, availability of equipment/supplies , or need for specialized skills to build or install system.
2 Project is cost effective compared to other, similar projects	2	2	1	2	2	2	2	2	2	2	Relative to other similar projects, low cost per acre irrigated and/or large number of landowners benefitting from project.
3 Project is ecnomically feasible and eiligible for funding via WWDC or other entities	1	2	2	3	3	1	3	3	1	3	Self expanatory
4 Project has no fatal flaws, can be permitted without undue hardship or effort	2	1	1	2	2	1	3	3	2	2	Self expanatory
5 Project is critical to maintain the continued diversion, storage, or delivery of water	3	3	3	2	3	3	N/A	3	3	3	Self explanatory
6 Project will improve water use efficiency for landowner	2	1	3	1	2	2	N/A	2	1	1	Self explanatory
7 Project positively effects water availability for other area water users and does not affect existing water compacts	3	3	3	2	3	3	N/A	2	3	2	Self explanatory
8 Project will improve the measurement and management of water flow	2	3	3	2	3	1	N/A	1	2	1	Self explanatory
9 Project supports or improves area hydrologic and ecological functioning	2	2	3	2	2	2	N/A	1	3	2	Protects springs, streambanks, improves water storage in riparian zones around streams, improves wildlife habitat, range condition, etc.
10 Project is sustainable - can withstand the rigors of weather and water impacts	1	1	1	1	1	1	2	2	2	1	Does the project require frequent maintenance? Will the project remain serviceable > 30 years?
11. Project is likely to have a positive effect on Owl Creek water quality, specifically E. coli levels	N/A	N/A	1	N/A	2	2	N/A	N/A	N/A	NA	Self explanatory
Composite Score (Average) for Factors 1 through 10 (Lower score is "better")	1.90	2.00	2.09	1.90	2.27	1.73	2.60	2.20	2.10	2.00	
PROJECT RANKING	**2**	**4**	**5**	**2**	**6**	**1**	**7**	**3**	**2**	**1**	

*SWPP Project Criteria: 1-Source water devel, 2 - Storage, 3 - Pipelines, Conveyance, Solar, Windmill, 4 - Irrigation, 5 - Environment

**Conventional Project Criteria: 1 - Multipurpose, 2 - Storage, 3- New irrigation & municipal, 4 - Water transmission facilities, 5 - Rural domestic I, 6 - Rural domestic II, 7 - Hydropower, 8 - Purchase of existing storage, 9 - Raw water wells for towns & lawns

NOTE: Not all numbers are represented in Ranking. If there are duplicates of the same rank, the rank number defaults to the higher (less desirable) rank in the pair.

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8 FUNDING OPPORTUNITIES

8.1 Overview

This section provides information on cost-share programs and grants available through a number of different agencies and organizations associated with the implementation of watershed improvement projects. Many of these programs provide technical and/or financial assistance to agricultural producers, private landowners, various land management agencies, and other organizations for implementation of activities that benefit future watershed improvements. Types of projects that may be pursued include storage reservoirs, irrigation infrastructure improvements, wildlife/stock watering, stream/riparian corridor rehabilitation, and other water-resource related projects.

Alternative sources of funding for watershed projects are discussed in the following pages. Potential funding sources include local, state, federal and private entities. Much of the information contained in this report was obtained through three main sources which provided information on grant, loan, and in-kind support for watershed related projects. The following information contains website addresses for funding clearing houses and resources. The websites may change, but the organizations remain; a Google search for the program itself should yield results:

- Water Management & Conservation Assistance Programs Directory, Fourth Edition (WWDC, May 2009). There are approximately 19 participating local, state and federal agencies and organizations that provide educational, technical, financial, planning and policy assistance to water users and the public in pursuing voluntary water management and conservation implementation. Access this directory through the following website: http://wwdc.state.wy.us/wconsprog/consdir/ConservationDirectoryFinal.pdfg
- The Catalog of Federal Funding Sources for Watershed Protection developed and maintained by the Environmental Protection Agency (EPA). This website is a searchable database of financial assistance sources (grants, loans, cost-sharing programs, etc.) available to fund a variety of watershed protection projects. Criteria searches include the type of organization (e.g., non-profit groups, private landowner, state, business), type of assistance sought (grants or loans), and keywords (e.g., watershed management). The website to explore opportunities is available here: https://ofmpub.epa.gov/apex/watershedfunding/f?p=fedfund:1
- Habitat Extension Bulletin available through the Wyoming Game and Fish Department (WGFD). A variety of extension bulletins are available to assist with planning. Bulletin 50 provides information on cost-share programs and grants available through a number of different agencies and organizations for fisheries and wildlife habitat projects. The habitat page is available here: http://gf.state.wy.us/habitat/ExtBulletinsCont/index.asp

Additional information of potential funding sources was extracted from previous watershed investigations completed on behalf of the Wyoming Water Development Commission, such as the Kirby Creek Watershed Study (PBS&J, 2010) or the Nowood River Storage/Watershed Study (ACE 2009). Other useful resources include the Wyoming Grants Information:

- Catalog of Wyoming State Grants Compiled by the Wyoming State Library. The Catalog of Wyoming State Grant Programs is a starting point for potential grant applicants and provides basic information on representative programs. It is accessible at http://library.wyo.gov/grant-opportunities-12/
- Cooperating Foundation Center Libraries (http://fdncenter.org/collections/index.html). The Foundation Center sponsors cooperating collections in libraries all over the country, including Wyoming. These facilities own all materials published by the Center. They also have full text financial reports filed with the IRS (990-PF) for foundations located in their state.
- Wyoming Foundations Directory (http://wycf.org/). The Wyoming Community Foundation is now providing the Wyoming Foundations Directory in an updated and revised on-line format.

It is important to understand that the potential sources identified within this section are not necessarily an exhaustive list of all the resources that may be available. Existing programs change, sometimes are removed or cancelled and new programs arrive, funding levels vary year to year, and competition for many of the programs is significant. Also, contact information for various programs and key people can also change. Key local contacts for current information on funding sources relevant to watershed protection, restoration and conservation, wildlife/stock watering, and irrigation infrastructure improvements include, but are not limited to the following:

- Hot Springs Conservation District (307-864-3488)
- Natural Resources Conservation Service Thermopolis Office (307-864-3488)
- Bureau of Land Management/Hot Springs District Office (307-332-8400

8.2 Potential Funding Sources and Requirements for Funding (State Agencies)

This section provides information on cost-share programs and grants available through a number of different agencies and organizations associated with the implementation of watershed improvement projects. Many of these programs provide technical and financial assistance to agricultural producers, private landowners, various land management agencies, and other organizations for implementation of activities that benefit future watershed improvements. Types of projects that may be pursued include storage reservoirs, irrigation infrastructure improvements, wildlife/stock watering, stream/riparian corridor rehabilitation, and other water-resource related projects.

Alternative sources of funding for watershed projects are discussed in the following pages. Potential funding sources include local, state, and federal agencies, and private entities including non-profit organizations. Much of the information contained in this report was obtained through three main sources which provided information on grant, loan, and in-kind funding for watershed related projects:

- **Water Management and Conservation Assistance Programs Directory**, is an overview of local, state, and federal programs with associated contact information. (http://wwdc.state.wy.us/wconsprog/2014WtrMgntConsDirectory.html)

- **Catalog of Federal Funding Sources for Watershed Protection** is a searchable database of financial assistance sources (grants, loans, and cost-sharing) available to fund a variety of watershed projects. (https://ofmpub.epa.gov/apex/watershedfunding/f?p=fedfund:1)
- **Habitat Extension Bulletin No. 50 – Fisheries and Wildlife Habitat Cost Share Programs and Grants** *is* published by the Wyoming Game and Fish Department (WGFD) and provides a very comprehensive listing of potential funding sources for fisheries and wildlife habitat projects. The document is available at the following website:

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

Additional information about potential funding sources were reviewed and incorporated from previous watershed studies completed on behalf of the WWDC and specifically included excerpts from the *Blacks Fork River Watershed Study Basinwide Watershed Management Plan* (Anderson Consulting Engineers 2015) and the *Middle North Platte River Watershed Management Plan, Level I Watershed Study* (RESPEC 2014). These potential sources described in this chapter are certainly not an all-inclusive listing of the available opportunities for water management and conservation projects. Also, the available funding levels for these programs vary annually because they are subject to budget appropriations; spending authorizations; and in some instances, donation amounts for private organizations.

8.2.1 WWDC

Introduction to 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 power boards. Projects must address water supply, transmission and storage. Key aspects of the Wyoming Water Development Program (WWDP) and the Small Water Project Program (SWPP) administered by WWDC are described in the following subsections.

Small Water Project Program or "SWPP"

The purpose of the WWDC SWPP is to participate with land management agencies and sponsoring entities in providing incentives for improving watershed condition and function. Projects eligible for SWPP grant funding assistance include the construction or rehabilitation of small reservoirs, wells, pipelines and conveyance facilities, springs, solar platforms, irrigation works, windmills and wetland developments. A small project is a project where estimated construction or rehabilitation costs, permit procurement, construction engineering and project land procurement are $135,000 or less and where the maximum financial contribution from the commission is $35,000.00 or less (WWDC 2015).

Planning for small water projects will be generated by a WWDC watershed study or equivalent as determined by the Wyoming Water Development Office (WDO). A watershed study will incorporate, at a minimum, available technical information describing conditions and assessments of the watershed including hydrology, geology, geomorphology, geography, soils, vegetation, water conveyance infrastructure, and stream system data. A plan outlining the site specific activities that may remediate existing impairments or address opportunities beneficial to the watershed may also be included. A watershed study should identify one or more projects that may qualify for SWPP funding. A professional engineer and/or geologist, as appropriate, will certify any analysis submitted unless generated by a federal agency (WWDC 2015).

Applications should be received by January 1 of each calendar year. Applications meeting criteria requirements will be considered during the regularly scheduled WWDC meetings in March. Applications should include a project application, sponsor project referral, project location map, project cost estimates and any letters of authorization or commitment of participation that may be available from other funding sources.

A management and rehabilitation plan outlining site specific projects that may remediate existing watershed impairments or address opportunities beneficial to the watershed is required for access to the SWPP. Activities should improve watershed condition and function and provide benefit for wildlife, livestock and the environment. Projects may provide improved water quality, riparian habitat, habitat for fish and wildlife and address environmental concerns by providing water supplies to support plant and animal species or serve to improve natural resource conditions (WWDC 2015).

Conventional Program

Water development projects are defined with three levels. Project planning is performed in Levels I and II, and project construction is performed in Level III. Level I studies carry out necessary reconnaissance work, while Level II studies determine a project's feasibility. Levels I and II are 100% grant funded. Projects originate with sponsoring public entities and come to the Agency through applications. Applications for new projects must be received by August 15th and ongoing projects by October 1st.

The Wyoming Water Development Program receives funding from severance tax distributions. Water Development Account I is utilized for new development projects. Water Development Account II is used to fund the rehabilitation of water projects that have been in existence for 15 years or longer. Water Development Account III is used to fund dam and reservoir projects. The legislature has the opportunity to authorize additional funding for water development from the Budget Reserve Account.

The project sponsor must be a public entity that can legally receive state funds, incur debt, generate revenues to repay a state loan, hold title and grant a minimum of a parity position mortgage on the existing water system and improvements appurtenant to the project or provide other adequate security for the anticipated state construction loan. A project sponsor can be a municipality, irrigation district, joint powers board, or other approved assessment district, which will realize the major direct benefits of the project. The project sponsor must be willing and capable of financially supporting a portion of the project development costs and all operation and maintenance costs. Sponsors request project technical and financial assistance from the WWDC through the application process.

Irrigation District Formation

An irrigation district is incorporated to provide a funding mechanism to develop a water project. At least a majority of landowners who represent one third of the land in the proposed district must agree to district formation. Once the district is formed it may purchase, extend, operate, maintain, or construct irrigation facilities, or act as a guarantor for loans for projects identified by the people forming the district. Forming an irrigation district allows a mechanism for on-going taxation to pay for system improvements and maintenance.

To form a district, a “petition’ is prepared that describes the lands to be within the district, lists the landowners names, and explains the need, purpose, and plan for the district. A preliminary engineering report must be prepared that describes the feasibility of the proposed district, whether there is enough water for the proposed projects, and a plan that includes estimated cost of construction. The report must be approved by the WSEO. The petition goes through the county court system and, if all is in place, the petition is approved and the District is formed. Wyoming Statute Title 41, Chapter 7 covers irrigation districts. The statute is available in various websites one of which is Justia US Law, at http://law.justia.com/codes/wyoming/2010/Title41/chapter7.html.

New Development Program

This program provides technical assistance and funding to develop waters of the state that are currently unused and/or unappropriated. The program encompasses a wide range of projects, including the following types:

- Multiple Purpose (including among other uses, two or more of the following: agriculture, recreation, environmental, and erosion control);
- New Storage (e.g., dams and reservoirs less than 2,000 ac-ft.)
- New Supply (e.g., deep wells, alluvial wells, diversion dams);
- Watershed Improvement (for components whose primary function or benefit is water development); and
- Recreation.

These project types are listed above in the order of preference assigned by the WWDC when determining what projects to pursue among all of the applications received for funding

Rehabilitation Program

The Rehabilitation Program addresses the improvement of water projects completed and in use for at least 15 years to assist in keeping existing water supplies effective and viable for the future. The Rehabilitation Program can improve existing agricultural storage facilities or conveyance systems to ensure safety, decrease operation and maintenance costs, and increase the efficiency of agricultural water use. The types of projects supported relevant to this watershed are essentially the same as listed above for the New Development Program.

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

Dam and Reservoir Program

Proposed new dams with storage capacity of 2,000 ac-ft. or more and proposed expansions of existing dams of 1,000 ac-ft. or more qualify for the Dam and Reservoir Program. No interest in larger reservoirs was shown by landowners in Owl Creek so this topic is not described further here. For further details, consult the “Operating Criteria of the Wyoming Water Development Program (2015).

Key Criteria and Procedures. An application for funding under the New Development and Rehabilitation Programs must meet the following key criteria most applicable to potential projects as identified in

Section 4:

- The project sponsor shall be a public entity that can legally receive state funds, incur debt, generate revenues to repay a state loan, hold title and grant a minimum of a parity position mortgage on the existing water system and improvements or provide other adequate security for the anticipated state construction loan.
- The proposed project must serve 2,000 or more acres of irrigated cropland, or must rehabilitate watershed infrastructure, which will develop or preserve the beneficial use of water in a watershed. The watershed rehabilitation projects must possess an estimated minimum useful life span of twenty-five years and demonstrate that sufficient public benefits will accrue to justify construction of the anticipated improvement.

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

- A fee of $1,000 must be submitted with the initial project applications; the fee does not apply to projects advanced to the next level of study or to construction.
- A certified resolution passed by the governing body of the sponsoring entity must accompany an application for a Level II study or Level III construction. This requirement may be deferred if the applicant is in the process of forming a public entity.
- A public entity must be in place before a Level II study or Level III construction can commence, with certain exceptions discussed below.
- The due date for new project applications is August 15 of each year; the due date for applications for advancing to the next study level or construction funding is October 1 of each year.

Two important criteria that apply specifically to dam and reservoir projects include the following:

- For projects that enlarge existing storage projects by 1,000 ac-ft. or greater or for proposed new dam and reservoirs with a capacity of 2,000 ac-ft. or greater, expenses associated with final engineering design and required National Environmental Policy Act reviews, including but not limited to environmental assessments and environmental Impact statements, are eligible components of a Water Development Program Level II, Phase III Study Projects.
- For dam and reservoir projects, the Commission may waive sponsor eligibility requirements through Level II, Phase II. However, the eligible entity requirements shall be met prior to initiation of Level II, Phase III activities described herein.

Financial Plan. The current standard terms of the WWDP financial plan are summarized as follows:

- A 67% grant to 33% loan mix.
- Minimum 4% loan interest rate (current rate is 4%, but legislature may increase the rate).
- Maximum 50-year term of loans; term shall not exceed the economic life of project.

- Payment of loan interest and principal may be deferred up to five years after substantial completion at WWDC's discretion under special circumstances.

In the document titled *Information for New Applicants*, the following additional relevant information is provided regarding financial terms:

- The best available project financial terms include a grant for Level I and Level II expenses, a grant of 75% of the Level III costs, a loan of 25% of the Level III costs with an interest rate of four percent (4%) and a term equal to the economic life of the project/improvements or fifty (50) years, whichever is less. Principal and interest payments may be deferred for five (5) years after project completion. However, these favorable terms will be granted when a project is essential and the project sponsor has a very limited ability to pay.
- Those sponsors who feel more favorable terms are warranted due to a limited ability to pay must make a formal presentation to the Commission documenting their case. Sponsors electing to pursue this option should be aware that the Commission is reluctant to deviate from this standard and such requests will be denied unless they are clearly documented and justified.

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

The project sponsor shall be a public entity that can legally receive state funds, incur debt, generate revenues to repay a state loan, hold title, and grant a minimum of a parity position mortgage on the existing water system and improvements appurtenant to the project or provide other adequate security for the anticipated state construction loan. The WWDC may waive the requirement that the project sponsor be a public entity under the following exceptions:

1) The WWDC may accept applications for Level I studies from applicants that are not public entities. Applicant may then know if there is a viable project before becoming a public entity. However, the applicant must be a public entity before applying for a Level II study. Under these circumstances, the Level I process will have a 2-year duration with the study being completed the first year and the sponsor forming the public entity the second year.
2) The WWDC may accept applications related to the construction of dams and reservoirs from applicants that are not public entities. Because evaluating the feasibility of new dams is complex, the applicant will know if the proposed reservoir is feasible before becoming a public entity. However, the applicant must be a public entity before applying for Level II, Phase III funding.
3) The sponsor may request that a Level I or Level II study be conducted to identify solutions and alternatives for addressing water supply issues or they may request funds for a Level III

construction project, if it is determined the project is technically and economically feasible and serves to meet a water supply need or alleviate a water supply problem.

8.2.2 Wyoming Game and Fish Department

Introduction

The Wyoming Game and Fish Department offers a funding program to help landowners, conservation groups, institutions, land managers, government agencies, industry and non-profit organizations develop and/or maintain water sources for fish and wildlife. This program also provides funding for the improvement and/or protection of riparian/wetland areas for fish and wildlife resources in Wyoming. Applications for projects are accepted any time with approval on January 1 and August 1 of each year.

Opportunities

Riparian Habitat Improvement Grant

The purpose of this program is to improve or maintain riparian and wetland resources. Fencing, herding, stock water development, streambank stabilization, small damming projects and beaver transplanting are a few examples of efforts that qualify under this program. Permits, National Environmental Policy Act (NEPA) compliance, construction, maintenance, access and management planning are all grantee responsibilities. There is $10,000/project maximum available with 50% cash or in-kind required from grantee.

Water Development/Maintenance Habitat Project Grant

The purpose of this program is to develop or maintain water for fish and wildlife. Spring development, windmills, guzzlers, water protection and pumping payments are examples of the extent of this program. Permits, NEPA compliance, maintenance, access and water righting are responsibilities of the grantee. There is a maximum of $7500 per project and 50% cash or in-kind contribution required from the grantee.

Industrial Water Habitat Project Fund

The purpose of this program is to develop water sources beneficial to fish and wildlife that are located by industrial drilling, mining or excavation operations. Examples of projects are tapped artesian wells, springs or ground water that could be used for wildlife watering or creation of wetlands or ponds. Industry must meet set criteria, obtain permitting and access, clean-up and restore the site and provide NEPA compliance. There is no funding limit nor no matching contribution needed for these projects.

Upland Development Grant. The purpose of this program is to develop upland wildlife habitat. Examples of projects in this program are shrub management, grazing systems, prescribed burning, wildlife food plots such as oat, millet or corn plantings, range pitting and range seeding. Permits, NEPA compliance, maintenance, access and management planning are responsibilities of the grantee. There is a maximum of $10,000 per project and 50% cash or in-kind contribution required from the grantee.

Fish Wyoming

The purpose of this program is to develop public fishing opportunities. Examples of projects within this effort are boat ramps and fishing access. This program provides a 50% match of funding which is channeled through a private organization or municipality.

Wyoming Sage Grouse Conservation Fund

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

During its 2016 session, the Wyoming Legislature approved the Governor's budget request to support the local sage-grouse working groups and fund conservation projects benefiting sage-grouse and their habitat. The following project application criteria are described below and can be found at https://wgfd.wyo.gov/Habitat/Sage-Grouse-Management:

1) Project funding is provided for the purpose of implementing projects that address the primary threats to sage-grouse as identified in local sage-grouse conservation plans. Applicants should read the appropriate plans and tailor projects accordingly.

2) Projects will be evaluated based on consistency with Wyoming's Core Area management strategy, local sage-grouse conservation plan, likelihood of success, project readiness, matching funds, multiple species benefits, significance at local/state/regional level, duration of benefits, and adequacy of monitoring.

3) Funds are distributed as reimbursable grants in most cases. This means the grantee must submit for reimbursement of expenses incurred as a result of the project. "Up front" funding is not allowed. Grantees (non-profit organization, government agency or private individuals) are required to enter into grant agreements and request reimbursement of expenditures made. For-profit entities are not eligible for grants but may be contracted by grantees to conduct actions prescribed by the grant. Spending against the grant may not begin until the last required signature is affixed to the grant agreement.

4) Capital equipment such as vehicles, computers or global positioning system (GPS) units is not allowed. Short-term lease of such equipment is acceptable.

5) For habitat improvement projects, including water developments, details of the post-treatment livestock grazing management plan must be included in the project description. Habitat treatment projects must also be consistent with Wyoming Game and Fish Department Protocols for Treating Sagebrush to Benefit Sage-Grouse.

6) Research projects, including all projects that involve radio telemetry, should be conducted with the rigor and intent to publish in peer-reviewed scientific press.

7) Habitat projects conducted on private lands should be partnered with programmatic sage-grouse efforts such as a U.S. Fish & Wildlife Service Candidate Conservation Agreement with Assurances (CCAA), Natural Resources Conservation Service (NRCS) Sage-Grouse Initiative (SGI) or other landscape scale, sage-grouse specific, effort.

8) Funds must be expended July 1, 2016 – September 30, 2018. Do not submit for funding needed outside of these dates. (WGFD 2016b)

8.2.3 Wyoming Department of Agriculture's (WDA) Water Quality Grant Improvement Program

Grant funding is available to Conservation Districts up to $20,000 for each project, to address impaired/threatened waters that are on the 303 (d) list. Grants may be written for a timeframe longer than the biennium. Funded projects will be required to submit at least one interim report and a final report. Final reports and return of unused funds will be due on the contracted ending date. The following criteria shall be considered by the Wyoming Association of Conservation Districts (WACD) when ranking and recommending water quality grant proposals.

- Listed on Table A (impaired) or Table C (threatened) of Wyoming final approved 303(d) list of impaired waters. Priority will be given to those Districts addressing waters listed on the state's 303(d) list. Projects with implementation measures specifically addressing the pollutant of concern, as identified on the 303(d) list, will receive a higher priority.
- Amount of land mass and number of citizens included in the proposal or possibly impacted by failure of the project to be carried out.
- Active Watershed Steering Committee providing local leadership for watershed effort and/or Best Management Practices (BMP) implementation identified in locally developed/adopted watershed plan or adopted Total Maximum Daily Load (TMDL) with local involvement.
- Augmentation or acceleration of existing assessment, planning, and implementation project.
- If monitoring is being conducted as part of the project it is being done under an acceptable Sampling and Analysis plan and by a trained/qualified individual as per Credible Data statute.
- Demonstrated need for funding or additional funding in order to continue existing work to address impairments.
- Project demonstrates ability to meet required match of 30%. If more than 30% match is provided, district must match at that higher level and account for the match in interim and final reports. (Local cash or in-kind contributions qualify as match, as well as, federal grant funds such as 205j or 319. Other state WDA funds cannot be used as match) (WDA 2016).

8.2.4 Wyoming Office of State Lands and Investments (OSLI)

Introduction

The OSLI is the administrative arm of the Board of Land Commissioners and the State Loan and Investment Board. It is the statutory responsibility of the OSLI to carry out the policy directives and decisions of these two boards. The organizational structure of OSLI consists of the Office of the Director and four divisions: Administrative Services Division, Trust Land Management Division, Field Service Division, and Wyoming State Forestry. Collectively, these divisions serve the trust beneficiaries– Wyoming's school children and state institutions; numerous clients in agriculture, mineral, timber, transportation, communication, public utility, recreation, tourism and other Wyoming industries; local government entities; state and federal agencies; and the resident and nonresident general public.

Explanation of Opportunities

The Farm Loan Program, established in 1921, provides long-term real estate loans to Wyoming's agricultural operators. The use of this program has been expanded over the years to also include loans for the purchase of livestock and to assist beginning agricultural producers. These loans are made for a wide range of agricultural purposes, including as most applicable to the potential projects identified in Section 5, purchasing, constructing or installing equipment and/or improvements necessary to maintain or improve the earning capacity of the farming operation. Eligible applicants include individuals whose primary residence is in Wyoming and legal entities with a majority of the ownership meeting the individual residency requirements. More information is available at: http://lands.wyo.gov/grantsloans/loans/farm.

The Irrigation Loans Program, established in 1955, is designed to support small and large agricultural water development projects. The Legislature has allocated a total of $275 million for loans under the Farm Loan Program, and $20 million for the Irrigation Loan Program. Both programs are funded from the Wyoming Permanent Mineral Trust Fund. Joint Powers Act Loan Program was established in 1974 and the Legislature authorized the Joint Powers Act Loan Program to benefit local communities for infrastructure needs. These loans are approved from funds within the state's Permanent Mineral Trust Fund. These programs are an aid to cities counties and special districts in providing needed government services and public facilities.

8.2.5 Wyoming Department of Environmental Quality (WDEQ)

Introduction

The WDEQ provides funding for implementation of BMPs to address non-point sources of pollution under Section 319 of the Clean Water Act. Section 319 grant funding requires a non-federal match of at least 40% of the total project cost. These matching funds may be provided by landowners, a conservation district, other non-governmental entities (e.g., watershed improvement district, irrigation district, etc.), and non-profit organizations (e.g., Trout Unlimited, Ducks Unlimited [DU], and the Rocky Mountain Elk Foundation). Proposal applications conforming to a specified format are required. The proposal describes in some detail the issues to be addressed and the proposed methods/BMPs to be implemented, as well as providing all other information required to evaluate the proposed project and matching fund entity. These proposals are normally due in August or September of each year. For more information please visit: http://deq.wyoming.gov/wqd/non-point-source/.

Explanation of Opportunities

The Clean Water State Revolving Fund (CWSRF) and Drinking Water State Revolving Fund (DWSRF) requires the WDEQ, the WDO, and the OSLI to review loan applicants' compliance with SRF program requirements. Eligible entities who may apply for funding include state agencies, counties, municipalities, joint powers boards, and other political subdivisions under the laws of the state (such as various types of special districts). All SRF awards are loans. Normal repayment terms are up to 20 years for most communities with an interest rate of 2.5% on most loans. Eligible projects for DWSRF include drinking water source, treatment, transmission, storage, and distribution projects for a public water system (as regulated by the U.S. Environmental Protection Agency [EPA]). Eligible projects for CWSRF include wastewater treatment facilities, sewer mains/collection systems, subsurface investigations or capping/closures at existing landfills, liners and leachate collection systems for new landfill cells, storm water facilities, septic systems, and other water pollution treatment or prevention related activities. All SRF loan projects must go through the State Environmental Review Process (SERP), which is similar to a review under the NEPA (WDEQ 201b). For more information please visit: http://deq.wyoming.gov/wqd/state-revolving-loan-fund/.

8.2.6 Wyoming Wildlife and Natural Resource Trust (WWNRT)

The Wildlife and Natural Resource Trust, created in 2005, is an independent state agency governed by a nine-member citizen board appointed by the Governor. Funded by interest earned on a permanent account, donations, and legislative appropriation, the purpose of the program is to enhance and conserve wildlife habitat and natural resource values throughout the state. Any project designed to improve wildlife habitat or natural resource values is eligible for funding. The office is centrally located in Riverton, Wyoming.

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

- Projects that improve or maintain existing terrestrial habitat necessary to maintain optimum wildlife populations may include grassland restoration, changes in management, prescribed fire, or treatment of invasive plants.
- Preservation of open space by purchase or acquisition of development rights, contractual obligations, or other means of maintaining open space.
- Improvement and maintenance of aquatic habitats, including wetland creation or enhancement, stream restoration, water management or other methods.
- Acquisition of terrestrial or aquatic habitat when existing habitat is determined crucial/critical, or is present in minimal amounts, and acquisition presents the necessary factor in attaining or preserving preferred wildlife or fish population levels.
- Mitigation of impacts detrimental to wildlife habitat, the environment, and the multiple use of renewable natural resources, or mitigation of conflicts and reduction of potential for disease transmission between wildlife and domestic livestock.

Allowable projects under this program that are potentially relevant to this watershed management plan study include:

- Improvement and maintenance of existing aquatic habitat necessary to maintain optimum fish populations.
- Conservation, maintenance, protection and development of wildlife resources, the environment, and Wyoming's natural resource heritage.
- Participation in water enhancement projects to benefit aquatic habitat for fish populations and allow for other watershed enhancements that benefit wildlife.

Funding is by grant with no matching funds required. Non-profit and governmental organizations (including watershed improvement districts, conservation districts, etc.) are eligible for funding by WWNRT. The application form has been included in the digital library and more information on the application process is available here: https://sites.google.com/a/wyo.gov/wwnrt/how-to-apply.

8.3 Potential Funding Sources and Requirements for Funding (Federal Agencies)

8.3.1 Bureau of Land Management (BLM)

Explanation of Opportunities

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

Partnerships have been available for riparian improvement projects and for research into riparian issues. Funding is available on an annual basis subject to budget allocations from Congress. All submitted cooperative projects compete for the funds available in the riparian program.

Range Improvement Planning and Development is a cooperative effort not only with the livestock operator but also with other outside interests including the various environmental/conservation groups. Water development, whether it be for better livestock distribution or improved wetland habitats for wildlife, is key to healthy rangelands and biodiversity. Before actual range improvement development occurs, an approved management plan must be in place. These plans outline a management strategy for an area and identify the type of range improvements needed to accommodate that management. Examples of these plans are Coordinated Resource Plans, Allotment Management Plans, and Wildlife Habitat Management Plans.

All rangeland improvement projects on lands administered by the BLM require the execution of a Permit. Although there are a couple of methods for authorizing range improvements on the public lands, Cooperative Agreement for Range Improvements form 4120-6 is the method most commonly used. This applies equally to range improvement projects involving water such as reservoirs, pits, springs, and wells including any associated pipelines for distribution. The major funding source for the BLM's share comes from the range improvement fund which is generated from the grazing fees collected. There, too, is a limited amount of funding from the general rangeland management appropriations. If the cooperator is a livestock operator, their contributions come generally in the form of labor. There are times they also provide some of the material costs as well. Contributions from the conservation/environmental interests is monetary and often come in the form of grants. They also contribute labor on occasion.

BLM's Watershed and Water Quality Improvement efforts are undertaken in a cooperative approach with the State of Wyoming, Conservation Districts, livestock operators and various conservation groups. Wyoming's BLM is partnering in the implementation of several Section 319 watershed plans state-wide.

It is anticipated that as the WDEQ continues the inventory of waters of the state and the identification of impaired and/or threatened water bodies, BLM will be partnering with the WDEQ to improve water quality in water bodies on public lands. In the course of developing watershed plans or TMDLs for these watersheds, BLM will be routinely involved in watershed health assessments, planning, project implementation and BMP monitoring.

Now, and in the future, the goals of cooperative watershed projects will typically be the restoration and maintenance of healthy watershed function. These goals will typically be accomplished through approved BMPs (e.g., prescribed burns, vegetation treatments, instream structures, vegetation cover enhancements, accelerated soil erosion control, increases in water infiltration, and stream flow and water quality enhancements).

Currently, in response to the Clean Water and Watershed Restoration initiative and associated funding increases, BLM is expanding its efforts to address water quality and environmental concerns associated with abandoned mines. This work will also be accomplished, in cooperation with the State Abandoned Mine Lands Division, on a priority watershed basis and will employ appropriate BMPs to address identified acid mine drainage and runoff problems from mine tailings and waste rock piles.

8.3.2 U.S. Bureau of Reclamation

Explanation of Opportunities

The USBR mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the public. The USBR has a major responsibility, in partnership with states, water users, and other interested parties, to help improve water resources and the water use efficiency in the western United States. After more than 100 years, USBR's primary role has evolved from one of water resource development to one of water resource management. More efficient water use is a key component of USBR's water resource management strategy.

The Sustain and Manage America's Resources for Tomorrow (WaterSMART) Program establishes a framework to provide federal leadership and assistance on the efficient use of water, integrating water and energy policies to support the sustainable use of all natural resources, and coordinating the water conservation activities of various department bureaus and offices. Through the WaterSMART Program, the department is working to achieve a sustainable water management strategy to meet the nation's water needs through projects that conserve and use water more efficiently, increase the use of renewable energy and improve energy efficiency, protect endangered and threatened species, facilitate water markets, or carry out other activities to address climate-related impacts on water or prevent any water related crisis or conflict.

A major component of WaterSMART is the Water and Energy Efficiency Grant Program, through which

USBR provides funding in two funding groups. In Funding Group I, up to $300,000 in federal funding is available per project, for smaller on-the-ground projects that can be completed within 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 west-wide competitive process that requires a minimum 50% cost share by the recipient.

The Water Conservation Field Services Program (WCFSP), by contrast, provides smaller amounts of funding ($100,000 per project maximum) through local competitions within a region or area. The projects funded are generally smaller in scope than Water and Energy Efficiency Grant projects and are focused on fundamental conservation improvements as identified in water conservation plans developed by water users. Financial assistance provided through the WCFSP also requires a minimum 50% cost share by the recipient. Funding opportunity announcements for WaterSMART grants and the WCFSP can be found at http://www.grants.gov/.

8.3.3 EPA

Introduction and Explanation of Opportunities

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 a competitive grant program based on the fundamental principles of environmental improvement: collaboration, new technologies, market incentives, and results-oriented strategies. The Targeted Watersheds Grant Program focuses on multifaceted plans for protecting and restoring water resources that are developed using partnership efforts of diverse stakeholders (http://water.epa.gov/grants_funding/twg/twg_basic.cfm). Organizations eligible for funding include nonprofits, tribes, and local governments. The assistance provided consists of grants for up to 75% of the total project costs. A match of at least 25% is required. The typical median amount awarded is $700,000 with a typical range of $300,000 to $900,000. It is important to note that application must be made by the governor, and that these grants are highly competitive.

8.3.4 Farm Service Agency (FSA)

Introduction

The FSA administers three different programs that may be applicable to some of the alternative projects identified in Section 5. Each of these three programs is briefly discussed below. The FSA is a member agency of the U.S. Department of Agriculture. Programs administered through the FSA are offered through local county committees. Technical assistance needed for implementing FSA programs is provided through the NRCS.

FSA programs available are the Conservation Reserve Program, the Emergency Conservation Program, and the Continuous Sign-up for High Priority Conservation Practices.

Explanation of Opportunities

Conservation Reserve Program (CRP) offers agricultural producers annual rental payments to remove highly erodible cropland from production. Farmers and ranchers establish long-term conservation practices on erodible and environmentally sensitive land. In exchange, they receive 10–15 years of annual rental payments and cost-share assistance. CRP is a voluntary program specifically for highly erodible lands currently in active production planted two of the five most recent crop years. Land offered for CRP is ranked according to environmental benefit for wildlife habitat, erosion control, water quality, and air quality.

Emergency Conservation Program (ECP) provides emergency funding and technical assistance for farmers and ranchers to rehabilitate farmland damaged by natural disasters and for carrying out emergency water conservation measures for livestock during periods of severe drought. Participants receive cost-share assistance of up to 75% of the cost to implement approved emergency conservation practices, as determined by county FSA committees. Some of the conservation practices included are removing debris, restoring fences and conservation structures, and providing water for livestock in drought situations.

Continuous Sign-Up for High Priority Conservation Practices provides management flexibility to farmers and ranchers to implement certain high priority conservation practices on eligible land. Land must meet the requirements of CRP and be determined by the NRCS to be eligible and suitable for the following:

Riparian buffers	Shelter belts	Salt tolerant vegetation
Filter strips	Living snow fences	Shallow water areas for wildlife
Grass waterways	Contour grass strips	

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% of the soil rental rate for field windbreaks, grass waterways, filter strips and riparian buffers. An additional 10% may be added if the land is located in an EPA-designated wellhead protection area. A provision for cost share of up to 50% of the cost of establishing permanent cover is available.

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

Introduction

Technical and financial assistance are available to private landowners, profit or nonprofit entities, public agencies and public-private partnerships under several programs addressing the management, conservation, restoration or enhancement of wildlife and aquatic habitat (including riparian areas, streams, wetlands, and grasslands). These programs include, but are not necessarily limited to, those the following in Section 8.3.5.2 Explanation of Opportunities.

Explanation of Opportunities

Partners for Fish and Wildlife Program serves as the primary tool for conservation delivery on privately owned land for the USFWS. The program provides technical and financial assistance to private landowners and tribes on a voluntary basis to help meet the habitat needs of federal trust species and conservation partner-designated species of interest. The program targets habitats that are in need of restoration or enhancement such as riparian areas, streams, wetlands, and grassland. Field biologists work one-on-one with landowners and partners to plan and implement a variety of projects, including grazing lands management, sage steppe enhancement, stream habitat improvement and fish passage, invasive species removal, and wetland establishment.

Wildlife and Sport Fish Restoration (WSFR) Program works with states, insular areas, and the District of Columbia to conserve, protect, and enhance fish, wildlife, their habitats, and the hunting, sport fishing, and recreational boating opportunities they provide. The WSFR Program provides oversight and/or administrative support for the following grant programs: Wildlife Restoration Grant Program, Sport Fish Restoration Grant Program, Boating Infrastructure Grant Program, State Wildlife Grant Program, Tribal Wildlife Grant Program, and Tribal Landowner Incentive Grant Program.

Cooperative Endangered Species Conservation Fund (Section 6 of the Endangered Species Act [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% of the estimated program costs of approved projects, or 10% when two or more states or territories implement a joint project.

North American Wetlands Conservation Act (NAWCA) Grant Program promotes long-term conservation of wetlands ecosystems and the waterfowl, migratory birds, fish and wildlife that depend upon such habitat. Conservation actions supported are acquisitioning, enhancing, and restoring wetlands and wetlands-associated habitat. This program encourages voluntary, public-private partnerships. Public or private, profit or nonprofit entities, or individuals establishing public/private sector partnerships are eligible. Cost-share partners must at least match grant funds with nonfederal monies.

Fish and Wildlife Service's (FWS) Challenge Cost Share Program started in 1988 as a way to enhance partnerships with state and local governments, individuals, and public and private groups. The program enables the USFWS to manage cooperatively its natural and cultural resources and fulfill stewardship responsibilities to fish and wildlife management. Under this program, projects must occur on a refuge or directly benefit a refuge. The program encourages refuge managers to form partnerships and leverage allocated funds to complete the projects.

Appropriated funds may be used to pay for no more than 50% 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% cost share. The cooperator share may be a nonmonetary contribution. Cooperative agreements are signed with the cost-share partners.

More information regarding these programs and others is available at: http://www.fws.gov/grants/programs.html.

8.3.6 U.S. Forest Service (USFS)

Introduction

A number of federal laws direct or authorize watershed management on National Forest Service lands. Some of these laws provide broad authority while others deal more narrowly with specific watershed management activities. The objectives of the USFS watershed management program are to protect and enhance soil productivity, water quality, water quantity, and timing of water flows and to maintain favorable conditions of stream flow and continuous production of resources from National Forest

System watersheds. The policy of the USFS is to implement watershed management activities on National Forest System lands in accordance with general objectives of multiple use and the specific objectives in the forest land management plans for the area involved. It is also the intent to design management activities of other resources to minimize short-term impacts on soil and water resources and to maintain or enhance long-term productivity, water quality, and water quantity.

Explanation of Benefits

The Clean Water Action Plan provides broad water quality direction for the USFS. Specific direction for water quality is contained in the Land and Resource Management Plan for each national forest. The forests in Wyoming are in the process of completing the Inland West Water Reconnaissance that will provide a classification of watersheds and stream reach conditions. USFS water quality programs are coordinated with the WDEQ and other appropriate agencies. USFS also has a water rights program that is coordinated with the Wyoming State Engineer's Office (WSEO). USFS, in conjunction with other federal, state, and local agencies, provides watershed management and condition training. T-WALK and Proper Functioning Condition surveys are field methods used to assess stream reach and other waterbody conditions.

8.3.7 NRCS

Introduction

The NRCS administers a number of funding and technical assistance programs applicable to many of the alternative projects. These programs are briefly described below. The NRCS provides leadership in a partnership effort to help people voluntarily conserve, improve, and sustain natural resources on private lands. The purpose and mission of the agency is to help landowners treat every acre of their private property according to its needs and within its capability. The treatment includes a balance between the land use for economic return and protecting its ability to be productive from generation to generation.

Conservation planning is key to successful land stewardship as NRCS employees and landowners work together to tailor-make voluntary conservation plans that meet the specific needs of individual customers. The NRCS workforce has the technical expertise and field experience to help land users solve their natural resource challenges and maintain and improve their ability to thrive economically. They are highly skilled in many scientific and technical specialties, including soil science, soil conservation, range conservation, engineering, agronomy, biology, geology, hydrology, forestry, cultural resources, GIS, and economics. NRCS conducts natural resource inventories and assessments to indicate status, conditions and trends of natural resources on private lands. This resource information and technology include science-based technical tools, technical guides, and performance specifications and standards that ensure quality and consistency of conservation planning and application across the nation.

Technical and cost-share assistance is available through the NRCS. This assistance includes designs, specifications, construction, and management and financial help for practice and system installation. Local people, individually and collectively, decide how to use NRCS capabilities in the natural resource conservation planning and application process. The role of NRCS is to support and facilitate these individual and local decisions based on good resource information, whether that is a grazing management plan or layout for an irrigation system.

Explanation of Opportunities

NRCS provides technical assistance for the following programs in Wyoming:

- **Grazing Lands Conservation Initiative (GLCI):** Accelerated range management technical assistance is available to producers in every county to support this initiative.
- **Small Watershed Program (PL-566):** NRCS works through local government sponsors to help solve natural resource and related economic problems on specific watersheds.
- **Snow, Water and Climate Services:** Snow survey crews collect information on snowpack conditions to provide Wyoming water users with forecasts of seasonal water supplies. This helps determine available water to meet agricultural, industrial, recreational, and urban area needs.
- **Soil Surveys:** Soil surveys provide a field-based scientific inventory of soil resources and information on the potentials and limitations of each soil. This information assists in determining the best uses of the land based on soil type.
- **Plant Materials:** Wyoming NRCS is serviced by the Plant Materials Center (PMC) at Bridger, Montana. The Plant Materials Program identifies, selects, and releases superior performing plant collections for a variety of conservation uses.

NRCS administers the following Landscape Planning Programs:

- **Emergency Watershed Protection (EWP) Program** assists in implementing emergency measures, including the purchase of flood plain easements, for runoff retardation and soil erosion prevention to safeguard lives and property from floods, drought, and the products of erosion on any watershed whenever fire, flood or any other natural occurrence is causing or has caused a sudden impairment of the watershed.
- **Watershed Protection and Flood Prevention Operations (WFPO) Program** provides technical and financial assistance to entities of state and local governments and tribes (project sponsors) for planning and installing watershed projects.
- **Watershed Surveys and Planning (WSP)** authorizes the NRCS to cooperate with federal, state, and local agencies and tribal governments to protect watersheds from damage caused by erosion, floodwater, sediment, and to conserve and develop water and land resources.

NRCS administers the following 2014 Farm Bill programs:

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

- The **Regional Conservation Partnership Program (RCPP)** promotes coordination between the NRCS and its partners to deliver conservation assistance to producers and landowners. The NRCS provides assistance to producers through partnership agreements and through program contracts or easement agreements. Assistance is delivered in accordance with the rules of EQIP, CSP, Agricultural Conservation Easement Program (ACEP) and Healthy Forests Reserve Program (HFRP), and in certain areas the Watershed Operations and Flood Prevention Program. The ACEP provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Agricultural Land Easements (ALE) component, NRCS helps tribes, state and local governments and nongovernmental organizations protect working agricultural lands and limit nonagricultural uses of the land. Under the Wetlands Reserve Easements (WRE) component, the NRCS helps to restore, protect and enhance enrolled wetlands.
- The **Agricultural Management Assistance (AMA)** provides financial assistance to agricultural producers to address resource issues such as water management, water quality, invasive species control, and erosion control by incorporating conservation into their farming or ranching operations. The purpose of the AMA is to assist producers in reducing risk to their operation.
- **Conservation Innovation Grants (CIG) Program** is intended to stimulate the development and adoption of innovative conservation approaches and technologies while leveraging federal investment in environmental enhancement and protection, in conjunction with agricultural production. Under CIG, EQIP funds are used to award competitive grants to nonfederal governmental or nongovernmental organizations, tribes, or individuals.
- **Sage Grouse Initiative (SGI)** is an organization of public and private entities conserving at-risk wildlife through voluntary cooperation, incentives, and community support. The Natural Resources
- Conservation Service launched SGI in 2010, applying the power of the Farm Bill to target lands where habitats are intact and sage grouse numbers are highest – covering 78 million acres across 11 western states. While private lands are the primary focus, the Initiative serves as a catalyst for public land enhancements. The SGI applies Farm Bill dollars and certifies conservation projects in the core areas for sage grouse with a dual goal of sustaining rangelands and sage grouse. In addition to directing dollars to private lands where 40% of sage grouse live, SGI dollars can be applied on public lands where ranchers have grazing leases. For more details related to funding opportunities, please contact your local NRCS office. Detailed information related to the SGI can be found at the following website: http://www.sagegrouseinitiative.com/.

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

Introduction

The USACE has civil responsibilities for flood damage reduction, hydroelectric power generation, and navigational improvement as well as other water and land resource problems and needs including environmental preservation and enhancement, ecosystem management, and comprehensive flood plain management. USACE is responsible for a worldwide military construction program, an extensive environmental program, and a broad national civil works program.

USACE is authorized to provide technical assistance to local communities, states, and federally recognized Indian Tribes in support of their efforts to alleviate flooding impacts, reduce erosion, and otherwise plan for the wise and prudent use of the nation's water and related land resources. They also have authority to construct certain water resources related projects and respond to water resource needs.

Explanation of Opportunities

Planning Assistance to States. This program provides for assistance in preparation of plans for the development, utilization and conservation of water and related land resources. USACE provide technical planning assistance in all areas related to water resources development such as bank stabilization, sedimentation, water conservation, ecosystem and watershed planning and water quality. Assistance is limited to $500,000 per state and studies are cost-shared on a 50-50 basis with a non-federal sponsor such as a state, public entity or an Indian Tribe.

Floodplain Management Services. This program provides technical services and planning guidance for support and promotion of effective flood plain management. Flood and flood plain data are developed and interpreted with assistance and guidance provided in the form of "Special Studies" on all aspects of flood plain management planning. All services are provided free of charge to local, regional, state or non-federal public agencies. Federal agencies and private entities have to cover 100% of costs.

Flood Damage Reduction Projects. This program provides structural and non-structural projects to reduce damages caused by flooding and focuses on solving local flood problems in urban areas, towns and villages. USACE works with the project sponsor to define the flood problem, evaluate solutions, select a plan, develop the design and construct a project. A feasibility study is conducted to identify potential projects with the first $100,000 of the cost covered by the federal agency. Any cost above this amount is cost-shared 50-50 with the sponsor in the form of cash and in-kind services. Construction lands, easements, rights-of-way, relocations and disposal and 5% of the project's costs are the sponsor's responsibility. Operation and maintenance and a maximum of 50% of total project cost are the sponsor's responsibility.

Project Modification for Improvement of Environment. The purpose of this program is to modify structures or operation of previously constructed water resources projects to improve environmental quality, especially fish and wildlife values. A study, at federal expense, is initiated followed by a feasibility plan that is cost-shared 25% by the sponsor.

Aquatic Ecosystem Restoration. This effort is for restoration of historic habitat conditions to benefit fish and wildlife resources. This is primarily to provide structural or operational changes to improve the environment such river channel reconnection, wetland creation or improving water quality. Conditions are similar to the Project Modification program with sponsor cost-share being 35%.

Water Resources Projects. The purpose of this program is to construct larger projects for flood damage reduction and to provide technical assistance in resolving more complex water resource problems. It is used to evaluate projects costing more than $10 million that include purposes of flood control, water supplies, water quality, environmental protection and restoration, sedimentation or recreation. This would include reservoirs, diversions, levees, channels or floodplain parks as examples. USACE works with a non-federal sponsor to define the flood or water resource related problem or opportunity, evaluate flood control or solutions, select a plan, develop a design and construct a project. This requires special authorization and funding from Congress with a reconnaissance study being federal cost. A feasibility study to establish solutions is cost-shared 50% by the non-federal sponsor with 35 to 50% of construction cost the responsibility of the sponsor.

Support for Others Program. This program provides for environmental protection and restoration of facilities and infrastructure. This includes Environmental Planning and Compliance, Economic and Financial Analyses, Flood Plain Management, Cultural Resources and General Planning. All costs for these programs are provided by the customer agency.

Regulatory Authority/Responsibility. USACE has regulatory authority under the Clean Water Act and the River and Harbor Act. The purpose of these laws is to restore and maintain the chemical, physical and biological integrity of waters of the U.S. Section 404 of the Clean Water Act authorizes USACE to regulate the discharge of dredged or fill material into waters. This would include dams and dikes, levees, riprap, bank stabilization and development fill. There are three kinds of permits issued by the USACE: individual, nationwide, and regional general.

8.3.9 Rural Utilities Service

Introduction

The USDA Rural Development's utilities program is authorized to provide financial assistance for water and waste disposal facilities in rural areas and towns of up to 10,000 people. This program is intended for non-profit corporations and public bodies such as municipalities, counties, and special purpose districts and authorities.

Explanation of Opportunities

Funding may be obtained through Rural Development only when the applicant is unable to secure funding from other sources at reasonable rates and terms. The applicant must have legal capacity to borrow and repay loans, to pledge security for loans and to operate and maintain the facilities. The applicant must be financially sound and able to manage the facility effectively as well as have a financially sound facility based upon taxes, assessments, revenues, fees or other satisfactory sources of income to pay costs of operating, debt service and reserve. Grants are also available and are used to supplement loans to reduce debt service where necessary to achieve reasonable user rates. Assistance is also available on how to assemble information concerning engineering, financing and management of proposed improvements.

Loans and grants may be used to construct, repair, improve, expand or modify rural water supplies and distribution facilities such as reservoirs, pipelines, wells and pumping stations, waste collection, pumping, treatment or other disposal facilities. This assistance may also be used to acquire a water supply or water right or finance facilities in conjunction with funds from other agencies or those provided by the applicant. These funds can be used to pay legal and engineering fees connected with the development of a facility or pay other costs related to development including rights-of-way or easements and relocation of roads or utilities. Loan terms are a maximum of 40 years, state statute, or the useful life, whichever is less with interest rates based on current market yields for municipal obligations.

USDA Rural Development also guarantees loans to eligible commercial lenders to improve, develop or finance water or waste disposal facilities in rural areas. This guarantee is a warrant to protect the lender and may cover up to 90% of the principal advanced. The guarantee fee is 1% of the loan amount multiplied by the percent of the guarantee. Interest rates will be negotiated between the lender and the borrower.

8.3.10 Wyoming Landscape Conservation Initiative (WLCI) (WLCI Website)

Introduction and Explanation of Opportunities

The WLCI is a long-term science based effort to assess and enhance aquatic and terrestrial habitats at a landscape scale in southwest Wyoming, while facilitating responsible development through local collaboration and partnerships. The WLCI is composed of numerous committees and teams made up of representatives from the participating agencies. These agencies include: BLM, U.S. Geological Survey

(USGS), USFWS, USFS, WGFD, WDA, Southwest Wyoming County Commissions, Southwest Wyoming Conservation Districts, U.S. National Park Service, NRCS, University of Wyoming, and the USBR.

Information gathered through scientific inventory and assessment of species and habitat is combined with local input and knowledge to develop and implement conservation projects. The WLCI conducts regular Local Project Development Team meetings, where public participation is needed and expected. If you have ideas for projects, they can be presented at these meetings or sent to the WLCI Coordination Team through the BLM High Desert District Office at (307) 352-0256 or WLCI_WYMail@blm.gov.

The project application form, project tracking and project ranking score sheet are available from the following website, and have been included in the digital library delivered with this report (http://www.wlci.gov/lpdt-resources).

8.4 Non-Profit and Other Organizations

8.4.1 Ducks Unlimited, Inc. (DU)

Introduction and Explanation of Opportunities

DU is a potential funding source for wetlands and waterfowl restoration projects. Although direct grant funding is limited (to the extent that there is generally about $20,000 to $30,000 available annually statewide), in-kind assistance may be available from the local chapter of DU. Additional information on DU's funding programs and opportunities is available in the Water Management and Conservation Assistance Program Directory referenced previously.

DU offers a waterfowl habitat development and protection program called Matching Aid to Restore States Habitat (MARSH). This is a reimbursement program that provides matching funds for restoring, protecting, or enhancing wetlands. The financial extent of this program is dependent on DU's income within the state. MARSH projects must significantly benefit waterfowl. Projects receiving funding support must be on lands that can demonstrate at least a 30-year project life at a minimum. Groups requesting assistance must be able to demonstrate capacity to execute long-term habitat agreements, deliver and manage projects, and be willing to assume project liability. DU's goal is to match MARSH funds equally with private, state, or federal sources. Their objective is to obtain maximum leverage possible to maximize benefit to waterfowl. Therefore, leveraged projects have a greater likelihood of being approved. Specifics for proposal submission, budget preparation, project development, and receipt of funding can be further explained by the DU local coordinator. The local coordinator can provide additional information relating to the program and provide partner contact opportunities at a local level.

8.4.2 National Fish and Wildlife Foundation (NFWF)

Introduction and Explanation of Opportunities

The NFWF is a private, non-profit, tax exempt organization chartered by Congress in 1984 to sustain, restore, and enhance the nation's fish, wildlife, plants, and habitats. NFWF provides grant funding on a competitive basis through their Keystone Initiative Grants and Special Grant Program. Some of the grants/programs that may be applicable to potential projects in the Owl Creek Watershed Study Area include, but are not limited to, the following:

Pulling Together Initiative. Provides support on a competitive basis for the formation of local Weed Management Area (WMA) partnerships that engage federal resource agencies, state and local governments, private landowners, and other interested parties in developing long-term weed management projects within the scope of an integrated pest management strategy; minimum 1:1 nonfederal match is required.

Native Plant Conservation Initiative. Funding preference for "on-the-ground" projects that involve local communities and citizen volunteers in the restoration of native plant communities.

Bring Back the Natives Grant Program. Funds to restore damaged or degraded riverine habitats and their native aquatic species provided by BLM, USBR, USFWS, USFS, and NFWF; minimum 2:1 nonfederal match required.

Five-Star Restoration Program. Provides modest financial assistance on a competitive basis to support community-based wetland, riparian, and coastal habitat restoration projects that build diverse partnerships and foster local natural resource stewardship through education, outreach and training activities; average grant is $13,000.

Information about all of these and other NFWF grants/programs is available at their website: http://nfwf.org/.

8.4.3 Trout Unlimited

Introduction and Explanation of Opportunities

The mission of the Wyoming Council of Trout Unlimited is to conserve, protect, and restore Wyoming's cold-water (trout) fisheries and their watersheds. The Council is made up of 16 chapters located throughout the state. While a majority of Trout Unlimited members are indeed enthusiastic anglers, their focus is not only on maintaining fisheries for the purpose of angling. Healthy trout fisheries are indicative of well-functioning, sound ecosystems and that the work we do toward restoring good trout habitat will ultimately benefit the overall environment.

Of special concern are Wyoming's four subspecies of native cutthroat trout that currently inhabit a tiny fraction of their historic range. Working with federal and state agencies, local officials and landowners, Wyoming Trout Unlimited is actively engaged in a battle to keep these fish from being listed under the ESA. Trout Unlimited provides funding and volunteer labor for a variety of stream and watershed projects such as erosion control and fish habitat structures, willow and other riparian plantings, and stream protection fencing. Embrace-A-Stream grants are available for up to $10,000 per project. Partnerships are encouraged and can include local conservation districts and state and federal agencies. Those interested should contact the Council office.

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9 PERMITS

9.1 Introduction

Projects proposed in the watershed management and rehabilitation plan include upland water development (wells/pipelines/stock tanks, stock ponds), stream channel restoration and mitigation of ongoing channel processes (historic meander reactivation, in-stream pond creation, headcut stabilization), and irrigation infrastructure improvements. Each of these project types will require that a specific set of permitting obligations are satisfied before the project implementation. This section of the report provides an outline of the anticipated permitting processes, including a summary of the necessary permits, requirements for environmental analysis and documentation, resource agency coordination, and estimated timelines. Numerous federal and state regulations may apply to the proposed projects, and relate to the following areas of concern: fish and wildlife; wetlands; state waters; cultural; water rights, water storage, and conveyance; rights-of-ways (ROW); stormwater elimination; and other miscellaneous issues such as noise and air quality.

The watershed area is comprised of federal BLM lands, State of Wyoming lands, USFS lands, and private property. Projects that are located on BLM- and USFS-managed land are subject to NEPA and other federal environmental regulations. The EPA, USACE, and the USFWS all administer additional federal regulations that may be relevant to proposed projects. State agencies that may have jurisdiction for certain projects include the WGFD, WDEQ, WSEO, State Historic Preservation Office (SHPO), and the WBLC through the OSLI.

Required permits and clearances for specific projects will require evaluation on a case-by-case basis. Specific permitting requirements for a given project should be identified as early in the planning process as possible to insure that the project is compliant with applicable laws and regulations. Timeframes to complete various permitting processes and obtain authorization to implement a project can be lengthy, which further supports getting as early a start as possible.

9.2 WBLC

The WBLC through the OSLI is responsible for regulating all activities on state lands, including granting of rights-of-way. Any facility, utility, road, railroad, ditch or reservoir to be constructed on state or school lands must have a right-of-way, as required in the “Rules and Regulations Governing the Issuance of Rights Of Way” (W.S. 36-20 and W.S. 36-202).

9.3 WSEO

The WSEO administers the water rights system of appropriation within the state. The applicant must obtain the necessary water rights permits from the State of Wyoming for the diversion and storage of the State’s surface water.

The Wyoming Dam Safety Law (W.S. 41-3) requires that any persons, public company, government entity or private company who proposes to construct a dam which is 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 cubic feet of water per second, must obtain approval for construction of the dam or ditch from the WSEO. The approval by the WSEO of a dam’s construction is contingent upon the Office’s review and approval of all dam plans and specifications, which must be prepared by a registered professional engineer licensed in Wyoming. Design, construction, and operation of jurisdictional dams must also comply with dam safety regulations promulgated pursuant to the Dam Safety Act.

In addition to the permits and clearances that are required for reservoir construction, existing irrigation ditches may require enlargement to convey water to off-channel reservoirs. If so, this would require an enlargement filing with the WSEO. Even if physical enlargement of the existing ditch was found to not be required, the enlargement filing would be a legal formality as a water right requirement.

9.4 WDEQ – WYPDES permit

The federal Clean Water Act is administered in Wyoming by the WDEQ, Water Quality Division (WQD) consistent with the Wyoming Environmental Quality Act. The Section 401 Certification is the State's approval to ensure that the activities authorized under Section 404 meet state water quality standards and do not degrade water quality. Any discharge of pollutants into the broadly defined "waters of the state" requires application to and permit issuance by WQD in accord with WQD's Rules and Regulations. This body of regulations sets forth classification of surface and groundwater uses and establishes water quality standards (Wyoming Water Quality Standards). The WQD administers the NPDES permit system including storm water permits and construction-related, short-term discharge permits.

Implementation of any of the action alternatives would require application for and compliance with the provisions of the statewide general NPDES Construction Storm Water Discharge Permit (WYR10-000).

Construction activities associated with dam construction or enlargement often result in the requirement to temporarily discharge pumped water. These discharges are provided for in a general permit. Upon acceptance of the application by WDEQ, the temporary discharge must be in compliance with the terms of the general permit and any stipulations applied as a result of the application's review.

EPA has oversight responsibility for federal Clean Water Act programs delegated to and administered by the State Water Quality Division. EPA also may intervene to resolve interstate disputes where discharges of pollutants in an upstream state may affect water quality in a downstream state.

9.5 WDEQ – Mining Permit

A Wyoming mining permit is not required for development of an aggregate and/or borrow material source solely for use in construction of one of the various reservoir alternatives and whose product is not for commercial sale. Commercial sources of aggregate, rock, or other mined materials are responsible for obtaining and maintaining all required permits and clearances for their operations.

9.6 Special Use Permits, Right of Ways, Easements

Special use permits, ROW, or easements will be required wherever access across the lands of others (private, state, or federal) is needed for construction and/or operation of the project facilities. These may be temporary (e.g., access to a temporary borrow area or quarry site to be closed and reclaimed, construction of a new haul road, etc.) or permanent (e.g., construction of a wildlife/livestock pipeline alignment). Usually privately owned lands that will be rendered permanently unavailable (such as the dam and reservoir footprint of a storage project) would be purchased unless the owner desired (and the sponsoring entity agreed) to a permanent easement. Permanent use of BLM lands would most likely be administered under a grant with an appropriate term issued under their ROW process; the USFS would use their equivalent special use process. An easement or ROW from the WYDOT, Hot Springs County, Fremont County, or Washakie County may also be required. The specific requirements for ROW, special use permits, and easements vary widely and should be determined as part of the early stages of planning for a specific proposed project. This will help to avoid the potential for significant project delay, higher costs, or required changes in location/alignment or design during project development and implementation.

9.7 NEPA

NEPA applies to any of the proposed actions for which the project site is located on federal land, federal funds may be used, and/or when formal federal agency actions are necessary for project approval. The intent of NEPA is to insure that projects in the federal domain (including lands and/or funding) adhere to guidelines that seek to avoid, minimize and mitigate adverse environmental impacts. NEPA requires that the potential adverse and beneficial effects of a proposed project be evaluated and documented, and that an alternatives analysis be performed. The BLM would likely be the lead agency for NEPA compliance and documentation on projects that affect lands under their management. For projects that occur within jurisdictional wetlands and/or waters of the U.S., the USACE may take control of the NEPA process as the lead agency. It is also possible that these agencies may work out a shared lead under a Memorandum of Understanding (MOU) if there are significant issues best led by both agencies for a given project.

9.8 USACE

Like all water development projects, any dam and reservoir storage project in the watershed will face environmental permitting issues. Typically the most significant environmental permit to be secured is a Section 404 Dredge and Fill permit from the USACE, Omaha District. Even when impacts are anticipated to be modest, the process of obtaining a Section 404 permit for new storage projects may take several years from initiation of the NEPA process.

9.9 Other

In addition to the above permits, there may be other permits and clearances required for a given dam and reservoir project. These might include permits typically required to be provided by the construction contractor (e.g., air quality permit, trash/slash burning permit, etc.).

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10 SUMMARY AND PATH FORWARD

A multidisciplinary inventory of the Owl Creek Watershed Study area, located in Hot Springs County, Wyoming, was conducted in an effort to identify and evaluate key resource issues and concerns related to water use and conservation. A series of public meetings, questionnaires, site visits, and interaction with the HSCD and the Project Sponsor, WWDC, were used to inform the study. Many people provided input for the Owl Creek Watershed Study with ideas they wanted to explore or implement to improve water use, water access, and water conservation on their farms, ranches, and properties. A total of 38 interviews were performed between August 2016 and April 2017. Of these, 21 interviews were completed on-site and 17 were completed in a meeting-room setting at the Bighorn Bank meeting room in Thermopolis. **Table 10-1** reviews the project categories and number of projects identified in each.

Table 10-1 Proposed projects identified during watershed study

Project Type	Total	Number of Projects Identified	
		On-site	*Workshop*
ISYS	52	32	20
ISTO	4	4	0
SCS	6	4	3
URI	14	9	5
OWI	10	7	3
Large-scale Level II	3	3	0
Subtotals		**59**	**30**
Total Projects		**89**	

A comprehensive Geographic Information System (GIS) was completed in conjunction with the inventory. The GIS incorporates the data collected and results generated during the study and collates it with information collected from a wide variety of sources. The GIS will be a valuable resource for the community and future studies which will likely be conducted in the watershed.

10.1 Summary by Project Type

The Watershed Management Plan was developed based upon findings of the inventory phase. The beginning of **Section 4** lists five key issues that the authors of this study believe need to be addressed in the Owl Creek drainage and surrounding areas in order to most efficiently utilize water resources and maintain the health of agriculture in the study area. These are:

1. Failing or inadequate infrastructure,
2. Poor or non-existent water measurement devices,
3. Excessively long open channel ditch laterals serving limited acreage,
4. Flashy or inadequate flows and limited water storage, and
5. Concern over water rights and distribution.

Interaction with landowners and others, as described above, made clear that people were very interested in improving watershed health and sustainability. However, people were more interested in small, on-farm or between-farm projects than they were in large-scale, district or county wide projects such as large reservoirs or infrastructure. People wanted projects that could be completed quickly so that benefits could be seen quickly. Cost of larger projects was also a factor. The study area, while rich in agricultural history, is not wealthy in crop value or acres irrigated. In addition, the one feature that represents large-money projects, Anchor Dam, did not deliver as promised. People are still gun-shy about investing large sums of money on a project that may not work.

Because small-scale projects were of most interest to landowners in the study area, small scale projects were the focus of this study. Based on input from landowners, projects identified were organized in the following categories:

- Irrigation System projects (ISYS),
- Irrigation Storage projects (ISTO),
- Stream Channel Stabilization projects (SCS),
- Upland Range Improvements (URI), and
- Other Watershed Improvements (OWI).

Below is a brief summary of the projects identified and some of the ways these projects can improve watershed function, in addition to the direct agricultural benefits of the project.

10.1.1 Irrigation System Projects (ISYS)

Landowner interest was highest in irrigation system improvements. These projects focus on improving irrigation ditches that feed one or more properties and includes projects such as construction of new headgates and diversion structures, or on-farm improvements like farm turn-outs off lateral ditches. Fifty two (52) individual projects were incorporated into the watershed management plan. Many of the projects convert open ditches to pipelines thereby satisfying multiple criteria. The majority of improvements to irrigation systems can be implemented either individually or as a group depending on neighbor collaboration and financial abilities. Potential environmental benefits of ISYS projects include, but are not limited to, conservation of water resources, decreased spread of noxious weeds along open irrigation ditches and canals, and improving water quality by lessening the volume of waste water that drains off fields into Owl Creek.

10.1.2 Irrigation Storage Projects (ISTO)

Four (4) small scale irrigation storage projects were identified, consisting mainly of rehabilitating existing reservoirs or enlargement of existing reservoirs. Construction of new, large scale surface water storage facilities was not identified as an area of interest for this watershed management plan. Two people were interested in exploring further repairs on Anchor Reservoir, but the Conservation District stated at the first Board Meeting LW attended that they did not want to study this option because information available indicated that further repair or lining would be a very costly endeavor.

Potential environmental benefits of the small-scale ISTO projects contained in this study include, but are not limited to, creation of additional wildlife habitat due to the construction of small ponds and providing livestock and wildlife watering opportunities that are away from streams and riparian areas. In some cases, holding water in reservoirs may have a localized, positive effect on groundwater due to percolation from the reservoir.

10.1.3 Stream Channel Stabilization Projects (SCS)

Four (4) projects were identified that addressed streambank erosion and stabilization of the stream channel. Conceptual site-specific solutions were developed that would control channel erosion were included in the watershed management plan. Potential environmental benefits of SCS projects include, but are not limited to, decreased sedimentation in streams and limiting upstream migration of headcuts, which can lower the water table and lead to changes in vegetation from a mesic to a more xeric system; such systems support lower biodiversity and total biomass. Other environmental benefits include mitigation of erosion, stabilization of water velocities, promotion of riparian area development, and fish propagation.

10.1.4 Upland Range Improvement (URI)

Fourteen (14) upland range improvement projects, such as creating or improving small ponds to be used for stock and/or wildlife watering and spring development were included in the watershed management plan. Rangeland improvements very directly affect watershed conditions.

Potential environmental benefits of URI project include increased upland water availability to livestock and wildlife, a lessening of trampling around natural springs or seeps, and improved distribution of livestock that would result in better overall forage utilization with less overgrazed areas. In general, most range improvement practices that improve watershed and livestock values also improve wildlife habitat values.

There are other potential range management improvements that were not proposed during interviews that could be beneficial to the watershed. For example, fencing can be used to keep livestock off streams or to divide open range into smaller units to enhance grazing management. Re-seeding of spring pastures can increase forage production. Shifting from a cow-calf operation (year-round operation where cows are over-wintered and calve in spring) to a calf operation (where calves are purchased in spring and kept until they wean in fall) can lower the need for hay production and thus irrigation water, and can be economically beneficial. There are as many options as there are operations.

Important to any range improvement is the use of flexible, adaptive management. Efforts to improve rangeland conditions using this management scheme will contribute to the maintenance, recovery or improvement of a variety of interrelated aspects of watershed function, including but not necessarily limited to:

- Improved infiltration of snowmelt and rainfall;
- Retention of soil moisture;
- Groundwater recharge;
- Sustained release of soil moisture and groundwater as seeps/springs; and
- Stabilization of soils against erosion into streams.
- Weeds and invasive plants
- Water quality

10.2 Other Watershed Improvements (OWI)

There were ten (10) projects identified that did not fit the above categories and were classified as other. Five (5) of these involved small water storage projects such as storing early and excess water. They required unconventional methods to achieve such water storage, which is why they were categorized here. This category also includes flood control projects and projects that were combined or unrelated to irrigation or upland range improvements. Potential benefits of OWI projects include those benefits listed above.

10.3 Observations

Of the 90 projects identified, 84 would be eligible for WWDC Small Water Project funding and six would be eligible for WWDC Conventional funding. Other project funding options, such as NRCS, WGFD, and Trout Unlimited loans and grants may be available on almost all projects identified.

Project construction costs were estimated using NRCS Historically Underserved rates from NRCS 2014 Cost Estimating Guide, Historically Underserved (HU) line items with an additional 20% cost added on to cover inflation, labor, mobilization, and overhead costs that were not included in the NRCS model. These costs are presented as Total Component Cost in Section 4, these costs are combined with other pre-construction costs, “soft costs” inflationary estimates, and contingency costs to arrive at Total Project Costs.

Overall, the project area has many old and poorly functioning irrigation structures. For example, motors for the Lucerne pump station are over 50 years old (personal communication, Gene Moody, Lucerne Pipeline and Pumping Co.). Many diversion structures are in poor condition, do not perform properly, or the structures are hazardous because the diversion structures are narrow, irregularly shaped, and unstable. From both a production and safety viewpoint, improvements to diversions is vital.

Head cutting is an issue throughout the drainage, though in most places the drop is not sudden, but spread over a long distance. The many diversion locations on Owl Creek essentially limit the rate of headward erosion. However, due to this headcutting, many of the diversions and headgates have been reconstructed upstream from their original SEO permitted location (Tim Hawkins, SEO, personal communication, March 2017). The upstream migration of diversions and headgates is important to the SEO and Owl Creek irrigators because, according to WSEO rules, water cannot be turned out to headgates that are not in their permitted locations. The SEO will be enforcing this rule by 2018, therefore, an effort by OCID members to address the issue is of high priority.

Replacing open, earthen ditches with pipe would improve the efficiency of water transport for irrigation, potentially increasing water available at the far ends of ditches. Using water more efficiently on croplands may increase crop yields, allow expansion of irrigated acreage, or increase the volume of in-stream flow in Owl Creek. Increasing flow would dilute pollutants and provide on-stream and in-stream habitat for animals including fish. However, a potential cost of shifting from ditch to pipe is the loss of seepage and the small riparian areas and trees adjacent to the seepage area that provides habitat for small animals and birds.

Roughly 640 acres of cultivated ground are presently irrigated with center pivot or other forms of sprinkler irrigation. Additional conversion to these on-farm systems will decrease the amount of water required for historic cropland, thereby making water available for use on new lands, or for other environmental benefits.

Whether watershed improvements include increased water storage facilities or on-farm improvements in water transport and use, more reliable or higher flows would provide a more consistent water supply for riparian areas along Owl Creek, such as the cottonwoods growing along North Fork Owl Creek. These “cottonwood galleries” provide shade, beauty, and habitat for small and large animals and store water in the organic materials of these areas, thus extending the length of stream flow. Riparian areas can also mitigate water pollutants as water passes through the alluvial material and organic material.

Creating new or improving existing stock ponds would provide water for wildlife and would open new areas to grazing. This would likely decrease grazing pressure on riparian areas and allow increase water storage within the sponge-like riparian zone.

Replacing failing headgates and diversions would allow more accurate measurement of water and more efficient operation of sand traps. Certain diversions no longer work because of headcutting; replacing these with properly designed diversions should decrease headcutting and channel movement. Some diversions are barriers to fish travel; these can be replaced with diversions that incorporate natural channel design.

Few of these projects would significantly improve or lengthen the period of irrigation. Increasing the length of time water flows in Owl Creek would require one or more additional storage reservoirs to contain water flowing in the Owl Creek drainage during high runoff periods. Only two interviewees out of 38 were interested in pursuing the revamping of existing reservoirs (Anchor). No one showed interest or proposed constructing a multi-user reservoir that would serve all or a significant part of the OCID.

10.3.1 Recommendations

After reviewing all of the collected data it is highly recommended that the following improvements be completed in order to maximize efficient use of water resources within the project area.

1. Replace failing or inadequate infrastructure
2. Replace poor or non-existent measurement capabilities
3. Eliminate excessively long open channel ditch laterals serving limited acreage.

By improving these three core areas, particularly in the Owl Creek Watershed, water delivery, consumption, and loss will all be greatly improved.

Based on the study’s review of water availability **Section 3.3.6**, the authors believe that further exploration of properly scaled water storage opportunities on both the North and South Forks Owl Creek should be evaluated. The model used in Section 3.3.6 determined that there should be excess water available for storage in late spring in wet and average years. Currently this water is utilized as much as possible but some water flushes through and is not available late for irrigation.

The overall limited availability of water in the Owl Creek drainage and the insecurity of access to those rights due to currently unused and untested use of Tribal and Walton Rights, make water storage more attractive to even out flows and provide longer water availability. Previous studies by Nelson Engineering (2004) and SEH (2008) provide study of and recommendations for reservoir siting. These studies should be reviewed and reconsidered with perhaps altered reservoir sizes or funding considered

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12 APPENDICES

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APPENDIX A – Ecological Site Description Reports

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Soil Survey

- Soil Survey - Home
- Soil Surveys by State
- Partnerships
- Publications
- Soil Classification
- Soil Geography
- Tools
- Soil Survey Regional Offices
  - Portland, OR (SSR 1)
  - Davis, CA (SSR 2)
  - Raleigh, NC (SSR 3)
  - Bozeman, MT (SSR 4)
  - Salina, KS (SSR 5)
  - Morgantown, WV (SSR 6)
  - Auburn, AL (SSR 7)
  - Phoenix, AZ (SSR 8)
  - Temple, TX (SSR 9)
  - St. Paul, MN (SSR 10)
  - Indianapolis, IN (SSR 11)
  - Amherst, MA (SSR 12)
    - Contacts
    - Ecological Site Information
    - Soil Information
- Soil Climate Research Stations

Ecological Site Information

Ecological Sites provide a consistent framework for classifying and describing rangeland and forestland soils and vegetation; thereby delineating land units that share similar capabilities to respond to management activities or disturbance. Ecological Site Descriptions are being developed for forests, freshwater wetlands, grasslands, and salt marshes in Soil Survey Region 12.

Technical Resources

- National Ecological Site Handbook
- National Biology Manual
- National Biology Handbook
- National Range and Pasture Handbook
- National Forestry Manual
- National Soil Survey Handbook

What are Ecological Site Descriptions (ESDs)?

Ecological Site Descriptions (ESDs) are reports that provide detailed information about a particular kind of land — a distinctive Ecological Site.

ESDs include site-specific management information about natural vegetation, weeds, forestry, grazing, wildlife, and dynamic soil properties. Land managers can use this information to evaluate land suitability and respond to different management activities or disturbance processes.

Where can I find Ecological Site Description Reports?

Ecological Site Information System (ESIS)

NRCS Ecological Site Description (ESD) reports are stored and accessed within the Ecological Site Information System (ESIS). All completed and approved ESDs, both rangeland and forestland sites, are available to the general public from ESIS.

Web Soil Survey

If your interest is to obtain soil and ESD information for your farm, ranch, or other lands, then use the NRCS Web Soil Survey application. You can create your personal Area of Interest (AOI) and view, save, and print maps and reports providing soil and ecological site information defining your specific piece of land.

United States Department of Agriculture Natural Resources Conservation Service
Ecological Site Description

Section I: Ecological Site Characteristics

Ecological Site Identification and Concept

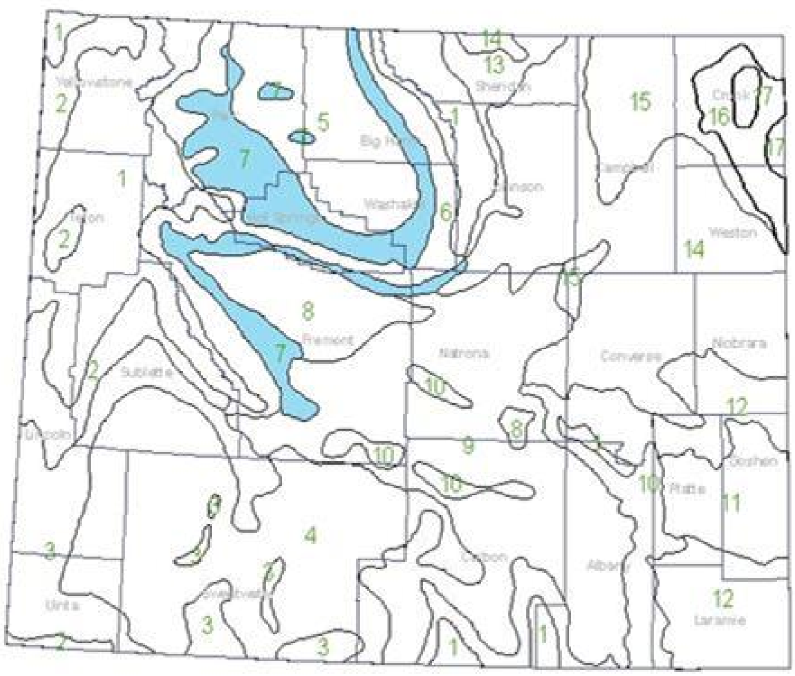
Site stage: Provisional

Provisional: an ESD at the provisional status represents the lowest tier of documentation that is releasable to the public. It contains a grouping of soil units that respond similarly to ecological processes. The ESD contains 1) enough information to distinguish it from similar and associated ecological sites and 2) a draft state and transition model capturing the ecological processes and vegetative states and community phases as they are currently conceptualized. The provisional ESD has undergone both quality control and quality assurance protocols. It is expected that the provisional ESD will continue refinement towards an approved status.

Site name: Loamy (Ly) 10-14" East Precipitation Zone

Site type: Rangeland
Site ID: R032XY322WY
Major land resource area (MLRA): 032-Northern Intermountain Desertic Basins

Precipitation Zones for Rangeland Ecological Site Descriptions



Physiographic Features

This site occurs on near level to gently undulating rolling land and on slope generally less than 20%.

Landform: (1) Hill
(2) Alluvial fan
(3) Ridge

	Minimum	Maximum
Elevation (feet):	5400	7500
Slope (percent):	0	30
Ponding		
Depth (inches):	0	0
Runoff class:	Negligible	High
Aspect:	No Influence on this site	

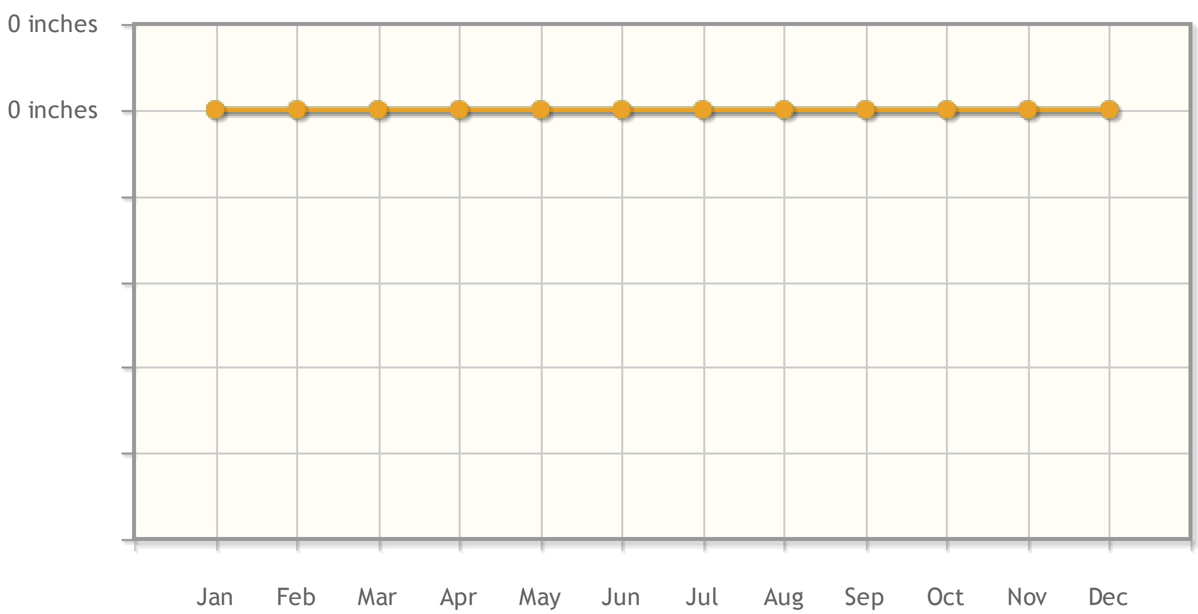
Climatic Features

Annual precipitation ranges from 10-14 inches per year. The normal precipitation pattern shows the least amount of precipitation in December, January, and February, increasing to a peak during the latter part of May. Amounts decrease through June, July, and August and then increase some in September. Much of the moisture that falls in the latter part of the summer is lost by evaporation and much of the moisture that falls during the winter is lost by sublimation. Average snowfall exceeds 20 inches annually. Wide fluctuations may occur in yearly precipitation and result in more dry years than those with more than normal precipitation. Temperatures show a wide range between summer and winter and between daily maximums and minimums, due to the high elevation and dry air, which permits rapid incoming and outgoing radiation. Cold air outbreaks from Canada in winter move rapidly from northwest to southeast and account for extreme minimum temperatures. Chinook winds may occur in winter and bring rapid rises in temperature. Extreme storms may occur during the winter, but most severely affect ranch operations during late winter and spring. Winds are generally not strong as compared to the rest of the state. Daytime winds are generally stronger than nighttime and occasional strong storms may bring brief periods of high winds with gusts to more than 75 mph. Growth of native cool-season plants begins about April 15 and continues to about July 15. Cool weather and moisture in September may produce some green up of cool season plants that will continue to late October. The following information is from the "Thermopolis 2" climate station: Minimum Maximum 5 yrs. out of 10 between Frost-free period (days): 74 149 May 23 – September 16 Freeze-free period (days): 112 180 May 8 – October 1 Annual Precipitation (inches): 7.6 21.9 Mean annual precipitation: 12.35 inches Mean annual air temperature: 46.2 F (30.1 F Avg. Min. to 62.3 F Avg. Max.) For detailed information visit the Natural Resources Conservation Service National Water and Climate Center at http://www.wcc.nrcs.usda.gov/ website. Other climate station(s) representative of this precipitation zone include" Grass Creek 1E", "Thermopolis", Thermopolis 25NW", "Buffalo Bill Dam" and "Black Mountain".

	Averaged
Frost-free period (days):	111
Freeze-free period (days):	146
Mean annual precipitation (inches):	14.00

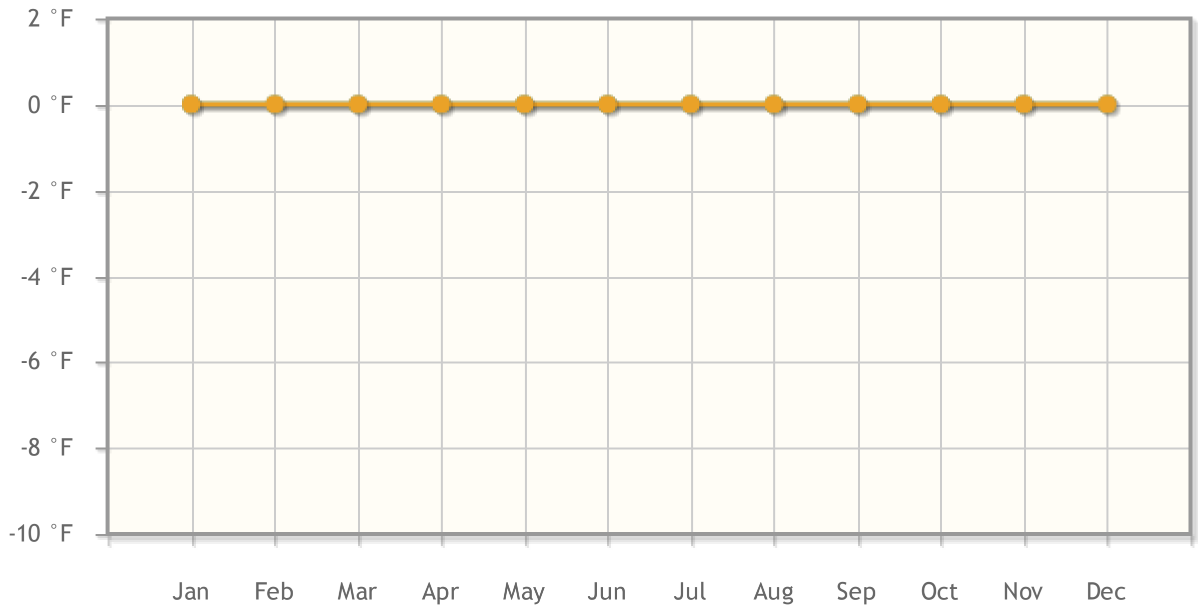
Monthly Precipitation (Inches):

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Low	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



Monthly Temperature (°F):

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Low	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Influencing Water Features

Stream Type: None

Representative Soil Features

The soils of this site are very deep to moderately deep (greater than 20" to bedrock), moderately well to well-drained & moderately slow to moderate permeable. The soil characteristic having the most influence on plant community is the available moisture and the potential to develop soluble salts near the surface.

Major Soil Series correlated to this site include: Lupinto, Frisite, Rock River, Sinkson, Elkol, Grieves, Yamac, Luhon, Rootel

Surface texture: (1) Loam
(2) Fine sandy loam
(3) Sandy loam

Subsurface texture group: Loamy

	Minimum	Maximum
Surface fragments <=3" (% cover):	0	10
Surface fragments >3" (% cover):	0	0
Subsurface fragments <=3" (% volume):	0	15
Subsurface fragments >3" (% volume):	0	10

Drainage class: Moderately well drained to well drained
Permeability class: Moderately slow to moderate

	Minimum	Maximum
Depth (inches):	20	60
Available water capacity (inches):	3.00	6.30
Electrical conductivity (mmhos/cm):	0	8
Sodium adsorption ratio:	0	13
Calcium carbonate equivalent (percent):	0	20
Soil reaction (1:1 water):	7.4	9.0

Plant Communities

Ecological Dynamics of the Site

Potential vegetation on this site is dominated by mid cool-season perennial grasses. Other significant vegetation includes winterfat, big sagebrush, and a variety of forbs. The expected potential composition for this site is about 75% grasses, 10% forbs and 15% woody plants. The composition and production will vary naturally due to historical use, fluctuating precipitation and fire frequency.

As this site deteriorates species such as blue grama, Sandberg bluegrass, and big sagebrush will increase. Plains pricklypear and weedy annuals will invade. Cool-season grasses such as Griffiths and bluebunch wheatgrass, rhizomatous wheatgrasses, needleandthread, and Indian ricegrass will decrease in frequency and production.

Big sagebrush may become dominant on areas with an absence of fire and sufficient amount of precipitation. Wildfires are actively controlled in recent times and as a resulted old decadent stands of big sagebrush persist. Chemical control using herbicides has replaced the historic role of fire on this site. Recently, prescribed burning has regained some popularity.

Due to the amount and pattern of the precipitation, the big sagebrush component may not be resilient once it has been removed or severely reduced if a vigorous stand of grass exists and is maintained. On these areas, blue grama may become dominant if the area is subjected to a combination of frequent and severe grazing especially yearlong grazing. As a result, a dense sod cover of blue grama will become established.

The Historic Climax Plant Community (description follows the plant community diagram) has been determined by study of rangeland relic areas, or areas protected from excessive disturbance. Trends in plant communities going from heavily grazed areas to lightly grazed areas, seasonal use pastures, and historical accounts have also been used.

The following is a State and Transition Model Diagram that illustrates the common plant communities (states) that can occur on the site and the transitions between these communities.

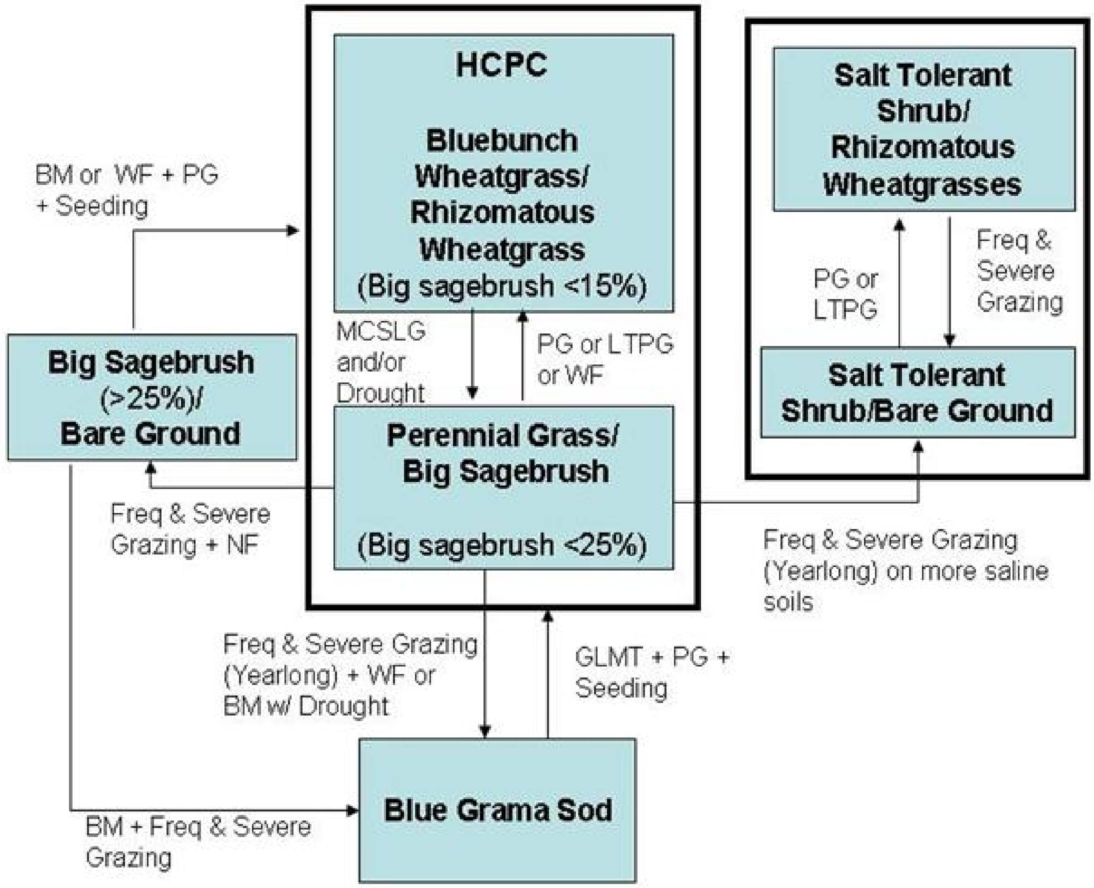
The ecological processes will be discussed in more detail in the plant community narratives following the diagram.

Plant Community Narratives
Following are the narratives for each of the described plant communities. These plant communities may not represent every possibility, but they probably are the most prevalent and repeatable plant communities. The plant composition tables shown above have been developed from the best available knowledge at the time of this revision. As more data is collected, some of these plant communities may be revised or removed, and new ones may be added. None of these plant communities should necessarily be thought of as “Desired Plant Communities”. According to the USDA NRCS National Range and Pasture Handbook, Desired Plant Communities (DPC’s) will be determined by the decision-makers and will meet minimum quality criteria established by the NRCS. The main purpose for including any description of a plant community here is to capture the current knowledge and experience at the time of this revision.

State-and-Transition Diagram

Site Type: Rangeland
MLRA: 32 – Northern Intermountain Desertic Basins

Loamy 10-14" E
032XY322WY



BM - Brush Management (fire, chemical, mechanical)
Freq. & Severe Grazing - Frequent and Severe Utilization of the Cool-season Mid-grasses during the Growing Season
GLMT - Grazing Land Mechanical Treatment
LTPG - Long-term Prescribed Grazing
MCSLG - Moderate, Continuous Season-long Grazing
NU, NF - No Use and No Fire
PG - Prescribed Grazing (proper stocking rates with adequate recovery periods during the growing season)
VLTPG - Very Long-term Prescribed Grazing (could possibly take generations)
WF - Wildfire (Natural or Human Caused)

Technical Guide
Section IIE

USDA-NRCS
Rev. 11-01-05

Bluebunch Wheatgrass/Rhizomatous Wheatgrass

This plant community is the interpretive plant community for this site and is considered to be the Historic Climax Plant Community (HCPC). This state evolved with grazing by large herbivores and periodic fires. The cyclical natural of the fire regime in this community prevented big sagebrush from being the dominant landscape. This plant community can be found on areas that are properly managed with grazing and/or prescribed burning, and on areas receiving occasional short periods of rest. The potential vegetation is about 75% grasses or grass-like plants, 10% forbs, and 15%

woody plants. This state is dominated by cool season mid-grasses.

The major grasses include Griffiths and bluebunch wheatgrasses, rhizomatous wheatgrasses, needleandthread, and Indian ricegrass. Other grasses occurring in this state include bottlebrush squirreltail, prairie junegrass, and Sandberg bluegrass. Big sagebrush is a conspicuous element of this state, occurs in a mosaic pattern, and makes up 5 to 15% of the annual production. Winterfat is a common component found on this site. A variety of forbs also occurs in this state and plant diversity is high (see Plant Composition Table).

The total annual production (air-dry weight) of this state is about 800 lbs./acre, but it can range from about 500 lbs./acre in unfavorable years to about 1100 lbs./acre in above average years.

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

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

• Moderate, continuous season-long grazing will convert the plant community to the Perennial Grass/Big Sagebrush Plant Community. Prolonged drought will exacerbate this transition.

Bluebunch Wheatgrass/Rhizomatous Wheatgrass Plant Species Composition

Grass/Grasslike

Group	Group name	Common name	Symbol	Scientific name	Annual Production (pounds per acre) Low	High
1					280	400
		Montana wheatgrass	ELAL7	*Elymus albicans*	280	400
		bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	280	400
2					0	80
		needle and thread	HECO26	*Hesperostipa comata*	0	80
3					40	120
		western wheatgrass	PASM	*Pascopyrum smithii*	40	120
4					0	80
		green needlegrass	NAVI4	*Nassella viridula*	0	80
5					0	80
		Indian ricegrass	ACHY	*Achnatherum hymenoides*	0	80
6					0	80
		kingspike fescue	LEKI2	*Leucopoa kingii*	0	80
7					0	80
		Grass, perennial	2GP		0	40
		blue grama	BOGR2	*Bouteloua gracilis*	0	40
		threadleaf sedge	CAFI	*Carex filifolia*	0	40
		bottlebrush squirreltail	ELEL5	*Elymus elymoides*	0	40

		prairie Junegrass	KOMA	*Koeleria macrantha*	0	40
		basin wildrye	LECI4	*Leymus cinereus*	0	40
			POCA	*Poa canbyi*	0	40
		alkali bluegrass	POSE	*Poa secunda*	0	40

Forb

Group	Group name	Common name	Symbol	Scientific name	Annual Production (pounds per acre) Low	High
8					40	120
		Forb, perennial	2FP		0	40
		textile onion	ALTE	*Allium textile*	0	40
		small-leaf pussytoes	ANPA4	*Antennaria parvifolia*	0	40
		rose pussytoes	ANRO2	*Antennaria rosea*	0	40
		fringed sagewort	ARFR4	*Artemisia frigida*	0	40
		Missouri milkvetch	ASMI10	*Astragalus missouriensis*	0	40
		wavyleaf Indian paintbrush	CAAPM	*Castilleja applegatei subsp. martinii*	0	40
		bastard toadflax	COUM	*Comandra umbellata*	0	40
		tapertip hawksbeard	CRAC2	*Crepis acuminata*	0	40
		little larkspur	DEBI	*Delphinium bicolor*	0	40
		threadleaf fleabane	ERFI2	*Erigeron filifolius*	0	40
		parsnipflower buckwheat	ERHE2	*Eriogonum heracleoides*	0	40
		bigseed biscuitroot	LOMA3	*Lomatium macrocarpum*	0	40
		leafy wildparsley	MUDI	*Musineon divaricatum*	0	40
		white locoweed	OXSES2	*Oxytropis sericea var. speciosa*	0	40
		beardtongue	PENST	*Penstemon*	0	40
		Hood's phlox	PHHO	*Phlox hoodii*	0	40
		scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0	40
		stemless mock goldenweed	STAC	*Stenotus acaulis*	0	40
		smooth woodyaster	XYGL	*Xylorhiza glabriuscula*	0	40
		meadow deathcamas	ZIVE	*Zigadenus venenosus*	0	40

Shrub/Vine

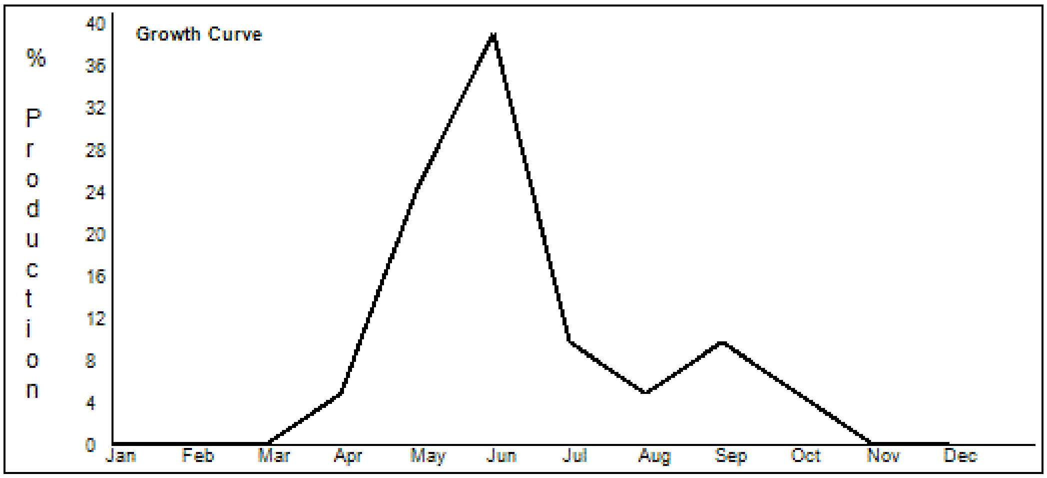
Group	Group name	Common name	Symbol	Scientific name	Annual Production (pounds per acre) Low	High
9					40	120
		big sagebrush	ARTR2	*Artemisia tridentata*	40	120
10					0	40
		antelope bitterbrush	PUTR2	*Purshia tridentata*	0	40
11					0	40
		rubber rabbitbrush	ERNA10	*Ericameria nauseosa*	0	40
12					0	40
		winterfat	KRASC	*Krascheninnikovia*	0	40
13					0	40
		Shrub (>.5m)	2SHRUB		0	40

Plant Growth Curve

Growth curve number:	WY0701
Growth curve name:	10-14E upland sites
Growth curve description:	

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	25	40	10	5	10	5	0	0



Perennial Grass/ Big Sagebrush

Historically, this plant community evolved under grazing and a low fire frequency. Currently, it is found under moderate, season-long grazing by livestock and will be exacerbated by prolonged drought conditions. In addition, the fire regime for this site has been modified and extended periods without fire is now common. This plant community is still dominated by cool-season grasses, while short warm-season grasses and miscellaneous forbs account for the balance of the understory. Wyoming big sagebrush is now a conspicuous part of the overall production and accounts for the majority of the overstory.

The dominant grasses include Griffiths and bluebunch wheatgrasses, rhizomatous wheatgrasses, and needleandthread. Grasses and grass-like species of secondary importance include prairie junegrass, blue grama, Sandberg bluegrass, and threadleaf sedge. Forbs commonly found in this plant community include scarlet globemallow, fringed sagewort, wavyleaf paintbrush, little larkspur, and Hood's phlox. Sagebrush can make up to 25% of the annual production. The overstory of sagebrush and understory of grasses and forbs provide a diverse plant community.

When compared to the Historic Climax Plant Community, big sagebrush and blue grama have increased. Plains pricklypear cactus will also have invaded, but occurs only in small patches. Indian ricegrass has decreased and may occur in only trace amounts under the sagebrush canopy or within the patches of pricklypear. In addition, the amount of winterfat may or may not have changed depending on the season of use.

The total annual production (air-dry weight) of this state is about 600 pounds per acre, but it can range from about 400 lbs./acre in unfavorable years to about 900 lbs./acre in above average years.

This plant community is resistant to change. The herbaceous species present are well adapted to grazing; however, species composition can be altered through long-term overgrazing. The herbaceous component is mostly intact and plant vigor and replacement capabilities are sufficient. Water flow patterns and litter movement may be occurring but only on steeper slopes. Incidence of pedestalling is minimal. Soils are mostly stable and the surface shows minimum soil loss. The watershed is functioning and the biotic community is intact.

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

• Prescribed grazing or possibly long-term prescribed grazing, will convert this plant community to the HCPC. The probability of this occurring is high especially if rotational grazing along with short deferred grazing is implemented as part of prescribed method of use. In addition, the removal of fire suppression will allow a somewhat natural fire regime to reoccur to more easily transition between this plant community and the HCPC. A prescribed fire treatment can be useful to hasten this transition, if desired.

• Frequent and severe grazing plus no fire on soils with limited soluble salts, will convert the plant community to the Big Sagebrush/Bare Ground Plant Community. The probability of this occurring is high. This is especially evident on areas with historically higher precipitation and the sagebrush stand is not adversely impacted by drought or heavy browsing.

• Frequent and severe grazing (yearlong grazing) plus wildfire or brush control, will convert the plant community to the Blue Grama Sod Plant Community. The probability of this occurring is high, especially if the sagebrush stand has been severely affected by drought or heavy use or has been removed altogether.

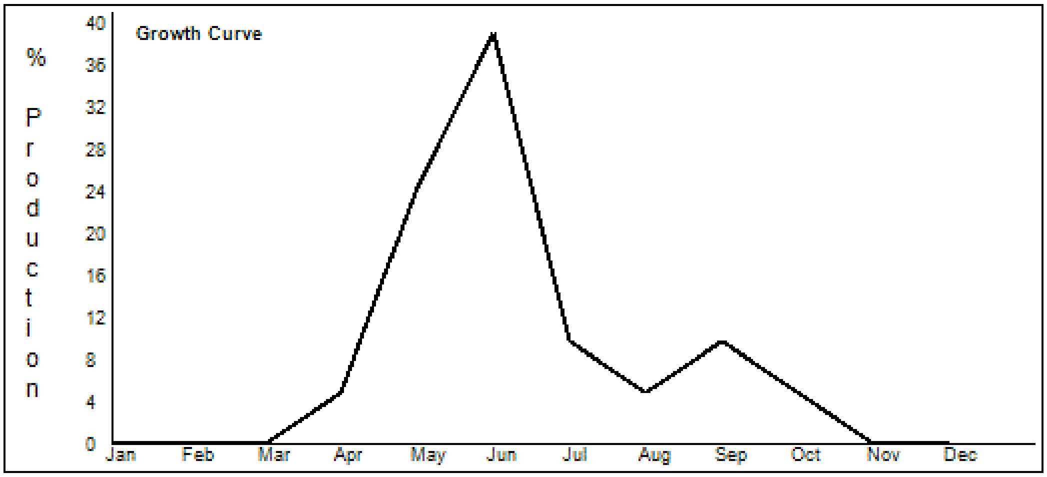
• Frequent and severe grazing (yearlong grazing) on more saline soils, will convert the plant community to the Salt Tolerant Shrub/Bare Ground Plant Community. The probability of this occurring is high especially on soils with elevated salts and the sagebrush stand has been severely affected by drought and heavy use or has been removed altogether.

Plant Growth Curve

Growth curve number:	WY0701
Growth curve name:	10-14E upland sites
Growth curve description:	

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	25	40	10	5	10	5	0	0



Big Sagebrush/ Bare ground

This plant community is the result of frequent and severe grazing and protection from fire. Sagebrush dominates this plant community, as the annual production of sagebrush excess 25%. Wyoming big sagebrush is a significant component of the plant community and the preferred cool season grasses have been greatly reduced.

The dominant grasses are prairie junegrass, Sandberg bluegrass, and blue grama. Weedy annual species such as cheatgrass may occupy the site if a seed source is available. Cactus and sageworts often invade. Noxious weeds such as Russian knapweed, leafy spurge, or Canada thistle may invade the site if a seed source is available. The interspaces between plants have expanded leaving the amount of bare ground more prevalent. As compared with the HCPC or the Perennial Grass/Big Sagebrush Plant Communities, the annual production is less, but the shrub production compensates for some of the decline in the herbaceous production.

The total annual production (air-dry weight) of this state is about 500 pounds per acre, but it can range from about 300 lbs./acre in unfavorable years to about 700 lbs./acre in above average years.

This plant community is resistant to change as the stand becomes more decadent. These areas may actually be more resistant to fire as less fine fuels are available and the bare ground between the sagebrush plants is increased. Continued frequent and severe grazing or the removal of grazing does not seem to affect the composition or structure of the plant community. Plant diversity is moderate to poor. The plant vigor is diminished and replacement capabilities are limited due to the reduced number of cool-season grasses. Plant litter is noticeably less when compared to the HCPC.

Soil erosion is accelerated because of increased bare ground. Water flow patterns and pedestalling are obvious. Infiltration is reduced and runoff is increased. Rill channels may be noticeable in the interspaces and gullies may be establishing where rills have concentrated down slope.

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

• Brush management, followed by prescribed grazing, will return this plant community at or near the HCPC. If prescribed fire is used as a means to reduce or remove the shrubs, sufficient fine fuels will need to be present. This may require deferment from grazing prior to treatment. Post management is critical to ensure success. This can range from two or more years of rest to partial growing season deferment, depending on the condition of the understory at the time of treatment and the growing conditions following treatment. In the case of an intense wildfire that occurs when desirable plants are not completely dormant, the length of time required to reach the HCPC may be increased and seeding of natives is recommended.

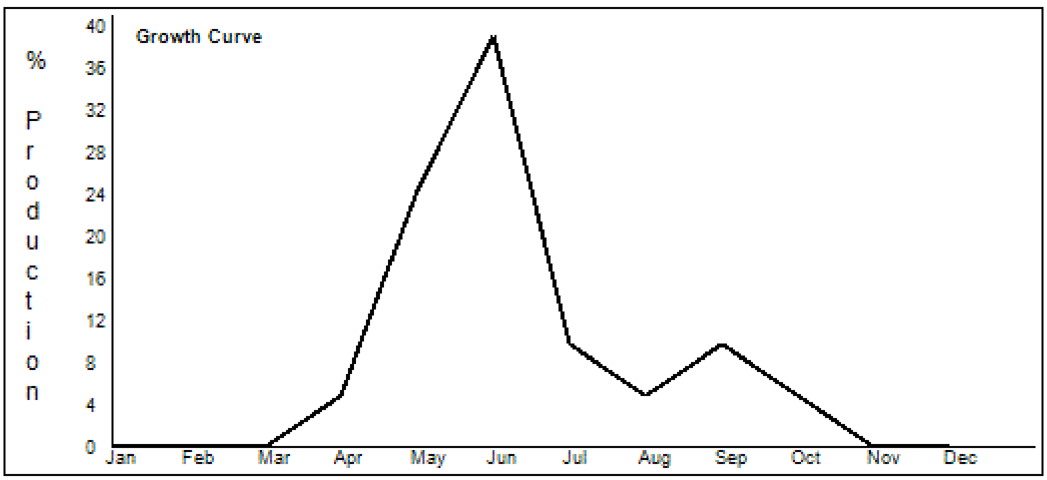
• Brush management, followed by frequent and severe grazing, will convert the plant community to the Blue Grama Sod Plant Community.

Plant Growth Curve

Growth curve number:	WY0701
Growth curve name:	10-14E upland sites
Growth curve description:	

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	25	40	10	5	10	5	0	0



Blue grama Sod

This plant community is the result of frequent and severe yearlong grazing, which has adversely affected the perennial grasses as well as impacted the shrub component. Other factors that can affect the shrubs include drought, heavy browsing, wildfires, and/or human brush control measures. A dense sod of blue grama with patches of threadleaf sedge dominates this state. Pricklypear cactus can become dense enough in patches so that livestock cannot graze forage growing within the cactus clumps. Big sagebrush has been reduced to small patches or in some cases removed. Rubber rabbitbrush may be the sole remaining shrub on the site.

When compared to the Historic Climax Plant Community, blue grama and threadleaf sedge,have increased. Pricklypear has invaded. All cool-season mid-grasses, forbs, and most shrubs have been greatly reduced. Production has been significantly decreased.

The total annual production (air-dry weight) of this state is about 200 pounds per acre, but it can range from about 100 lbs./acre in unfavorable years to about 300 lbs./acre in above average years.

This sod is extremely resistant to change and continued frequent and severe grazing or the removal of grazing does not seem to affect the plant composition or structure of the plant community. The biotic integrity of this state is not functional and plant diversity is extremely low. The plant vigor is significantly weakened and replacement capabilities are limited due to the reduced number of cool-season grasses.

This sod bound plant community is very resistant to water infiltration. While this sod protects the site itself, off-site areas are affected by excessive runoff that can cause rills and gully erosion. Water flow patterns are obvious in the bare ground areas and pedestalling is apparent along the sod edges. Rill channels are noticeable in the interspaces and down slope. The watershed may or may not be functioning, as runoff may affect adjoining sites.

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

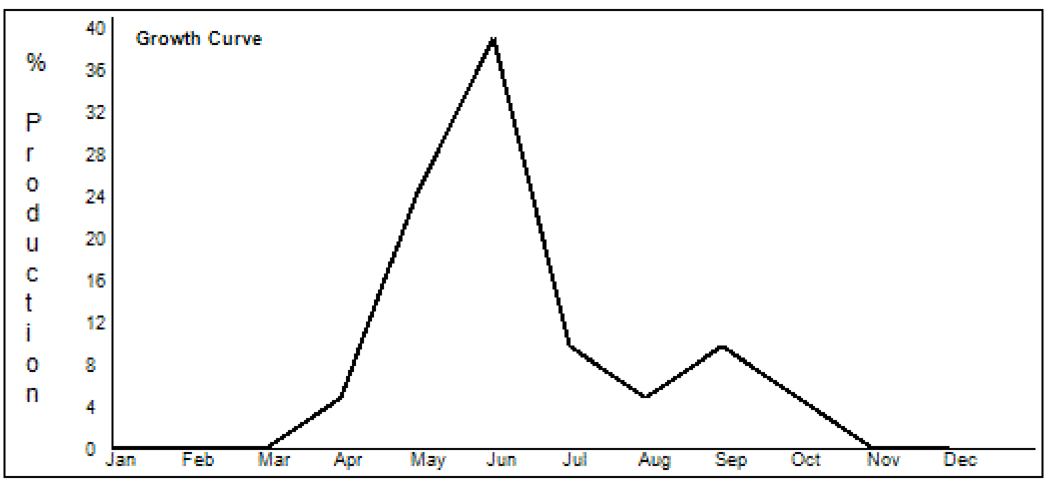
• Grazing land mechanical treatment (chiseling, etc.) and pricklypear cactus control (if needed), followed by prescribed grazing, and possibly seeding of natives will return this plant community to near Historic Climax Plant Community condition.

Plant Growth Curve

Growth curve number:	WY0701
Growth curve name:	10-14E upland sites
Growth curve description:	

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	25	40	10	5	10	5	0	0



Salt Tolerant Shrub/ Bare Ground

This plant community can occur on sites subjected to frequent and severe grazing and on soils influenced by elevated amounts of soluble salts. Salt tolerant shrubs replace Wyoming big sagebrush as the major overstory species while the preferred cool season grasses have been eliminated or greatly reduced. Bare ground and weedy grasses and forbs dominate the understory.

This state is dominated by an overstory of salt tolerant shrubs, such as greasewood, birdfoot sagebrush and saltbushes, which can vary widely in their composition and production. The leaves of some of these plants contain high amounts of sodium and other salts, and when shed these soluble salts are transferred to the soils underneath the plants. Consequently, the soil can exhibit wide variations in soluble salts, which can explain the variation in shrub composition. Big sagebrush and rubber rabbitbrush are present but are mostly in small patches.

Perennial cool season mid-grasses have been removed leaving mostly patches of blue grama and annuals. Cheatgrass and weedy annual forbs such as halogeton, Russian thistle, and kochia, will occupy the site if a seed source is available. Noxious weeds such as Russian knapweed may also invade the site. Plant diversity is moderate to poor.

When compared to the HCPC, grass production has diminished but is off set by the increase in shrub production. The interspaces between plants have expanded leaving the amount of bare ground more prevalent. Surface salts have increased, especially on sites dominated by greasewood and saltbushes.

The total annual production (air-dry weight) of this state is about 450 pounds per acre, but it can range from about 250 lbs./acre in unfavorable years to about 550 lbs./acre in above average years.

This plant community is resistant to change. These areas are actually more resistant to fire as less fine fuels are available and the bare ground between the shrubs has increased. Continued frequent and severe grazing does not affect the composition or structure of the plant community. Plant diversity is moderate to poor. The biotic integrity of this state is mostly dysfunctional because of the predominant salt tolerant shrub overstory and absence of perennial cool-season grasses.

Soil erosion is accelerated because of increased bare ground. Water flow patterns and pedestalling are obvious. Infiltration is reduced and runoff is increased. Rill channels may be noticeable in the interspaces and gullies may be establishing where rills have concentrated down slope.

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

• Prescribed grazing or possibly long-term prescribed grazing, will convert this plant community to the Salt Tolerant Shrub/Rhizomatous Wheatgrass Plant community. Recovery to near Historic Climax Plant Community condition is difficult to impossible due to the resistance of these shrubs to herbicides and other brush management techniques. In addition, the increase in surface salts has had accumulated effects on the soil so most of the herbaceous plants associated with the HCPC are no longer suitable for this site. The most notable exception is the rhizomatous wheatgrasses and bottlebrush squirreltail. Soil remediation to reduce the surface salts is not recommended, as this is mostly ineffective and extremely costly. Seeding more salt-tolerant native grasses and forbs will improve the productivity of site and plant cover.

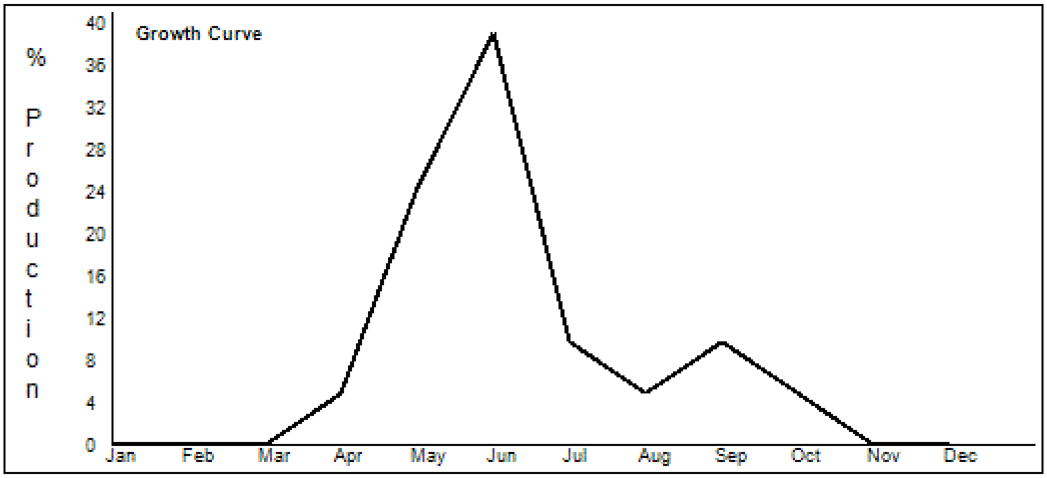
Plant Growth Curve

Growth curve number:	WY0701
Growth curve name:	10-14E upland sites
Growth curve description:	

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

0	0	0	5	25	40	10	5	10	5	0	0



Salt Tolerant Shrub/ Rhizomatous Wheatgrasses

This plant community can occur where the Salt Tolerant/Bare Ground Plant Community is rested and a prescribed grazing management practice is implemented. Salt tolerant shrubs and Wyoming big sagebrush remain a significant component of the plant community but preferred cool season grasses have reestablished.

This site is dominated by an overstory of a variety of shrubs, such as Wyoming big sagebrush, rubber rabbitbrush, greasewood, and a variety of saltbushes. Some perennial cool season mid-grasses have once again reestablished such as rhizomatous wheatgrasses and bottlebrush squirreltail. Other important grasses include prairie junegrass, Sandberg bluegrass and blue grama. Patches of annuals such as cheatgrass and other weedy annual forbs such as halogeton, Russian thistle, and kochia, will persist on this site. Noxious weeds such as Russian knapweed may also remain if not treated. The interspaces between plants will have diminished in size. When compared with the HCPC or the Perennial Grass/Big Sagebrush Plant Communities, the annual production is somewhat similar, but the plant species are mostly unique.

The total annual production (air-dry weight) of this state is about 650 pounds per acre, but it can range from about 400 lbs./acre in unfavorable years to about 800 lbs./acre in above average years.

This plant community is mostly resistant to change, but species composition can be altered through long-term overgrazing. The herbaceous component is stable, but does not include most climax species. Plant vigor and replacement capabilities are sufficient. The biotic community is not intact because of the predominant salt tolerant shrub overstory and lack of climax grass species. Plant diversity is moderate.

Soils are mostly stable and recent soil loss is minimal. This should not be confused with evidence of remnant erosion. Water flow patterns and litter movement is stable but is still occurring on steeper slopes. Incidence of pedestalling is improving. The watershed may or may not be functioning

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

• Frequent and severe grazing will convert the plant community to the Salt Tolerant Shrub/Bare Ground Plant Community.

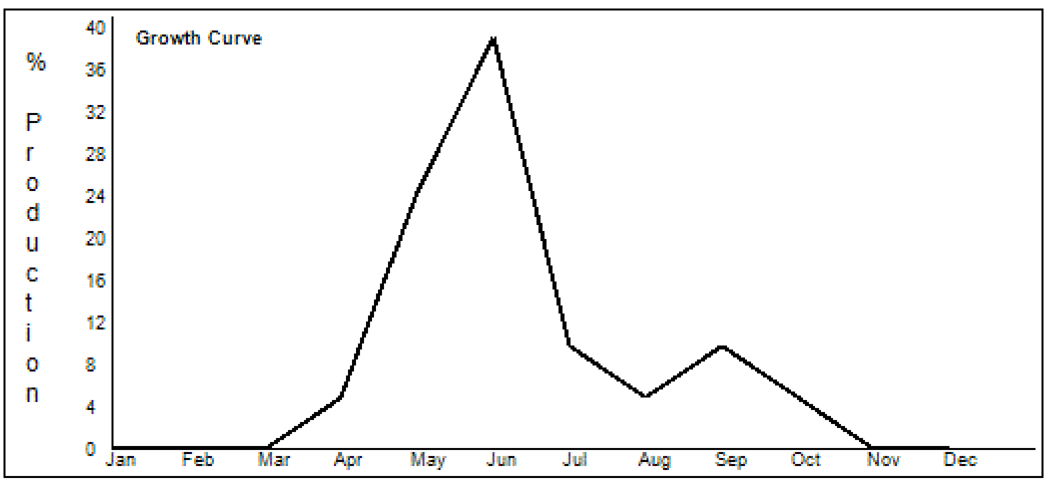
• Recovery to near Historic Climax Plant Community condition is difficult to impossible due to the resistance of these shrubs to herbicides and other brush management techniques. In addition, the increase in surface salts has had accumulated effects on the soil so most of the herbaceous plants associated with the HCPC are no longer suitable for this site. The most notable exception is the rhizomatous wheatgrasses and bottlebrush squirreltail. Soil remediation to reduce the surface salts is not recommended, as this is mostly ineffective and extremely costly. Seeding more salt-tolerant grasses and forbs will improve the productivity of site and plant cover, but will not improve the biotic integrity.

Plant Growth Curve

Growth curve number:	WY0701
Growth curve name:	10-14E upland sites
Growth curve description:	

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	25	40	10	5	10	5	0	0



Section II: Ecological Site Interpretations

Animal Community

Animal Community – Wildlife Interpretations
Bluebunch Wheatgrass/Rhizomatous Wheatgrasses (HCPC): The predominance of grasses in this plant community favors grazers and mixed-feeders, such as bison, elk, and antelope. Suitable thermal and escape cover for deer may be limited due to the low quantities of woody plants. However, topographical variations could provide some escape cover. When found adjacent to sagebrush dominated states, this plant community may provide brood rearing/foraging areas for

sage grouse, as well as lek sites. Other birds that would frequent this plant community include western meadowlarks, horned larks, and golden eagles. Many grassland obligate small mammals would occur here.

Perennial Grass/Big Sagebrush Plant Community: The combination of an overstory of sagebrush and an understory of grasses and forbs provide a very diverse plant community for wildlife. The crowns of sagebrush tend to break up hard crusted snow on winter ranges, so mule deer and antelope may use this state for foraging and cover year-round, as would cottontail and jack rabbits. It provides important winter, nesting, brood-rearing, and foraging habitat for sage grouse. Brewer's sparrows' nest in big sagebrush plants and hosts of other nesting birds utilize stands in the 20-30% cover range.

Big Sagebrush/Bare Ground Plant Community: This plant community can provide important winter foraging for elk, mule deer and antelope, as sagebrush can approach 15% protein and 40-60% digestibility during that time. This community provides excellent escape and thermal cover for large ungulates, as well as nesting habitat for sage grouse.

Blue Grama Sod Plant Community: These communities provide limited foraging for antelope and other grazers. They may be used as a foraging site by sage grouse if proximal to woody cover and if the Historic Climax Plant Community or the Perennial Grass/ Big Sagebrush Plant Community is limited. Generally, these are not target plant communities for wildlife habitat management.

Salt Tolerant Shrub/Bare Ground Plant Community: This plant community exhibits a low level of plant species diversity due to the accumulation of salts near the soil surface. It may provide some thermal and escape cover for deer and antelope if no other woody community is nearby, but in most cases, it is not a desirable plant community to select as a wildlife habitat management objective.

Salt Tolerant Shrub/Rhizomatous Wheatgrass Plant Community: The combination of an overstory of sagebrush and an understory of grasses and forbs provide a diverse plant community for wildlife. The crowns of these shrubs tend to break up hard crusted snow on winter ranges, so mule deer and antelope may use this state for foraging and cover year-round, as would cottontail and jack rabbits. It provides important winter nesting, brood-rearing, and foraging habitat for sage grouse and other upland birds. Brewer's sparrows' nest in big sagebrush plants and hosts of other nesting birds utilize stands in the 20-30% cover range.

Animal Community – Grazing Interpretations

The following table lists suggested stocking rates for cattle under continuous season-long grazing under normal growing conditions. These are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. Often, the current plant composition does not entirely match any particular plant community (as described in this ecological site description). Because of this, a field visit is recommended, in all cases, to document plant composition and production. More precise carrying capacity estimates should eventually be calculated using this information along with animal preference data, particularly when grazers other than cattle are involved. Under more intensive grazing management, improved harvest efficiencies can result in an increased carrying capacity. If distribution problems occur, stocking rates must be reduced to maintain plant health and vigor.

Plant Community Production Carrying Capacity*
(lb./ac) (AUM/ac)
Bluebunch Wheatgrass/ Rhizomatous Wheatgrasses 500-1100 .40
Perennial Grass/Big Sagebrush 400-900 .30

Big Sagebrush/Bare Ground 300-700 .20
Blue Grama Sod 100-300 .10
Salt Tolerant Shrub/Bare Ground 250-550 .13
Salt Tolerant Shrub/Rhizomatous Wheatgrasses 400-800 .22

* - Continuous, season-long grazing by cattle under average growing conditions.

Grazing by domestic livestock is one of the major income-producing industries in the area. Rangeland in this area may provide yearlong forage for cattle, sheep, or horses. During the dormant period, the forage for livestock use needs to be supplemented with protein because the quality does not meet minimum livestock requirements.

Plant Preference by Animal Kind

Animal kind: ALL antelope

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
agoseris	*Agoseris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
textile onion	*Allium textile*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
threeawn	*Aristida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
birdfoot sagebrush	*Artemisia pedatifida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Fendler threeawn	*Aristida purpurea var. longiseta*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
big sagebrush	*Artemisia tridentata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
milkvetch	*Astragalus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fourwing saltbush	*Atriplex canescens*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
shadscale saltbush	*Atriplex confertifolia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Gardner's saltbush	*Atriplex gardneri*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
blue grama	*Bouteloua gracilis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	*Carex aquatilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
		Entire												

golden sedge	Carex aurea	plant	U	U	U	U	U	U	U	U	U	U	U	U
threadleaf sedge	Carex filifolia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland sedge	Carex interior	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
prairie sandreed	Calamovilfa longifolia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Nebraska sedge	Carex nebrascensis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sedge	Carex	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beaked sedge	Carex rostrata	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pond water-starwort	Callitriche stagnalis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Indian paintbrush	Castilleja	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Douglas rabbitbrush	Chrysothamnus viscidiflorus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
pale bastard toadflax	Comandra umbellata subsp. pallida	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
tufted hairgrass	Deschampsia caespitosa	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
larkspur	Delphinium	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland saltgrass	Distichlis spicata	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Canada wildrye	Elymus canadensis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bottlebrush squirreltail	Elymus elymoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	Elymus lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	Elymus lanceolatus subsp. lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	Elymus trachycaulus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
horsetail	Equisetum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
fleabane	Erigeron	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
buckwheat	Eriogonum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
rubber rabbitbrush	Ericameria nauseosa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
aster	Eucephalus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spiny hopsage	Grayia spinosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

needle and thread	Hesperostipa comata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
iris	Iris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Baltic rush	Juncus balticus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Rocky Mountain juniper	Juniperus scopulorum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
prairie Junegrass	Koeleria macrantha	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
winterfat	Krascheninnikovia lanata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
basin wildrye	Leymus cinereus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
biscuitroot	Lomatium	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
tufted evening-primrose	Oenothera caespitosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
nailwort	Paronychia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	Pascopyrum smithii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beardtongue	Penstemon	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	Phlox	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
bud sagebrush	Picrothamnus desertorum	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal kind: all antelope

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
	Poa juncifolia	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal kind: ALL antelope

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
cottonwood	Populus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
alkali bluegrass	Poa secunda	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	Pseudoroegneria spicata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Nuttall's alkaligrass	Puccinellia nuttalliana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
skunkbush sumac	Rhus trilobata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Woods' rose	Rosa woodsii var. woodsii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

dock	Rumex	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	Salix	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
greasewood	Sarcobatus vermiculatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	Sedum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver buffaloberry	Shepherdia argentea	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
blue-eyed grass	Sisyrinchium	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: All antelope

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
alkali sacaton	Sporobolus airoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal kind: ALL antelope

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
scarlet globemallow	Sphaeralcea coccinea	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sand dropseed	Sporobolus cryptandrus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: all antelope

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
alkali cordgrass	Spartina gracilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: ALL antelope

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
princesplume	Stanleya	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
stemless four-nerve daisy	Tetraneuris acaulis var. acaulis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arrowgrass	Triglochin	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
salsify	Tragopogon porrifolius	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
false carrot	Turgenia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
woodyaster	Xylorhiza	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
yucca	Yucca	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal kind: ALL cattle

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	Achnatherum hymenoides	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
agoseris	Agoseris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
textile onion	Allium textile	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	Antennaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	Artemisia cana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threeawn	Aristida	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	Artemisia nova	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
birdfoot sagebrush	Artemisia pedatifida	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Fendler threeawn	Aristida purpurea var. longiseta	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
big sagebrush	Artemisia tridentata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
milkvetch	Astragalus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fourwing saltbush	Atriplex canescens	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
shadscale saltbush	Atriplex confertifolia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Gardner's saltbush	Atriplex gardneri	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
blue grama	Bouteloua gracilis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	Carex aquatilis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
golden sedge	Carex aurea	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threadleaf sedge	Carex filifolia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland sedge	Carex interior	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
prairie sandreed	Calamovilfa longifolia	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nebraska sedge	Carex nebrascensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
sedge	Carex	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beaked sedge	Carex rostrata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pond water-starwort	Callitriche stagnalis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Indian paintbrush	Castilleja	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Douglas rabbitbrush	Chrysothamnus viscidiflorus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pale bastard toadflax	Comandra umbellata subsp. pallida	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
tufted hairgrass	Deschampsia caespitosa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
larkspur	Delphinium	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland saltgrass	Distichlis spicata	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Canada wildrye	Elymus canadensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
bottlebrush squirreltail	Elymus elymoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	Elymus lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	Elymus lanceolatus subsp. lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	Elymus trachycaulus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
horsetail	Equisetum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
fleabane	Erigeron	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
buckwheat	Eriogonum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
rubber rabbitbrush	Ericameria nauseosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
aster	Eucephalus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spiny hopsage	Grayia spinosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
needle and thread	Hesperostipa comata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
iris	Iris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Baltic rush	Juncus balticus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Rocky Mountain juniper	Juniperus scopulorum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
prairie Junegrass	Koeleria macrantha	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
winterfat	Krascheninnikovia lanata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
basin wildrye	Leymus cinereus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

biscuitroot	Lomatium	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
tufted evening-primrose	Oenothera caespitosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
nailwort	Paronychia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	Pascopyrum smithii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beardtongue	Penstemon	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	Phlox	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
bud sagebrush	Picrothamnus desertorum	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal kind: all cattle

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
	Poa juncifolia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal kind: ALL cattle

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
cottonwood	Populus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
alkali bluegrass	Poa secunda	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	Pseudoroegneria spicata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nuttall's alkaligrass	Puccinellia nuttalliana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
skunkbush sumac	Rhus trilobata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Woods' rose	Rosa woodsii var. woodsii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dock	Rumex	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	Salix	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
greasewood	Sarcobatus vermiculatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	Sedum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver buffaloberry	Shepherdia argentea	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
blue-eyed grass	Sisyrinchium	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: All cattle

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
alkali sacaton	Sporobolus airoides	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal kind: ALL cattle

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
scarlet globemallow	Sphaeralcea coccinea	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sand dropseed	Sporobolus cryptandrus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal kind: all cattle

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
alkali cordgrass	Spartina gracilis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal kind: ALL cattle

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
princesplume	Stanleya	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
stemless four-nerve daisy	Tetraneuris acaulis var. acaulis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arrowgrass	Triglochin	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
salsify	Tragopogon porrifolius	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
false carrot	Turgenia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
woodyaster	Xylorhiza	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
yucca	Yucca	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal kind: ALL deer

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	Achnatherum hymenoides	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
agoseris	Agoseris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
textile onion	Allium textile	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	Antennaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	Artemisia cana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
threeawn	Aristida	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
		Entire												

black sagebrush	Artemisia nova	plant	P	P	P	P	P	P	P	P	P	P	P	P
birdfoot sagebrush	Artemisia pedatifida	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Fendler threeawn	Aristida purpurea var. longiseta	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
big sagebrush	Artemisia tridentata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
milkvetch	Astragalus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fourwing saltbush	Atriplex canescens	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
shadscale saltbush	Atriplex confertifolia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Gardner's saltbush	Atriplex gardneri	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
blue grama	Bouteloua gracilis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	Carex aquatilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
golden sedge	Carex aurea	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
threadleaf sedge	Carex filifolia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland sedge	Carex interior	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
prairie sandreed	Calamovilfa longifolia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Nebraska sedge	Carex nebrascensis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sedge	Carex	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beaked sedge	Carex rostrata	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pond water-starwort	Callitriche stagnalis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Indian paintbrush	Castilleja	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Douglas rabbitbrush	Chrysothamnus viscidiflorus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
pale bastard toadflax	Comandra umbellata subsp. pallida	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
tufted hairgrass	Deschampsia caespitosa	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
larkspur	Delphinium	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland saltgrass	Distichlis spicata	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Canada wildrye	Elymus canadensis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

bottlebrush squirreltail	Elymus elymoides	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
streambank wheatgrass	Elymus lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	Elymus lanceolatus subsp. lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	Elymus trachycaulus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
horsetail	Equisetum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
fleabane	Erigeron	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
buckwheat	Eriogonum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
rubber rabbitbrush	Ericameria nauseosa	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	Eucephalus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spiny hopsage	Grayia spinosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
needle and thread	Hesperostipa comata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
iris	Iris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Baltic rush	Juncus balticus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Rocky Mountain juniper	Juniperus scopulorum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
prairie Junegrass	Koeleria macrantha	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
winterfat	Krascheninnikovia lanata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
basin wildrye	Leymus cinereus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
biscuitroot	Lomatium	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
tufted evening-primrose	Oenothera caespitosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
nailwort	Paronychia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	Pascopyrum smithii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beardtongue	Penstemon	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	Phlox	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
bud sagebrush	Picrothamnus desertorum	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal kind: all deer

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
	Poa juncifolia	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal kind: ALL deer

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
cottonwood	*Populus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
alkali bluegrass	*Poa secunda*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	*Pseudoroegneria spicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Nuttall's alkaligrass	*Puccinellia nuttalliana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
skunkbush sumac	*Rhus trilobata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Woods' rose	*Rosa woodsii var. woodsii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dock	*Rumex*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	*Salix*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
greasewood	*Sarcobatus vermiculatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	*Sedum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver buffaloberry	*Shepherdia argentea*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
blue-eyed grass	*Sisyrinchium*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: All deer

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
alkali sacaton	*Sporobolus airoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal kind: ALL deer

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
scarlet globemallow	*Sphaeralcea coccinea*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sand dropseed	*Sporobolus cryptandrus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: all deer

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
		Entire												

alkali cordgrass	*Spartina gracilis*	plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: ALL deer

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
princesplume	*Stanleya*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
stemless four-nerve daisy	*Tetraneuris acaulis var. acaulis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arrowgrass	*Triglochin*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
salsify	*Tragopogon porrifolius*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
false carrot	*Turgenia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
woodyaster	*Xylorhiza*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
yucca	*Yucca*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal kind: ALL horses

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
agoseris	*Agoseris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
textile onion	*Allium textile*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threeawn	*Aristida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
birdfoot sagebrush	*Artemisia pedatifida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Fendler threeawn	*Aristida purpurea var. longiseta*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
big sagebrush	*Artemisia tridentata*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
milkvetch	*Astragalus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fourwing saltbush	*Atriplex canescens*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
shadscale saltbush	*Atriplex confertifolia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Gardner's		Entire												

saltbush	Atriplex gardneri	plant	D	D	D	D	D	D	D	D	D	D	D	D
blue grama	Bouteloua gracilis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	Carex aquatilis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
golden sedge	Carex aurea	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threadleaf sedge	Carex filifolia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland sedge	Carex interior	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
prairie sandreed	Calamovilfa longifolia	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nebraska sedge	Carex nebrascensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
sedge	Carex	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beaked sedge	Carex rostrata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pond water-starwort	Callitriche stagnalis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Indian paintbrush	Castilleja	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Douglas rabbitbrush	Chrysothamnus viscidiflorus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale bastard toadflax	Comandra umbellata subsp. pallida	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
tufted hairgrass	Deschampsia caespitosa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
larkspur	Delphinium	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland saltgrass	Distichlis spicata	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Canada wildrye	Elymus canadensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
bottlebrush squirreltail	Elymus elymoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	Elymus lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	Elymus lanceolatus subsp. lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	Elymus trachycaulus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
horsetail	Equisetum	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
fleabane	Erigeron	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
buckwheat	Eriogonum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

rubber rabbitbrush	Ericameria nauseosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
aster	Eucephalus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spiny hopsage	Grayia spinosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
needle and thread	Hesperostipa comata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
iris	Iris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Baltic rush	Juncus balticus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Rocky Mountain juniper	Juniperus scopulorum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
prairie Junegrass	Koeleria macrantha	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
winterfat	Krascheninnikovia lanata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
basin wildrye	Leymus cinereus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
biscuitroot	Lomatium	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
tufted evening-primrose	Oenothera caespitosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
nailwort	Paronychia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	Pascopyrum smithii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beardtongue	Penstemon	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	Phlox	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
bud sagebrush	Picrothamnus desertorum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal kind: all horses

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
	Poa juncifolia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal kind: ALL horses

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
cottonwood	Populus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
alkali bluegrass	Poa secunda	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	Pseudoroegneria spicata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Nuttall's alkaligrass	Puccinellia nuttalliana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
skunkbush sumac	Rhus trilobata	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Woods' rose	Rosa woodsii var. woodsii	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
dock	Rumex	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	Salix	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
greasewood	Sarcobatus vermiculatus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
stonecrop	Sedum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver buffaloberry	Shepherdia argentea	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
blue-eyed grass	Sisyrinchium	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: All horses

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
alkali sacaton	Sporobolus airoides	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal kind: ALL horses

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
scarlet globemallow	Sphaeralcea coccinea	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sand dropseed	Sporobolus cryptandrus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal kind: all horses

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
alkali cordgrass	Spartina gracilis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal kind: ALL horses

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
princesplume	Stanleya	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
stemless four-nerve daisy	Tetraneuris acaulis var. acaulis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arrowgrass	Triglochin	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
salsify	Tragopogon porrifolius	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
false carrot	Turgenia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

woodyaster	Xylorhiza	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
yucca	Yucca	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: ALL sheep

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	Achnatherum hymenoides	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
agoseris	Agoseris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
textile onion	Allium textile	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	Antennaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	Artemisia cana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threeawn	Aristida	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	Artemisia nova	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
birdfoot sagebrush	Artemisia pedatifida	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Fendler threeawn	Aristida purpurea var. longiseta	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
big sagebrush	Artemisia tridentata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
milkvetch	Astragalus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fourwing saltbush	Atriplex canescens	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
shadscale saltbush	Atriplex confertifolia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Gardner's saltbush	Atriplex gardneri	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
blue grama	Bouteloua gracilis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	Carex aquatilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
golden sedge	Carex aurea	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threadleaf sedge	Carex filifolia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland sedge	Carex interior	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
prairie sandreed	Calamovilfa longifolia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Nebraska sedge	Carex nebrascensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

sedge	Carex	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beaked sedge	Carex rostrata	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pond water-starwort	Callitriche stagnalis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Indian paintbrush	Castilleja	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Douglas rabbitbrush	Chrysothamnus viscidiflorus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pale bastard toadflax	Comandra umbellata subsp. pallida	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
tufted hairgrass	Deschampsia caespitosa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
larkspur	Delphinium	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland saltgrass	Distichlis spicata	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Canada wildrye	Elymus canadensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
bottlebrush squirreltail	Elymus elymoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	Elymus lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	Elymus lanceolatus subsp. lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	Elymus trachycaulus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
horsetail	Equisetum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
fleabane	Erigeron	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
buckwheat	Eriogonum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
rubber rabbitbrush	Ericameria nauseosa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
aster	Eucephalus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spiny hopsage	Grayia spinosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
needle and thread	Hesperostipa comata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
iris	Iris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Baltic rush	Juncus balticus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Rocky Mountain juniper	Juniperus scopulorum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

prairie Junegrass	Koeleria macrantha	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
winterfat	Krascheninnikovia lanata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
basin wildrye	Leymus cinereus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
tufted evening-primrose	Oenothera caespitosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
nailwort	Paronychia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	Pascopyrum smithii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beardtongue	Penstemon	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	Phlox	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
bud sagebrush	Picrothamnus desertorum	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal kind: all sheep

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
	Poa juncifolia	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal kind: ALL sheep

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
cottonwood	Populus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
alkali bluegrass	Poa secunda	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	Pseudoroegneria spicata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nuttall's alkaligrass	Puccinellia nuttalliana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
skunkbush sumac	Rhus trilobata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Woods' rose	Rosa woodsii var. woodsii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dock	Rumex	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	Salix	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
greasewood	Sarcobatus vermiculatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	Sedum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver buffaloberry	Shepherdia argentea	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

blue-eyed grass	Sisyrinchium	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: All sheep

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
alkali sacaton	Sporobolus airoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal kind: ALL sheep

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
scarlet globemallow	Sphaeralcea coccinea	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sand dropseed	Sporobolus cryptandrus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal kind: all sheep

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
alkali cordgrass	Spartina gracilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: ALL sheep

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
princesplume	Stanleya	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
stemless four-nerve daisy	Tetraneuris acaulis var. acaulis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arrowgrass	Triglochin	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
salsify	Tragopogon porrifolius	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
false carrot	Turgenia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
woodyaster	Xylorhiza	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
yucca	Yucca	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Legend: P=Preferred; D=Desirable; U=Undesirable; N=Not consumed; E=Emergency; T=Toxic; X=Used, but degree of utilization unknown

Hydrology Functions

Water is the principal factor limiting forage production on this site. This site is dominated by soils in hydrologic group B and C, with localized areas in hydrologic group D. Infiltration ranges from moderately slow to moderate. Runoff potential for this site varies from low to moderate depending on soil hydrologic group and ground cover. In many cases, areas with greater than 75% ground cover have the greatest potential for high infiltration and lower runoff. An example of an exception would be where short-grasses form a strong sod and dominate the site. Areas where ground cover is less than 50% have the greatest potential to have reduced infiltration and higher runoff (refer to Part 630, NRCS National Engineering Handbook for detailed hydrology information).

Rills and gullies should not typically be present. Water flow patterns should be barely distinguishable if at all present. Pedestals are only slightly present in association with bunchgrasses. Litter typically falls in place, and signs of movement are not common. Chemical and physical crusts are rare to non-existent. Cryptogamic crusts are present, but only cover 1-2% of the soil surface.

Recreational Uses

This site provides hunting opportunities for upland game species. The wide varieties of plants which bloom from spring until fall have an esthetic value that appeals to visitors.

Wood Products

No appreciable wood products are present on the site.

Other Products

none noted

Supporting Information

Associated Sites

Site name	Site ID	Site narrative
Clayey (Cy)	R032XY304WY	
Lowland (LL)	R032XY328WY	
Sandy (Sy)	R032XY350WY	
Shallow Loamy (SwLy)	R032XY362WY	

Similar Sites

Site name	Site ID	Site narrative
Loamy (Ly)	R032XY122WY	
Loamy (Ly)	R032XY222WY	

State Correlation

This site has been correlated with the following states: WY

Inventory Data References

Information presented here has been derived from NRCS inventory data. Field observations from range trained personnel were also used. Those involved in developing this site include: Chris Krassin, Range Management Specialist, NRCS and Everet Bainter, Range Management Specialist. Other sources used as references include USDA NRCS Water and Climate Center, USDA NRCS National Range and Pasture Handbook, USDI and USDA Interpreting Indicators of Rangeland Health Version 3, and USDA NRCS Soil Surveys from various counties.

Site Authors

D. Tranas

Quality Assurance

Provisional Status Verified in Legacy System

Reference Sheet

Author(s)/participant(s): Ray Gullion, E. Bainter

Contact for lead author: ray.gullion@wy.usda.gov or 307-347-2456

Date: 5/1/2008 **MLRA:** 032X **Ecological Site:** Loamy (Ly) 10-14" East Precipitation Zone R032XY322WY This *must* be verified based on soils and climate (see Ecological Site Description). Current plant community cannot be used to identify the ecological site.

Composition (indicators 10 and 12) based on: X Annual Production, Foliar Cover, Biomass

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Indicators. For each indicator, describe the potential for the site. Where possible, (1) use numbers, (2) include expected range of values for above- and below-average years for **each** community and natural distrurbance regimes within the reference state, when appropriate and (3) cite data. Continue descriptions on separate sheet.

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1. **Number and extent of rills:** Rare to nonexistent. Where present, short and widely spaced.

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2. **Presence of water flow patterns:** Barely observable.

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3. **Number and height of erosional pedestals or terracettes:** Rare to nonexistent.

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, standing dead, lichen, moss, plant canopy are not bare ground):** Bare ground can range from 10-30%.

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5. **Number of gullies and erosion associated with gullies:** Active gullies should not be present.

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6. **Extent of wind scoured, blowouts and/or depositional areas:** Rare to nonexistent.

7. **Amount of litter movement (describe size and distance expected to travel):** Herbaceous litter expected to move only in small amounts (to leeward side of shrubs). Large woody debris from sagebrush will show no movement.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil Stability Index ratings range from 1 (interspaces) to 6 (under plant canopy), but average values should be 3.0 or greater.

9. **Soil surface structure and SOM content (include type and strength of structure, and A-horizon color and thickness):** Soil data is limited for this site. Described A-horizons vary from 1-12 inches (3-30 cm) with OM of 1 to 2%.

10. **Effect on plant community composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Plant community consists of 55-75% grasses, 15% forbs, and 10-30% shrubs. Evenly distributed plant canopy (50-75%) and litter plus moderate to moderately rapid infiltration rates result in minimal runoff. Basal cover is typically less than 5% for this site and does very little to effect runoff on this site.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None

12. **Functional/Structural Groups (list in order of descending dominance by above-ground weight using symbols: >>, >, = to indicate much greater than, greater than, and equal to) with dominants and sub-dominants and "others" on separate lines:**
    Dominant: Mid-size, cool season bunchgrasses>> perennial shrubs=cool season rhizomatous grasses>>perennial forbs>short cool season bunchgrasses
    Sub-dominant:
    Other:
    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Minimal decadence, typically associated with shrub component.

14. **Average percent litter cover (30 - 70%) and depth (.1 - .4inches):** Litter ranges from 5-30% of total canopy measurement with total litter (including beneath the plant canopy) from 30-70% expected. Herbaceous litter depth typically ranges from 3-10mm. Woody litter can be up to a couple inches (4-6 cm).

15. **Expected annual production (this is TOTAL above-ground production, not just forage production):** English: 500-1100 lb/ac (800 lb/ac average); Metric 560-1232 kg/ha (896 kg/ha average).

16. **Potential invasive (including noxious) species (native and non-native). List Species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicator, we are describing what is NOT expected in the reference state for the ecological site:** Bare ground greater than 50% is the most common indicator of a threshold being crossed. Blue grama, Sandberg bluegrass, big sagebrush, buckwheat, and phlox are common increasers. Annual weeds such as kochia, mustards, lambsquarter, and Russian thistle are common invasive species in disturbed sites.

17. **Perennial plant reproductive capability:** All species are capable of reproducing, except in drought years.

Reference Sheet Approval

Approval	Date
E. Bainter	5/1/2008

United States Department of Agriculture Natural Resources Conservation Service Ecological Site Description

Section I: Ecological Site Characteristics

Ecological Site Identification and Concept

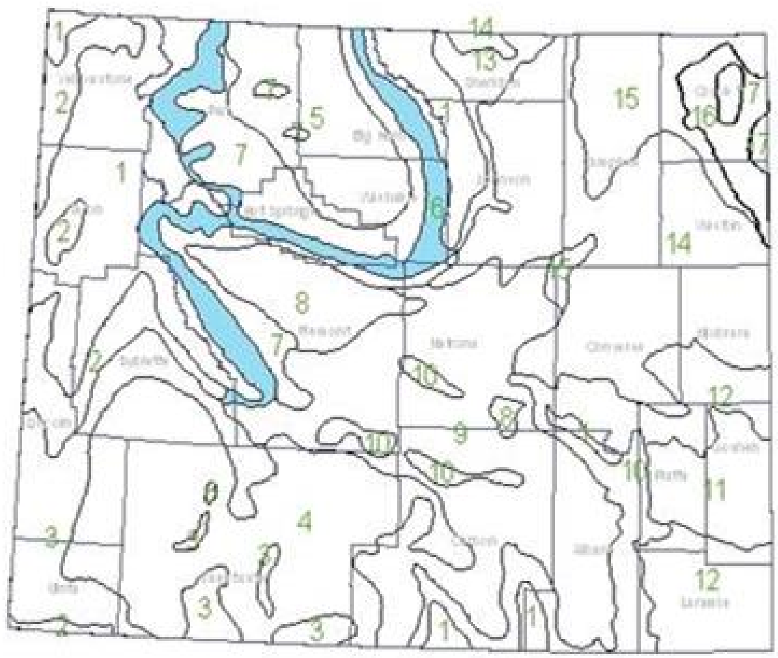
Site stage: Provisional

Provisional: an ESD at the provisional status represents the lowest tier of documentation that is releasable to the public. It contains a grouping of soil units that respond similarly to ecological processes. The ESD contains 1) enough information to distinguish it from similar and associated ecological sites and 2) a draft state and transition model capturing the ecological processes and vegetative states and community phases as they are currently conceptualized. The provisional ESD has undergone both quality control and quality assurance protocols. It is expected that the provisional ESD will continue refinement towards an approved status.

Site name: Loamy (Ly) 15-19” Foothills and Mountains East Precipitation Zone

Site type: Rangeland
Site ID: R043BY322WY
Major land resource area (MLRA): 043B-Central Rocky Mountains

Precipitation Zones for Rangeland Ecological Site Descriptions



Physiographic Features

This site typically occurs on gently undulating rolling land, but can occur on steeper gradual slopes.

Landform: (1) Hill
(2) Alluvial fan
(3) Ridge

	Minimum	Maximum
Elevation (feet):	6000	9000
Slope (percent):	0	30
Flooding		
Frequency:	None	None
Ponding		
Depth (inches):	0	0
Frequency:	None	None
Runoff class:	Negligible	High
Aspect:	No Influence on this site	

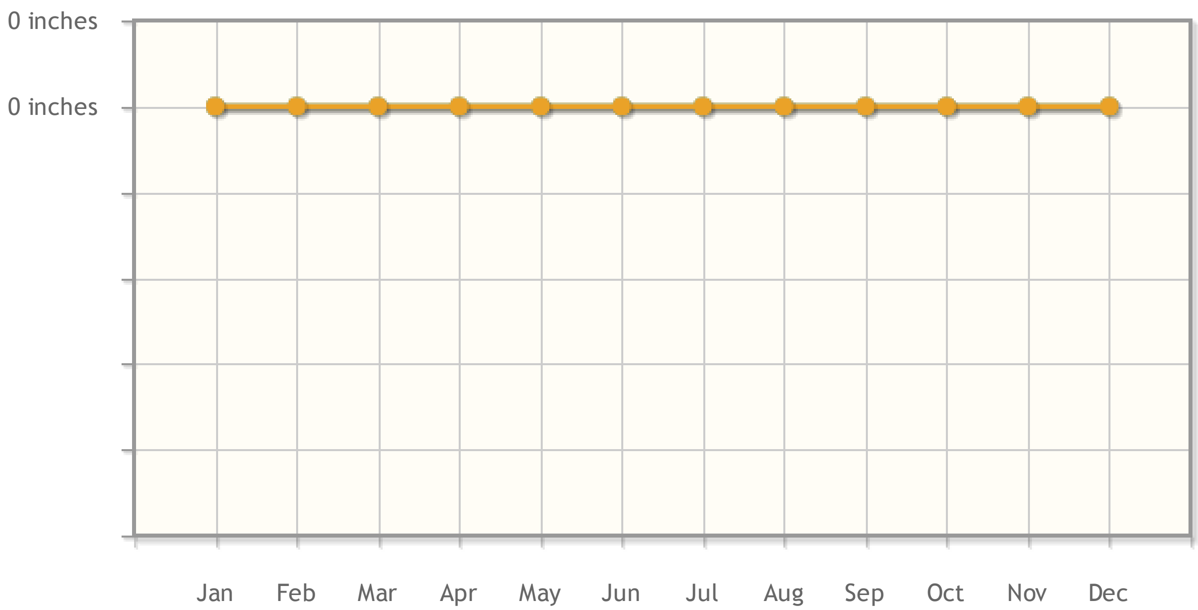
Climatic Features

Annual precipitation ranges from 15-19 inches per year. June is generally the wettest month. July, August, and September are somewhat less with daily amounts rarely exceeding one inch. Snowfall is quite heavy in the area. Annual snowfall averages about 150 inches. Because of the varied topography, the wind will vary considerably for different parts of the area. The wind is usually much lighter at the lower elevations and in the valleys as compared with the higher terrain. The average winter wind velocity is 8.5 mph while the summer wind velocity averages 7.5 mph. Winds during storms and on ridges may exceed 45 mph. Growth of native cool-season plants begins about May 1 to May 15 and continues to about October 10. The following information is from the “Crandall Creek” climate station, at the lower end of this precipitation zone: Minimum Maximum 5 yrs. out of 10 between Frost-free period (days): 16 80 July 8 – August 20 Freeze-free period (days): 37 120 June 17 – September 5 Mean Annual Precipitation (inches): 10.24 21.23 Mean annual precipitation: 14.90 inches Mean annual air temperature: 38.16 F (21.88 F Avg. Min. to 54.66 F Avg. Max.) For detailed information, visit the Natural Resources Conservation Service National Water and Climate Center at http://www.wcc.nrcs.usda.gov/ website. There are no other climate station(s) known to be representative of this precipitation zone.

	Averaged
Frost-free period (days):	48
Freeze-free period (days):	78
Mean annual precipitation (inches):	19.00

Monthly Precipitation (Inches):

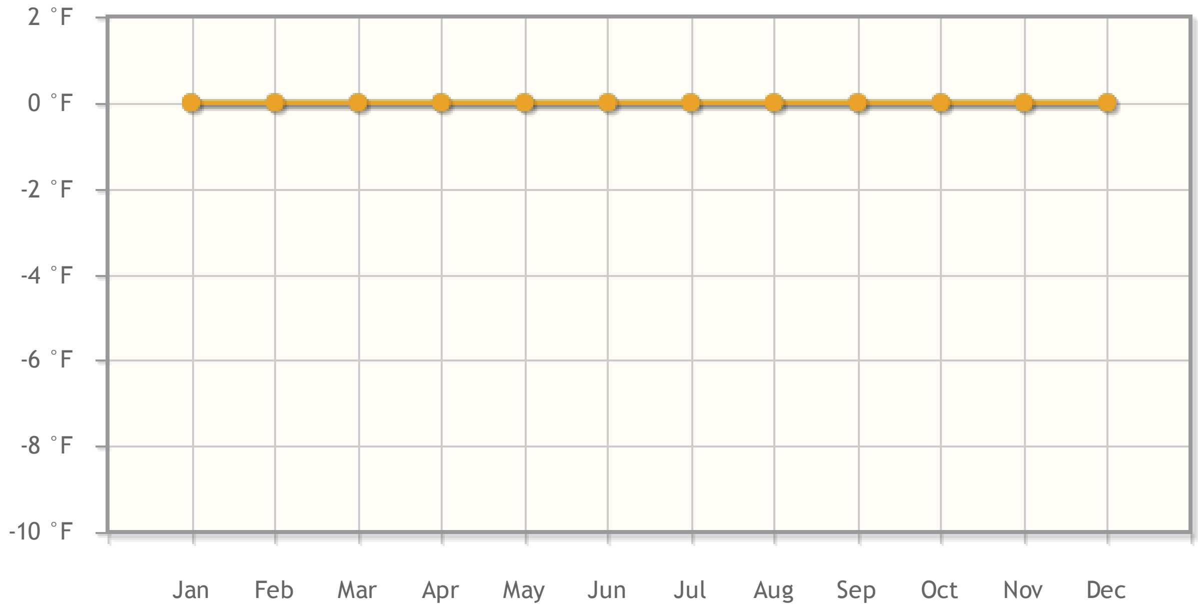
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Low	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00



Monthly Temperature (°F):

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Low	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



Influencing Water Features

Stream type: None

Representative Soil Features

The soils of this site are deep to moderately deep (greater than 20" to bedrock), moderately well to well-drained & moderately slow to moderately permeable. The surface soil will vary from 3" to 6" in thickness depending on the texture and permeability of the subsoil. The soil characteristic having the most influence on the plant community is the available moisture and depth to a root restrictive barrier.

Surface texture: (1) Loam
(2) Silt loam
(3) Very fine sandy loam

Subsurface texture group: Loamy

	Minimum	Maximum
Surface fragments <=3" (% cover):	0	0
Surface fragments >3" (% cover):	0	10
Subsurface fragments <=3" (% volume):	0	15
Subsurface fragments >3" (% volume):	0	10

Drainage class: Moderately well drained to well drained

Permeability class: Moderately slow to moderate

	Minimum	Maximum
Depth (inches):	20	60
Available water capacity (inches):	3.00	6.30
Electrical conductivity (mmhos/cm):	0	4
Sodium adsorption ratio:	0	5
Calcium carbonate equivalent (percent):	0	10
Soil reaction (1:1 water):	6.6	8.4

Plant Communities

Ecological Dynamics of the Site

Ecological Dynamics of the Site:
Potential vegetation on this site is dominated by mid cool-season perennial grasses. Other significant vegetation includes big sagebrush, rubber rabbitbrush, and a variety of forbs. The expected potential composition for this site is about 75% grasses, 15% forbs and 10% woody plants. The composition and production will vary naturally due to historical use, fluctuating precipitation and fire frequency.

As this site deteriorates species such as big sagebrush, rubber rabbitbrush, and bluegrasses will increase. Cool season grasses such as Columbia needlegrass, spikefescue, and Idaho fescue will decrease in frequency and production. As conditions deteriorate further, annuals such as cheatgrass will invade.

Big sagebrush may become dominant on areas with an absence of fire and a sufficient amount of precipitation. Wildfires are actively controlled in recent times and as a result old decadent stands of big sagebrush persist. Chemical and mechanical controls have replaced the historic role of fire on this site. Recently, prescribed burning has regained some popularity.

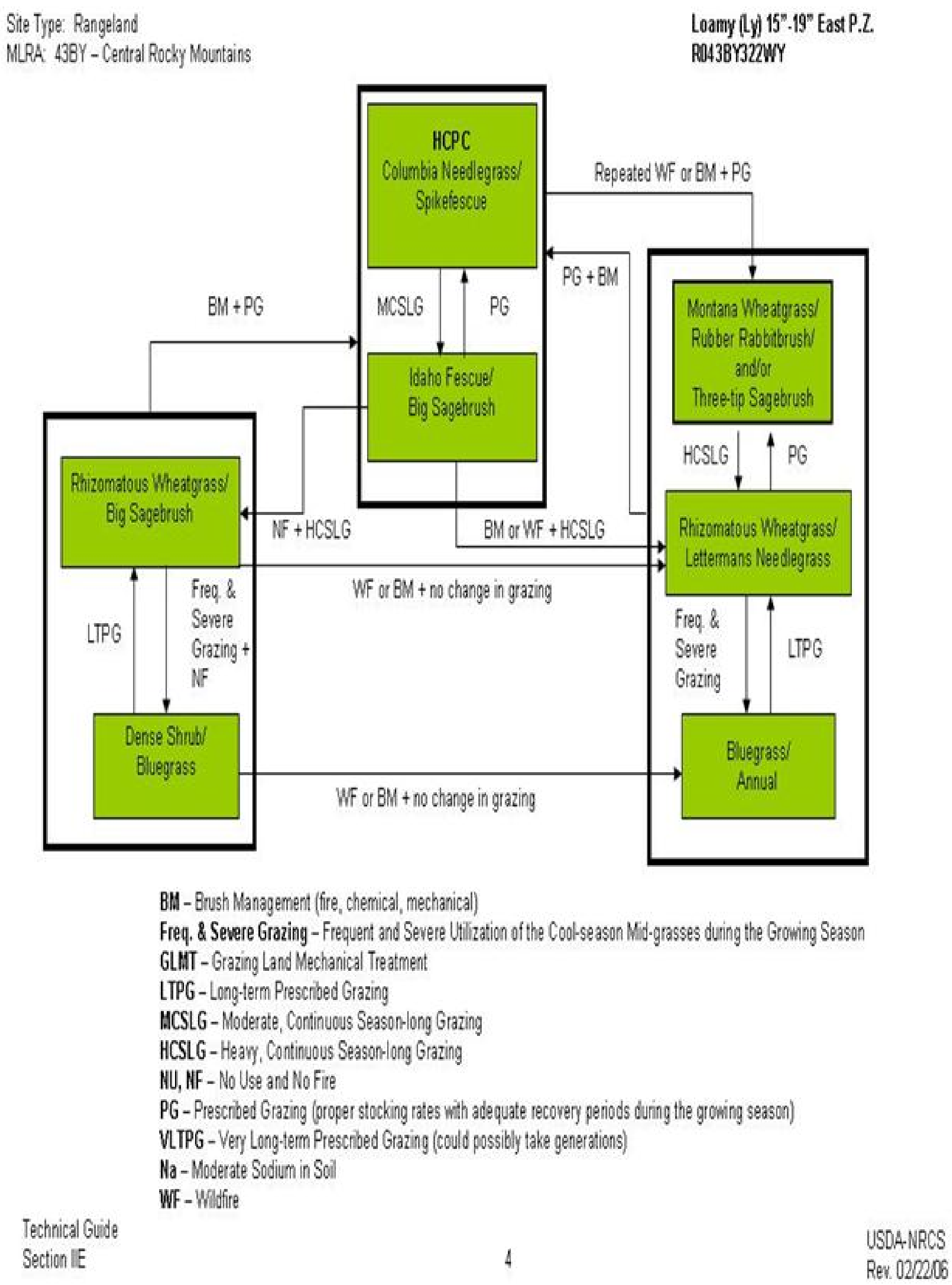
The big sagebrush component may not be as resilient once it has been removed or severely reduced, if a vigorous stand of grass exists and is maintained. The exception to this is where the herbaceous component is severely degraded at the time of treatment, growing conditions are unfavorable after treatment, and/or recovery of herbaceous species are inadequate due to poor grazing management. Regeneration of big sagebrush may also be suppressed if three-tip sagebrush and rubber rabbitbrush are established. This situation is more likely to develop in areas where fires have occurred in a relatively short cycle. Three-tip sagebrush and rubber rabbitbrush are strong resprouters and will out compete other shrubs where a site is disturbed. Any thinning project should be designed in a way to maintain the viability of the stand and to consider wildlife requirements.

The Historic Climax Plant Community (description follows the plant community diagram) has been determined by study of rangeland relic areas, or areas protected from excessive disturbance. Trends in plant communities going from heavily grazed areas to lightly grazed areas, seasonal use pastures, and historical accounts have also been used.

The following is a State and Transition Model Diagram that illustrates the common plant communities (states) that can occur on the site and the transitions between these communities.

The ecological processes will be discussed in more detail in the plant community narratives following the diagram.

State-and-Transition Diagram



Columbia Needlegrass/Spikefescue Plant Community

The interpretive plant community for this site is the Historic Climax Plant Community. This state

The interpretive plant community for this site is the Historic Climax Plant Community. This state evolved with grazing by large herbivores and periodic fires. Potential vegetation is about 75% grasses or grass-like plants, 15% forbs, and 10% woody plants. This plant community can be found on areas that are properly managed with grazing and/or prescribed burning, and on areas receiving periods of rest. The cyclical nature of the fire regime in this community prevents big sagebrush from being the dominant landscape.

Cool season midgrasses dominate the site. The major grasses include Columbia needlegrass, spikefescue, Idaho fescue, and bluebunch wheatgrass. Big sagebrush is a conspicuous element of this site, occurs in a mosaic pattern, and makes up 5 to 10% of the annual production. Natural fire occurred in this community and prevented sagebrush from being the dominant landscape. A variety of forbs also occurs in this state and plant diversity is high (see Plant Composition Table).

Annual production on this site ranges from 1100 to 1600 pounds depending on climatic conditions.

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

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

• Moderate, continuous season-long grazing will convert the plant community to the Idaho Fescue/Big Sagebrush Plant Community.

• Repeated Wild Fire or Brush Management + Prescribed Grazing will convert the HCPC to the Montana Wheatgrass/Rubber Rabbitbrush and/or Three-tip Sagebrush Plant Community.

Columbia Needlegrass/Spikefescue Plant Community Plant Species Composition

Grass/Grasslike

Group	Group name	Common name	Symbol	Scientific name	Annual Production (pounds per acre) Low	High
1					135	338
		Columbia needlegrass	ACNE9	*Achnatherum nelsonii*	135	338
2					135	338
		kingspike fescue	LEKI2	*Leucopoa kingii*	135	338
3					135	338
		Idaho fescue	FEID	*Festuca idahoensis*	135	338
4					68	203
		bluebunch wheatgrass	PSSP6	*Pseudoroegneria spicata*	68	203
5					135	338
		Grass, perennial	2GP		0	68
		Letterman's needlegrass	ACLE9	*Achnatherum lettermanii*	0	68
		nodding brome	BRAN	*Bromus anomalus*	0	68
		Pumpelly's brome	BRINP5	*Bromus inermis var. pumpellianus*	0	68
		mountain brome	BRMA4	*Bromus marginatus*	0	68

		mountain brome	BRMA4	Bromus marginatus	0	68
		sedge	CAREX	Carex	0	68
		California danthonia	DACA3	Danthonia californica	0	68
		onespike danthonia	DAUN	Danthonia unispicata	0	68
		Montana wheatgrass	ELAL7	Elymus albicans	0	68
		slender wheatgrass	ELTR7	Elymus trachycaulus	0	68
		needle and thread	HECO26	Hesperostipa comata	0	68
		prairie Junegrass	KOMA	Koeleria macrantha	0	68
		western wheatgrass	PASM	Pascopyrum smithii	0	68
			POAM	Poa ampla	0	68
			POCA	Poa canbyi	0	68
		mutton bluegrass	POFE	Poa fendleriana	0	68
		alkali bluegrass	POSE	Poa secunda	0	68
		spike trisetum	TRSP2	Trisetum spicatum	0	68

Forb

Group	Group name	Common name	Symbol	Scientific name	Annual Production (pounds per acre) Low	High
6 -null					68	203
		Forb, perennial	2FP		0	68
		yarrow	ACHIL	Achillea	0	68
		agoseris	AGOSE	Agoseris	0	68
		pussytoes	ANTEN	Antennaria	0	68
		milkvetch	ASTRA	Astragalus	0	68
		balsamroot	BALSA	Balsamorhiza	0	68
		corn gromwell	BUAR3	Buglossoides arvensis	0	68
		Indian paintbrush	CASTI2	Castilleja	0	68
		field chickweed	CEAR4	Cerastium arvense	0	68
		tapertip hawksbeard	CRAC2	Crepis acuminata	0	68
		buckwheat	ERIOG	Eriogonum	0	68
		green gentian	FRASE	Frasera	0	68
		common sneezeweed	HEAU	Helenium autumnale	0	68
		flax	LINUM	Linum	0	68
		wild bergamot	MOFI	Monarda fistulosa	0	68
		lousewort	PEDIC	Pedicularis	0	68
		beardtongue	PENST	Penstemon	0	68
		phlox	PHLOX	Phlox	0	68
		silky phacelia	PHSE	Phacelia sericea	0	68
		American vetch	VIAM	Vicia americana	0	68
		mule-ears	WYETH	Wyethia	0	68

Shrub/Vine

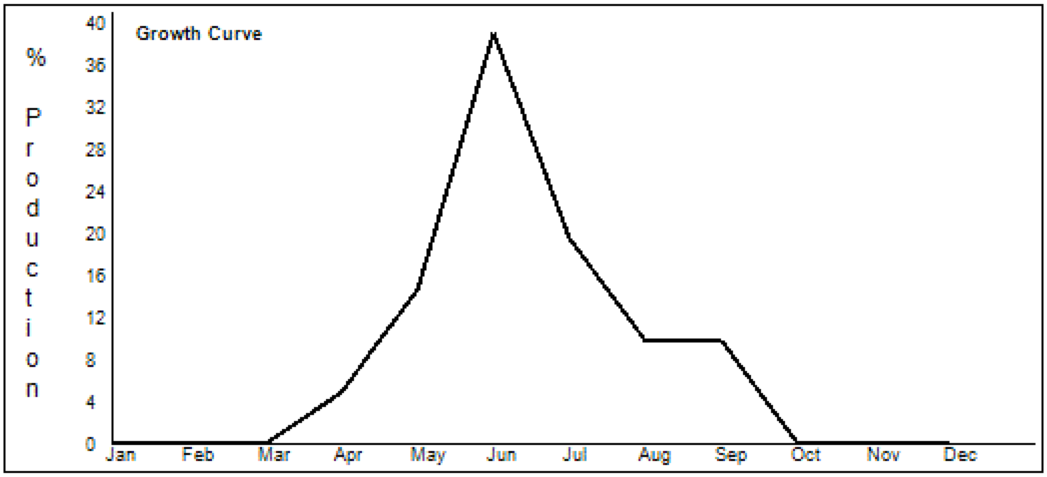
Group	Group name	Common name	Symbol	Scientific name	Annual Production (pounds per acre) Low	High
7					0	135
		big sagebrush	ARTR2	Artemisia tridentata	0	135
8					0	68
		rubber rabbitbrush	ERNA10	Ericameria nauseosa	0	68
9					0	68
		Shrub (>.5m)	2SHRUB		0	68

Plant Growth Curve

Growth curve number:	WY0601
Growth curve name:	15-19E all upland sites
Growth curve description:	

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	15	40	20	10	10	0	0	0



Idaho Fescue/Big Sagebrush Plant Community

Historically, this plant community evolved under grazing by large ungulates and a low fire frequency. Currently, this site is normally found under a moderate, season-long grazing regime and will be exacerbated by prolonged drought conditions. In addition, the fire regime for this site has been modified and extended periods without fire is now common. Big sagebrush is an important component of this plant community. Cool-season grasses make up the majority of the understory with the balance made up of miscellaneous forbs.

Dominant grasses include Idaho fescue and bluebunch wheatgrass and of less frequency Columbia needlegrass and spikefescue. Grasses of secondary importance include prairie junegrass, rhizomatous wheatgrasses, bluegrasses, and spike trisetum. Forbs commonly found in this plant community include agoseris, balsamroot, phlox, buckwheat, pussytoes, hawksbeard, paintbrush, and western yarrow. Sagebrush and rubber rabbitbrush make up to 20% of the total annual production.

When compared to the Historical Climax Plant Community, big sagebrush, rubber rabbitbrush, rhizomatous wheatgrasses, and bluegrasses have increased. Columbia needlegrass and spikefescue have decreased, often occurring only where protected from grazing by the sagebrush canopy. Some weedy species such as cheatgrass and annual forbs may have invaded the site but are in small patches.

This state produces between 1000 and 1500 pounds annually, depending on the growing conditions.

This plant community is resistant to change. The herbaceous species present are well adapted to grazing; however, species composition can be altered through long-term overgrazing. The herbaceous component is mostly intact and plant vigor and replacement capabilities are sufficient. Water flow patterns and litter movement may be occurring but only on steeper slopes. Incidence of pedestalling is minimal. Soils are mostly stable and the surface shows minimum soil loss. The watershed is functioning and the biotic community is intact.

Transitions or pathways leading to other plant communities are as follows:
• Prescribed grazing will convert this plant community to the HCPC. The probability of this occurring is high especially if rotational grazing along with short deferred grazing is implemented as part of the prescribed method of use. In addition, the removal of fire suppression will allow a somewhat natural fire regime to reoccur to more easily transition between this plant community and the HCPC. A prescribed fire treatment can be useful to hasten this transition if desired.

• Heavy, continuous, season-long grazing plus no fires will convert the plant community to the Rhizomatous Wheatgrass/ Big Sagebrush Plant Community. The probability of this occurring is high. This is especially evident on areas where drought or heavy browsing does not adversely impact the shrub stand.

• Heavy, continuous, season-long grazing plus wildfire or brush management, will convert the plant community to a Rhizomatous Wheatgrass/Lettermans Needlegrass Plant Community. The probability for this is high, especially on areas were the shrubs have been heavily browsed or removed by natural or human causes. Drought can also exacerbate this transition.

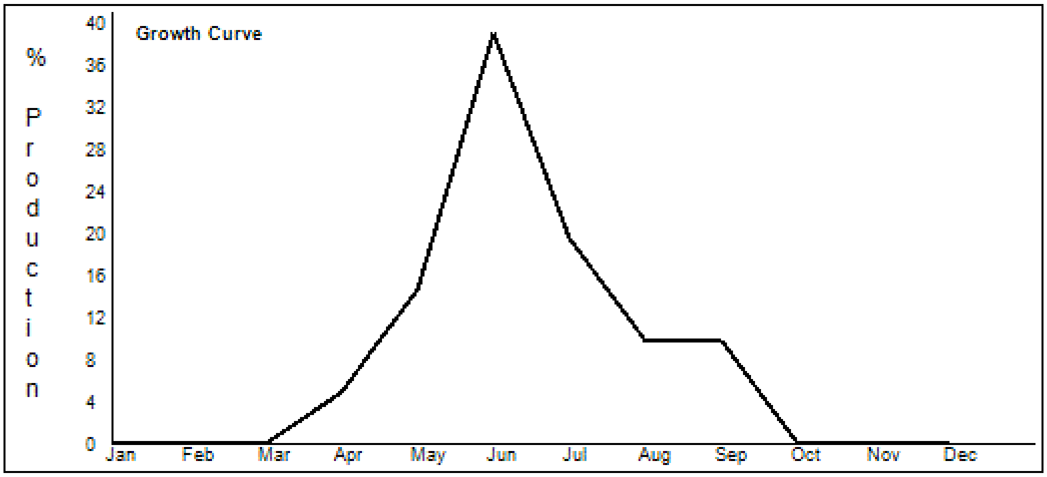
• Repeated Wild Fire or Brush Management plus Prescribed Grazing will convert the this plant community to the Montana Wheatgrass/Rubber Rabbitbrush and/or Three-tip Sagebrush Plant Community.

Plant Growth Curve

Growth curve number:	WY0601
Growth curve name:	15-19E all upland sites
Growth curve description:	

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	15	40	20	10	10	0	0	0



Rhizomatous Wheatgrass/Big Sagebrush Plant Community

This plant community currently is found under heavy continuous season-long grazing by livestock and protection from fire. Big sagebrush is a significant component of this plant community although rubber rabbitbrush may be as abundant. Cool-season grasses make up the majority of the understory, but some of the preferred grasses have been reduced or are absent.

Dominant grasses include rhizomatous wheatgrasses, Lettermans needlegrass, bluegrasses, and of less frequency Columbia needlegrass, spikefescue, Idaho fescue and bluebunch wheatgrass. Grasses of secondary importance include prairie junegrass, slender wheatgrass, spike trisetum and native bromes. Forbs commonly found in this plant community include balsamroot, hawksbeard, paintbrush, groundsel, buckwheat, phlox, lupine, larkspur, sneezeweed, pussytoes, and American vetch. Big Sagebrush and rubber rabbitbrush can make up to 30% of the total annual production.

When compared to the Historic Climax Plant Community, big sagebrush, rubber rabbitbrush, bluegrasses, Lettermans needlegrass, and rhizomatous wheatgrasses have increased. Most of the preferred grasses have been reduced and some are absent. Some annuals, such as cheatgrass, as well as noxious weeds such as leafy spurge have invaded the site, but are not yet abundant.

Annual production ranges from 800 to 1300 pounds.

This plant community is resistant to change as the shrubs become more abundant. These areas may actually be more resistant to fire as less fine fuels are available and the bare ground between the shrubs is increased. The herbaceous component is not as diverse and plant vigor and species regeneration capabilities of some cool-season perennials are deficient. The removal of grazing does not seem to affect the plant composition or structure of the plant community.

Soil erosion is accelerated because of increased bare ground. Water flow patterns and pedestalling is more noticeable. Infiltration is reduced and runoff is increased. Rill channels may be noticeable in the interspaces on steeper areas and gullies may be establishing where rills have concentrated down slope.

Transitions or pathways leading to other plant communities are as follows:
• Prescribed grazing plus brush management will convert this plant community to near HCPC. If prescribed fire is used as a means to reduce or remove the shrubs, sufficient fine fuels will need to be present. This may require deferment from grazing prior to treatment. Post management is critical to ensure success. This can range from two or more years of rest to partial growing season deferment, depending on the condition of the understory at the time of treatment and the growing

conditions following treatment. Seeding will be required regardless of the brush treatment to reestablish the major cool-season grasses.

• Frequent and severe grazing plus no fires will convert the plant community to the Dense Shrub/Bluegrass Plant Community. The probability of this occurring is high and is especially evident on areas where drought or heavy browsing does not adversely impact the shrub stand.

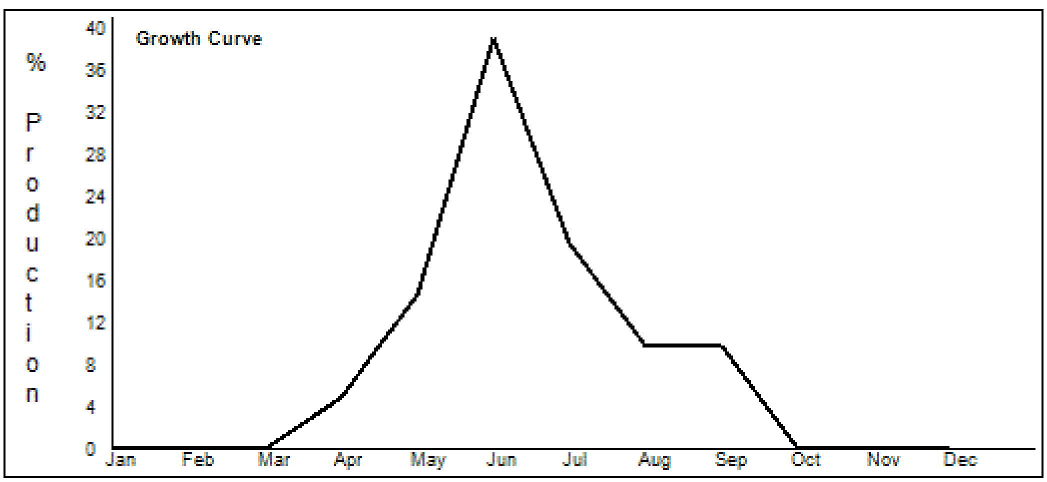
• Brush management or Wildfire with no change in grazing management will convert this plant community to the Rhizomatous Wheatgrass/Lettermans Needlegrass Plant Community.

Plant Growth Curve

Growth curve number:	WY0601
Growth curve name:	15-19E all upland sites
Growth curve description:	

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	15	40	20	10	10	0	0	0



Dense Shrub/Bluegrass Plant Community

This plant community is the result of frequent and severe grazing and protection from fire. Big sagebrush and rubber rabbitbrush are the dominant shrubs of this plant community as the annual production will exceed 30%. Preferred cool season grasses have been eliminated or greatly reduced. The interspaces between plants have expanded leaving the amount of bare ground more prevalent and more soil surface exposed to erosive elements.

Bluegrasses such as Sandberg, mutton, big, and Canby dominate the understory. Weedy annual species such as cheatgrass, kochia, Russian thistle, and a variety of mustards may occupy the site. Noxious weeds such as Canada thistle and leafy spurge may invade the site if a seed source is available. When compared with the HCPC the annual production is less, as the major cool-season grasses are reduced, but the shrub production has increased significantly and compensates for some of the decline in the herbaceous production.

some of the decline in the herbaceous production.

Annual production ranges from 700 to 1000 pounds.

This plant community is resistant to change as the stand becomes more decadent. These areas may actually be more resistant to fire as less fine fuels are available and the bare ground between the shrubs is increased. The herbaceous component is not as diverse and plant vigor and species regeneration capabilities of cool-season perennials are deficient. The removal of grazing does not seem to affect the plant composition or structure of the plant community.

Soil erosion is accelerated because of increased bare ground. Water flow patterns and pedestalling are obvious. Infiltration is reduced and runoff is increased. Rill channels may be noticeable in the interspaces and gullies may be establishing where rills have concentrated down slope.

Transitions or pathways leading to other plant communities are as follows:
• Prescribed grazing plus brush management will convert this plant community to near HCPC. If prescribed fire is used as a means to reduce or remove the shrubs, sufficient fine fuels will need to be present. This may require deferment from grazing prior to treatment. Post management is critical to ensure success. This can range from two or more years of rest to partial growing season deferment, depending on the condition of the understory at the time of treatment and the growing conditions following treatment. Seeding will be required regardless of the brush treatment to reestablish the major cool-season grasses.

• Long-term prescribed grazing will convert this plant community to the Rhizomatous Wheatgrass/Big Sagebrush Plant Community.

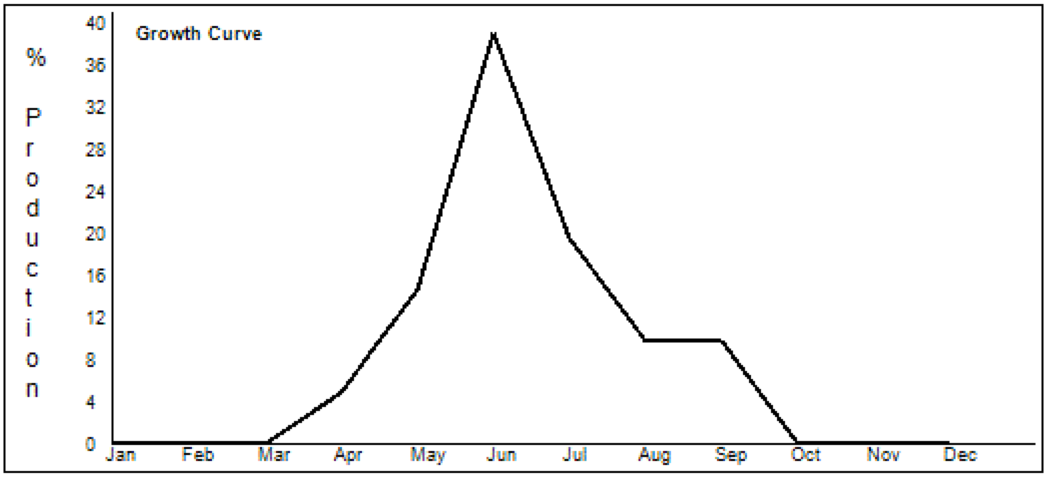
• Brush management or Wildfire with no change in grazing management will convert this plant community to the Bluegrass/Annual Plant Community.

Plant Growth Curve

Growth curve number:	WY0601
Growth curve name:	15-19E all upland sites
Growth curve description:	

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	15	40	20	10	10	0	0	0



Montana Wheatgrass/Rubber Rabbitbrush and/or Three-tip Sagebrush Plant Community

This plant community currently is found under prescribed grazing or possibly no use by livestock and is perpetuated by a fire cycle that maintains the removal of big sagebrush. Rubber rabbitbrush and three-tip sagebrush are significant components of this plant community. Cool-season grasses remain an important component, but some bunchgrasses are not as abundant.

Dominant grasses include Montana wheatgrass, Lettermans needlegrass, and rhizomatous wheatgrasses, and of less frequency Columbia needlegrass, Idaho fescue, bluebunch wheatgrass, and spikefescue. Grasses of secondary importance include prairie junegrass, slender wheatgrass, spike trisetum, and bluegrasses. Forbs commonly found in this plant community include balsamroot, paintbrush, phlox, groundsel, penstemon, larkspur, lupine, pussytoes, hawksbeard, and American vetch. Rubber rabbitbrush and/or three-tip sagebrush can comprise as much as 25% of the total production.

When compared to the Historical Climax Plant Community, Montana wheatgrass, rhizomatous wheatgrasses, three-tip sagebrush and rubber rabbitbrush have increased. Columbia needlegrass, bluebunch wheatgrass, spikefescue, and Idaho fescue have decreased. Production of cool-season grasses has remained about the same. Cheatgrass can be common and in large patches, but mostly invaded areas are relatively small.

Annual production ranges from 1000 to 1500 pounds.

This plant community is resistant to change as once three-tip sagebrush and rubber rabbitbrush become the dominant shrubs it is difficult for other shrubs to become established. The herbaceous species present are well adapted to grazing; however, species composition can be altered through long-term overgrazing. The herbaceous component is mostly intact and plant vigor and replacement capabilities are sufficient. Water flow patterns and litter movement may be occurring but only on steeper slopes. Incidence of pedestalling is minimal. Soils are mostly stable and the surface shows minimum soil loss. The watershed is functioning and the biotic community is intact.

Transitions or pathways leading to other plant communities are as follows:
• Prescribed grazing and brush management will convert this plant community to the HCPC. Controlling three-tip sagebrush and rubber rabbitbrush is difficult as both are strong resprouters. Reestablishing the big sagebrush stand may be difficult and may take many years.

• Heavy, continuous, season-long grazing will convert this plant community to a Rhizomatous

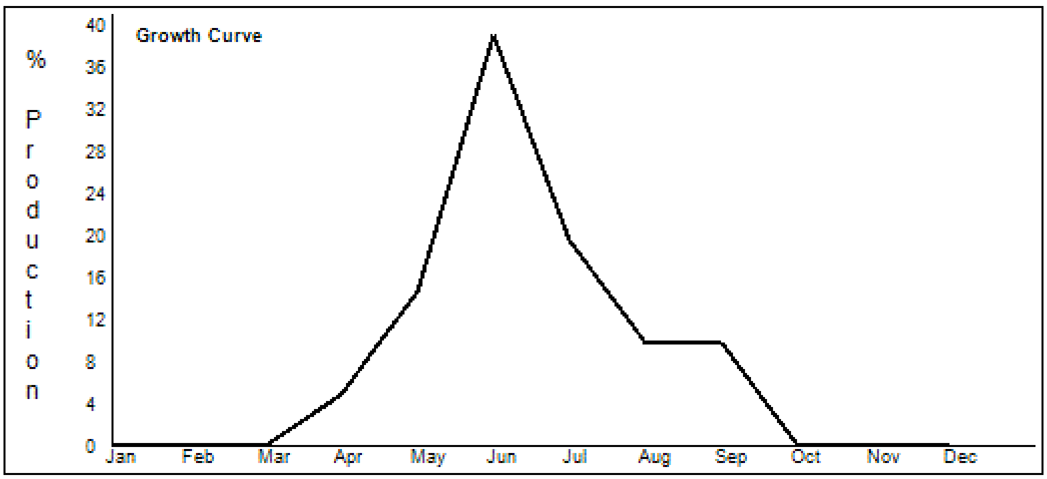
Wheatgrass/Lettermans Needlegrass Plant Community. More than likely, three-tip sage and rubber rabbitbrush will persist in varying degrees, as both are strong resprouters and difficult to control.

Plant Growth Curve

Growth curve number:	WY0601
Growth curve name:	15-19E all upland sites
Growth curve description:	

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	15	40	20	10	10	0	0	0



Rhizomatous Wheatgrass/Lettermans Needlegrass Plant Community

This plant community currently is found under heavy continuous season-long grazing by livestock and is perpetuated by either brush management or a wildfire, which removes big sagebrush from this plant community. Three-tip sagebrush and/or rubber rabbitbrush can be significant components of this plant community, but also may be lacking. Some of the major cool-season bunchgrasses have been reduced and some may have been removed.

Dominant grasses include rhizomatous wheatgrasses, Lettermans needlegrass, bluegrasses, prairie junegrass, spike trisetum, and Montana wheatgrass, and of less frequency Columbia needlegrass, Idaho fescue, bluebunch wheatgrass, and spikefescue. Forbs commonly found in this plant community include phlox, groundsel, balsamroot, paintbrush, larkspur, lupine, pussytoes, hawksbeard, and American vetch. Three-tip sagebrush and/or rubber rabbitbrush can comprise as much as 25% of the total production.

When compared to the Historical Climax Plant Community, rhizomatous wheatgrass, prairie junegrass, Montana wheatgrass, three-tip sagebrush and rubber rabbitbrush have increased. Columbia needlegrass, bluebunch wheatgrass, Idaho fescue, and big sagebrush have decreased or been removed. Production of the preferred cool-season grasses has been reduced. Cheatgrass can be common and in large patches, but mostly invaded areas are relatively small.

Annual production ranges from 700 to 1000 pounds.

This plant community is resistant to change as the herbaceous species present are well adapted to grazing and if three-tip and rubber rabbitbrush become the dominant shrubs it is difficult for other shrubs to become established. However, species composition can be altered through long-term overgrazing. The herbaceous component is mostly intact, but some cool-season bunchgrasses associated with the site have been reduced or removed. Plant vigor and replacement capabilities are sufficient for some species but not all. Water flow patterns and litter movement is occurring but only on steeper slopes. Incidence of pedestalling is moderate to slight. Soils are mostly stable and the surface shows minimum soil loss. The watershed is functioning and the biotic community is partially intact.

Transitions or pathways leading to other plant communities are as follows:
• Prescribed grazing plus brush management will convert this plant community to near HCPC. Controlling three-tip sagebrush and rubber rabbitbrush, if present, is difficult as these are strong resprouters. Reestablishing big sagebrush may be difficult and may take many years. Seeding may be required to reestablish any of the lost major bunchgrasses.

• Prescribed grazing will convert this plant community to the Montana Wheatgrass/Rubber Rabbitbrush and/or Three-tip Sagebrush Plant Community.

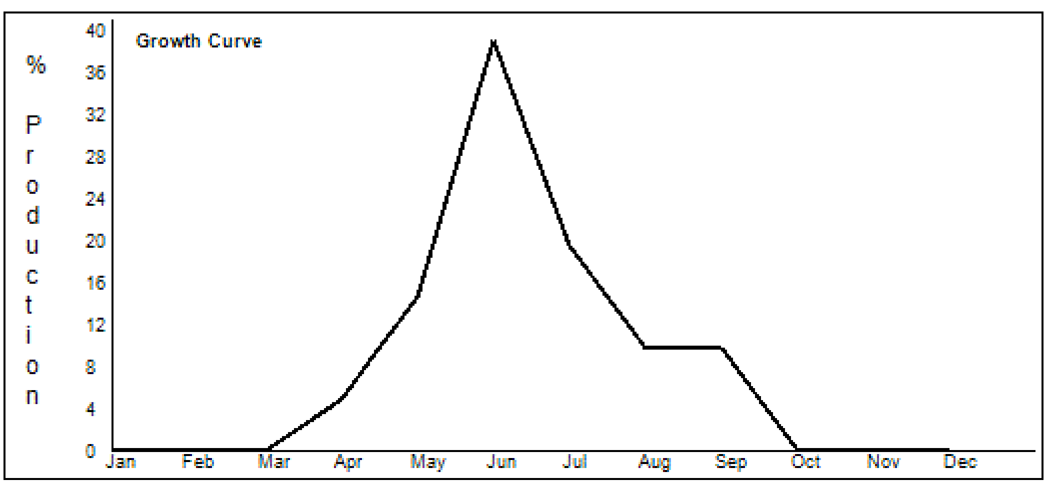
• Frequent and severe grazing will convert this plant community to a Bluegrass/Annual Plant Community. If three-tip sage and rubber rabbitbrush are present more than likely, they will persist in varying degrees as both are difficult to control.

Plant Growth Curve

Growth curve number:	WY0601
Growth curve name:	15-19E all upland sites
Growth curve description:	

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	15	40	20	10	10	0	0	0



Bluegrass/Annual Plant Community

This plant community evolved under frequent and severe heavy grazing and the big sagebrush shrub component has been removed by heavy browsing, wildfire or human means. Weedy annuals and bluegrasses are the most dominant plants and occupy any open bare ground area. Three-tip sagebrush and rubber rabbitbrush may or may not be present. However, it is common for these shrubs to occur as both are strong resprouters and may quickly re-establish the site after a disturbance.

Compared to the HCPC, weedy annual species and bluegrasses are widespread and virtually all of the major cool-season mid-grasses are absent or severely decreased. Big sagebrush has also been removed. Weedy annuals may include cheatgrass, kochia, Russian thistle, and a variety of mustards. Bluegrass species will include Sandberg, mutton, Canby, and big. Noxious weeds such as Canada thistle and leafy spurge may invade the site if a seed source is available. The interspaces between plants have expanded leaving the amount of bare ground more prevalent and more soil surface exposed to erosive elements.

Annual production ranges from 350 to 650 pounds.

This plant community is relatively stable and resistant to overgrazing. Annuals and bluegrasses are effectively competing against the establishment of perennial cool-season grasses. Plant diversity is greatly altered and the herbaceous component is not intact. Recruitment of the major perennial grasses is not occurring and the replacement potential is absent. The biotic integrity is missing.

The soils are unstable and not protected from excessive erosion. Rill channels and maybe even gullies may be present on site and adjacent areas are impacted by excessive runoff. Water flow patterns and pedestalling are obvious. The watershed is not functioning.

Transitions or pathways leading to other plant communities are as follows:
• Prescribed grazing plus brush management may convert this plant community to near HCPC, although it will require major investment and time. Controlling three-tip sagebrush and rubber rabbitbrush, if present, is difficult as both are strong resprouters. Reestablishing the big sagebrush stand may be difficult and may take many years. Seeding will be required to reestablish any of the lost major bunchgrasses.

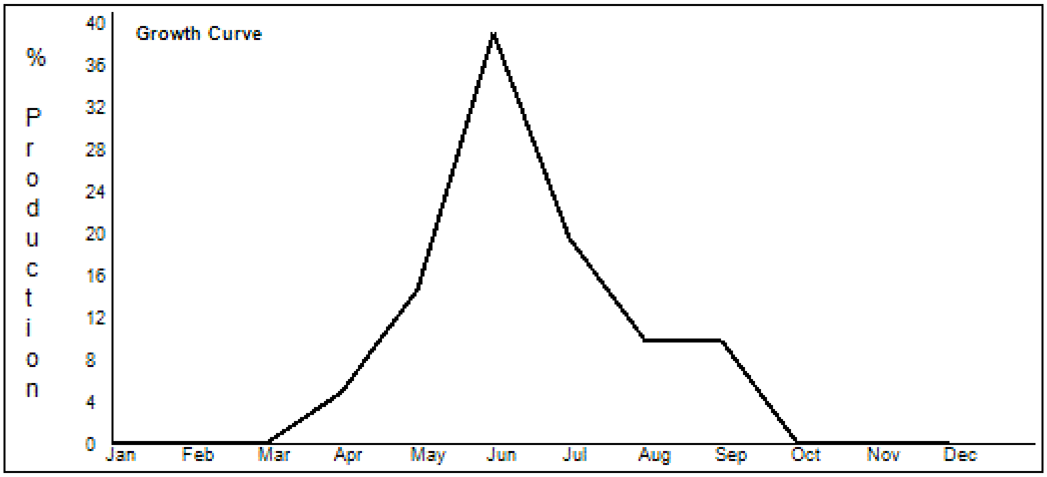
• Prescribed grazing will convert this plant community to the Rhizomatous Wheatgrass/Lettermans Needlegrass Plant Community.

Plant Growth Curve

Growth curve number:	WY0601
Growth curve name:	15-19E all upland sites
Growth curve description:	

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	15	40	20	10	10	0	0	0



Section II: Ecological Site Interpretations

Animal Community

Animal Community – Wildlife Interpretations
Columbia Needlegrass/Spikefescue Plant Community (HCPC): The predominance of grasses in this plant community favors grazers and mixed-feeders, such as deer, bison, elk, and antelope. Suitable thermal and escape cover for deer may be limited due to the low quantities of woody plants. However, topographical variations could provide some escape cover. Due to the location of these sites on the foot slopes of mountains they are valuable for elk and deer winter ranges. When found adjacent to sagebrush dominated states, this plant community may provide brood rearing/foraging areas for sage grouse, as well as lek sites. Other birds that would frequent this plant community include western meadowlark, lark bunting, sage thrasher, horned larks, red-tail and ferruginous hawks, and golden eagles. Many grassland obligate small mammals would occur here.

Idaho Fescue/Big Sagebrush Plant Community: The combination of an overstory of big sagebrush and an understory of grasses and forbs provides a very diverse plant community for wildlife. The crowns of sagebrush tend to break up hard crusted snow on winter ranges, so mule deer, elk, and antelope may use this state for foraging and cover year-round, as would cottontail and jack rabbits. It provides important winter, nesting, brood-rearing, and foraging habitat for sage grouse. Brewer's sparrows' nest in big sagebrush plants and hosts of other nesting birds utilize stands in the 20-30% cover range. Other birds that would frequent this plant community include western meadowlark, lark bunting, sage thrasher, horned larks, red-tail and ferruginous hawks, and golden eagles.

Rhizomatous Wheatgrass/Big Sagebrush Plant Community: The combination of an overstory of big sagebrush and an understory of grasses and forbs provides a very diverse plant community for wildlife. The crowns of sagebrush tend to break up hard crusted snow on winter ranges, so mule deer, elk, and antelope may use this state for foraging and cover year-round, as would cottontail and jack rabbits. It provides important winter, nesting, brood-rearing, and foraging habitat for sage grouse. Brewer's sparrows' nest in big sagebrush plants and hosts of other nesting birds utilize stands in the 20-30% cover range. Other birds that would frequent this plant community include western meadowlark, lark bunting, sage thrasher, horned larks, red-tail and ferruginous hawks, and golden eagles.

Dense Shrub/Bluegrass Plant Community: This plant community can provide important winter foraging for elk, mule deer and antelope, as sagebrush can approach 15% protein and 40-60% digestibility during that time. This community provides escape and thermal cover for large ungulates, as well as nesting and brood rearing habitat for sage grouse. Other birds that would frequent this plant community include western meadowlark, lark bunting, sage thrasher, horned larks, red-tail and ferruginous hawks, and golden eagles.
Due to the lack of herbaceous production and diversity of mid cool season grasses on this site, it is not as beneficial to grazers.

Montana Wheatgrass/Rubber Rabbitbrush and/or Three-tip Sagebrush Plant Community: The production of herbaceous species provided for good foraging to grazers. However, the lack of tall or mid growing shrubs does not benefit browsers nor provides cover for many wildlife species. As these site greens-up sooner in the spring, this site tends to provide early new growth for foraging large and small mammals. If located adjacent to shrub dominated sites, It provides good foraging habitat for sage grouse. Other birds that would frequent this plant community include western meadowlark, lark bunting, sage thrasher, horned larks, red-tail and ferruginous hawks, and golden eagles.

Rhizomatous Wheatgrass/Lettermans Needlegrass Plant Community: The production of herbaceous species provided for good foraging for grazers. However, the lack of tall or mid growing shrubs does not benefit browsers nor provides cover for many wildlife species. As these site greens-up sooner in the spring, this site tends to provide early new growth for foraging large and small mammals. If located adjacent to shrub dominated sites, It provides good foraging habitat for sage grouse.

Bluegrass/Annual Plant Community: This community provides limited foraging for elk and other grazers. They may be used as a foraging site by sage grouse if proximal to woody cover. Generally, these are not target plant communities for wildlife habitat management.

Animal Community – Grazing Interpretations

The following table lists suggested stocking rates for cattle under continuous season-long grazing under normal growing conditions. These are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. Often, the current plant composition does not entirely match any particular plant community (as described in this ecological site description). Because of this, a field visit is recommended, in all cases, to document plant composition and production. More precise carrying capacity estimates should eventually be calculated using this information along with animal preference data, particularly when grazers other than cattle are involved. Under more intensive grazing management, improved harvest efficiencies can result in an increased carrying capacity. If distribution problems occur, stocking rates must be reduced to maintain plant health and vigor.

Plant Community Production Carrying Capacity*
(lb./ac) (AUM/ac)
Columbia Needlegrass/Spikefescue 1100-1600 .6
Idaho Fescue/Big Sagebrush 1000-1500 .5
Rhizomatous WG/Big Sagebrush 800-1300 .4
Dense Shrub/Bluegrass 700-1000 .3
Montana WG/R. Rabbitbrush/Three-tip Sagebrush 1000-1500 .5
Rhizomatous WG/Lettermans Needlegrass 700-1000 .3
Bluegrass/Annual 350-650 .2

Bluegrass/Annual 300-600 .2

* - Continuous, season-long grazing by cattle under average growing conditions.

Grazing by domestic livestock is one of the major income-producing industries in the area. Rangeland in this area may provide seasonal forage for cattle, sheep, or horses. During the dormant period, the forage for livestock use needs to be supplemented with protein because the quality does not meet minimum livestock requirements.

Plant Preference by Animal Kind

Animal kind: ALL antelope

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	Achnatherum hymenoides	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	Achnatherum lettermanii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
western yarrow	Achillea millefolium var. occidentalis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Columbia needlegrass	Achnatherum nelsonii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
boxelder	Acer negundo var. interius	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	Agoseris glauca	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Saskatoon serviceberry	Amelanchier alnifolia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pussytoes	Antennaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	Artemisia cana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
sandwort	Arenaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	Arnica	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	Artemisia nova	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	Artemisia tridentata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threetip sagebrush	Artemisia tripartita	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water birch	Betula occidentalis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	Betula pumila	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	Bromus anomalus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Pumpelly's brome	Bromus inermis var. pumpellianus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain brome	Bromus marginatus	Entire	U	U	U	U	U	U	U	U	U	U	U	U

mountain brome	*Bromus marginatus*	Entire plant	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
water sedge	*Carex aquatilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Macoun's reedgrass	*Calamagrostis canadensis var. macouniana*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Nebraska sedge	*Carex nebrascensis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slough sedge	*Carex obnupta*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunehead sedge	*Carex phaeocephala*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	*Calamagrostis stricta subsp. inexpansa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
field chickweed	*Cerastium arvense*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	*Cercocarpus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
snowbrush ceanothus	*Ceanothus velutinus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
rabbitbrush	*Chrysothamnus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
water hemlock	*Cicuta*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	*Cornus sericea*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
California danthonia	*Danthonia californica*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
shrubby cinquefoil	*Dasiphora floribunda*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber danthonia	*Danthonia intermedia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
onespike danthonia	*Danthonia unispicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
tufted hairgrass	*Deschampsia caespitosa*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	*Elymus albicans*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bottlebrush squirreltail	*Elymus elymoides subsp. elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	*Elymus lanceolatus subsp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fleabane	*Erigeron*	Entire	D	D	D	D	D	D	D	D	D	D	D	D

		plant												
aster	Eucephalus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	Festuca idahoensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
strawberry	Fragaria vesca	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Glyceria elata	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
needle and thread	Hesperostipa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	Hordeum brachyantherum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	Hydrophyllum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
iris	Iris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Baltic rush	Juncus balticus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
alpine laurel	Kalmia microphylla	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	Koeleria macrantha	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
kingspike fescue	Leucopoa kingii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
lupine	Lupinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	Muhlenbergia montana	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mat muhly	Muhlenbergia richardsonis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	Oligoneuron	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	Pascopyrum smithii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	Phleum alpinum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
phlox	Phlox	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	Pinus flexilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	Pinus ponderosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	Polygonum bistortoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

mutton bluegrass	Poa fendleriana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
alkali bluegrass	Poa secunda	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	Prunus virginiana var. virginiana	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
bluebunch wheatgrass	Pseudoroegneria spicata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
antelope bitterbrush	Purshia tridentata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
dock	Rumex	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	Salix	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
stonecrop	Sedum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	Symphoricarpos occidentalis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spike trisetum	Trisetum spicatum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mule-ears	Wyethia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: ALL bighorn sheep

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	Achnatherum hymenoides	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	Achnatherum lettermanii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Columbia needlegrass	Achnatherum nelsonii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
boxelder	Acer negundo var. interius	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	Agoseris glauca	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Saskatoon serviceberry	Amelanchier alnifolia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	Antennaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	Artemisia cana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sandwort	Arenaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	Arnica	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	Artemisia nova	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	Artemisia tridentata	Entire	D	D	D	D	D	D	D	D	D	D	D	D

		plant												
threetip sagebrush	Artemisia tripartita	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water birch	Betula occidentalis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	Betula pumila	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	Bromus anomalus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Pumpelly's brome	Bromus inermis var. pumpellianus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain brome	Bromus marginatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	Carex aquatilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Macoun's reedgrass	Calamagrostis canadensis var. macouniana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Nebraska sedge	Carex nebrascensis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slough sedge	Carex obnupta	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunehead sedge	Carex phaeocephala	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	Carex	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	Calamagrostis stricta subsp. inexpansa	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
field chickweed	Cerastium arvense	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	Cercocarpus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
snowbrush ceanothus	Ceanothus velutinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
rabbitbrush	Chrysothamnus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water hemlock	Cicuta	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	Cornus sericea	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
California danthonia	Danthonia californica	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
shrubby cinquefoil	Dasiphora floribunda	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber danthonia	Danthonia intermedia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
onespike danthonia	Danthonia unispicata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
tufted hairgrass	Deschampsia caespitosa	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

larkspur	Delphinium	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	Elymus albicans	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bottlebrush squirreltail	Elymus elymoides subsp. elymoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	Elymus lanceolatus subsp. lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	Elymus trachycaulus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fleabane	Erigeron	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	Eucephalus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	Festuca idahoensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
strawberry	Fragaria vesca	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Glyceria elata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
needle and thread	Hesperostipa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	Hordeum brachyantherum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	Hydrophyllum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
iris	Iris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Baltic rush	Juncus balticus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
alpine laurel	Kalmia microphylla	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	Koeleria macrantha	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
kingspike fescue	Leucopoa kingii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
lupine	Lupinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	Muhlenbergia montana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mat muhly	Muhlenbergia richardsonis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	Oligoneuron	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	Pascopyrum smithii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	Phleum alpinum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

phlox	Phlox	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	Pinus flexilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	Pinus ponderosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	Polygonum bistortoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mutton bluegrass	Poa fendleriana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
alkali bluegrass	Poa secunda	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	Prunus virginiana var. virginiana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	Pseudoroegneria spicata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
antelope bitterbrush	Purshia tridentata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
dock	Rumex	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	Salix	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	Sedum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	Symphoricarpos occidentalis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spike trisetum	Trisetum spicatum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mule-ears	Wyethia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: ALL cattle

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	Achnatherum hymenoides	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	Achnatherum lettermanii	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
western yarrow	Achillea millefolium var. occidentalis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Columbia needlegrass	Achnatherum nelsonii	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
boxelder	Acer negundo var. interius	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	Agoseris glauca	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Saskatoon serviceberry	*Amelanchier alnifolia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sandwort	*Arenaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	*Arnica*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	*Artemisia tridentata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threetip sagebrush	*Artemisia tripartita*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water birch	*Betula occidentalis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	*Betula pumila*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	*Bromus anomalus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Pumpelly's brome	*Bromus inermis var. pumpellianus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mountain brome	*Bromus marginatus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
water sedge	*Carex aquatilis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Macoun's reedgrass	*Calamagrostis canadensis var. macouniana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nebraska sedge	*Carex nebrascensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
slough sedge	*Carex obnupta*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunehead sedge	*Carex phaeocephala*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	*Calamagrostis stricta subsp. inexpansa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
field chickweed	*Cerastium arvense*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	*Cercocarpus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
snowbrush ceanothus	*Ceanothus velutinus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
rabbitbrush	*Chrysothamnus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

water hemlock	*Cicuta*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	*Cornus sericea*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
California danthonia	*Danthonia californica*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
shrubby cinquefoil	*Dasiphora floribunda*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber danthonia	*Danthonia intermedia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
onespike danthonia	*Danthonia unispicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
tufted hairgrass	*Deschampsia caespitosa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	*Elymus albicans*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bottlebrush squirreltail	*Elymus elymoides subsp. elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	*Elymus lanceolatus subsp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
fleabane	*Erigeron*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	*Eucephalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	*Festuca idahoensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
strawberry	*Fragaria vesca*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Glyceria elata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
needle and thread	*Hesperostipa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	*Hordeum brachyantherum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	*Hydrophyllum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
iris	*Iris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Baltic rush	*Juncus balticus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine laurel	*Kalmia microphylla*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	*Koeleria macrantha*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
kingspike fescue	*Leucopoa kingii*	Entire	P	P	P	P	P	P	P	P	P	P	P	P

		plant												
lupine	Lupinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	Muhlenbergia montana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mat muhly	Muhlenbergia richardsonis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	Oligoneuron	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	Pascopyrum smithii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	Phleum alpinum	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	Phlox	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	Pinus flexilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	Pinus ponderosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	Polygonum bistortoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mutton bluegrass	Poa fendleriana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
alkali bluegrass	Poa secunda	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	Prunus virginiana var. virginiana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	Pseudoroegneria spicata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
antelope bitterbrush	Purshia tridentata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
dock	Rumex	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	Salix	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	Sedum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	Symphoricarpos occidentalis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spike trisetum	Trisetum spicatum	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mule-ears	Wyethia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: ALL deer

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	Achnatherum hymenoides	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	Achnatherum lettermanii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
western yarrow	Achillea millefolium var. occidentalis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Columbia needlegrass	Achnatherum nelsonii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
boxelder	Acer negundo var. interius	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	Agoseris glauca	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Saskatoon serviceberry	Amelanchier alnifolia	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
pussytoes	Antennaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	Artemisia cana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
sandwort	Arenaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	Arnica	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	Artemisia nova	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	Artemisia tridentata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threetip sagebrush	Artemisia tripartita	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water birch	Betula occidentalis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	Betula pumila	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	Bromus anomalus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Pumpelly's brome	Bromus inermis var. pumpellianus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain brome	Bromus marginatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	Carex aquatilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Macoun's reedgrass	Calamagrostis canadensis var. macouniana	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Nebraska sedge	Carex nebrascensis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slough sedge	Carex obnupta	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunehead	Carex phaeocephala	Entire	U	U	U	U	U	U	U	U	U	U	U	U

sedge		plant												
sedge	Carex	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	Calamagrostis stricta subsp. inexpansa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
field chickweed	Cerastium arvense	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	Cercocarpus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
snowbrush ceanothus	Ceanothus velutinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
rabbitbrush	Chrysothamnus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water hemlock	Cicuta	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	Cornus sericea	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
California danthonia	Danthonia californica	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
shrubby cinquefoil	Dasiphora floribunda	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber danthonia	Danthonia intermedia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
onespike danthonia	Danthonia unispicata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
tufted hairgrass	Deschampsia caespitosa	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
larkspur	Delphinium	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	Elymus albicans	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bottlebrush squirreltail	Elymus elymoides subsp. elymoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	Elymus lanceolatus subsp. lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	Elymus trachycaulus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fleabane	Erigeron	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	Eucephalus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	Festuca idahoensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
strawberry	Fragaria vesca	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Glyceria elata	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
needle and thread	Hesperostipa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

meadow barley	Hordeum brachyantherum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	Hydrophyllum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
iris	Iris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Baltic rush	Juncus balticus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
alpine laurel	Kalmia microphylla	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	Koeleria macrantha	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
kingspike fescue	Leucopoa kingii	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
lupine	Lupinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	Muhlenbergia montana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mat muhly	Muhlenbergia richardsonis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	Oligoneuron	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	Pascopyrum smithii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	Phleum alpinum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
phlox	Phlox	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	Pinus flexilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	Pinus ponderosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	Polygonum bistortoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mutton bluegrass	Poa fendleriana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
alkali bluegrass	Poa secunda	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	Prunus virginiana var. virginiana	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
bluebunch wheatgrass	Pseudoroegneria spicata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
antelope bitterbrush	Purshia tridentata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

dock	Rumex	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	Salix	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
stonecrop	Sedum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	Symphoricarpos occidentalis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
spike trisetum	Trisetum spicatum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mule-ears	Wyethia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: ALL elk

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	Achnatherum hymenoides	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	Achnatherum lettermanii	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
western yarrow	Achillea millefolium var. occidentalis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Columbia needlegrass	Achnatherum nelsonii	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
boxelder	Acer negundo var. interius	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	Agoseris glauca	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Saskatoon serviceberry	Amelanchier alnifolia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	Antennaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	Artemisia cana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sandwort	Arenaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	Arnica	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	Artemisia nova	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	Artemisia tridentata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threetip sagebrush	Artemisia tripartita	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water birch	Betula occidentalis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	Betula pumila	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	Bromus anomalus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Pumpelly's brome	*Bromus inermis var. pumpellianus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mountain brome	*Bromus marginatus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
water sedge	*Carex aquatilis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Macoun's reedgrass	*Calamagrostis canadensis var. macouniana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nebraska sedge	*Carex nebrascensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
slough sedge	*Carex obnupta*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunehead sedge	*Carex phaeocephala*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	*Calamagrostis stricta subsp. inexpansa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
field chickweed	*Cerastium arvense*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	*Cercocarpus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
snowbrush ceanothus	*Ceanothus velutinus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
rabbitbrush	*Chrysothamnus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water hemlock	*Cicuta*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	*Cornus sericea*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
California danthonia	*Danthonia californica*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
shrubby cinquefoil	*Dasiphora floribunda*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber danthonia	*Danthonia intermedia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
onespike danthonia	*Danthonia unispicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
tufted hairgrass	*Deschampsia caespitosa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	*Elymus albicans*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bottlebrush squirreltail	*Elymus elymoides subsp. elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	*Elymus lanceolatus subsp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

slender wheatgrass	Elymus trachycaulus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
fleabane	Erigeron	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	Eucephalus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	Festuca idahoensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
strawberry	Fragaria vesca	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Glyceria elata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
needle and thread	Hesperostipa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	Hordeum brachyantherum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	Hydrophyllum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
iris	Iris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Baltic rush	Juncus balticus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine laurel	Kalmia microphylla	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	Koeleria macrantha	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
kingspike fescue	Leucopoa kingii	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
lupine	Lupinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	Muhlenbergia montana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mat muhly	Muhlenbergia richardsonis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	Oligoneuron	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	Pascopyrum smithii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	Phleum alpinum	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	Phlox	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	Pinus flexilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	Pinus ponderosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	Polygonum bistortoides	Entire	D	D	D	D	D	D	D	D	D	D	D	D

		plant												
	Poa canbyi	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mutton bluegrass	Poa fendleriana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
alkali bluegrass	Poa secunda	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	Prunus virginiana var. virginiana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	Pseudoroegneria spicata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
antelope bitterbrush	Purshia tridentata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
dock	Rumex	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	Salix	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	Sedum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	Symphoricarpos occidentalis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spike trisetum	Trisetum spicatum	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mule-ears	Wyethia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: ALL horses

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	Achnatherum hymenoides	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	Achnatherum lettermanii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
western yarrow	Achillea millefolium var. occidentalis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Columbia needlegrass	Achnatherum nelsonii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
boxelder	Acer negundo var. interius	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	Agoseris glauca	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Saskatoon serviceberry	Amelanchier alnifolia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pussytoes	Antennaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	Artemisia cana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sandwort	Arenaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	Arnica	Entire	U	U	U	U	U	U	U	U	U	U	U	U

		plant												
black sagebrush	Artemisia nova	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
big sagebrush	Artemisia tridentata	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
threetip sagebrush	Artemisia tripartita	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water birch	Betula occidentalis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	Betula pumila	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	Bromus anomalus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Pumpelly's brome	Bromus inermis var. pumpellianus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain brome	Bromus marginatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	Carex aquatilis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Macoun's reedgrass	Calamagrostis canadensis var. macouniana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nebraska sedge	Carex nebrascensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
slough sedge	Carex obnupta	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunehead sedge	Carex phaeocephala	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	Carex	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	Calamagrostis stricta subsp. inexpansa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
field chickweed	Cerastium arvense	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	Cercocarpus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
snowbrush ceanothus	Ceanothus velutinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
rabbitbrush	Chrysothamnus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water hemlock	Cicuta	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	Cornus sericea	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
California danthonia	Danthonia californica	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
shrubby cinquefoil	Dasiphora floribunda	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber	Danthonia intermedia	Entire	D	D	D	D	D	D	D	D	D	D	D	D

danthonia		plant												
onespike danthonia	Danthonia unispicata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
tufted hairgrass	Deschampsia caespitosa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
larkspur	Delphinium	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	Elymus albicans	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bottlebrush squirreltail	Elymus elymoides subsp. elymoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	Elymus lanceolatus subsp. lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	Elymus trachycaulus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
fleabane	Erigeron	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	Eucephalus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	Festuca idahoensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
strawberry	Fragaria vesca	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Glyceria elata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
needle and thread	Hesperostipa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	Hordeum brachyantherum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	Hydrophyllum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
iris	Iris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Baltic rush	Juncus balticus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine laurel	Kalmia microphylla	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	Koeleria macrantha	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
kingspike fescue	Leucopoa kingii	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
lupine	Lupinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	Muhlenbergia montana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mat muhly	Muhlenbergia richardsonis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	Oligoneuron	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

western wheatgrass	Pascopyrum smithii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	Phleum alpinum	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	Phlox	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	Pinus flexilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	Pinus ponderosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	Polygonum bistortoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mutton bluegrass	Poa fendleriana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
alkali bluegrass	Poa secunda	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	Prunus virginiana var. virginiana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	Pseudoroegneria spicata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
antelope bitterbrush	Purshia tridentata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dock	Rumex	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	Salix	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	Sedum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	Symphoricarpos occidentalis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spike trisetum	Trisetum spicatum	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mule-ears	Wyethia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal kind: ALL moose

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	Achnatherum hymenoides	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	Achnatherum lettermanii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Columbia needlegrass	Achnatherum nelsonii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
boxelder	Acer negundo var. interius	Entire	U	U	U	U	U	U	U	U	U	U	U	U

		plant												
pale agoseris	Agoseris glauca	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Saskatoon serviceberry	Amelanchier alnifolia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	Antennaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	Artemisia cana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sandwort	Arenaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	Arnica	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	Artemisia nova	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	Artemisia tridentata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threetip sagebrush	Artemisia tripartita	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water birch	Betula occidentalis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	Betula pumila	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	Bromus anomalus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Pumpelly's brome	Bromus inermis var. pumpellianus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain brome	Bromus marginatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	Carex aquatilis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Macoun's reedgrass	Calamagrostis canadensis var. macouniana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Nebraska sedge	Carex nebrascensis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slough sedge	Carex obnupta	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunehead sedge	Carex phaeocephala	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	Carex	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	Calamagrostis stricta subsp. inexpansa	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
field chickweed	Cerastium arvense	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	Cercocarpus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
snowbrush ceanothus	Ceanothus velutinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

rabbitbrush	*Chrysothamnus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water hemlock	*Cicuta*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	*Cornus sericea*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
California danthonia	*Danthonia californica*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
shrubby cinquefoil	*Dasiphora floribunda*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber danthonia	*Danthonia intermedia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
onespike danthonia	*Danthonia unispicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
tufted hairgrass	*Deschampsia caespitosa*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	*Elymus albicans*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bottlebrush squirreltail	*Elymus elymoides subsp. elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	*Elymus lanceolatus subsp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fleabane	*Erigeron*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	*Eucephalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	*Festuca idahoensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
strawberry	*Fragaria vesca*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Glyceria elata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
needle and thread	*Hesperostipa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	*Hordeum brachyantherum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	*Hydrophyllum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
iris	*Iris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Baltic rush	*Juncus balticus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
alpine laurel	*Kalmia microphylla*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T

prairie Junegrass	Koeleria macrantha	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
kingspike fescue	Leucopoa kingii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
lupine	Lupinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	Muhlenbergia montana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mat muhly	Muhlenbergia richardsonis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	Oligoneuron	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	Pascopyrum smithii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	Phleum alpinum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
phlox	Phlox	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	Pinus flexilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	Pinus ponderosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	Polygonum bistortoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mutton bluegrass	Poa fendleriana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
alkali bluegrass	Poa secunda	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	Prunus virginiana var. virginiana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	Pseudoroegneria spicata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
antelope bitterbrush	Purshia tridentata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
dock	Rumex	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	Salix	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
stonecrop	Sedum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	Symphoricarpos occidentalis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spike trisetum	Trisetum spicatum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mule-ears	Wyethia	Entire	U	U	U	U	U	U	U	U	U	U	U	U

plant

Animal kind: ALL sheep

Common name	Scientific name	Plant part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	*Achnatherum lettermanii*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
western yarrow	*Achillea millefolium var. occidentalis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Columbia needlegrass	*Achnatherum nelsonii*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
boxelder	*Acer negundo var. interius*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	*Agoseris glauca*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Saskatoon serviceberry	*Amelanchier alnifolia*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sandwort	*Arenaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	*Arnica*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	*Artemisia tridentata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threetip sagebrush	*Artemisia tripartita*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water birch	*Betula occidentalis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	*Betula pumila*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	*Bromus anomalus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Pumpelly's brome	*Bromus inermis var. pumpellianus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mountain brome	*Bromus marginatus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
water sedge	*Carex aquatilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Macoun's reedgrass	*Calamagrostis canadensis var. macouniana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Nebraska sedge	*Carex nebrascensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
slough sedge	*Carex obnupta*	Entire	D	D	D	D	D	D	D	D	D	D	D	D

		plant												
dunehead sedge	Carex phaeocephala	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	Carex	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	Calamagrostis stricta subsp. inexpansa	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
field chickweed	Cerastium arvense	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	Cercocarpus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
snowbrush ceanothus	Ceanothus velutinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
rabbitbrush	Chrysothamnus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
water hemlock	Cicuta	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	Cornus sericea	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
California danthonia	Danthonia californica	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
shrubby cinquefoil	Dasiphora floribunda	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber danthonia	Danthonia intermedia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
onespike danthonia	Danthonia unispicata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
tufted hairgrass	Deschampsia caespitosa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
larkspur	Delphinium	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	Elymus albicans	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bottlebrush squirreltail	Elymus elymoides subsp. elymoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
streambank wheatgrass	Elymus lanceolatus subsp. lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	Elymus trachycaulus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fleabane	Erigeron	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	Eucephalus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	Festuca idahoensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
strawberry	Fragaria vesca	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Glyceria elata	Entire	U	U	U	U	U	U	U	U	U	U	U	U

		plant												
needle and thread	Hesperostipa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	Hordeum brachyantherum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	Hydrophyllum	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
iris	Iris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Baltic rush	Juncus balticus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
alpine laurel	Kalmia microphylla	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	Koeleria macrantha	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
kingspike fescue	Leucopoa kingii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
lupine	Lupinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	Muhlenbergia montana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mat muhly	Muhlenbergia richardsonis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	Oligoneuron	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	Pascopyrum smithii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	Phleum alpinum	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	Phlox	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	Pinus flexilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	Pinus ponderosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	Polygonum bistortoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mutton bluegrass	Poa fendleriana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
alkali bluegrass	Poa secunda	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	Prunus virginiana var. virginiana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	Pseudoroegneria spicata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

antelope bitterbrush	Purshia tridentata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
dock	Rumex	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	Salix	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
stonecrop	Sedum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	Symphoricarpos occidentalis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spike trisetum	Trisetum spicatum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mule-ears	Wyethia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Legend: P=Preferred; D=Desirable; U=Undesirable; N=Not consumed; E=Emergency; T=Toxic; X=Used, but degree of utilization unknown

Hydrology Functions

Water is the principal factor limiting forage production on this site. This site is dominated by soils in hydrologic group C, with localized areas in hydrologic group B and D. Infiltration ranges from moderately slow to moderate. Runoff potential for this site varies from low to moderate depending on soil hydrologic group and ground cover. In many cases, areas with greater than 75% ground cover have the greatest potential for high infiltration and lower runoff. An example of an exception would be where short-grasses form a strong sod and dominate the site. Areas where ground cover is less than 50% have the greatest potential to have reduced infiltration and higher runoff (refer to Part 630, NRCS National Engineering Handbook for detailed hydrology information).

Rills and gullies should not typically be present. Water flow patterns should be barely distinguishable if at all present. Pedestals are only slightly present in association with bunchgrasses. Litter typically falls in place, and signs of movement are not common. Chemical and physical crusts are rare to non-existent. Cryptogamic crusts are present, but only cover 1-2% of the soil surface.

Recreational Uses

This site provides hunting opportunities for upland game species. The wide varieties of plants that bloom from spring until fall have an esthetic value that appeals to visitors. Other recreational uses may included hiking, camping, mountain biking, and in the winter snowshoeing and cross-country skiing.

Wood Products

No appreciable wood products are present on the site.

Other Products

None noted.

Supporting Information

Supporting Information

Associated Sites

Site name	Site ID	Site narrative
Coarse Upland (CU)	R043BY308WY	Coarse Upland
Overflow (Ov)	R043BY330WY	Overflow
Shallow Loamy (SwLy)	R043BY362WY	Shallow Loamy
Shallow Sandy (SwSy)	R043BY366WY	Shallow Sandy

Similar Sites

Site name	Site ID	Site narrative
Loamy (Ly)	R032XY322WY	Loamy 10-14” Foothills and Basins East P.Z., has lower production.

State Correlation

This site has been correlated with the following states: WY

Inventory Data References

Information presented here has been derived from NRCS clipping data and other inventory data. Field observations from range trained personnel were also used. Those involved in developing this site include: Chris Krassin, Range Management Specialist, James Haverkamp, Range Management Specialist, Steven Gullion, Range Management Specialist, James Mischke, District Conservationist, and Everet Bainter, State Range Management Specialist. Other sources used as references include USDA NRCS Water and Climate Center, USDA NRCS National Range and Pasture Handbook, and USDA NRCS Soil Surveys from various counties.

Site Authors

J. Haverkamp

Quality Assurance

Provisional Status Verified in Legacy System

Reference Sheet

Author(s)/participant(s): Ray Gullion, E. Bainter

Contact for lead author: ray.gullion@wy.usda.gov 307-347-2456

Date: 5/1/2008 **MLRA:** 043B **Ecological Site:** Loamy (Ly) 15-19” Foothills and Mountains East Precipitation Zone R043BY322WY This *must* be verified based on soils and climate (see Ecological Site Description). Current plant community cannot be used to identify the ecological site.

Composition (indicators 10 and 12) based on: X Annual Production, Foliar Cover, Biomass

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Indicators. For each indicator, describe the potential for the site. Where possible, (1) use numbers, (2) include expected range of values for above- and below-average years for **each** community and natural distrurbance regimes within the reference state, when appropriate and (3) cite data. Continue descriptions on separate sheet.

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1. **Number and extent of rills:** Rare to nonexistent. Where present, short and widely spaced.

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2. **Presence of water flow patterns:** Barely observable.

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3. **Number and height of erosional pedestals or terracettes:** Rare to nonexistent.

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, standing dead, lichen, moss, plant canopy are not bare ground):** Bare ground can range from 0-20%.

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5. **Number of gullies and erosion associated with gullies:** Active gullies should not be present.

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6. **Extent of wind scoured, blowouts and/or depositional areas:** Rare to nonexistent.

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7. **Amount of litter movement (describe size and distance expected to travel):** Herbaceous and large woody litter not expected to move.

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil Stability Index ratings range from 3 (interspaces) to 6 (under plant canopy), but average values should be 4.0 or greater.

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9. **Soil surface structure and SOM content (include type and strength of structure, and A-horizon color and thickness):** Soil data is limited for this site. Described A-horizons vary from 6-23 inches (15-58 cm) with OM of 2 to 5%.

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10. **Effect on plant community composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Plant community consists of 70-80% grasses, 15% forbs, and 5-15% shrubs. Evenly distributed plant canopy (60-95%)

and litter plus moderate infiltration rates result in minimal runoff. Basal cover is typically 5-15% for this site and does affect runoff on this site.

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11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None.

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12. **Functional/Structural Groups (list in order of descending dominance by above-ground weight using symbols: >>, >, = to indicate much greater than, greater than, and equal to) with dominants and sub-dominants and "others" on separate lines:**
 Dominant: Mid-size, cool season bunchgrasses>> perennial shrubs=perennial forbs>tall, cool season bunchgrasses>cool season rhizomatous grasses=short cool season bunchgrasses
 Sub-dominant:
 Other:
 Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Minimal decadence, typically associated with shrub component.

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14. **Average percent litter cover (50 - 90%) and depth (.2 - .6inches):** Litter ranges from 5-40% of total canopy measurement with total litter (including beneath the plant canopy) from 50-90% expected. Herbaceous litter depth typically ranges from 5-15mm. Woody litter can be up to a couple inches (4-6 cm).

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15. **Expected annual production (this is TOTAL above-ground production, not just forage production):** English: 1100-1600 lb/ac (1350 lb/ac average); Metric 1232-1792 kg/ha (1512 kg/ha average).

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16. **Potential invasive (including noxious) species (native and non-native). List Species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicator, we are describing what is NOT expected in the reference state for the ecological site:** Bare ground greater than 30% is the most common indicator of a threshold being crossed. Big sagebrush, rubber rabbitbrush, and bluegrasses are common increasers. Kentucky bluegrass, common dandelion, thistles, and annual weeds such as kochia and mustards are common invasive species in disturbed sites.

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17. **Perennial plant reproductive capability:** All species are capable of reproducing, except in extreme drought years.

Reference Sheet Approval

Approval	Date
E. Bainter	5/1/2008

APPENDIX B – Water-bearing Characteristics of Geologic Units

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Table B Water-bearing Characteristics of Geologic Units in Vicinity of Owl Creek Basin

Series/ Epoch	Unit	Thickness[1]	Physical Description[1]	Water-Bearing Characteristics	HSU[2]
Holocene	Alluvium	0-40'	Boulders, cobbles, pebbles, gravel & sand; in places mixed with clay and silt, material fining down-basin.	Contains zone of saturation adjacent to and underlying stream channels; recharged mainly by run-off. Provides some storage of groundwater sustaining surface water late-season. Supplies water chiefly for livestock and locally for domestic. Can be important for source for irrigation where thick and permeable.	Quaternary unconsolidated deposit aquifers (major)
	Slope Deposits	0-40' (?)	Alluvial fan, pediment, landslide derived gravel, sand, silt, clay, & talus; residual or transported under gravity, chiefly overlies parent material generally as a relatively thin veneer.	Lies mainly above water table, not presumed to be an aquifer, but important for catchment of precipitation or snow melt and conduction of overland flow, or infiltrated water downslope as interflow or throughflow.	
Pleistocene (?)	Terrace Deposits	0-40' ±	Mainly gravel, sand and silt; locally mantled by slope wash or thin soil.	Locally yields water for domestic, stock, and limited irrigation use. Where thick and permeable, moderate to large supplies may be obtained.	
Eocene	Absaroka Volcanics & related rocks	0-5,500' ±	Volcanic tuffs and breccia, reworked volcanoclastics. Crops out in west end of Owl Creek Basin in headwaters regions.	Hydrologic properties vary greatly due to diverse lithologies. Could include largely undeveloped groundwater resources, the exploitation of which is impeded by inaccessibility, and chaotic stratigraphy.	Wagon Bed confining unit
	Willwood Formation	0-8,000' ±	Claystone, sandstone, and conglomerate, drab to varicolored. Appears to outcrop only locally north of Rattlesnake Creek along north edge of basin.	Willwood aquifer (minor). Might yield enough water from sandstones for domestic or stock use.	Lower Tertiary/Upper Cretaceous aquifer system
Paleocene	Fort Union Formation	0-8,000' ±	Claystone, siltstone and sandstone with local conglomerate and some carbonaceous material. Does not crop out in Owl Creek basin, but occurs within the study area north of Sand Draw.	Fort Union aquifer (major), where thicknesses and areal extent of sandstones are sufficient.	
Upper Cretaceous	Lance Formation	700-1,200' ±	Light yellowish brown, poorly indurated concretionary sandstone interbedded with claystone, shale & thin beds of carbonaceous shale. Does not crop out in Owl Creek basin, but occurs within the study area along Sand Draw	Lance aquifer (major). Not extensively developed, might yield enough water from sandstones for domestic or stock use.	
	Meeteetse	700-1,500'	Siltstone, claystone, and shale, poorly indurated sandstone and thin	Meeteetse aquifer and	

Table B-1 Water-bearing Characteristics of Geologic Units in Vicinity of Owl Creek Basin					
Series/ Epoch	**Unit**	**Thickness[1]**	**Physical Description[1]**	**Water-Bearing Characteristics**	**HSU[2]**
	Formation	±	lenticular coal beds mostly in upper portion. Does not crop out in Owl Creek basin, but occurs within the study area near Kirby Creek.	Lewis Shale confining unit. Sandstones might yield enough water for domestic or stock use.	
	Mesaverde Formation	0-1,200' ±	Buff & gray massive to thin-bedded sandstone; carbonaceous shale, some coal. Crops out locally only on the north edge of the basin on structures, and near Sand Draw within the study area.	Mesaverde aquifer (major), however, areal extent is limited in Owl Creek area.	
	Cody shale	0-2,500' ±	Gray to black shale, think limy sandstone un upper part; zones of limy concretions may be present. Crops out north of Owl creek, middle to east end of basin.	Major confining unit. May yield small supplies of water under artesian conditions, generally from upper part and where fracturing in shale provides sufficient permeability.	Cody Confining Unit
	Frontier Formation	0-800' ±	Sandstone lenticular, contains thin layers of intercalated shale and bentonite, and locally, thin coal beds in lower part. Crops out in narrow band from center to east end of basin.	Frontier aquifer (minor), sandstone beds yield water under artesian conditions.	Lower and middle Mesozoic aquifers and confining units
	Mowry Shale	0-800' ±	Gray shale, siliceous, contains thin bentonite beds and a few thin sandstone beds. Crops out in central basin from middle to east end.	Mowry confining unit	
Lower Cretaceous	Thermopolis Shale	0-800' ±	Black soft shale, locally with gray to brown, 40-ft.thick Muddy Sandstone member about 200 ft. above base Crops out in central basin from middle to east end.	Muddy Sandstone aquifer (minor) can yield small quantities to wells. Thermopolis confining unit	
	Cloverly Formation	0-240' ±	Contains three distinct units: upper silt & sandstone, middle shale, and locally a lower lenticular sandstone bed. Crops out on lower slopes in east half of the basin.	Cloverly aquifer (major), lower sandstone yields small quantities of water sufficient for domestic or stock use.	
Jurassic	Morrison Formation	0-300' ±	Calcareous sandstone and sandy mudstone with lenticular freshwater limestone. Crops out on lower slopes in east half of the basin.	Morrison confining unit and aquifer (minor), sandstones might yield enough water for domestic or stock use.	
	Sundance Formation	0-400' ±	Greenish-ray, glauconitic calcareous sandstone, limestone, siltstone and shales. Crops out on lower slopes in east half of the basin and in a narrow	Sundance confining unit and aquifer (marginal), sandstones might yield enough water	

Table B-1 Water-bearing Characteristics of Geologic Units in Vicinity of Owl Creek Basin					
Series/ Epoch	Unit	Thickness[1]	Physical Description[1]	Water-Bearing Characteristics	HSU[2]
			band in contact with Precambrian rocks near headwaters of Willow Creek.	for domestic or stock use.	
	Gypsum Spring Formation	275'±	Reddish-brown claystone and siltstone with thin limestone and massive gypsum beds. May crop out on lower slopes in east half of the basin and a narrow band in contact with Precambrian rocks near headwaters of Willow Creek.	Gypsum Spring confining unit and aquifer (marginal), solution zone in gypsum beds may yield small amounts of water.	
Triassic	Chugwater Formation	0-300' ±	Very fine-grained red sandstone, siltstone, and shale, with one limestone member locally. Crops out mid-basin east of Anchor area, and in the Southeast corner of the basin.	Chugwater aquifer (marginal), reported moderately high flows (50 gpm) from a spring far to the east on Bridger Creek.	
	Dinwoody Formation	0-80' ±	Yellowish siltstone interbedded with gypsum and shales. Crops out mid-basin east of Anchor area, and in the Southeast corner of the basin	Dinwoody confining unit	Paleozoic aquifer system
Permian	Phosphoria Formation	0-270' ±	Tan to gray cherty dolomite and sandy limestone. Crops out primarily in basin-center near Anchor, between Red and Mud Creeks, and the in the Southeast corner of the basin where it underlies an extensive dip slope.	Phosphoria aquifer and confining unit. Yields as large as 1 ,000 gpm were observed from Wind River Canyon spring near Wedding of the Waters.	
Pennsylvanian	Tensleep Formation	350-375'	Tan to white massive sandstone with some interbedded limestone in lower part. Crops only in the south-central and southwestern portions of the Owl Creek area, in narrow bands along the flanks of anticlinal structures at Anchor and Embar and along crest of Owl Creek Mountains above and west of Wind River Canyon.	Tensleep aquifer (major), flowing wells yield large and dependable supplies of potable water in the region.	
	Amsden Formation	250' ±	Red Shale with some limestone and dolomite in lower part. Darwin Sandstone member locally at base. Crops only in the south-central and southwestern portions of the Owl Creek area, in narrow bands along the flanks of anticlinal structures at Anchor and Embar and along crest of Owl Creek Mountains above and west of Wind River Canyon.	Amsden confining unit, Darwin Sandstone known to yield artesian water.	

Table B-1 Water-bearing Characteristics of Geologic Units in Vicinity of Owl Creek Basin					
Series/ Epoch	**Unit**	**Thickness[1]**	**Physical Description[1]**	**Water-Bearing Characteristics**	**HSU[2]**
Mississippian	Madison Limestone	465-480'	Blue-gray massive limestone, dolomitic in part. Upper portion is more massive and thicker bedded. Crops out along north flank of Owl Mountains mid-basin and Wind River Canyon.	Madison aquifer (major), secondary porosity due to solution along joints and fractures, yields as large as 3,000 gpm, but usually less.	Madison-Bighorn aquifer
Devonian	Darby Formation	0-400' ±	Yellow to dark-gray dolomitic siltstone, black fissile shale, silty dolomite, brown dolomite, gray to tan limestone and yellowish-gray siltstone. Crops out along north flank of Owl Mountains mid-basin and Wind River Canyon.	Darby aquifer (major)	
Ordovician	Bighorn Dolomite	140' ±	Gray massive cliff-forming dolomite and dolomitic limestone. Crops out along north flank of Owl Mountains mid-basin and Wind River Canyon.	Bighorn aquifer (major), porosity primarily due to fracturing and solution.	
Cambrian	Gallatin Limestone	455' ±	Grayish-green calcareous shale and flat-pebble conglomerate. Basal ledge-forming massive limestone present to northwest and south. Crops out along north flank of Owl Mountains mid-basin and Wind River Canyon.	Gallatin confining unit, combines with Gros Ventre to confine Flathead groundwater.	Gallatin-Gros Ventre Confining Unit
	Gros Ventre Formation	400' ±	Greenish-gray thin-bedded limestone and limestone-pebble conglomerate. Crops out along north flank of Owl Mountains mid-basin and Wind River Canyon.	Gros Ventre confining unit, Thin sandstone beds indicate potential for small yields.	
	Flathead Quartzite	100-250'	Red quartzitic arkosic sandstone, softer and lighter colored and interbedded with shale in upper part. Does not outcrop within the study area.	Flathead Aquifer (major), reported water yields over 2,000 gal/min.	
Precambrian	Igneous & Metamorphic Rocks	?	Granite, gneiss and schist.	Precambrian basal confining unit Can yield water where weathered or fractured within 100 ft. of surface.	

NOTES

1. Thicknesses and descriptions modified after Berry and Littleton (1961), Lowry et al. (1976), and Libra et al. (1981).
2. Nomenclature and rating of hydrostratigraphic units (HSUs) modified after Libra et al. (1981), Cooley (1986), Plafcan and Ogle (1994) and Taucher et al. (2012).

APPENDIX C – Table Showing Available Flow for Eighty Nodes Used in Model

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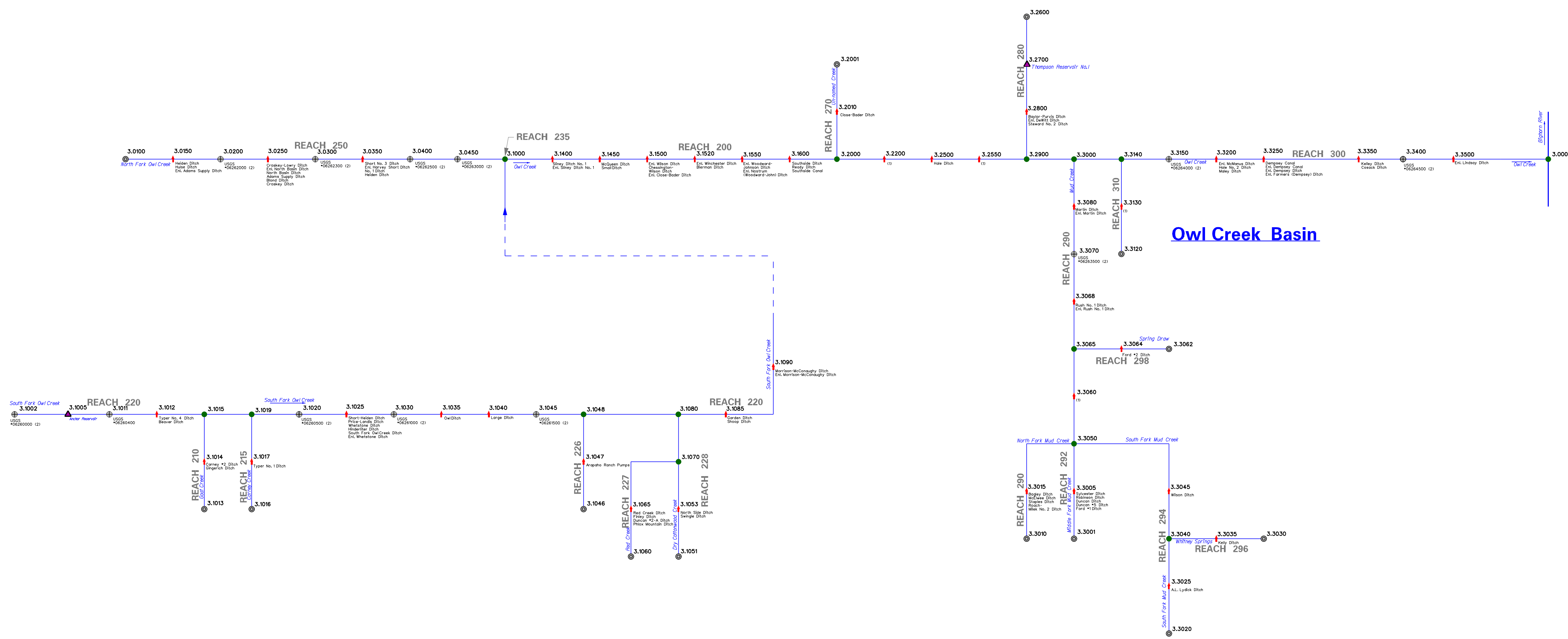
Comparison of Available Streamflow by Node for Wet, Normal, and Dry Hydrologic Conditions																						
		April			May			June			July			August			September			October		
NODE	Reach	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet
3.14	200	16	31	354	1659	3746	6919	2767	8251	16392	1454	3480	5719	1178	1696	3116	1131	1427	1804	2292	2683	3255
3.145	200	0	0	241	1394	3482	6654	2404	7888	16029	1108	3135	5374	930	1448	2868	937	1233	1609	2292	2683	3255
3.15	200	0	0	0	48	2136	5308	531	6016	14156	0	1298	3537	0	202	1622	0	245	621	2292	2683	3255
3.152	200	0	0	0	0	1600	4772	0	5278	13419	0	575	2814	0	0	1131	0	0	229	2292	2683	3255
3.155	200	0	0	0	0	1454	4626	0	5024	13165	0	267	2506	0	0	897	0	0	120	2292	2683	3255
3.16	200	0	0	0	0	0	1943	0	1402	9543	0	0	0	0	0	0	0	0	0	2301	2786	3434
3.2	200	184	168	58	1267	145	1300	1167	2162	5873	1909	2597	2880	2859	2905	3162	2649	2535	2610	3238	3806	4391
3.22	200	184	168	58	1267	145	1300	1167	2162	5873	1909	2597	2880	2859	2905	3162	2649	2535	2610	3238	3806	4391
3.25	200	68	53	0	1045	0	1078	857	1852	5563	1605	2293	2576	2653	2699	2956	2489	2375	2450	3238	3806	4391
3.255	200	0	0	0	902	0	936	658	1652	5363	1410	2098	2381	2520	2566	2823	2386	2272	2347	3238	3806	4391
3.29	200	0	0	0	902	0	936	658	1652	5363	1410	2098	2381	2520	2566	2823	2386	2272	2347	3238	3920	4465
3.3	200	191	542	1475	1660	3108	7671	856	6105	15041	1596	3522	5433	2702	3460	4585	2579	2868	3558	3630	4767	5858
3.1013	210	14	26	67	112	236	444	70	438	1042	12	48	145	3	16	31	6	15	27	14	27	42
3.1014	210	11	23	64	45	169	376	0	330	933	0	0	44	0	0	0	0	0	0	14	27	42
3.1016	215	7	14	41	118	230	423	99	547	1206	15	61	164	4	18	36	6	15	27	11	22	35
3.1017	215	7	13	41	112	224	416	89	537	1197	6	52	155	0	12	30	2	10	23	11	22	35
3.1002	220	1092	1008	1106	3427	4849	6282	5641	8071	14491	2749	3884	4901	1020	1429	2275	721	920	1128	695	789	1041
3.1005	220	659	543	515	2432	2751	3611	3592	5565	7666	1712	3341	4193	928	1173	2271	639	656	940	422	537	730
3.1011	220	659	543	515	2619	2947	3743	3738	5758	7666	2137	4103	5253	1406	1736	3184	833	841	1183	422	537	730
3.1012	220	656	541	513	2576	2903	3700	3671	5691	7599	2075	4041	5190	1359	1689	3138	801	809	1151	424	539	732
3.1015	220	667	564	577	2620	3072	4076	3671	6021	8532	2075	4041	5234	1359	1689	3138	801	809	1151	437	567	774
3.1019	220	675	578	618	2755	3319	4515	3797	6602	9773	2113	4134	5438	1383	1731	3204	823	844	1205	459	602	824
3.102	220	676	579	620	2778	3342	4538	3834	6646	9817	2144	4175	5487	1406	1762	3241	843	869	1235	469	614	839
3.1025	220	205	108	148	1204	1768	2964	1560	4373	7544	0	2013	3326	0	176	1655	0	0	62	469	614	839
3.103	220	205	108	148	1204	1768	2964	1560	4373	7544	0	2013	3326	0	176	1655	0	0	62	469	614	839
3.1035	220	50	0	0	672	1236	2432	799	3611	6782	0	1292	2604	0	0	1124	0	0	0	469	614	839
3.104	220	65	0	13	790	1344	2549	1025	3832	7007	39	1559	2873	0	149	1379	0	43	120	495	681	946
3.1045	220	180	115	127	1220	1775	2979	1732	4539	7715	807	2330	3645	634	816	2046	517	583	732	756	954	1255
3.1048	220	228	163	175	1400	1952	3147	1998	4803	7964	1134	2675	3994	937	1132	2371	757	834	994	850	1054	1360
3.108	220	279	317	655	1822	3203	5782	2258	6829	13001	1299	3025	4910	1029	1344	2672	820	977	1212	985	1318	1770
3.1085	220	64	102	440	1260	2641	5220	1481	6052	12224	564	2290	4175	490	806	2134	406	563	798	985	1318	1770
3.109	220	0	0	213	726	2106	4686	750	5321	11493	0	1590	3476	0	309	1637	15	172	408	985	1318	1770
3.1046	226	101	101	101	295	293	284	400	397	383	443	444	444	363	363	363	256	255	254	0	0	0
3.1047	226	0	0	0	23	21	11	17	14	0	79	80	80	97	96	96	53	52	51	0	0	0
3.106	227	92	163	369	476	1012	1818	361	1647	3478	84	286	803	31	103	192	43	93	160	72	133	208
3.1065	227	19	90	297	225	760	1567	0	1279	3110	0	0	454	0	0	0	0	0	0	72	133	208
3.1051	228	41	78	197	335	715	1294	264	1041	2221	63	207	527	20	71	138	23	51	94	30	59	92
3.1053	228	0	29	148	0	232	811	0	276	1456	0	0	0	0	0	0	0	0	0	30	59	92
3.107	228	50	154	480	422	1250	2635	259	2026	5037	165	350	916	92	212	301	63	143	219	135	264	410
3.1	235	692	707	1030	3062	5150	8322	4673	10158	18298	3319	5345	7584	2445	2963	4383	2135	2432	2808	2292	2683	3255

Comparison of Available Streamflow by Node for Wet, Normal, and Dry Hydrologic Conditions

		April			May			June			July			August			September			October		
NODE	Reach	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet
3.01	250	428	398	433	1517	2016	2520	2490	3344	5600	1436	1835	2192	729	873	957	515	585	658	288	321	410
3.015	250	428	398	433	1248	1748	2252	2027	2881	5137	1010	1409	1767	403	546	630	297	367	441	288	321	410
3.02	250	505	506	564	1859	2517	3123	3031	3925	5983	2019	2323	2604	1205	1311	1370	851	915	981	335	363	453
3.025	250	505	506	564	1187	1844	2451	1945	2839	4897	1024	1327	1609	445	551	610	336	400	466	335	363	453
3.03	250	505	506	564	1409	2109	2676	2282	3192	5147	1521	1893	2235	848	992	1072	641	721	801	447	475	565
3.035	250	457	458	516	1104	1804	2371	1825	2734	4689	1087	1459	1801	527	671	751	415	495	575	447	475	565
3.04	250	477	478	536	1473	2174	2740	2526	3435	5390	1867	2239	2581	1215	1359	1439	1031	1111	1190	758	785	875
3.045	250	477	478	536	1473	2174	2740	2526	3435	5390	1867	2239	2581	1215	1359	1439	1031	1111	1190	758	785	875
3.2001	270	559	559	559	1234	1225	1185	1636	1622	1565	1868	1871	1870	1421	1420	1420	1047	1044	1039	0	0	0
3.201	270	0	0	0	97	89	48	71	57	0	333	336	335	379	377	377	217	215	209	0	0	0
3.26	280	102	202	404	192	564	1108	9	214	584	1	4	20	0	1	2	1	3	5	11	22	33
3.27	280	0	12	300	181	400	1189	0	483	720	0	220	495	132	196	317	137	103	188	0	114	74
3.28	280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	114	74
3.301	290	173	293	591	470	1071	1961	235	1414	3177	51	187	616	20	71	129	38	86	138	93	168	259
3.3015	290	78	197	495	263	864	1754	0	1132	2895	0	0	349	0	0	0	0	0	0	93	168	259
3.305	290	202	410	937	630	1717	3662	209	2135	5901	135	274	828	80	172	236	63	138	205	212	403	608
3.306	290	209	423	966	660	1783	3745	234	2240	6030	150	333	915	87	204	283	68	157	234	215	413	623
3.3065	290	382	735	1572	997	2661	5387	289	2896	7585	164	394	1076	95	232	328	77	186	278	259	496	748
3.3068	290	305	658	1495	852	2516	5242	84	2692	7380	0	194	876	0	96	192	0	81	173	259	496	748
3.307	290	336	689	1526	925	2589	5315	195	2802	7491	108	313	995	82	196	292	71	173	265	295	542	794
3.308	290	164	516	1353	610	2273	5000	0	2343	7032	0	0	549	0	0	0	0	0	33	295	542	794
3.3001	292	60	107	234	220	505	947	93	663	1583	17	68	230	6	24	45	12	30	49	34	64	98
3.3005	292	0	0	0	0	0	365	0	0	779	0	0	0	0	0	0	0	0	0	34	64	98
3.302	294	72	125	262	205	481	909	81	596	1467	15	61	217	5	22	42	12	30	48	36	68	103
3.3025	294	42	95	231	138	414	842	0	506	1377	0	0	131	0	0	0	0	0	0	36	68	103
3.304	294	74	153	357	248	672	1334	58	717	1902	34	58	204	19	36	50	15	31	47	52	100	150
3.3045	294	73	152	356	195	619	1281	0	636	1820	0	0	128	0	0	0	0	0	8	52	100	150
3.303	296	28	54	122	93	241	475	13	181	495	1	7	31	0	2	5	2	4	7	8	16	24
3.3035	296	14	41	108	63	211	445	0	141	454	0	0	0	0	0	0	0	0	0	8	16	24
3.3062	298	170	305	589	321	837	1590	43	591	1474	5	25	107	2	8	15	7	18	25	40	75	113
3.3064	298	167	301	586	314	830	1583	34	581	1464	0	15	98	0	2	8	2	13	20	40	75	113
3.314	300	198	557	1512	1694	3204	7868	857	6149	15176	1596	3522	5436	2702	3460	4585	2579	2868	3559	3631	4770	5862
3.315	300	198	557	1512	1694	3204	7868	857	6149	15176	1596	3522	5436	2702	3460	4585	2579	2868	3559	3631	4770	5862
3.32	300	63	422	1378	1454	2964	7628	503	5795	14822	1252	3178	5091	2468	3226	4351	2401	2691	3381	3631	4770	5862
3.325	300	0	0	0	0	0	4041	0	1011	10038	0	0	383	0	106	1281	88	463	1202	3730	4910	6027
3.335	300	0	0	0	0	0	3473	0	248	9275	0	0	0	0	0	785	0	95	834	3745	4926	6043
3.34	300	4	11	30	36	69	3564	32	376	9414	41	122	152	60	112	912	80	200	947	3786	4979	6100
3.35	300	0	0	14	7	40	3535	0	338	9375	2	83	114	34	86	886	61	181	929	3786	4979	6100
3.312	310	6	14	37	34	96	197	1	45	135	0	0	2	0	0	0	0	0	0	1	2	4
3.313	310	6	14	37	34	96	197	1	45	135	0	0	2	0	0	0	0	0	0	1	2	4



Please refer to the Diversion Node Summary Table located in this Appendix for diversion names.

Full size diagram may be downloaded from the Wyoming State Water Planning website.

Diagram Notes

(1) No data associated with node. For future use.
(2) Inactive gage. Data reconstructed for use in model or serves as a node for flow accumulation.

Legend

Network Nodes	Network Links
Confluence	River
Diversion	Canal
Municipal Diversion	
Natural Flow	
Gage	
Reservoir	

Wind/Bighorn River Basin Plan
Owl Creek Basin Model Schematic
January 2003

Wyoming Water Development Commission
Wind/Bighorn Basin Advisory Group

MWH
MONTGOMERY WATSON HARZA
Denver
Colorado

BRS
ENGINEERING

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APPENDIX D – Further Information on Groundwater Quality

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Groundwater Review

Major Ionic Species Chemistry

Analytical results from spring sampling conducted by the USGS were summarized and averaged for major ionic species. **Figure 3.4.1-4** presents Stiff diagrams of USGS spring samples. Stiff patterns are most useful for in making a rapid visual comparison between waters from different sources, or to detect unusually sample results in a series of results from the same source.

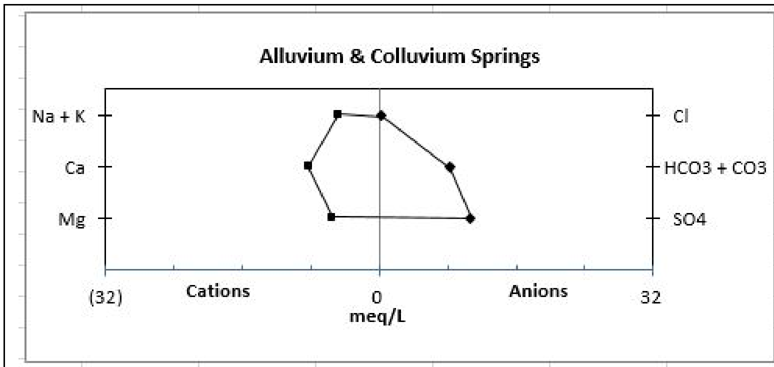


Figure 3.4.1-4a. Stiff diagram for springs hosted in Pleistocene-recent alluvium and colluvium. Data source: USGS National Water Information Service (NWIS) Water Quality Database, available at https://waterdata.usgs.gov/nwis, accessed 7/19/2016.

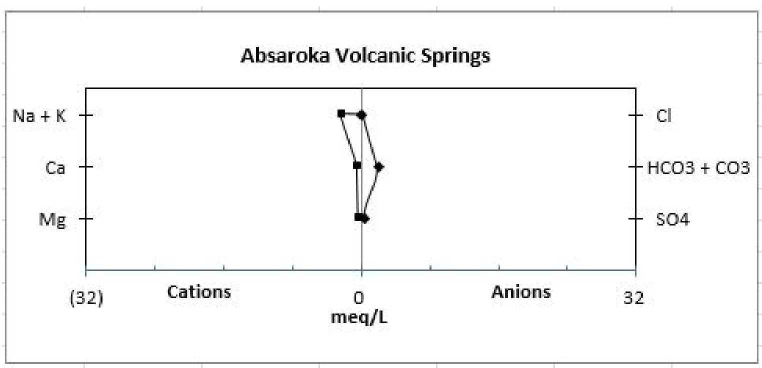


Figure 3.4.1-4b. Stiff diagram for springs hosted in Eocene-age Absaroka volcanic rocks. Data source: USGS National Water Information Service (NWIS) Water Quality Database, available at https://waterdata.usgs.gov/nwis, accessed 7/19/2016.

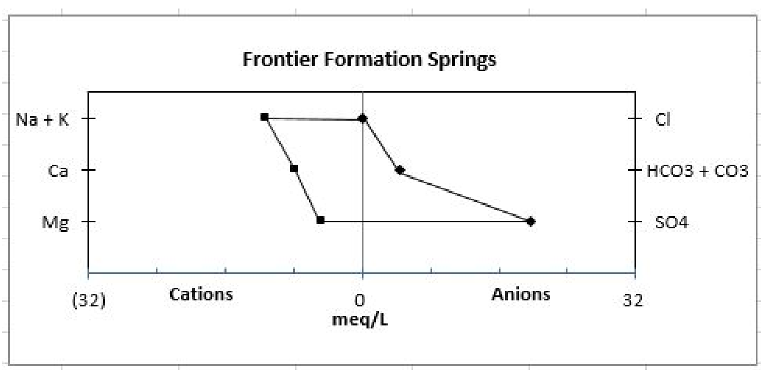


Figure 3.4.1-4c. Stiff diagram for springs hosted in the upper Cretaceous-age Frontier Formation. Data source: USGS National Water Information Service (NWIS) Water Quality Database, available at https://waterdata.usgs.gov/nwis, accessed 7/19/2016.

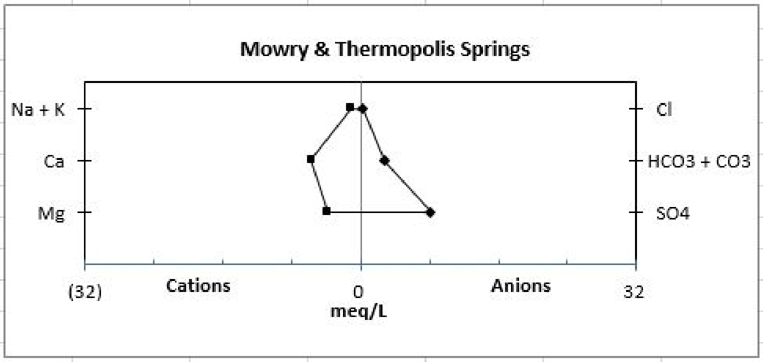


Figure 3.4.1-4d. Stiff diagram for Springs hosted in Cretaceous-age Mowry and Thermopolis Shales. Data source: USGS National Water Information Service (NWIS) Water Quality Database, available at https://waterdata.usgs.gov/nwis, accessed 7/19/2016.

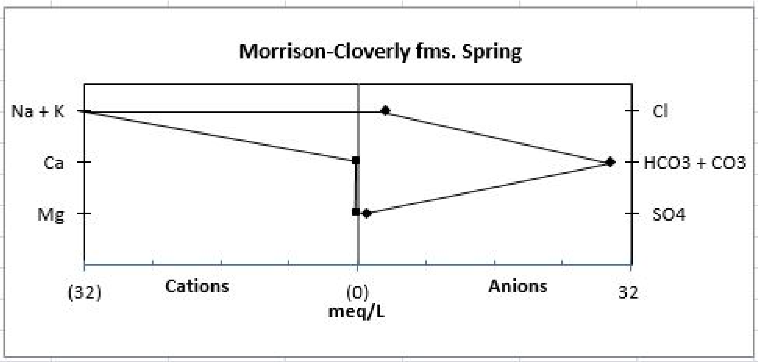


Figure 3.4.1-4e. Stiff diagram for springs hosted in undifferentiated rocks belonging to upper Jurassic-age Morrison Formation-to lower-Cretaceous-age Cloverly Formation. Data source: USGS National Water Information Service (NWIS) Water Quality Database, available at https://waterdata.usgs.gov/nwis, accessed 7/19/2016.

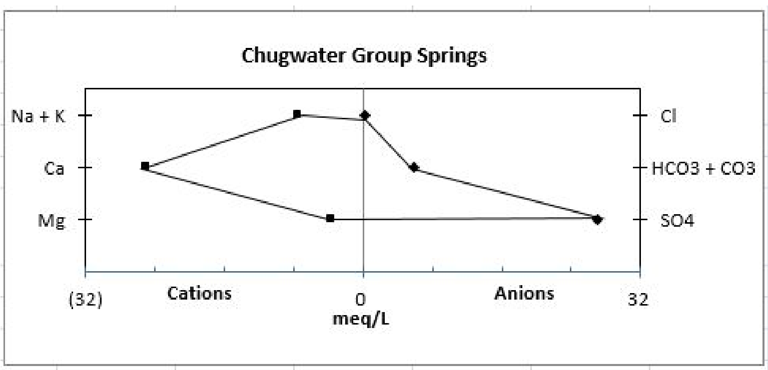


Figure 3.4.1-4f. Stiff diagram for springs hosted in Triassic-age Chugwater Group rocks. Data source: USGS National Water Information Service (NWIS) Water Quality Database, available at https://waterdata.usgs.gov/nwis, accessed 7/19/2016.

Figure 3.4.1-4 Stiff Diagrams depicting Major Ion Water Chemistry for USGS Spring Samples.

Figure 3.4.1-4 Stiff Diagrams depicting Major Ion Water Chemistry for USGS Spring Samples.

The Stiff diagram is a graphical representation of chemical analyses represented by a polygonal shape created from three to four parallel horizontal axes extending on either side of a vertical zero axis (Fetter, 1994). Cations are plotted in milliequivalents per liter on the left of the zero axis, one to each horizontal axis, and anions are plotted on the right. The larger the area of the polygonal shape, the greater the concentration of the various ions in the sample.

All stiff diagrams for the spring water samples show markedly different patterns, indicative of different sources and chemical evolution. Spring water from the Chugwater Group source followed closely by the sample from the Morrison-Cloverly (undifferentiated) spring show the highest concentrations of dissolved major ion. Sample results from Absaroka volcanic rocks show the lowest concentrations of dissolved major ions. To avoid unintended consequences, the wide distribution of chemical character shown by spring water indicates additional sampling should be performed before such water sources are developed.

Additional summaries of analytical results useful in characterizing overall spring water quality are discussed further below.

Locations and Period of Record for Water Quality Data

Table 3.4.2-1 Summary of USGS Surface Water Sampling Locations (Source: USGS NWIS Water-Quality Database).

Stream/Location	Site No.	Lat.	Long.	Period	No. of Samples
Owl Creek at mouth near Lucerne, WY	434319108093100	43.7219	-108.1586	7/2/1947, 9/14/1976, 11/8/76	3
Owl Creek above Mud Creek near Thermopolis, WY	06263300	43.6919	-108.3228	5/20/1965	1
Owl Creek near Thermopolis, WY	06264000	43.6858	-108.3022	5/20/1965, 6/26/1965, 12/19/1975, 5/20/1976, 9/14/1976, 11/14/1976	6
S.F. Owl Creek at Embar Ranch, WY	434250108401900	43.7139	-108.6719	5/20/1976, 9/14/1976	2
Owl Creek at Middleton School, WY	434207108281700	43.7019	-108.4714	5/20/1976, 9/14/1976	2
S.F. Owl Creek near Embar Ranch, WY	434229108425500	43.7081	-108.7153	5/20/1976, 9/14/1976	2
S.F. Owl Creek near Arapahoe Ranch, WY	434326108355900	43.7239	-108.5997	5/20/1976, 9/14/1976	2
Owl Creek at Arapahoe Ranch, WY	434327108320500	43.7242	-108.5347	5/20/1976, 9/14/1976	2
Owl Creek near Thompson Reservoir No. 1 near Thermopolis, WY	434128108233400	43.6911	-108.3928	5/20/1976, 9/14/1976	2
Mud Creek at mouth near Thermopolis, WY	434104108200500	43.6844	-108.3347	5/20/1976, 9/14/1976	2

Owl Creek at US Hwy 20 near Lucerne, WY	434255108103200	43.7153	-108.1756	5/20/1976, 9/14/1976, 11/8/1976	3
Owl Creek 1.0 mi above Meeteetse Draw near Thermopolis, WY	434137108143500	43.6936	-108.2431	9/4/1976, 11/4/1976	2
S.F. Owl Creek at mouth near Arapahoe Ranch, WY	434336108352800	43.7267	-108.5911	9/14/1976	1
Owl Creek below Meeteetse Draw near Thermopolis, WY	434152108141100	43.6978	-108.2364	11/4/1976	1
Owl Creek 3.1 mi below Eagle Draw near Thermopolis, WY	434134108150400	43.6928	-108.2511	11/4/1976	1
Owl Creek 1.7 mi above Meeteetse Draw near Thermopolis, WY	434129108145400	43.6914	-108.2483	11/4/1976	1
Owl Creek 0.5 mi below Eagle Draw near Thermopolis, WY	434112108160800	43.6867	-108.2689	11/4/1976	1
Owl Creek at Sunnyside Lane near Thermopolis, WY	434208108133000	43.7022	-108.2250	11/8/1976	1
South Fork Owl Creek near Anchor, WY	06260000	43.6667	-108.8550	1977-2000	121
Owl Creek at Arapahoe Ranch near Thermopolis, WY	434331108321601	43.7253	-108.5378	3/6/1989	1
Owl Creek near Hamilton Dome, WY	434326108320201	43.7239	-108.5339	10/2/1989	1
S.F. Owl Creek above Rock Creek near Anchor Reservoir, WY	434035109062101	43.6764	-109.1058	10/18/1989	1
Owl Creek at Hwy 120 near Thermopolis, WY	434106108180401	43.6850	-108.3011	7/22/1991, 11/17/1991	2
S.F. Owl Creek at old oil field pad near Anchor, WY	434206108425501	43.7017	-108.7153	7/23/1991	1
N.F. Owl Creek above Basin near Anchor, WY	06262300	43.6892	-108.8400	7/23/1991	1
N.F Owl Creek in Sec. 31, near Embar, WY	434406108393201	43.735	-108.6589	11/13/1991	1
N.F. Owl Creek above Rattlesnake Creek near Anchor, WY	434204108473201	43.7011	-108.7922	11/13/1991	1
N.F. Owl Creek at Knob above Arapahoe Ranch near Hamilton Dome, WY	434357108352201	43.7325	-108.5894	11/13/1991	1
S.F. Owl Creek at trailer near Hamilton Dome, WY	434326108355101	43.7239	-108.5975	11/15/1991	1

Red Creek at Hwy 170 crossing below Embar, WY	434223108390401	43.7064	-108.6511	11/15/1991	1
Pumpkin Creek at ditch near Thompson Reservoir near Thermopolis, WY	434037108225201	43.6769	-108.3811	11/16/1991	1
Pumpkin Draw near Thompson Reservoir near Thermopolis, WY	434134108275701	43.6928	-108.4658	11/16/1991	1
Owl Creek at steel building near Thompson reservoir near Thermopolis, WY	434128108233301	43.6911	-108.3925	11/17/1991	1
Owl Creek at Sunnyside Lane near Thermopolis, WY	434206108133501	43.7017	-108.2264	11/17/1991	1
Owl Creek at Sand Points near Thermopolis, WY	434112108160901	43.6867	-108.2692	11/17/1991	1
Owl Creek near Lucerne, WY	06264500	43.7153	-108.1761	7/13/2000	1

NOTES

1. Station 06264000 (Owl Creek near Thermopolis, WY) is located just below Hwy 120 crossing (marked on USGS topo map), and is probably same or very near location of Station 434106108180401 (Owl Creek at Hwy 120 near Thermopolis, WY).
2. Station 434327108320500 (Owl Creek at Arapahoe Ranch, WY) and Station 434326108320201 (Owl Creek near Hamilton Dome, WY) appear to be co-located, but has slightly different coordinates.
3. Station 434128108233400 (Owl Creek near Thompson Reservoir No. 1 near Thermopolis, WY) and Station 434128108233301 (Owl Creek at steel building near Thompson reservoir near Thermopolis, WY) appear co-located but have slightly different location descriptions and coordinates.
4. Station 434112108160901 (Owl Creek at Sand Points near Thermopolis, WY) appears to be co-located with Station 434112108160800 (Owl Creek 0.5 mi below Eagle Draw near Thermopolis, WY), but has slightly different coordinates.
5. Station 434208108133000 and Station 434206108133501 have the same location description (Owl Creek at Sunnyside Lane near Thermopolis, WY), but different site ID's and slightly different coordinates.
6. Station 434255108103200 (Owl Creek at US Hwy 20 near Lucerne, WY) appears to be co-located with Station 06264500 (Owl Creek near Lucerne, WY) but has slightly different coordinates.
7. Station 0626000 (South Fork Owl Creek near Anchor has most complete record with flow data.

Table 3.4.2-2 Summary of WDEQ and WREQC Surface Water Sampling Locations (Source: EPA STORET database).

Stream	**Location**	**Station ID**	**Lat.**	**Long.**	**Agency**	**Period**	**No. of Samples**
2. WDEQ Water Quality Division Watershed Program Surface Water Assessment (September 1997 – July 2004)							
Rock Creek	Lower Rock Creek	MRW77	43.6947	-109.1086	WDEQ	9/3/1997	1
Rock Creek	Upper Rock Creek	MRWI42	43.7306	-109.1394	WDEQ	9/3/1997	1
Owl Creek	Owl Creek Hwy 120	WB0231	43.6866	-108.3047	WDEQ	7/6/2004	1
Owl Creek	Owl Creek Jones Rd	WB0232	43.6900	-108.3748	WDEQ	7/6/2004	1

Red Canyon Creek	Red Canyon Creek - Bison Ranch	WB149	43.6005	-108.3324	WDEQ	8/13/2001	1
Owl Creek	Owl Creek - Hwy 20/789 crossing	WB152	43.7158	-108.1786	WDEQ	8/22/2001 7/6/2004	2
3. WREQC 106 CWA Water Quality and Baselines Project (January 1997 – March 2004)							
S.F. Owl Creek	Above Anchor Reservoir	G-54	43.66	-108.854	WREQC	1/9/1997 – 8/29/2000	14
S.F. Owl Creek	Owl Creek Rd, 2mi W. of Embar	G-58	43.711	-108.718	WREQC	7/24/1998 – 3/24/2004	34
S.F. Owl Creek	Below mouth of Red Creek	G-60	43.715	-108.611	WREQC	10/8/2002	1
Owl Creek	Near Owl Creek Rd. (Hwy 170) crossing	M-37	43.704	-108.475	WREQC	1/9/1997 – 7/23/2003	39
4. WREQC 106 Main Water Monitoring Activities (January 1997 – June 2011)							
S.F. Owl Creek	Mislocated in intermittent stream tributary to SF Owl Creek	206	43.6600	-108.8542	WREQC	1/9/1997 – 8/29/2000	14
S.F. Owl Creek	S.F. Owl Creek	207	43.7108	-108.7181	WREQC	7/24/1998 – 9/29/2010	53
Owl Creek	Owl Creek	223	43.7044	-108.4750	WREQC	1/9/1997 - 3/25/2005	47
S.F. Owl Creek	Upper S.F. Owl Creek	1051	43.7108	-108.7181	WREQC	4/24/2009 - 9/28/2011	12
Owl Creek	Owl Creek at Arapaho Ranch	1115	43.7224	-108.5257	WREQC	4/24/2009 - 9/28/2011	12
5. WREQC SW-R 2012, 106 CWA Sampling of Rivers and Streams in 2012.							
S.F. Owl Creek	Below Anchor Dam, near intersection Merrit Pass Road and Owl Creek Road	G-58	43.7073	-108.7152	WREQC	4/12/2012 – 6/21/2013	4
Owl Creek	Owl Creek at Arapaho Ranch	OCAR	43.7240	-108.5351	WREQC	4/12/2012 – 6/21/2013	3

NOTES

1. Station WB0232 location description would put this station at same location where USGS 434128108233301 plots at the Jones Road crossing, but station WB0232 actually plots 2.1 miles downstream from Jones Road crossing.
2. Station G-54 and Station 206 appear as same location.
3. Station 207 and Station 1051 appear as same location, and very near Station G-58.
4. Station M-37 and Station 223 appear as same location.
5. Station 1115 and Station OCAR have same description but Station 1115 plots about 4,200 ft downstream.

Total Maximum Daily Load Summary

Waterbody Name/Description	Owl Creek (from the confluence with the Big Horn River to a point 3.8 miles upstream)
Assessment Unit I.D.	WYBH100800070305_01
Size of Impaired Waterbody	3.8 miles (6.1 kilometers)
Size of Watershed (Cumulative)	517.7 square miles (1,338.3 square kilometers)
Location	12-digit Hydrologic Unit Code (HUC): 100800070305
Impaired Designated Use(s)	Recreation
Impairment	Fecal Coliform (written for *E. coli*)
Stream Class	2AB
Cause(s) of Impairment	Unknown
Cycle Most Recently Listed	2012
Total Maximum Daily Load Water-Quality Targets	Indicator Name: *E. coli* Primary Contact Recreation: Summer Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 126 organisms per 100 milliliters (org/100 mL). These criteria apply from May 1 through September 30. Winter Recreation Season: a geometric mean of not less than five samples obtained during separate 24-hour periods for any 30-day period 630 org/ 100 mL. These criteria apply from October 1 through April 30.
Analytical Approach	HSPF, Load Duration Curves

E. coli Total Maximum Daily Load Component (expressed as 10^9 cfu/day)	Flow Zone				
	High	**Moist**	**Midrange**	**Dry**	**Low**
	> 169 cfs	**169–76 cfs**	**76–31 cfs**	**31–4 cfs**	**< 4 cfs**
Load Allocation	682	415	178	49	8
Wasteload Allocation	0	0	0	0	0
Margin of Safety	98	70	53	39	3
Total Maximum Daily Load	780	485	231	88	11

cfu/day = colony-forming units per day
cfs = cubic feet per second

GROUNDWATER

Spring Water Quality

Limited water quality data (17 samples) from 11 springs in the study area are available from the USGS (**Figure D-1**). Formations hosting sampled springs include Tertiary-age Absaroka Volcanic Group igneous rocks, Triassic-age Chugwater Group, Jurassic/Cretaceous-age Cloverly-Morrison Formations, Cretaceous-age Mowry/Thermopolis Shale and Frontier Formation, and Quaternary alluvium/colluvium (**Table D-1**).

Table D-1 Summary of USGS Spring Water Quality Sampling Locations

USGS Site Number	Spring ID	Host Formation	Sub-Watershed
434017109065101	8N-3W-16add01	Absaroka Volcanics	Middle S.F. Owl Creek
434130109041901	43N-102W-15daa01	Absaroka Volcanics	Middle S.F Owl Creek
434341108511201	43N-100W-4aad01	Absaroka Volcanics	Lower N.F. Owl Creek
434220108441301	43N-99W-9dac01	Chugwater Group	Lower N.F. Owl Creek
434102108353401	8N-2E-12bcc01 (Knight Spring)	Frontier Formation	Upper Owl Creek
434113108363001	8N-2E-11bac01 (Blue Hill Spring)	Frontier Formation	Upper Owl Creek
433744108323401	8N-3E-32abc01 (Iron Creek Spring)	Mowry/Thermopolis shale	N.F. Mud Creek
433828108341601	8N-3E-30bca01 (Chokecherry Spr.)	Mowry/Thermopolis shale	N.F. Mud Creek
434030108345501	8N-2E-13aba01 (Love Spring)	Frontier Formation	Upper Owl Creek
434301108362701	9N-2E-35bdb01	Alluvium and colluvium	Lower S.F. Owl Creek
434148108133901	43N-95W-14bdb01	Cloverly-Morrison Fms.	Lower Owl Creek

Source: USGS National Water Information Service (NWIS) Water Quality Database, accessed 7/19/2016.

Due to the limited spatial distribution, the number of samples obtained at each location, and because a variety of different analytes were tested in each sample, it is difficult to draw reliable conclusions from the USGS spring water quality results. However, there are some insights which may be gained from considering those samples that shared many of the same analytes.

For example, only one of the 17 samples were analyzed for strontium, therefore, there is little to be gained in evaluating one result in the context of general discussion of springs that occur in the Owl Creek basin. On the other hand, all 17 samples were analyzed for total dissolved solids (TDS), therefore further considering of these results may be useful in characterizing the quality of spring waters.

With the aforementioned in mind, the following discussion focuses on selected analytes for which relatively more abundant data are available. In most cases, the sample results are averaged per geologic host formation due to the expectation that different host rocks would give rise to differing water chemistry. Refer to Table 11 for the assigned host formation for each of the samples.

Groundwater Hydrochemical Facies. As presented in **Table D-2**, more than 90% of the dissolved solids in groundwater can be attributed to eight ions: sodium (Na^-), calcium (Ca^{2+}), potassium (K^+), magnesium (Mg^{2+}), chlorine (Cl^-), sulfate (SO_4^{2-}), carbonate (CO_3^{2-}), and bicarbonate (HCO_3^-) (Fetter, 1994).

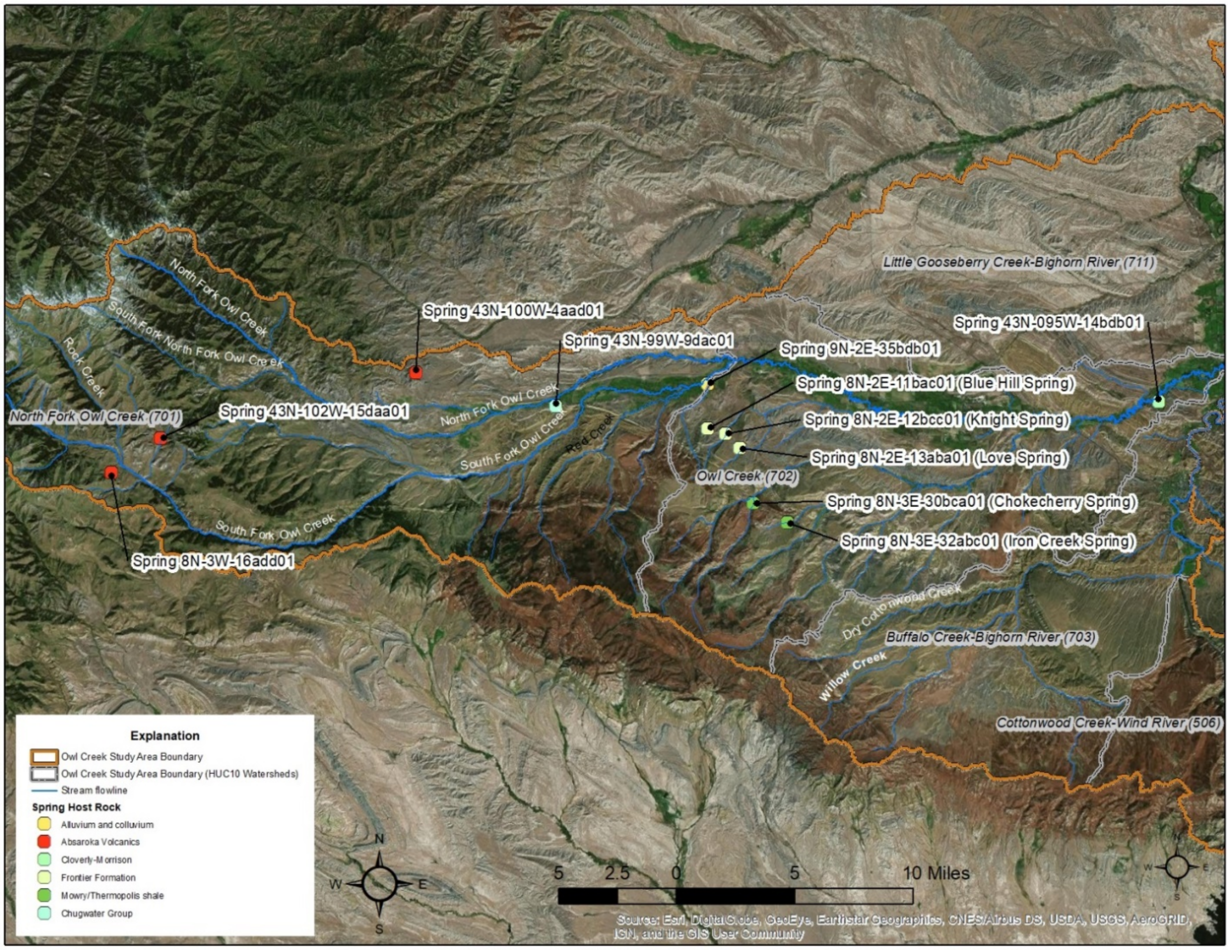


Figure D-1. Locations of Springs with USGS Water Quality Data.

Table D-2 Major dissolved species in groundwater.			
Ion	**Type**	**Examples of Typical Sources**	**Importance**
Sodium (Na^-)	Cation	In igneous rocks, plagioclase feldspar; unaltered mineral grains or cementing material in weathered sediments, common in evaporites; connate water trapped in marine sediments; human sources such as road salt, oil fields brines, irrigation return flow from saline soils.	Important element in human and all animal physiology. Important micronutrient in some plants, but excess sodium in the soil limits the uptake of water by decreasing the water potential, which may result in plant wilting

Table D-2 Major dissolved species in groundwater.			
Ion	**Type**	**Examples of Typical Sources**	**Importance**
Calcium (Ca^{2+})	Cation	Generally, the predominant cation in river water. Essential constituent of many igneous rocks (pyroxene, amphiboles and feldspars; some metamorphic rocks; carbonate rocks such as limestone and dolomite; gypsum-bearing sedimentary rocks; cementation in detrital rocks such as sandstones.	Important physiologically in animals (e.g., building of structures such as teeth, bones, shells; major contributor to water hardness; can be important for natural softening of natural water by exchange with sodium
Potassium (K^{+})	Cation	In igneous rocks, silicate minerals such as feldspars and micas; unaltered feldspar or mica particles in sedimentary rocks; evaporite rocks containing beds of potassium salts	Essential element in plants and animals. Maintenance of soil fertility requires a supply of available potassium
Magnesium (Mg^{2+})	Cation	Typically, a major constituent of dark-colored ferromagnesium minerals in igneous rocks; chlorite and serpentinite in altered rocks, Dolomite (calcium-magnesium carbonate).	Essential element in plant and animal nutrition; major contributor to water hardness
Chlorine (Cl^{-})	Anion	Principally sedimentary rocks, particularly evaporates or as connate brines in marine rocks; less common other sources include feldspathoids minerals in some igneous rocks, phosphate minerals in some sedimentary rocks; human sources such as road salt, oil fields brines, irrigation return flow from saline soils.	Affects aesthetics such as taste, plays few vital biochemical roles other than assisting in maintaining electrolytic balance in organisms; good indicator of anthropogenic water contamination; significantly aggravates the conditions for pitting corrosion of most metals
Sulfate (SO_4^{2-})	Anion	Sulfur widely distributed in reduced form in both igneous and sedimentary rocks (e.g., coals, evaporites) as metallic sulfides when weathered release sulfate ions into water; bacterial conversion of hydrogen sulfide gas in geothermal systems; human sources such as combustion of hydrocarbons	Essential plant nutrient; can contribute to algal growth in surface waters; major factor in producing acid rain, acidity is attributed to high-dissolved solids content of many streams
Carbonate (CO_3^{2-})	Anion	In natural waters, dissolved carbon dioxide species principally sourced from the gas fraction of the atmosphere, or atmospheric gases in the soil or unsaturated zone; metamorphism of carbonate rocks	Important participants in mediating pH of natural waters, e.g., the capacity of water to resist acidification, therefore important physiologically; important part of the carbon cycle
Bicarbonate (HCO_3^{-})	Anion	In natural waters, dissolved carbon dioxide species principally sourced from the gas fraction of the atmosphere, or atmospheric gases in the soil or unsaturated zone; metamorphism of carbonate rocks	Important participants in mediating pH of natural waters, e.g., the capacity of water to resist acidification, therefore important physiologically; important part of the carbon cycle

NOTES: Sources and importance summarized from Hem (1986).

The trilinear diagram or "Piper diagram" is a data presentation scheme used to show correlative water chemistry and provide insight to as to groundwater origin, compositional trends and evolution, and mixing of waters, etc. (Hem, 1985). The trilinear diagram is composed of a diamond-shape plot, sometimes referred to as "hydrochemical" facies, flanked by two triangular plots each containing the major cation and anion species respectively, with sodium and potassium grouped as one on the cation plot and carbonate and bicarbonate combined on the anion plot. Each apex of a triangle represents

100% concentration of one of three constituents. The cation point on the left triangular plot is projected onto the diamond-shaped plot parallel to the side labeled "magnesium," and anion points are similarly project up parallel to the side labeled "sulfate."

As water flows through an aquifer it assumes a diagnostic chemical composition because of interaction with the lithologic material (Fetter, 1994). Hydrochemical facies is a term used to describe groundwaters in an aquifer which may be differentiated by their chemical composition, therefore inferring origin, or suggest a residence time within aquifer materials. Hydrochemical facies can be classified based on the dominant ions in the facies by means of the trilinear diagram (**Figure D-2**).

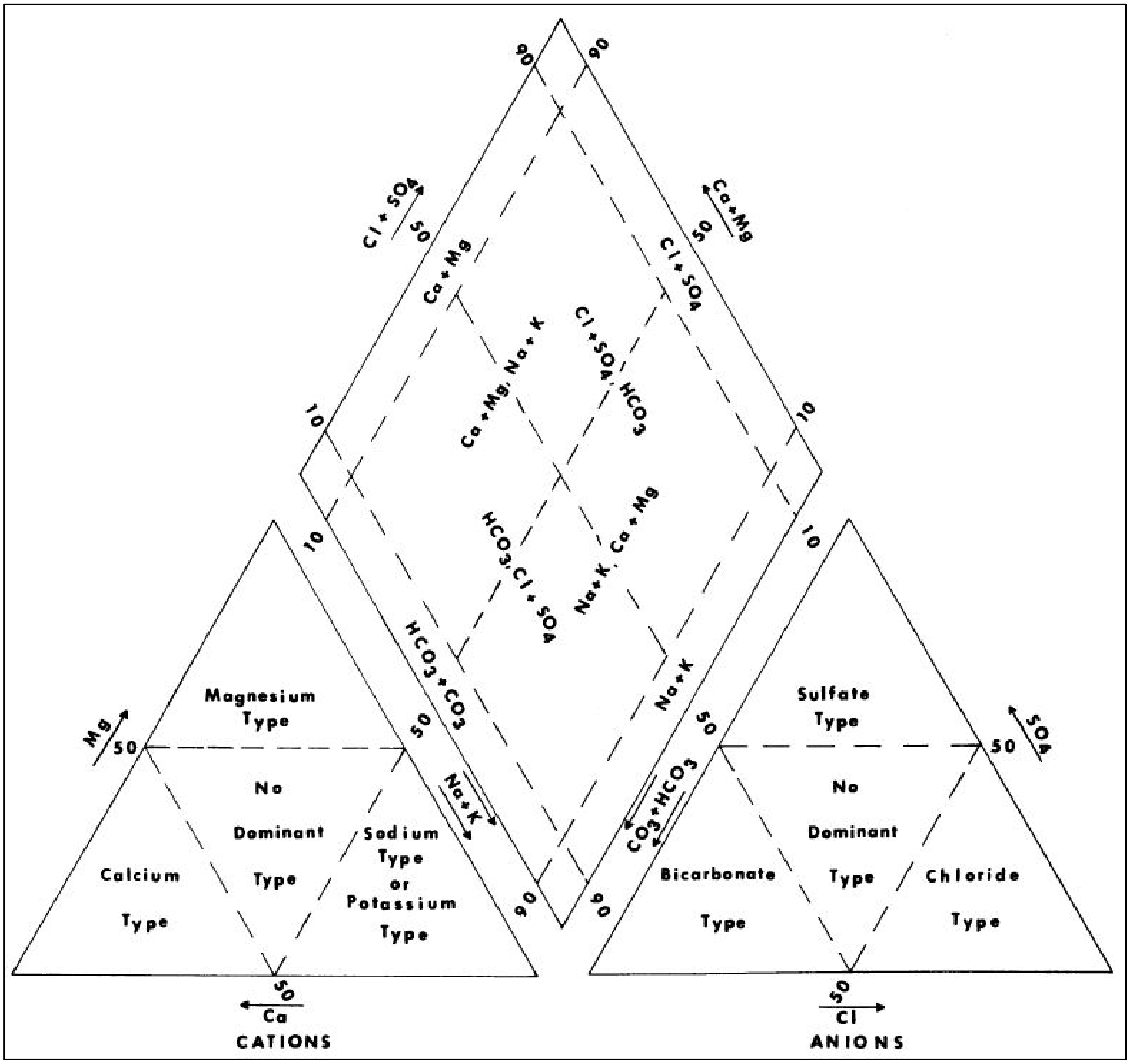


Figure D-2 Hydrogeochemical Classification System for Natural Waters (Back, 1960).

Figure D-3 presents a trilinear diagram summarizing the major ion chemistry of each individual spring sample obtain by the USGS in the Owl Creek watershed. In general, the data plot in distinct regions, allowing for some discrimination between sample origin. Due to the small number of samples for each geologic region, there little information about trend or evolution within or between geologic regions.

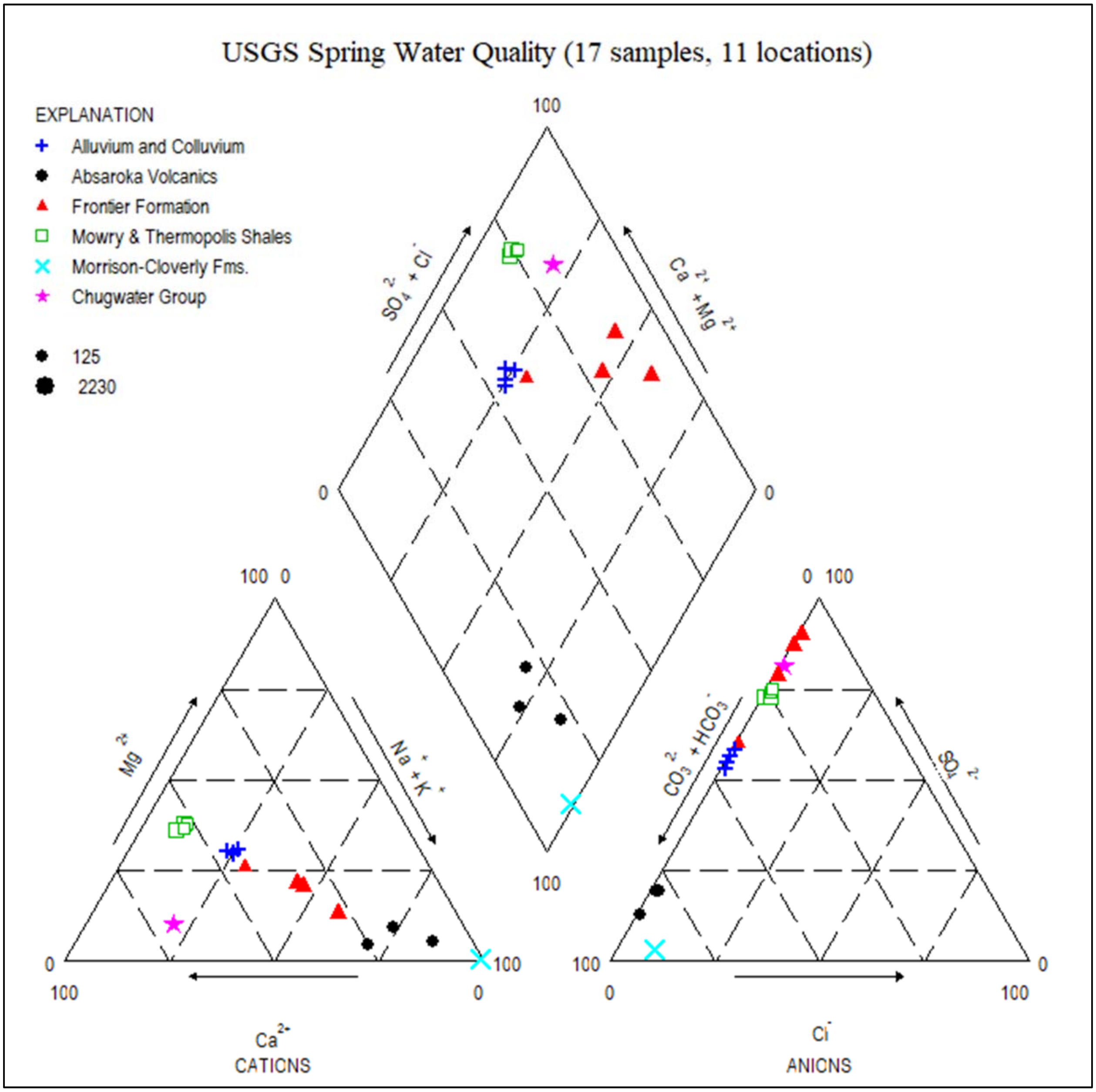


Figure D-3. Trilinear Diagram Prepared for 17 Spring Samples Obtained by the USGS.

The one sample taken from a spring located in rocks belonging to Morrison Formation-Cloverly Formation (undifferentiated) has a distinct chemistry due to the large amount of sodium contained in that sample (sodium makes up approximately 99% of the cations in the sample). This suggests that this water is largely connate, probably from Cloverly Formation sources, or has been contaminated by irrigation run-off. Though the spring's location is low in the basin (near the intakes for South Side Ditch and Dempsey Canal) its position does not plot within a floodplain, suggesting that the connate water source explanation is probably more likely if the location is correct. The lack of chloride and potassium and magnesium suggest cation exchange where the calcium and magnesium in the water are exchanged for sodium, resulting in a sodium-bicarbonate facies water.

Spring water from the Chugwater Formation and Mowry/Thermopolis Shales appears to contain calcium as the dominant cation. Mowry/Thermopolis and Chugwater Group samples could be classified as Ca-SO_4 facies water, suggesting the influence of gypsum contained with the host rocks.

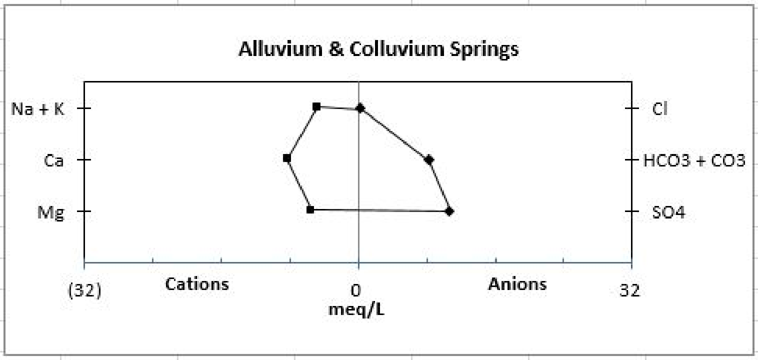
Samples from springs within the Frontier Formation indicate a mixture predominately of sodium and to a lesser degree, calcium as the dominant cation. The water chemistry indicates a transitional chemistry between Ca-SO_4 and Na-Cl water facies, which suggests influence of marine and deep ancient groundwater (probably indicating the influence of connate water on the overall chemistry). These data are suggestive of older water, with some suggestion of influence of connate water incorporated into the rocks during deposition, and comparatively less influence of form modern, meteoric sources when compared to alluvial groundwater. These characteristics might need to be considered or more fully investigated if such water sources are to be exploited as recharge may be occurring more slowly (conceivably less affected by seasonal events) and therefore may not constitute a reliable source of groundwater at all times.

Groundwater samples from springs in Absaroka volcanic rocks indicate sodium as the dominant cation. The samples suggest a Na-HCO_3 groundwater source, typical of deeper groundwater influenced by ion exchange, where the calcium and magnesium in the water are exchanged for sodium that was adsorbed to aquifer solids such as clay minerals (altered tuffs?), resulting in higher sodium concentrations and softer water due to decreased calcium and magnesium concentrations (Bartos and Ogle, 2002). Meteoric water dissolving Na from Na-bearing silicates could also produce Na-HCO_3 water type, a believable assumption for a volcanic terrane.

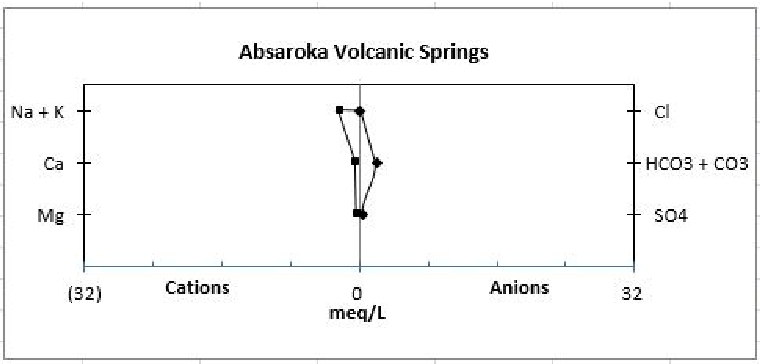
Alluvial spring samples were tightly clustered on all accounts, which is not surprising because all four samples were obtained from the same spring over a three-year period. Alluvial samples showed a mixture of cation facies, but biased toward calcium as the dominant cation. Sulfate is the principal anion in all spring samples except for Absaroka volcanic rocks, where bicarbonate appears to be the dominant anion. These samples indicate a transitional classification between Ca-SO_4 water and Ca-HCO_3 water the latter facies typical of shallow, fresh groundwater. Such alluvial sources of groundwater would be expected to be more influenced by modern meteoric water and therefore supplies may be more tightly coupled to seasonal and annual variations in precipitation as the bulk of recharge is expected to be sourced from direct precipitation and infiltration as well as from surface waters in floodplain areas.

Major Ionic Species Chemistry

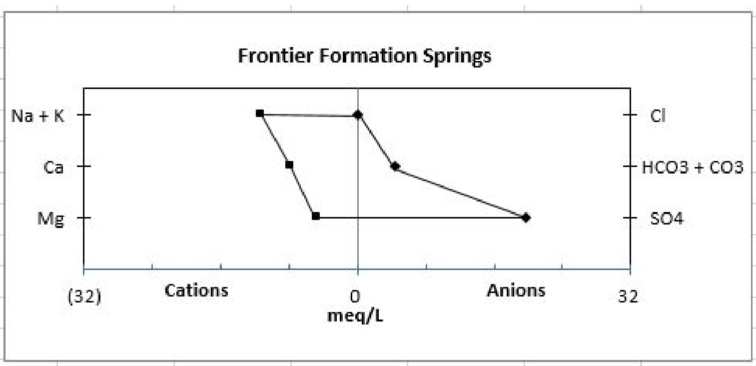
Analytical results from spring sampling conducted by the USGS were summarized and averaged for major ionic species. **Figure D-4** presents Stiff diagrams of USGS spring samples. Stiff patterns are most useful for in making a rapid visual comparison between waters from different sources, or to detect unusually sample results in a series of results from the same source.



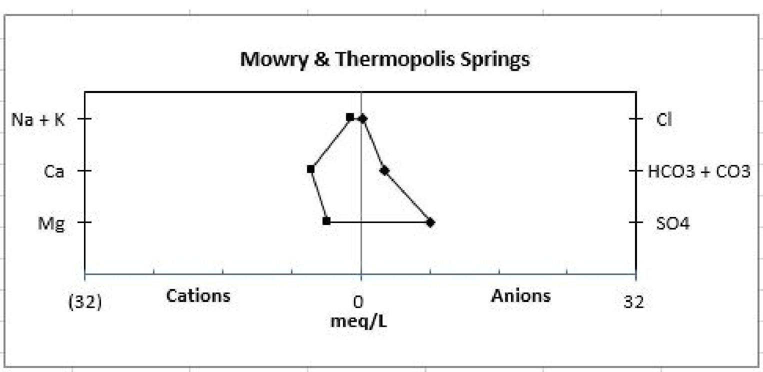
Plot a. Stiff diagram for springs hosted in Pleistocene-recent alluvium and colluvium. Data source: USGS National Water Information Service (NWIS) Water Quality Database, available at https://waterdata.usgs.gov/nwis, accessed 7/19/2016.



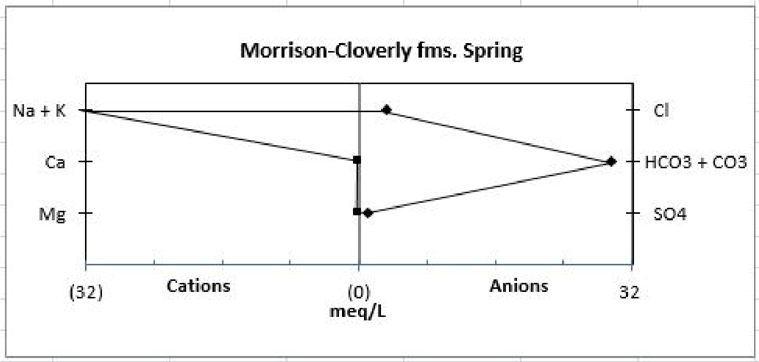
Plot b. Stiff diagram for springs hosted in Eocene-age Absaroka volcanic rocks. Data source: USGS National Water Information Service (NWIS) Water Quality Database, available at https://waterdata.usgs.gov/nwis, accessed 7/19/2016.



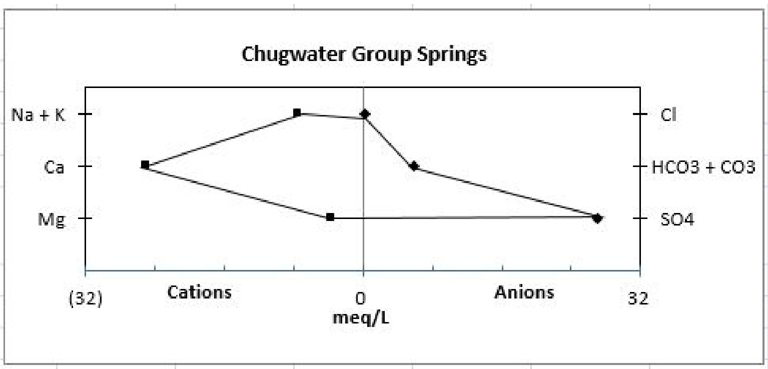
Plot c. Stiff diagram for springs hosted in the upper Cretaceous-age Frontier Formation. Data source: USGS National Water Information Service (NWIS) Water Quality Database, available at https://waterdata.usgs.gov/nwis, accessed 7/19/2016.



Plot d. Stiff diagram for Springs hosted in Cretaceous-age Mowry and Thermopolis Shales. Data source: USGS National Water Information Service (NWIS) Water Quality Database, available at https://waterdata.usgs.gov/nwis, accessed 7/19/2016.



Plot e. Stiff diagram for springs hosted in undifferentiated rocks belonging to upper Jurassic-age Morrison Formation-to lower-Cretaceous-age Cloverly Formation. Data source: USGS National Water Information Service (NWIS) Water Quality Database, available at https://waterdata.usgs.gov/nwis, accessed 7/19/2016.



Plot f. Stiff diagram for springs hosted in Triassic-age Chugwater Group rocks. Data source: USGS National Water Information Service (NWIS) Water Quality Database, available at https://waterdata.usgs.gov/nwis, accessed 7/19/2016.

Figure D-4 Stiff Diagrams depicting Major Ion Water Chemistry for USGS Spring Samples.

The Stiff diagram is a graphical representation of chemical analyses represented by a polygonal shape created from three to four parallel horizontal axes extending on either side of a vertical zero axis (Fetter, 1994). Cations are plotted in milliequivalents per liter on the left of the zero axis, one to each horizontal axis, and anions are plotted on the right. The larger the area of the polygonal shape, the greater the concentration of the various ions in the sample.

All stiff diagrams for the spring water samples show markedly different patterns, indicative of different sources and chemical evolution. Spring water from the Chugwater Group source followed closely by the sample from the Morrison-Cloverly (undifferentiated) spring show the highest concentrations of dissolved major ion. Sample results from Absaroka volcanic rocks show the lowest concentrations of dissolved major ions. To avoid unintended consequences, the wide distribution of chemical character shown by spring water indicates additional sampling should be performed before such water sources are developed.

Additional summaries of analytical results useful in characterizing overall spring water quality are discussed further below.

Total Dissolved Solids (TDS)

TDS results were available for all 17 USGS samples. **Figure D-5** presents a summary of TDS results averaged for each spring source host rock. Notably, except for the three samples from Absaroka volcanic springs, all samples contained high TDS (> 500 mg/L).

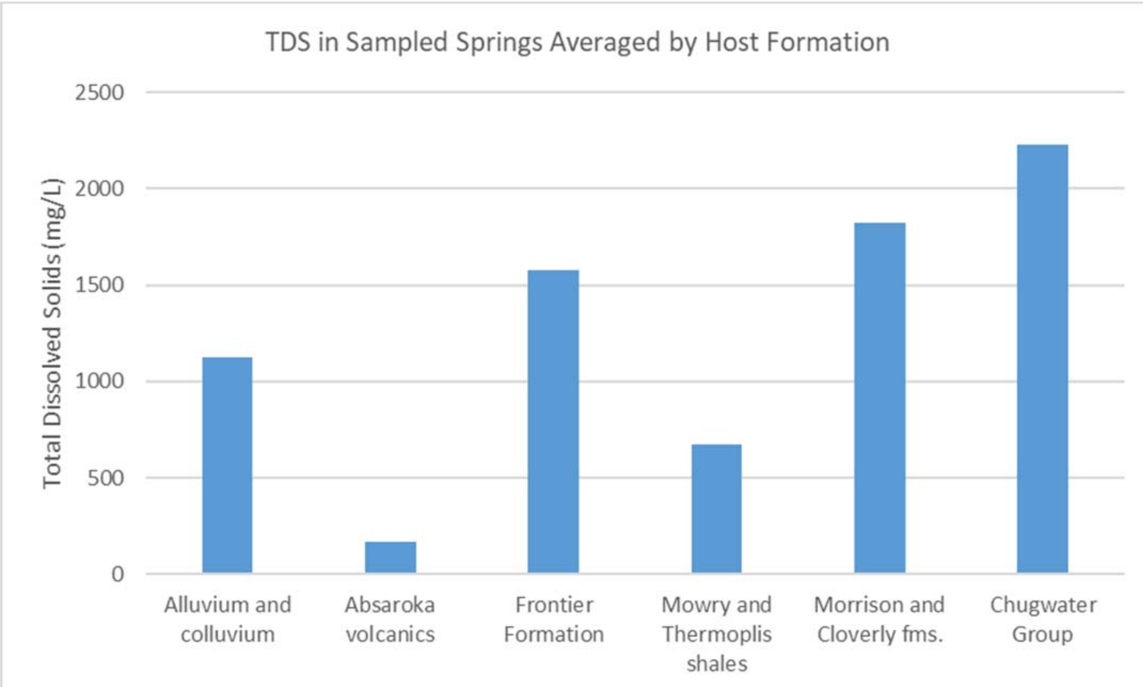


Figure D-5. Total Dissolved Solids Results Averaged by Host Formation

Based on the TDS, all samples from the alluvium and Chugwater sources and three of the four Frontier samples would be considered "brackish" water (Fetter, 1994). While high TDS would not be unexpected for the Chugwater and Frontier aquifers based on their lithologies and age, it is not clear what is responsible for the high TDS in the alluvial spring. Certainly, the results from one alluvial spring should not be used to generalize groundwater quality from alluvial sources at other locations.

Additional sampling of these springs and perhaps others in the area may be required to more fully understand the patterns and sources of TDS in alluvial groundwater. A likely explanation might be that alluvial groundwater is freely exchanging with surface water which may be carrying unusually high loads at certain times, or which might be affected by run-off from livestock areas or irrigation return flow, or evaporation resulting in a greater concentration of solutes.

Hardness

Hardness is mainly a measure of calcium and magnesium salts. Although strontium, aluminum, barium, iron, manganese, and zinc also cause hardness in water, they are not usually present in large enough concentrations to contribute significantly to total hardness. Because calcium carbonate is one of the more common causes of hardness, total hardness is usually reported in terms of calcium carbonate concentration (mg/L as CaCO3). According to the USGS (Hem, 1985), general guidelines for classification of waters are:

- 0 to 60 mg/L (milligrams per liter) as calcium carbonate is classified as soft;
- 61 to 120 mg/L as moderately hard;

- 121 to 180 mg/L as hard; and,
- Greater than 180 mg/L as very hard.

Hardness is a property of water that is not specifically a health concern, but it can be of concern with respect to water delivery system performance. For example, hard water can cause mineral scale buildup in piping, fixtures, and particularly water well screens, requiring periodic acidification treatment to remove scale clogging the screen openings.

Figure 3.4.1-6 presents a summary of hardness results averaged for each spring source host rock. These data show that most spring sources exhibited very hard groundwater, and that spring water sourced from Chugwater Group rocks contain the highest levels of hardness, which is not surprising due to the evaporite deposits often contained within Chugwater Group rocks. By comparison, ground water sourced from Absaroka volcanic sourced is classified as soft.

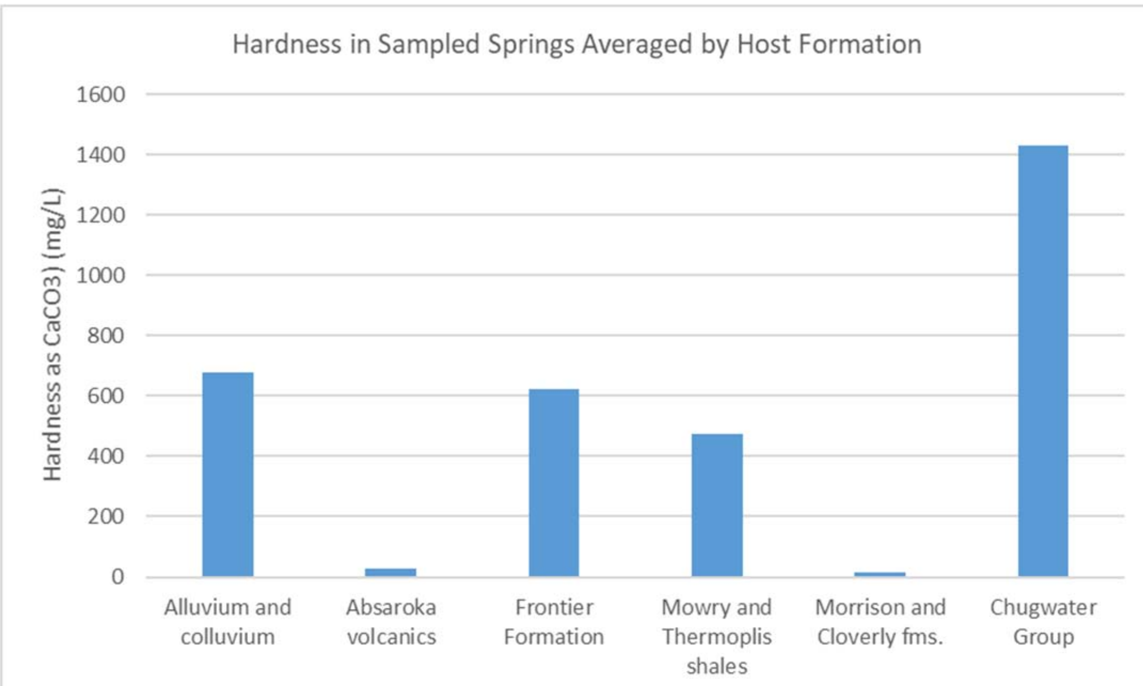


Figure D-6 Total Hardness Results (expressed as Calcium Carbonate) averaged by Host Formation.

Sodium Adsorption Ratio (SAR).

SAR is an important water quality parameter for agricultural concerns. SAR is a reasonable predictor of the degree to which irrigation water tends to enter into cation-exchange reactions in soil (Hem, 1985). High values of SAR imply a hazard of sodium replacing adsorbed calcium and magnesium, a situation ultimately damaging to soil structure. This will also lead to a decrease in infiltration and permeability of the soil to water, leading to problems with crop production. Generally, sands soils are less affected, but fine-textured soils (e.g., higher silt and clay content) can have be impacted when SAR is greater than 9. When SAR is less than a value of 3, impacts are generally not of concern. As shown in **Figure D-7**, only groundwater from spring sources in Absaroka volcanic rocks and Frontier Formation exceed a SAR value of 3, and generally not my much. With the exception of the SAR value measured in spring water from the Morrison-Cloverly (undifferentiated) source, SAR in the other spring waters sampled do not appear to be an issue. The extremely high SAR value for the Morrison-Cloverly spring is due to the high value of sodium measured in the water sample (750 mg/L). The sodium fraction of all cations determined for this samples is 99%. Additional sampling of this spring should be conducted to further conform the water quality results and flow rate at this spring.

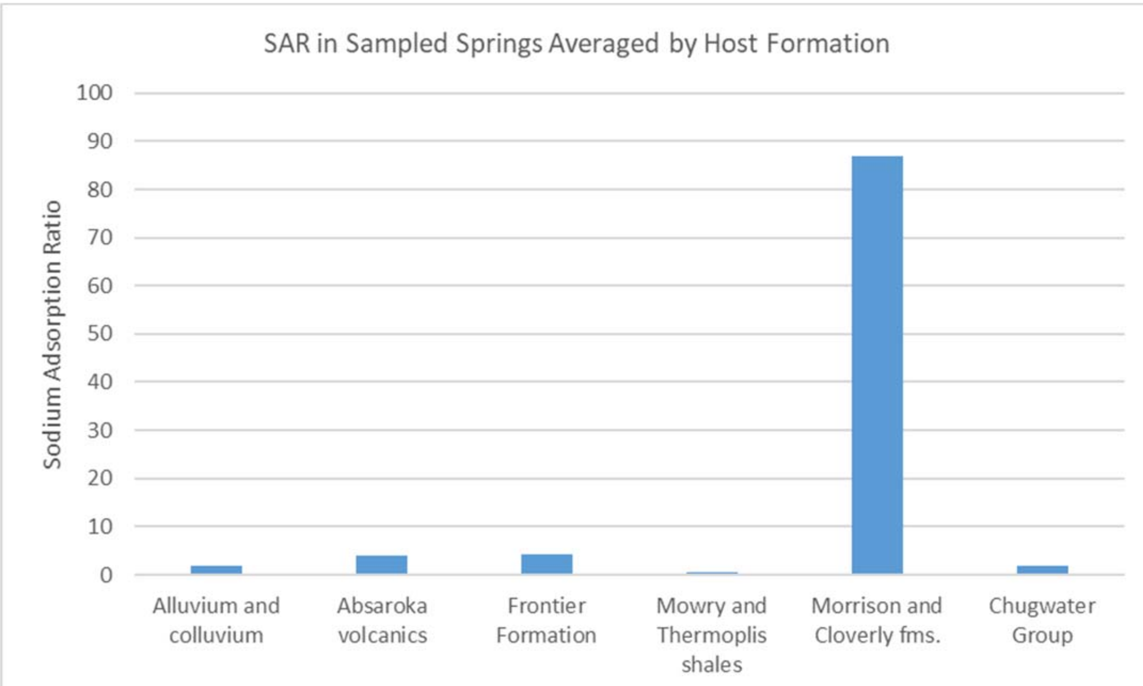


Figure D-7. Sodium Adsorption Ratio (SAR) Results averaged by Host Formation.

Alkalinity

The alkalinity of a water solution may be defined as the capacity for solutes it contains to react with and neutralize acid (Hem, 1985). Alkalinity was not determined for any of the spring samples obtained by the USGS. According to Rounds (2012), acid-neutralizing capacity (ANC) is equivalent to alkalinity in samples without titratable particulate matter because ANC is a measure of the acid-neutralizing capacity of solutes plus particulates in an unfiltered water sample, reported in milliequivalents or microequivalents per liter. Because ANC was determined in USGS samples rather than alkalinity, it is used a surrogate for alkalinity.

Figure D-8 presents results of ANC determined in the USGS spring samples. These data show that spring water from Morrison-Cloverly sources followed by alluvium/colluvium contained the highest value of ANC. In the case of the spring water from the alluvial/colluvium source, the relatively high ANC value may indicate impacts from human activities This could likely be the cases where alluvial/colluvial springs periodically source water from seasonally high water tables affected by surface water recharge (e.g., flood plains or terrace deposits). In the case of the spring water from Morrison-Cloverly Formations, high ANC is more likely the result impacts caused by connate water either from the Cloverly Formation or connate-affected groundwater migrating up-section from Sundance or Gypsum Springs Formations.

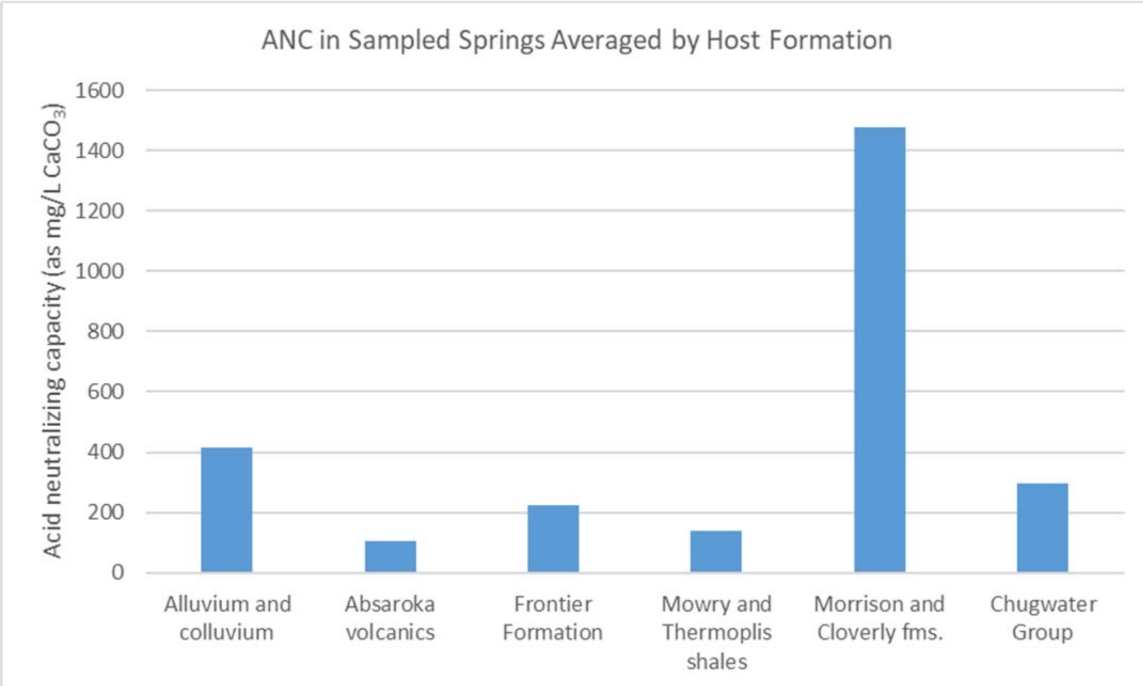


Figure D-8. USGS ANC Results Averaged by Host Formation.

In summary, the USGS spring sample data indicate a wide variety of water quality characteristics, such that different outcomes from spring development may be the result. Accordingly, additional sampling at these springs and others which may be located advantageously for development should be carried to characterize water quality and gauge possible impacts the use of such water in domestic, agricultural or industrial applications.

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APPENDIX E – Further Information on Surface Water Quality

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SURFACE WATER QUALITY

Surface Water Quality Program Results

Surface water quality for the Owl Creek basin area are available from a variety of government agency program sources that include the following datasets:

1. USGS National Water Information Services (NWIS) Water-Quality Database (mainly grab samples at various locations and dates).
2. Wyoming Department of Environmental Quality (WDEQ) Water Quality Division Watershed Program Surface Water Assessment (September 1997 – July 2004).
3. Wind River Environmental Quality Commission (WREQC) 106 CWA Water Quality and Baselines Project (January 1997 – March 2004).
4. Wind River Environmental Quality Commission (WREQC) 106 main water monitoring activities (January 1997 – September 2011).
5. Wind River Environmental Quality Commission (WREQC) SW-R 2012, 106 CWA Sampling of Rivers and Streams (April 2012 – June 2013.

Table E-1 summarizes locations and period of record for surface water quality data collected by the USGS and obtained from the NWIS Water-Quality Database. **Table E-2** summarizes locations and period of record for surface water quality data collected by WDEQ and WREQC agencies.

Review of the datasets summarized in the following tables indicates that some stations are located at or near stations named or described differently in the same dataset. These occurrences are described in the notes below each table. It is possible that due to a long duration between samples, the original site could not be precisely located and instead of using the original station name or ID no. a new name was established. In addition, there are some stations across the datasets that appear to be co-located but have very different site descriptions or similar site descriptions but different coordinates. These might be clerical errors or the agency establishing a station was unaware that a previous station was established at the site by a different agency. Unfortunately, this can cause come confusion and can disrupt the temporal continuity in a series of samples that may have been obtained from the same or near same location over time.

Rounding errors, or clerical errors in coordinates obtained from GPS location devices may also contribute to error in locations. For these reason, most of the data will be discussed by source (USGS, WDEQ, and WREQC) and may be compared where it seems clear that the station is indeed the same.

The five datasets range in quality and number of stations sampled. The USGS dataset (dataset 1) consists of many stations, but save for a couple stations, consist mainly of samples collected at one location for a single time period. These data, however appear to be of the highest quality due to requirements of the USGS water quality sampling and analytical standards. The WDEQ sampling (dataset 2) consists of one set of samples obtained at two locations on Rock Creek and three locations on Owl Creek, and one on Red Canyon Creek. The WREQC sampling programs appears to be conducted under Section 106 Clean Water Act grants and were reported back to the US Environmental Protection Agency (EPA) and uploaded to EPA's STORET database for distribution to interested parties. Three WREQC datasets were obtained from STORET: dataset 3, a 1997-2004 effort to obtain data for baseline water quality information for 305b reports at four stations, dataset 4, consisting of many samples obtained 1997 and 2011 from three stations on South Fork Owl Creek and two stations on Owl Creek, and dataset 5, consisting of field parameters measured on several dates at two locations, one on South Fork of Owl Creek and one on Owl Creek during 2012 and 2013.

Unfortunately, after significant time and effort was spent evaluating the WRECQ datasets, dataset 4 was set aside from further discussion in this report. This set of data probably represents the most extensive sampling to date of locations on Owl Creek and South Fork Owl Creek but due to significant errors in the data, improper use of units attached to result values and an overall lack of documentation, there appeared no viable way to present these data in a meaningful way that makes sense and is consistent with results from other sampling programs.

Table E-1 Summary of USGS Surface Water Sampling Locations (Source: USGS NWIS Water-Quality Database).

Stream/Location	Site No.	Lat.	Long.	Period	No. of Samples
Owl Creek at mouth near Lucerne, WY	434319108093100	43.7219	-108.1586	7/2/1947, 9/14/1976, 11/8/76	3
Owl Creek above Mud Creek near Thermopolis, WY	06263300	43.6919	-108.3228	5/20/1965	1
Owl Creek near Thermopolis, WY	06264000	43.6858	-108.3022	5/20/1965, 6/26/1965, 12/19/1975, 5/20/1976, 9/14/1976, 11/14/1976	6
S.F. Owl Creek at Embar Ranch, WY	434250108401900	43.7139	-108.6719	5/20/1976, 9/14/1976	2
Owl Creek at Middleton School, WY	434207108281700	43.7019	-108.4714	5/20/1976, 9/14/1976	2
S.F. Owl Creek near Embar Ranch, WY	434229108425500	43.7081	-108.7153	5/20/1976, 9/14/1976	2
S.F. Owl Creek near Arapahoe Ranch, WY	434326108355900	43.7239	-108.5997	5/20/1976, 9/14/1976	2
Owl Creek at Arapahoe Ranch, WY	434327108320500	43.7242	-108.5347	5/20/1976, 9/14/1976	2
Owl Creek near Thompson Reservoir No. 1 near Thermopolis, WY	434128108233400	43.6911	-108.3928	5/20/1976, 9/14/1976	2
Mud Creek at mouth near Thermopolis, WY	434104108200500	43.6844	-108.3347	5/20/1976, 9/14/1976	2
Owl Creek at US Hwy 20 near Lucerne, WY	434255108103200	43.7153	-108.1756	5/20/1976, 9/14/1976, 11/8/1976	3

Table E-1 Summary of USGS Surface Water Sampling Locations (Source: USGS NWIS Water-Quality Database).					
Stream/Location	**Site No.**	**Lat.**	**Long.**	**Period**	**No. of Samples**
Owl Creek 1.0 mi above Meeteetse Draw near Thermopolis, WY	434137108143500	43.6936	-108.2431	9/4/1976, 11/4/1976	2
S.F. Owl Creek at mouth near Arapahoe Ranch, WY	434336108352800	43.7267	-108.5911	9/14/1976	1
Owl Creek below Meeteetse Draw near Thermopolis, WY	434152108141100	43.6978	-108.2364	11/4/1976	1
Owl Creek 3.1 mi below Eagle Draw near Thermopolis, WY	434134108150400	43.6928	-108.2511	11/4/1976	1
Owl Creek 1.7 mi above Meeteetse Draw near Thermopolis, WY	434129108145400	43.6914	-108.2483	11/4/1976	1
Owl Creek 0.5 mi below Eagle Draw near Thermopolis, WY	434112108160800	43.6867	-108.2689	11/4/1976	1
Owl Creek at Sunnyside Lane near Thermopolis, WY	434208108133000	43.7022	-108.2250	11/8/1976	1
South Fork Owl Creek near Anchor, WY	06260000	43.6667	-108.8550	1977-2000	121
Owl Creek at Arapahoe Ranch near Thermopolis, WY	434331108321601	43.7253	-108.5378	3/6/1989	1
Owl Creek near Hamilton Dome, WY	434326108320201	43.7239	-108.5339	10/2/1989	1
S.F. Owl Creek above Rock Creek near Anchor Reservoir, WY	434035109062101	43.6764	-109.1058	10/18/1989	1
Owl Creek at Hwy 120 near Thermopolis, WY	434106108180401	43.6850	-108.3011	7/22/1991, 11/17/1991	2
S.F. Owl Creek at old oil field pad near Anchor, WY	434206108425501	43.7017	-108.7153	7/23/1991	1
N.F. Owl Creek above Basin near Anchor, WY	06262300	43.6892	-108.8400	7/23/1991	1
N.F Owl Creek in Sec. 31, near Embar, WY	434406108393201	43.735	-108.6589	11/13/1991	1
N.F. Owl Creek above Rattlesnake Creek near Anchor, WY	434204108473201	43.7011	-108.7922	11/13/1991	1
N.F. Owl Creek at Knob above Arapahoe Ranch near Hamilton Dome, WY	434357108352201	43.7325	-108.5894	11/13/1991	1
S.F. Owl Creek at trailer near Hamilton Dome, WY	434326108355101	43.7239	-108.5975	11/15/1991	1

Table E-1 Summary of USGS Surface Water Sampling Locations (Source: USGS NWIS Water-Quality Database).					
Stream/Location	**Site No.**	**Lat.**	**Long.**	**Period**	**No. of Samples**
Red Creek at Hwy 170 crossing below Embar, WY	434223108390401	43.7064	-108.6511	11/15/1991	1
Pumpkin Creek at ditch near Thompson Reservoir near Thermopolis, WY	434037108225201	43.6769	-108.3811	11/16/1991	1
Pumpkin Draw near Thompson Reservoir near Thermopolis, WY	434134108275701	43.6928	-108.4658	11/16/1991	1
Owl Creek at steel building near Thompson reservoir near Thermopolis, WY	434128108233301	43.6911	-108.3925	11/17/1991	1
Owl Creek at Sunnyside Lane near Thermopolis, WY	434206108133501	43.7017	-108.2264	11/17/1991	1
Owl Creek at Sand Points near Thermopolis, WY	434112108160901	43.6867	-108.2692	11/17/1991	1
Owl Creek near Lucerne, WY	06264500	43.7153	-108.1761	7/13/2000	1

NOTES

1. Station 06264000 (Owl Creek near Thermopolis, WY) is located just below Hwy 120 crossing (marked on USGS topo map), and is probably same or very near location of Station 434106108180401 (Owl Creek at Hwy 120 near Thermopolis, WY).
2. Station 434327108320500 (Owl Creek at Arapahoe Ranch, WY) and Station 434326108320201 (Owl Creek near Hamilton Dome, WY) appear to be co-located, but has slightly different coordinates.
3. Station 434128108233400 (Owl Creek near Thompson Reservoir No. 1 near Thermopolis, WY) and Station 434128108233301 (Owl Creek at steel building near Thompson reservoir near Thermopolis, WY) appear co-located but have slightly different location descriptions and coordinates.
4. Station 434112108160901 (Owl Creek at Sand Points near Thermopolis, WY) appears to be co-located with Station 434112108160800 (Owl Creek 0.5 mi below Eagle Draw near Thermopolis, WY), but has slightly different coordinates.
5. Station 434208108133000 and Station 434206108133501 have the same location description (Owl Creek at Sunnyside Lane near Thermopolis, WY), but different site ID's and slightly different coordinates.
6. Station 434255108103200 (Owl Creek at US Hwy 20 near Lucerne, WY) appears to be co-located with Station 06264500 (Owl Creek near Lucerne, WY) but has slightly different coordinates.
7. Station 0626000 (South Fork Owl Creek near Anchor has most complete record with flow data.

Table E-2 Summary of WDEQ and WREQC Surface Water Sampling Locations (Source: EPA STORET database).							
Stream	**Location**	**Station ID**	**Lat.**	**Long.**	**Agency**	**Period**	**No. of Samples**
2. WDEQ Water Quality Division Watershed Program Surface Water Assessment (September 1997 – July 2004)							
Rock Creek	Lower Rock Creek	MRW77	43.6947	-109.1086	WDEQ	9/3/1997	1
Rock Creek	Upper Rock Creek	MRWI42	43.7306	-109.1394	WDEQ	9/3/1997	1
Owl Creek	Owl Creek Hwy 120	WB0231	43.6866	-108.3047	WDEQ	7/6/2004	1
Owl Creek	Owl Creek Jones Rd	WB0232	43.6900	-108.3748	WDEQ	7/6/2004	1
Red Canyon Creek	Red Canyon Creek - Bison Ranch	WB149	43.6005	-108.3324	WDEQ	8/13/2001	1
Owl Creek	Owl Creek - Hwy 20/789 crossing	WB152	43.7158	-108.1786	WDEQ	8/22/2001 7/6/2004	2
3. WREQC 106 CWA Water Quality and Baselines Project (January 1997 – March 2004)							
S.F. Owl Creek	Above Anchor Reservoir	G-54	43.66	-108.854	WREQC	1/9/1997 – 8/29/2000	14
S.F. Owl Creek	Owl Creek Rd, 2mi W. of Embar	G-58	43.711	-108.718	WREQC	7/24/1998 – 3/24/2004	34
S.F. Owl Creek	Below mouth of Red Creek	G-60	43.715	-108.611	WREQC	10/8/2002	1
Owl Creek	Near Owl Creek Rd. (Hwy 170) crossing	M-37	43.704	-108.475	WREQC	1/9/1997 – 7/23/2003	39
4. WREQC 106 Main Water Monitoring Activities (January 1997 – June 2011)							
S.F. Owl Creek	Mislocated in intermittent stream tributary to SF Owl Creek	206	43.6600	-108.8542	WREQC	1/9/1997 – 8/29/2000	14
S.F. Owl Creek	S.F. Owl Creek	207	43.7108	-108.7181	WREQC	7/24/1998 – 9/29/2010	53
Owl Creek	Owl Creek	223	43.7044	-108.4750	WREQC	1/9/1997 - 3/25/2005	47
S.F. Owl Creek	Upper S.F. Owl Creek	1051	43.7108	-108.7181	WREQC	4/24/2009 - 9/28/2011	12
Owl Creek	Owl Creek at Arapaho Ranch	1115	43.7224	-108.5257	WREQC	4/24/2009 - 9/28/2011	12
5. WREQC SW-R 2012, 106 CWA Sampling of Rivers and Streams in 2012.							

Table E-2 Summary of WDEQ and WREQC Surface Water Sampling Locations (Source: EPA STORET database).							
Stream	**Location**	**Station ID**	**Lat.**	**Long.**	**Agency**	**Period**	**No. of Samples**
S.F. Owl Creek	Below Anchor Dam, near intersection Merrit Pass Road and Owl Creek Road	G-58	43.7073	-108.7152	WREQC	4/12/2012 – 6/21/2013	4
Owl Creek	Owl Creek at Arapaho Ranch	OCAR	43.7240	-108.5351	WREQC	4/12/2012 – 6/21/2013	3

NOTES

1. Station WB0232 location description would put this station at same location where USGS 434128108233301 plots at the Jones Road crossing, but station WB0232 actually plots 2.1 miles downstream from Jones Road crossing.
2. Station G-54 and Station 206 appear as same location.
3. Station 207 and Station 1051 appear as same location, and very near Station G-58.
4. Station M-37 and Station 223 appear as same location.
5. Station 1115 and Station OCAR have same description but Station 1115 plots about 4,200 ft downstream.

Overall Water Quality

Overall water quality for all sample stations is summarized by Piper diagram in **Figure E-1**. Refer to Section 3.4.1 for additional discussion regarding the use of the Piper diagram in classifying water based on major ionic species. The samples from Owl Creek basin streams contain water generally classified as calcium sulfate or bicarbonate water. None of these samples fall within the saline region. There are also quite a few stations that plot in the indeterminate cation region caused by low levels of other cations (see **Figure E-2** for definition of regions).

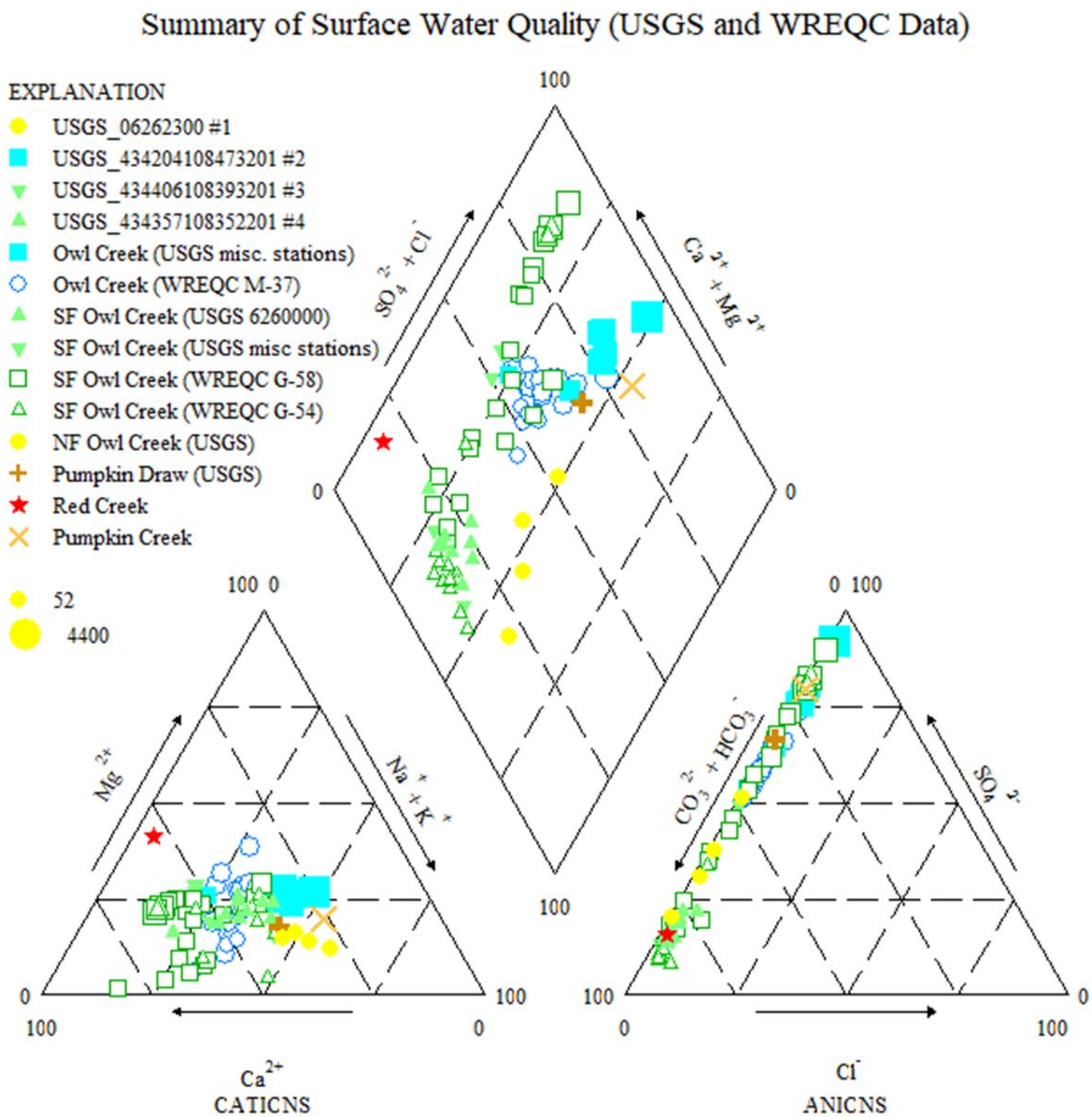

Figure E-1. USGS and WREQC data plotted on Piper diagram, and color-coded by stream (blue colors – Owl Creek, green = South Fork Owl Creek, yellow = North Fork Ow Creek;, see legend for additional symbology.

One outlier is apparent from the data analyzed. The sample from Red Creek indicates a comparatively different water quality, possibly reflecting the geologic composition of its source area (Precambrian granitic rocks). Note also that the two samples from Pumpkin Draw and Pumpkin Creek essentially plot similarly to Owl Creek samples which is not surprising as these station locations are essentially adjacent to the channel of Owl Creek and at least Pumpkin Draw seems to contain water diverted from Owl Creek. There may be other outliers from other areas which could be revealed by additional sampling and analysis of stream water.

In general, through the data do no cover all dates and locations, it is likely that the compositional ranges shown by the values in **Figure 3.4.2-1** are influenced by watershed position and time of year. It is also apparent that all streams become enriched with respect to sulfate in the downstream direction and exhibit a general increase in TDS. Because it is difficult to depict compositional nuances over such a large and varied set of station locations and timeframes, stiff diagrams were prepared to further the discussion of water quality through the Owl Creek basin. See Section 3.4.1 for a discussion of Stiff diagram preparation. Variations in water quality on a per-stream basis will be discussed in more detail below in conjunction as supported by the Piper diagram (**Figure 3.4.2-1**) and additional Stiff plots where available.

North Fork Owl Creek Surface Water Stations

Only four of the North Fork Owl Creek Stations sampled by the USGS included sufficient data to generate Stiff plots. These stations are tabulated in Table E-3.

Table E-3 South Fork Owl Creek Stations and Dates used in Stiff Analysis.

Station	Dates	Description	HUC10	HUC12
USGS_ 06262300	7/23/91	N.F. Owl Creek above Basin near Anchor, WY	NF Owl Creek 1008000701	Lower NF Owl Creek 70107
USGS_434204108473201	11/13/91	N.F. Owl Creek above Rattlesnake Creek near Anchor	NF Owl Creek 1008000701	Lower NF Owl Creek 70107
USGS_434357108352201	11/13/91	N.F. Owl Creek at Knob above Arapahoe Ranch near Hamilton Dome, WY	NF Owl Creek 1008000701	Lower NF Owl Creek 70107
USGS_434406108393201	11/13/91	N.F Owl Creek in Sec. 31, near Embar, WY	NF Owl Creek 1008000701	Lower NF Owl Creek 70107

The data from these stations, while limited, seem to be mostly influenced by position in the watershed rather than seasonal effects (three of the four stations were sampled on the same day (11/13/1991) and exhibit compositional trend as shown in **Figure E-2** where water quality becomes more enriched with respect to calcium sulfate in the downstream direction. Although not well depicted on the Piper diagram, TDS also increases in the downstream direction from 182 mg/L to approximately 500 mg/L.

Figure E-3 shows the Stiff plots graphically and arranged in order from highest to lowest position in the South Fork watershed. As shown, the quantity of sulfate increases downstream as does overall dissolved species as illustrated by the overall area of each plot. **Figure E-4** depicts the four North Fork Owl Creek stations plotted on a map and symbolized with the applicable stiff plot to better illustrate the spatial distribution of the change in water quality.

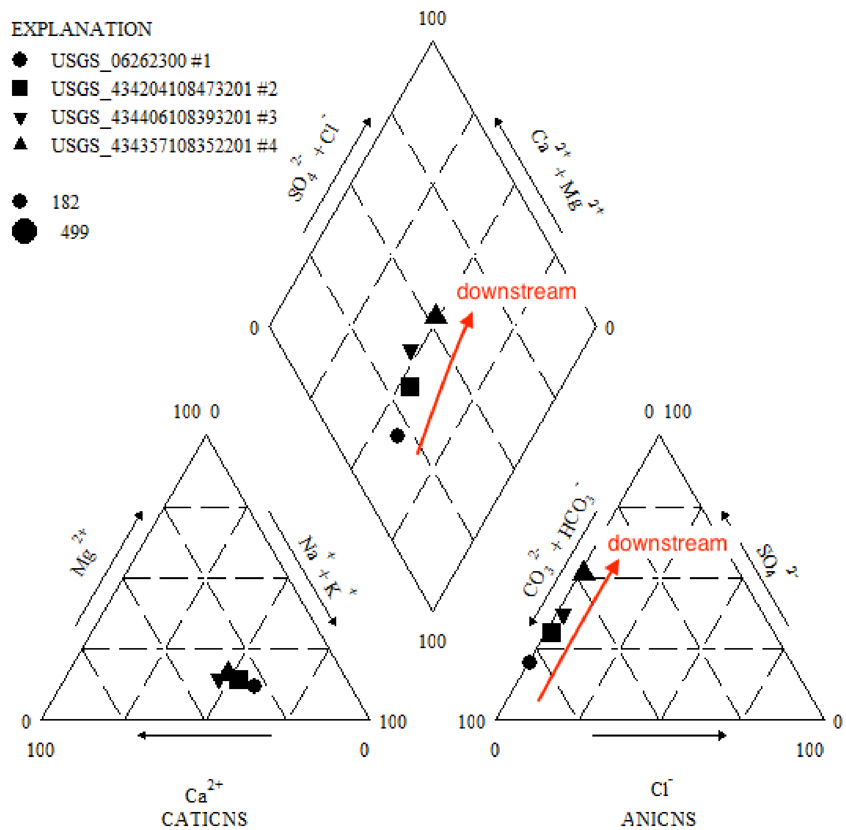

Figure E-2. North Fork Owl Creek USGS Stations showing trend on Piper Diagram.

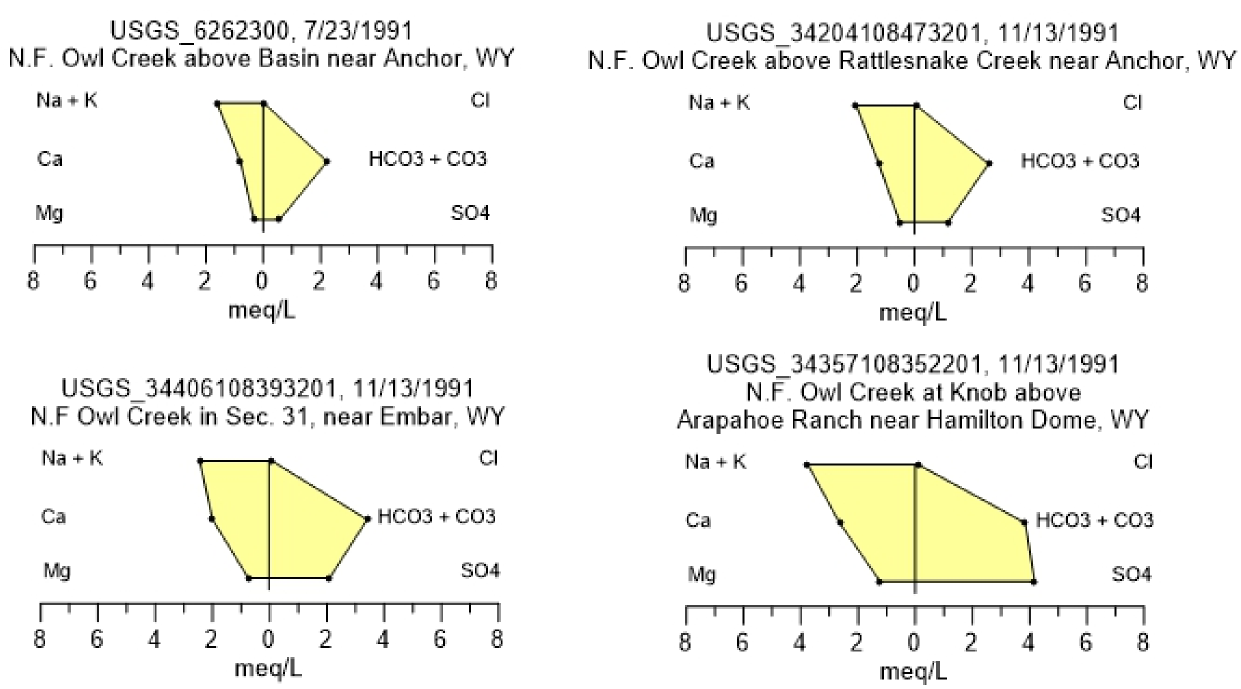

Figure E-3. North Fork Owl Creek USGS Stations Stiff plots arranged in order from upstream to downstream.

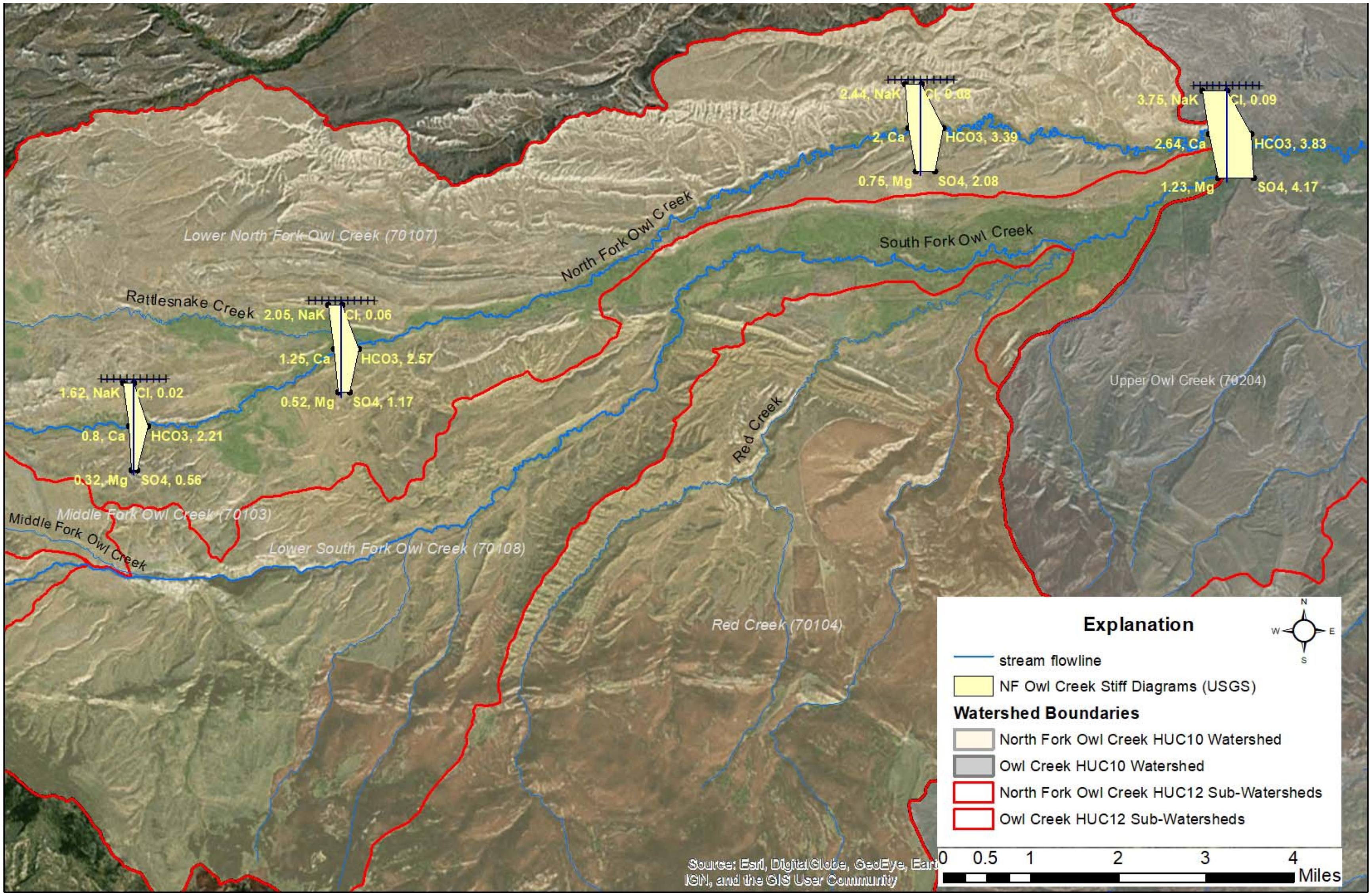

Figure E-4. Map of USGS North Fork Owl Creek stations annotated with Stiff plots. Note the increase of sulfate and dissolved major constituents in the downstream direction.

South Fork Owl Creek Surface Water Stations

Only a subset of USGS and WREQC stations on the South Fork of Owl Creek collected sufficient data to analyze by Stiff plot. These stations are tabulated as **Table E-4.**

Table E-4 South Fork Owl Creek Stations and Dates used in Stiff Analysis.

Station	Dates	Description	HUC10	HUC12
USGS_ 06260000	5/12/77, 6/6/77, 6/16/77, 6/30/77, 7/12/77, 4/8/78, 5/25/78, 6/22/78, 7/12/78, 7/26/78	South Fork Owl Creek near Anchor, WY	NF Owl Creek 1008000701	Middle SFOC 70102
USGS_434035109062101	10/18/89	S.F. Owl Creek above Rock Creek near Anchor Reservoir	NF Owl Creek 1008000701	Upper SFOC 70101
USGS_434206108425501	7/23/91	S.F. Owl Creek at old oil field pad near Anchor, WY	NF Owl Creek 1008000701	Lower SFOC 70108
USGS_434326108355101	11/15/91	S.F. Owl Creek at trailer near Hamilton Dome, WY	NF Owl Creek 1008000701	Lower SFOC 70108
USGS_434336108352800	9/14/76	S.F. Owl Creek at mouth near Arapahoe Ranch, WY	NF Owl Creek 1008000701	Lower SFOC 70108
USGS_34223108390401	11/15/91	Red Creek at Hwy 170 crossing below Embar, WY	NF Owl Creek 1008000701	Red Creek 70104
WREQC-G-54	Monthly- Jan 1997-Nov 1997, 9/15/98, 7/7/99, 3/25/00, 8/29/00	S.F. Owl Creek above Anchor Reservoir	NF Owl Creek 1008000701	Lower SFOC 70108
WREQC G-58	Monthly- Jul 1998-Nov 1998, Monthly-Jan 1999-May 1999, Monthly-Jul 1999-Nov 1999, Monthly-Feb 2000-Jun 2000, 8/29/2000	S.F. Owl Creek 2 mi W. of Embar	NF Owl Creek 1008000701	Lower SFOC 70108

The six USGS stations are, graphically presented in **Figure E-5 and Figure E-6.** The station on Red Creek is included with the South Fork stations because it monitors Red Creek near its mouth, and Red Creek tributary to the South Fork Owl Creek. The difference in water quality between Red Creek and South Fork Owl Creek is marked (a calcium bicarbonate water), even though the Red Creek station is located within 3 miles upstream of USGS_434326108355101 and 3.5 miles upstream of USGS USGS_434336108352800. As mentioned before, the Red Creek sample is probably influenced by its source area which is underlain by Precambrian granitic rocks rather than the Mesozoic marine sedimentary rocks underlying much of the South Fork Stations.

One opportunity presented by the South Fork dataset shown in **Figure E-5 and Figure E-6** is the ability to compare seasonal variation with spatial variation. For example, the samples from USGS Site 6260000 (South Fork Owl Creek) were obtained over a one-year period (May 1977 to July 1978) and therefore do not vary in terms of geographic position but probably contain some minor degree of temporal variation due to the contributions of precipitation and snowmelt to discharge. Because this station is located high in the watershed and has little to no influence from tributary streams draining areas with differing geology, little variation is shown even though samples were obtained at many different times of the year. In contrast, comparing all the South Fork Owl Creek stations (arranged across both figures in descending order from highest to lowest in the South Fork watershed) shows virtually steady increase in both calcium and sulfate, and overall dissolved concentration of major water quality parameters.

The USGS South Fork Owl Creek stations are spatially presented on **Figure E-7.** Note that USGS_434336108352800 and the WREQC stations were not plotted on **Figure E-7** due to the proximity of their locations to the USGS stations (which obscured their locations) and the difference in sample dates.

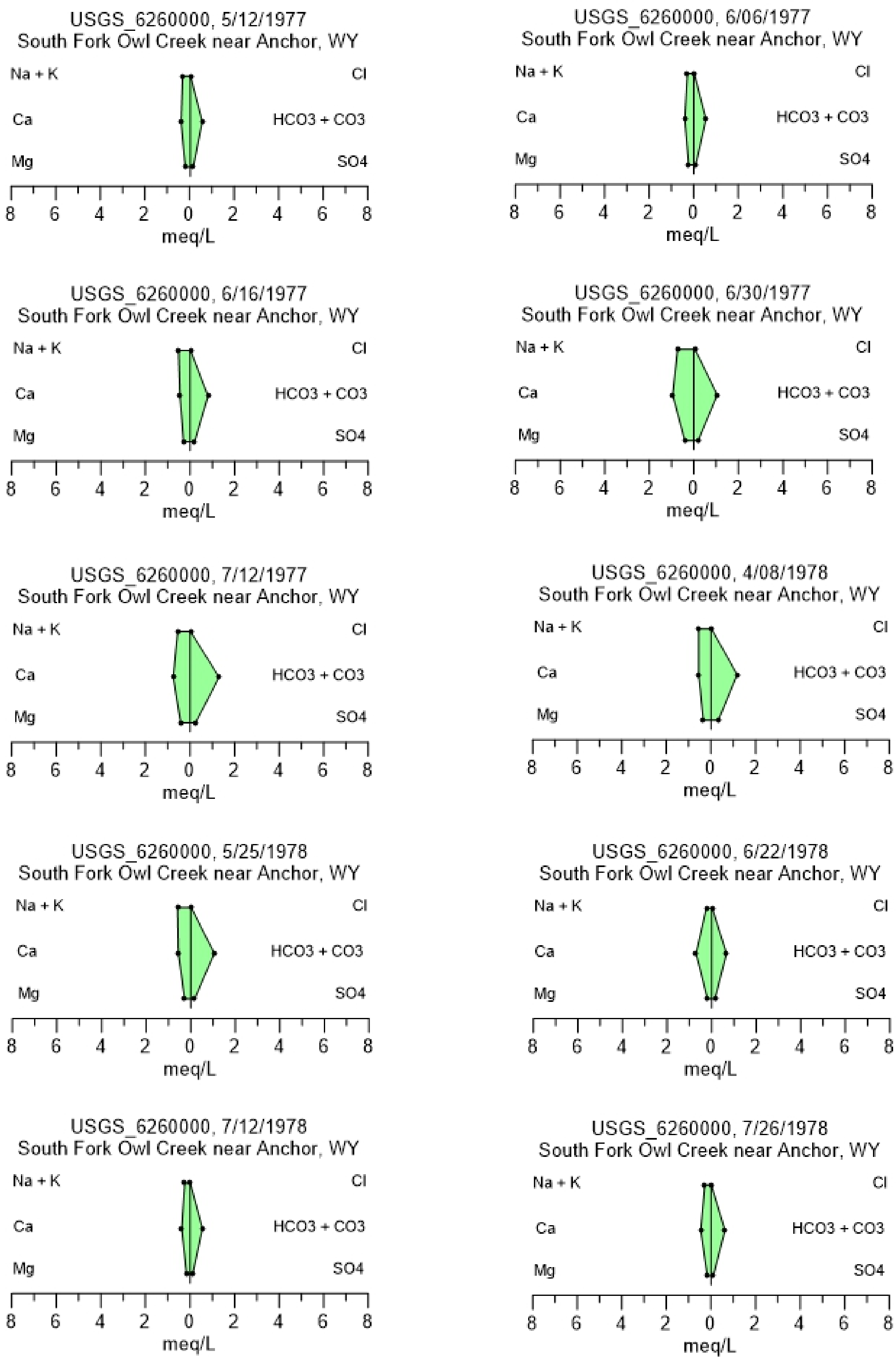

Figure E-5. North Fork Owl Creek USGS Station 626000 Stiff plots 1997-1998.

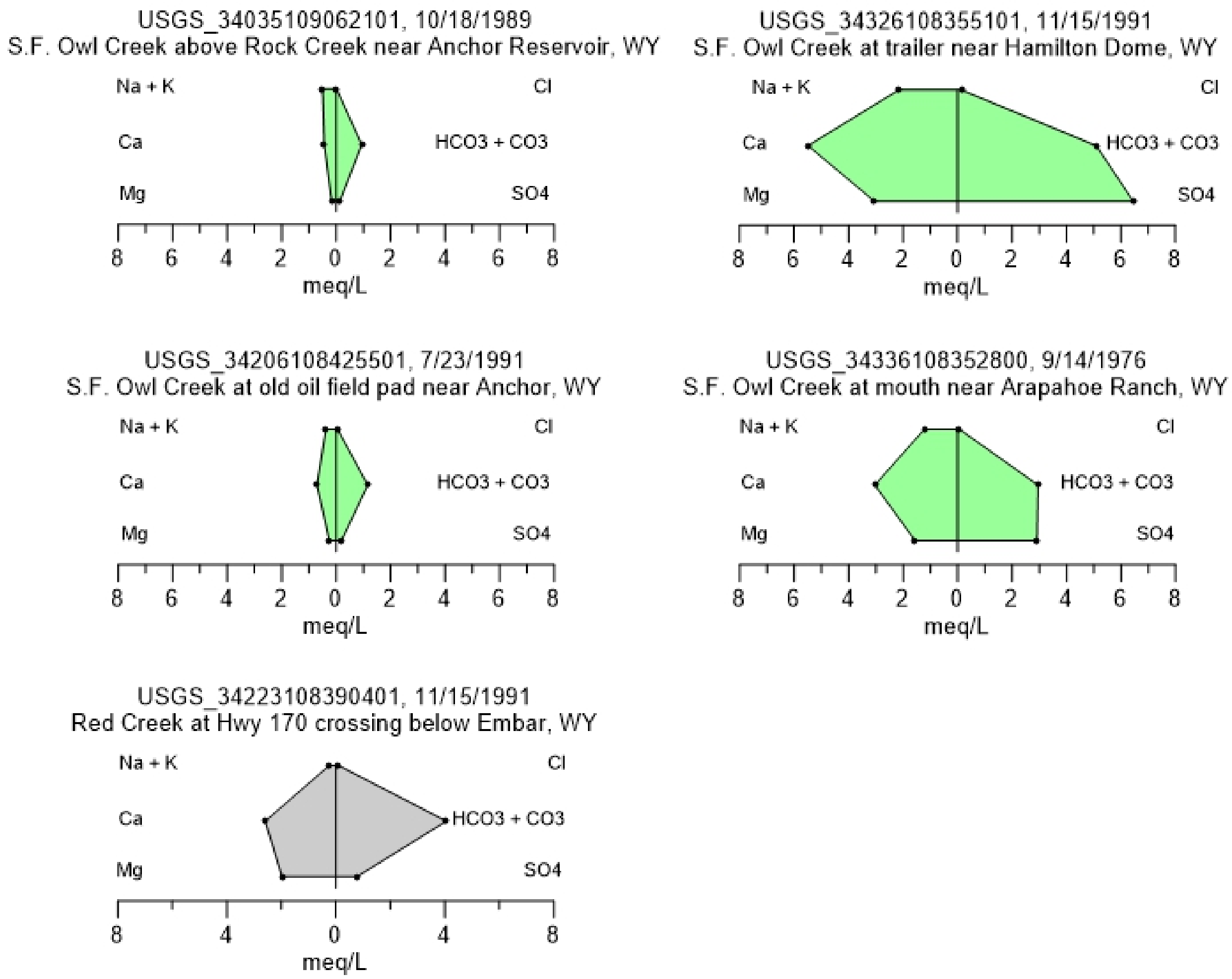

Figure E-6. Stiff Plots for Additional North Fork Owl Creek USGS Stations and the Red Creek Station all sampled in during 1989-1991 except USGS_34336108352800.

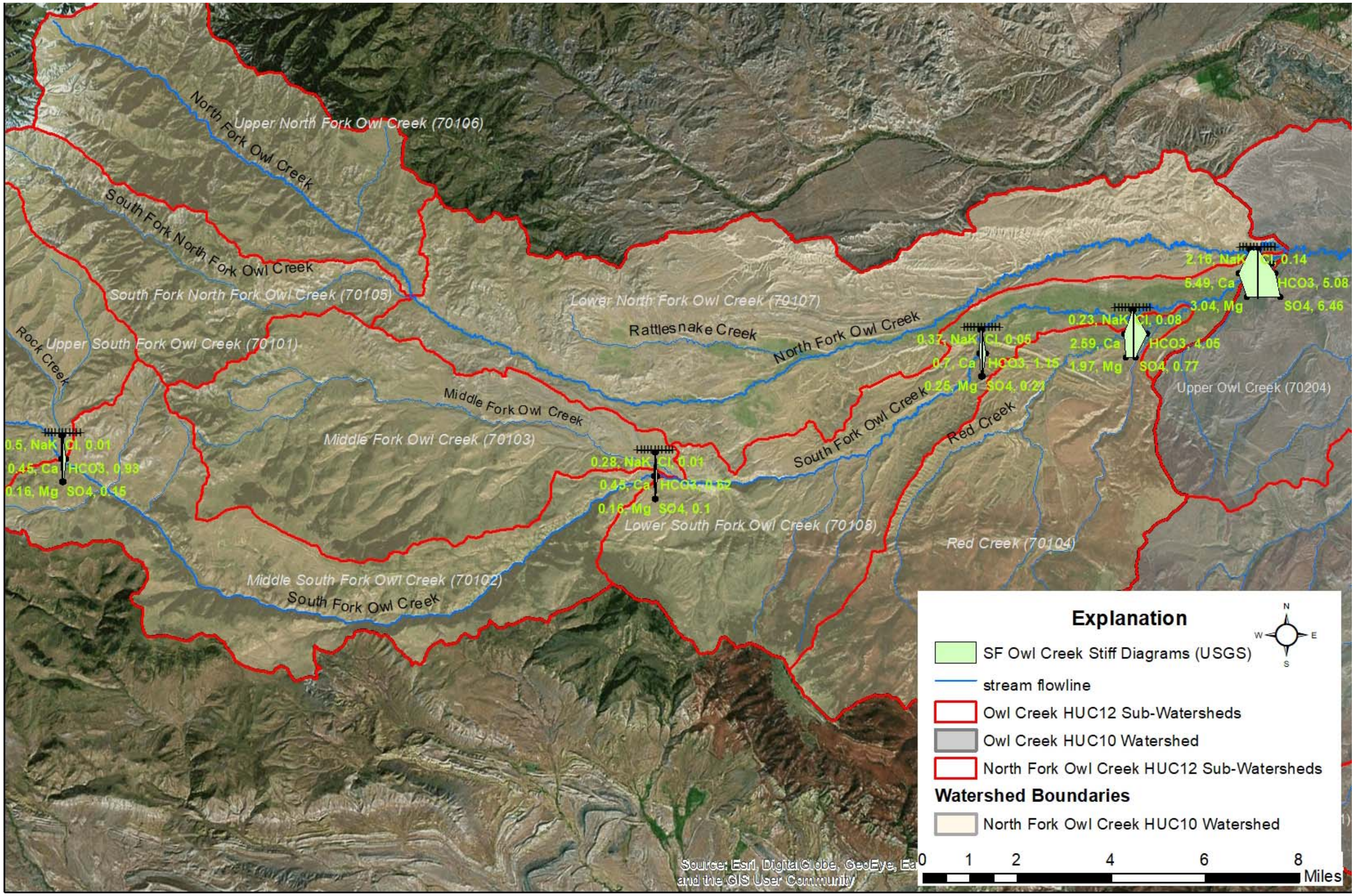

Figure E-7. Map of USGS South Fork Owl Creek stations annotated with Stiff plots. Note that the upper two stations have such comparatively low dissolved solids they can barely be depicted.

Data from WREQC Station G-54 mostly cluster tightly together on the Piper plot (**Figure E-2**), and were obtained over a three-year period (1997-2000), so what little variation is shown in overall composition is likely due to temporal influences (precipitation and snow melt affecting discharge). The location of WREQC G-54 is above Anchor Reservoir, probably co-located with USGS_6260000 or located very close by. Thus, the record for G-54 can essentially be treated as a continuation of the USGS_626000 record which is presented through 1978. Comparison of these two datasets shows little difference even though 19 years lapsed between the end of USGS_6260000 and WREQC G-54.

Of note is a large increase in overall concentration of dissolved constituents at station WREQC G-54 in year 2000 (see Stiff figures later in the document). Discharge data are not included with the WREQC water quality data, so it is difficult to ascertain stream conditions during the sampling, which took place during March and August of 2000. Review of SEO discharge data from nearby gage 03050C01 on those dates shows that no flow was recorded on 3/25/2000 (sample date), which indicates no flowing water or the gage was not operating. Only 7 cfs was recorded on 8/29/2000 (sample date), which is comparatively low considering the entire annual record of daily average flow (**Figure E-8**). It is likely the high values of dissolved solids are related to low flow conditions due to lack of diluting water normally available at higher rates of flow.

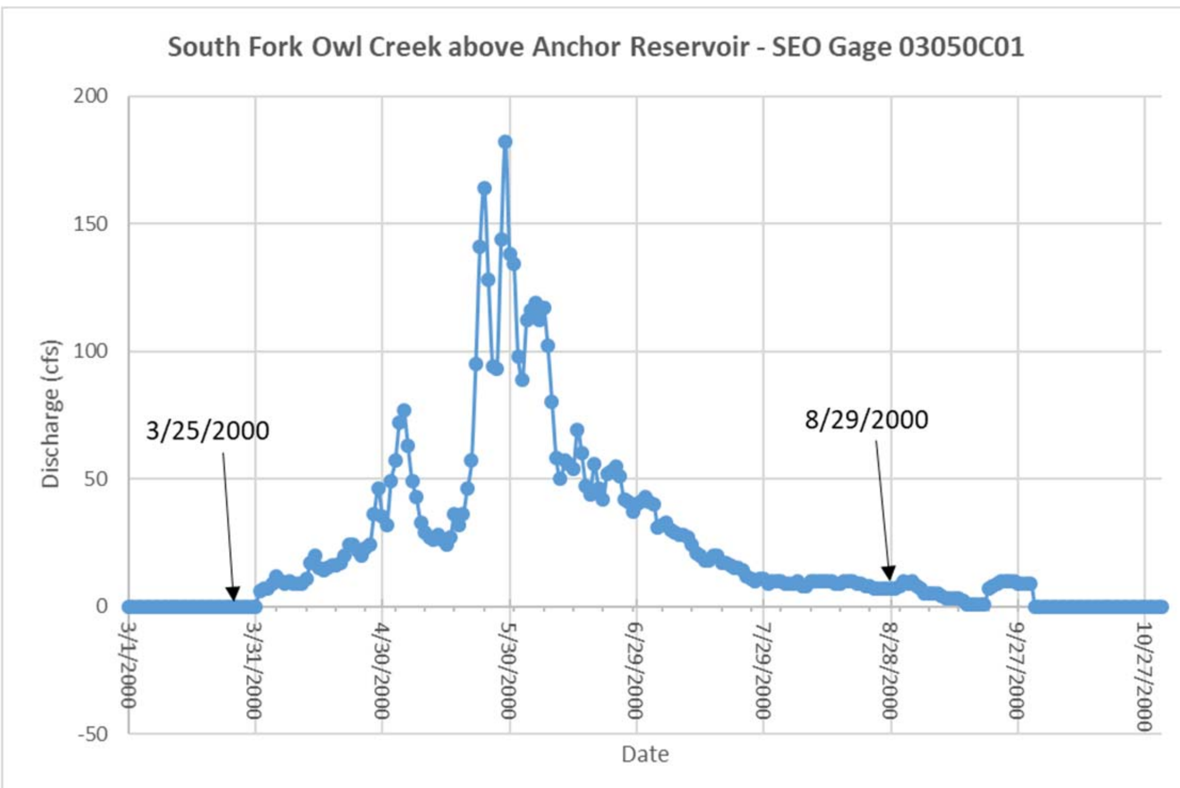

Figure E-8. Hydrograph of Year 2000 for South Fork Gage SEO 03050C01 showing no flow or inoperable gage for March and 7 cfs for 8/29/2000.r

Plotting discharge from the nearby USGS station 6260000 against total dissolved solids measured at the time of the flow measurement (**Figure 3.4.2-9**), indicates an inverse relationship between discharge and dissolved solids (at least for the years 1974 through 1985), which provides supporting evidence for the argument that low flow at G-54 is linked to the anomalously high TDS values measured in 2000.

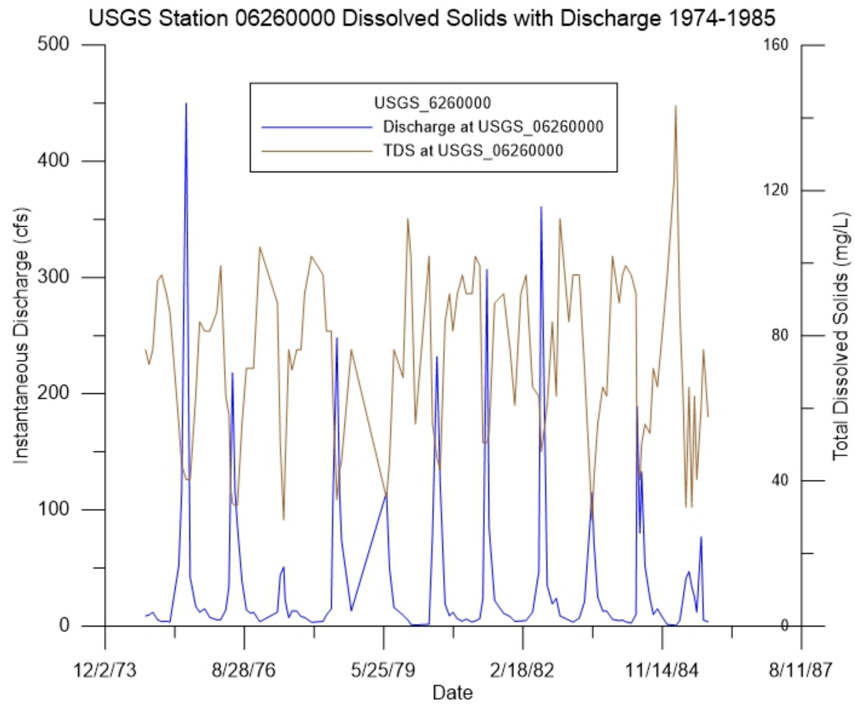

Figure E-9. Graph of Discharge and Dissolved Solids Measured at South Fork Owl Creek USGS Station 6260000.

Stiff plot results from the WREQC South Fork Stations G-54 and G-58 are shown in **Figure E-10** through **Figure E-13**. These Stiff plots seems to reflect a variety of influences. When conducting comparative analysis of these plots, note that the scale of the two G-54 plots from year 2000 is doubled to accommodate the increase which is about 8 times the values shown in previous years (discussed in more detail above). Overall, dissolved solids are lower at station G-54 (located above Anchor Reservoir) in comparison to station G-58, which is lower in the watershed (located near Embar).

WREQC station G-58 shows greater variation on the Piper diagram, with water ranging from a calcium sulfate type to a calcium bicarbonate type (See **Figure E-1**). Note that when comparing Stiff plots for WREQC station G-58 the scale used must be considered because the increase in dissolved solids at numerous is tripled in size (e.g., see station G-54 on 2/22/2000).

In comparison to G-54, Station G-58 is lower in the watershed (near Embar), and therefore might be subject to the additional influence of variable geology, additional tributary inputs, and effects due to irrigation use (return flow) and therefore not so tightly coupled to natural discharge as was hypothesized for station G-54. Without a detailed analysis of discharge, precipitation and irrigation use for the area near station G-58, a full understanding of the periodic influx of calcium sulfate water at this station is probably not likely.

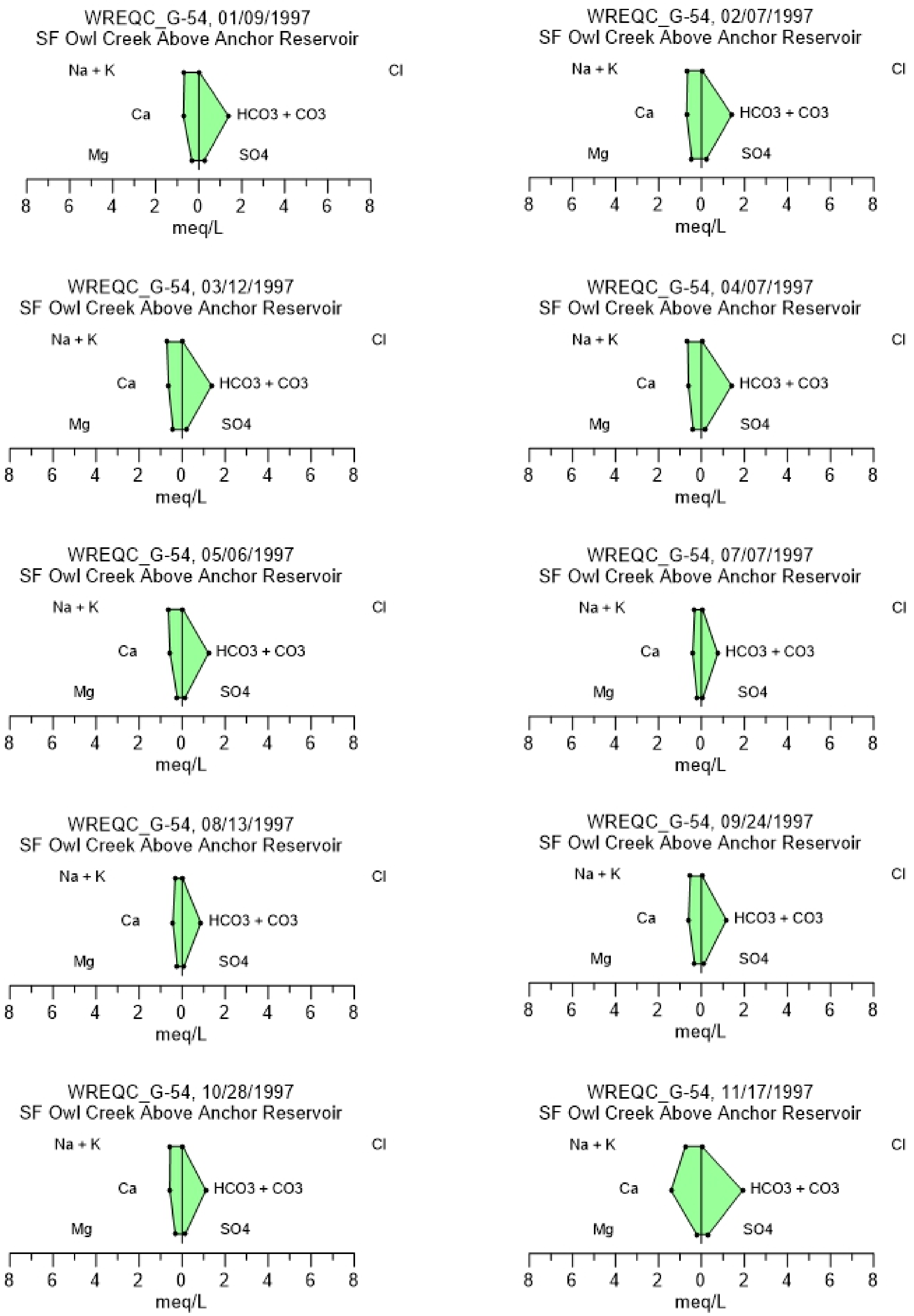

Figure E-10. Stiff Plots for WREQC Station G-54 for data obtained during 1997.

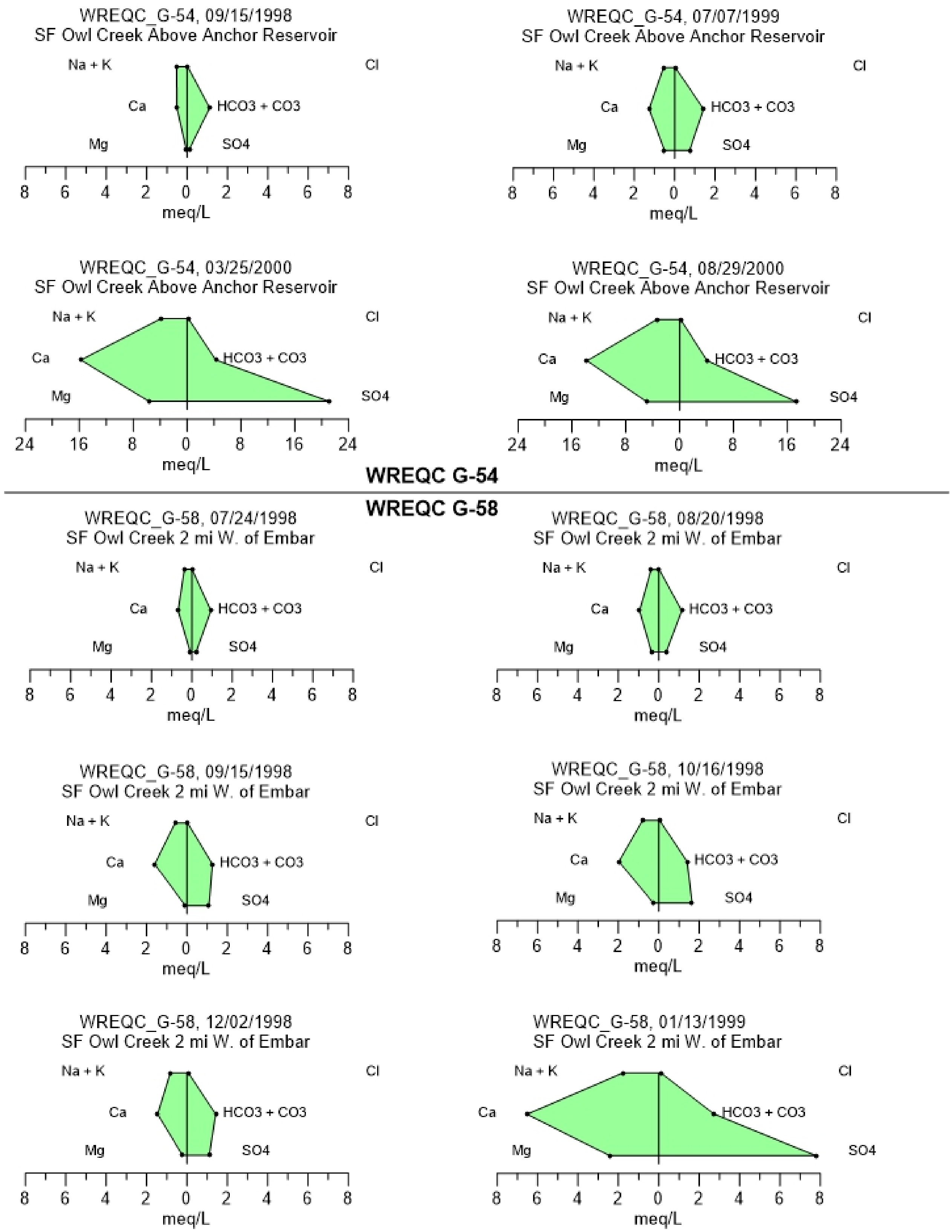

Figure E-11. Stiff Plots for WREQC Station G-54 (1998-2000) and WREQC Station G-58 (1998-1999).

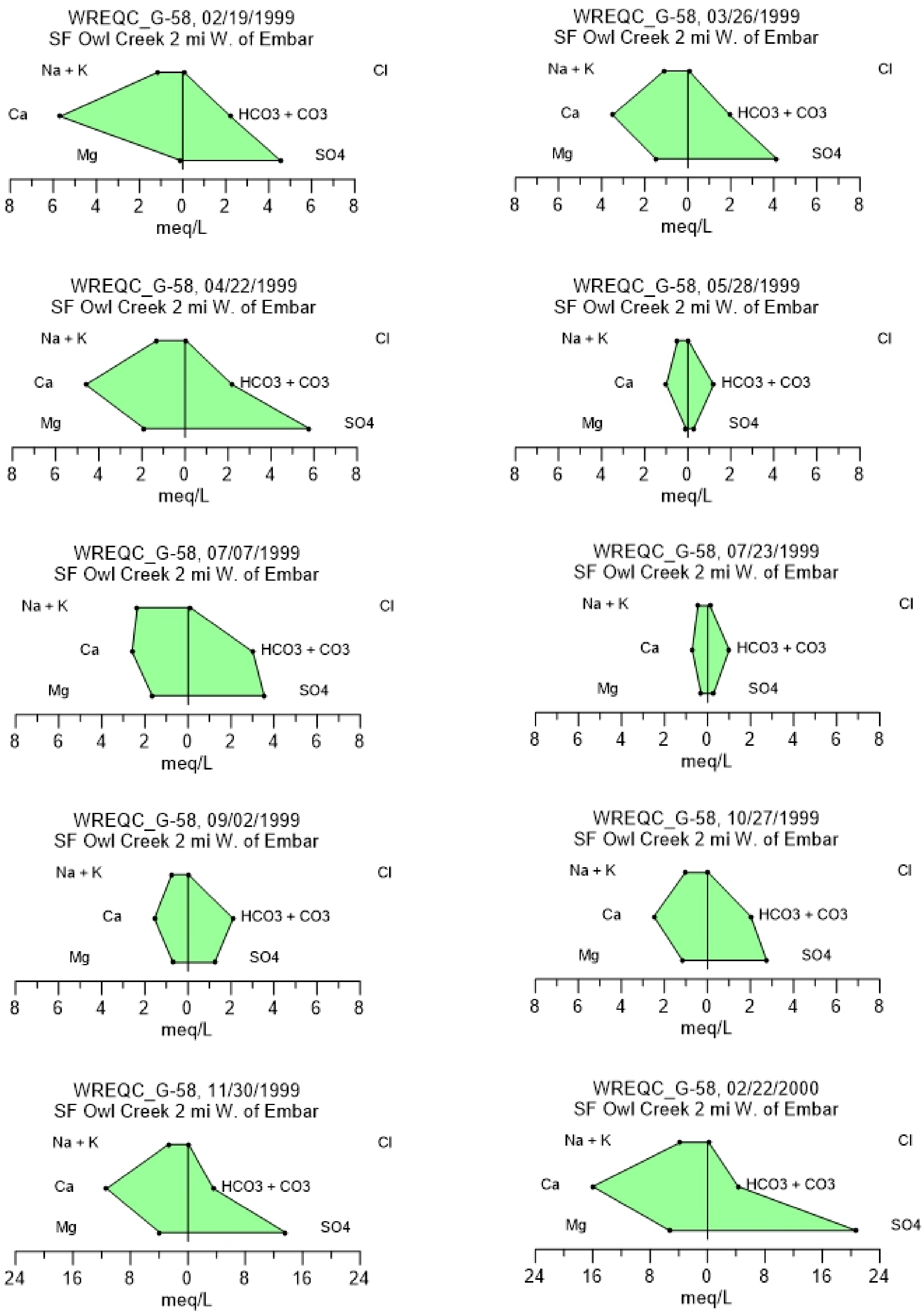

Figure E-12. Stiff Plots for WREQC Station G-58 for data obtained during 1999-2000.

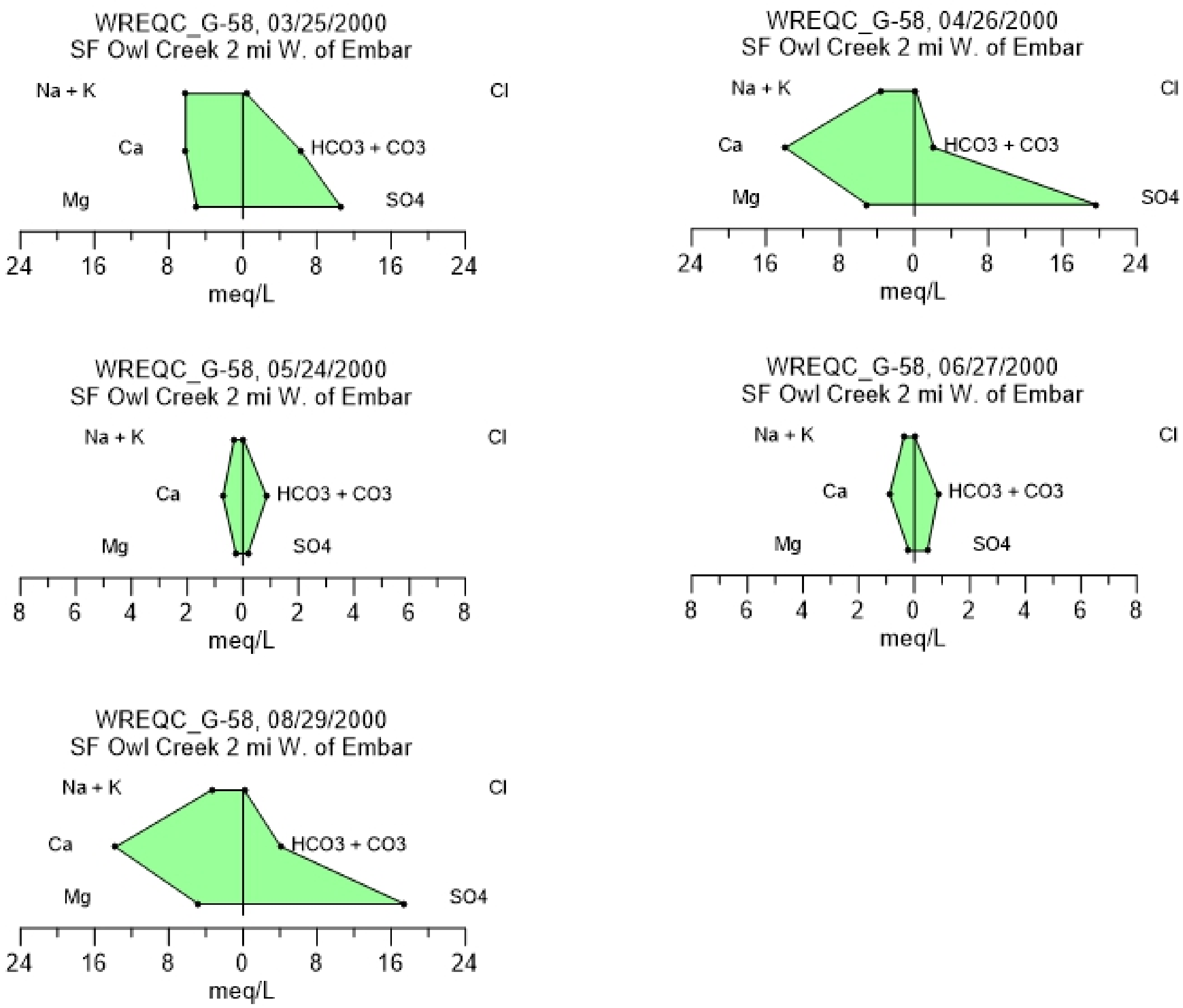

Figure E-13. Stiff Plots for WREQC Station G-58 for data obtained during year 2000.

Owl Creek Surface Water Stations

Owl Creek stations with data sufficient to prepare the Piper diagram and Stiff plots are tabulated in **Table E-5**. The Owl Creek stations show a clustering of results on the Piper Diagram (**Figure E-1**), but for perhaps a different reason. Here, because all the measured Owl Creek stations are significantly lower in the overall Owl Creek basin, below the inputs from all other significant sources of tributary surface water, and in a region of generally similar geology, there are limited variables which could influence water composition temporally or spatially between stations. The exception to this again maybe sulfate which seems to steadily increase downstream in Owl Creek. However, calcium does not appear to increase downstream, but instead the water retains a slightly saline mixture of cations.

Because of the particular array of data available for Owl Creek stations, two figures depicting spatial distribution of water quality were prepared. **Figure E-14** presents a view of available stations on Owl Creek. Again, the common these is the general increase in dissolved solids and the tailing of sulfate, both in the downstream direction.

Table 3.4.2-5 Owl Creek Stations and Dates used in Stiff Analysis.				
Station	**Dates**	**Description**	**HUC10**	**HUC12**
USGS_434326108320201	10/2/1989	Owl Creek near Hamilton Dome, WY	Owl Creek 1008000702	Upper Owl Creek
WREQC M-37	Monthly- Jan 1997-Nov 1997, Monthly-Jun 1998-Mar 1999, 5/28/99, 7/23/99, 9/2/99, 10/27/99, 11/30/99, 2/22/00, 4/26/00, 5/24/00,6/27/00, 8/29/00, 3/8/01	Owl Creek 1 mi above Pumpkin Draw	Owl Creek 1008000702	Upper Owl Creek
USGS_434134108275701	11/16/1991	Pumpkin Draw near Thompson Reservoir near Thermopolis	Owl Creek 1008000702	Upper Owl Creek
USGS_434128108233301	11/17/1991	Owl Creek at steel building near Thompson reservoir near Thermopolis	Owl Creek 1008000702	Upper Owl Creek
USGS_434037108225201	11/16/1991	Pumpkin Creek at ditch near Thompson Reservoir near Thermopolis	Owl Creek 1008000702	Upper Owl Creek
USGS_434106108180401	7/22/1991, 11/17/1991	Owl Creek at Hwy 120 near Thermopolis, WY	Owl Creek 1008000702	Lower Owl Creek
USGS_434112108160901	11/17/1991	Owl Creek at Sand Points near Thermopolis, WY	Owl Creek 1008000702	Lower Owl Creek
USGS_434112108160800	11/4/1976	Owl Creek 0.5 mi below Eagle Draw near Thermopolis	Owl Creek 1008000702	Lower Owl Creek
USGS_434137108143500	9/4/1976	Owl Creek 1.0 mi above Meeteetse Draw near Thermopolis, WY	Owl Creek 1008000702	Lower Owl Creek
USGS_434206108133501	11/17/1991	Owl Creek at Sunnyside Lane near Thermopolis, WY	Owl Creek 1008000702	Lower Owl Creek
USGS_434319108093100	9/14/1976	Owl Creek at mouth	Owl Creek	Lower Owl

Table 3.4.2-5 Owl Creek Stations and Dates used in Stiff Analysis.				
Station	**Dates**	**Description**	**HUC10**	**HUC12**
		near Lucerne, WY	1008000702	Creek

Stiff Plots for the Owl Creek stations shown above in Table E-5 are shown in **Figure E-15** through **Figure E-19**. Both Pumpkin Draw and Pumpkin Creek are included due to the proximity to Owl Creek and the probable routing of irrigation water from Owl Creek through Pumpkin Draw.

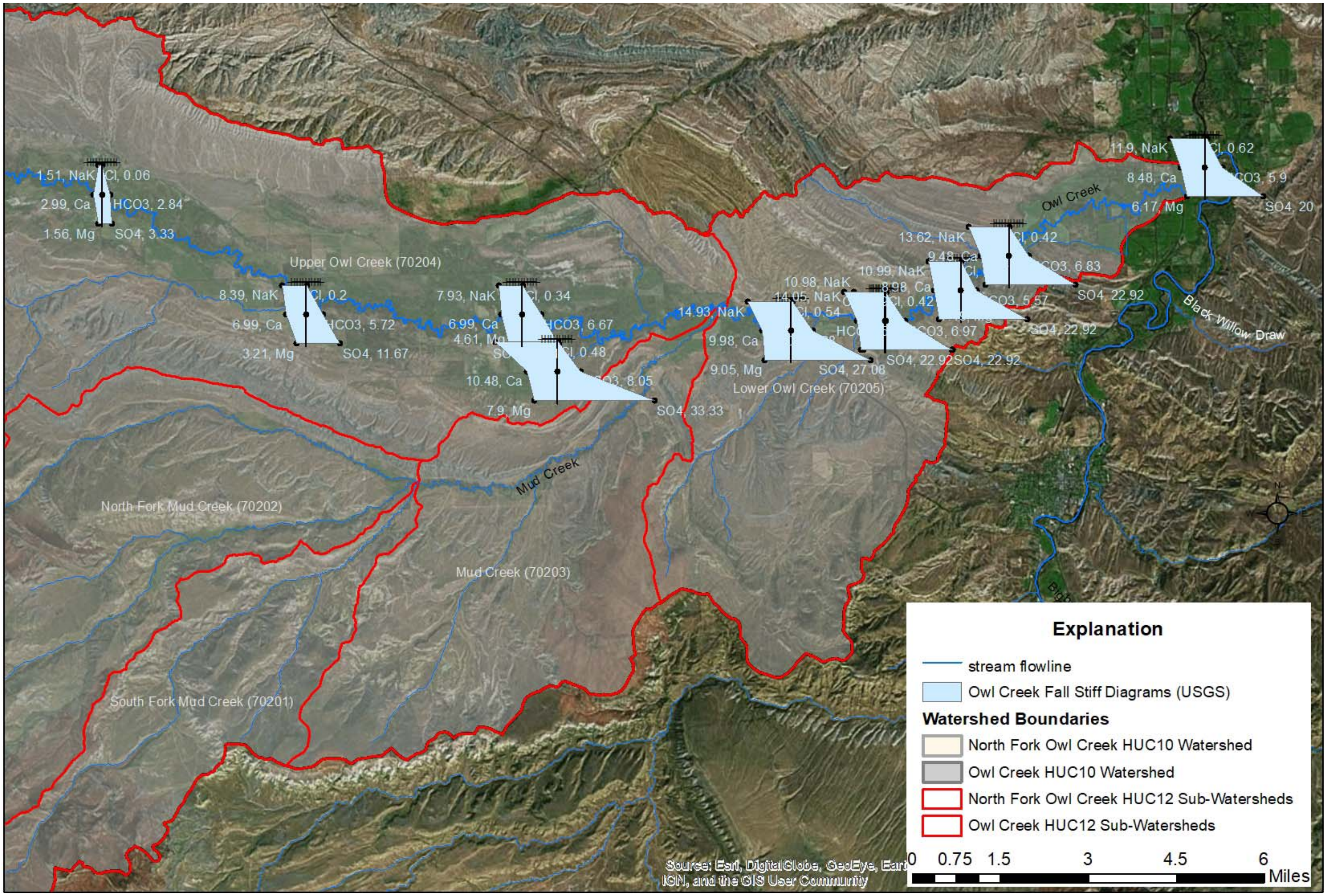

Figure E-14. Map of Stiff Plot Water Quality Data from Owl Creek Stations, including Pumpkin Creek and Pumpkin Draw.

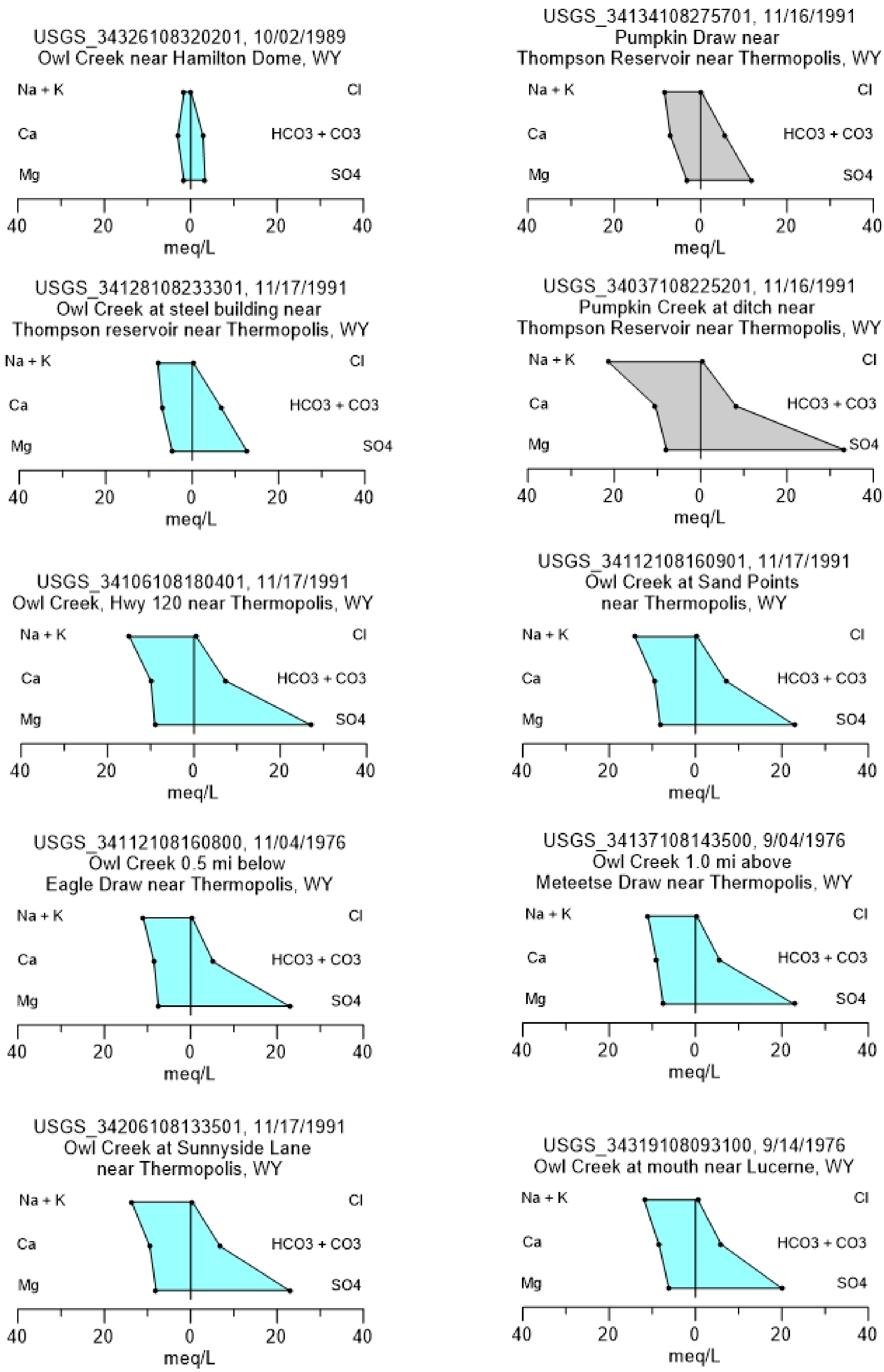

Figure E-15. Stiff Plots for various USGS Owl Creek stations arranged in descending order of position in the Owl Creek watershed. The position of WREQC station M-37 would be second, before Pumpkin Draw.

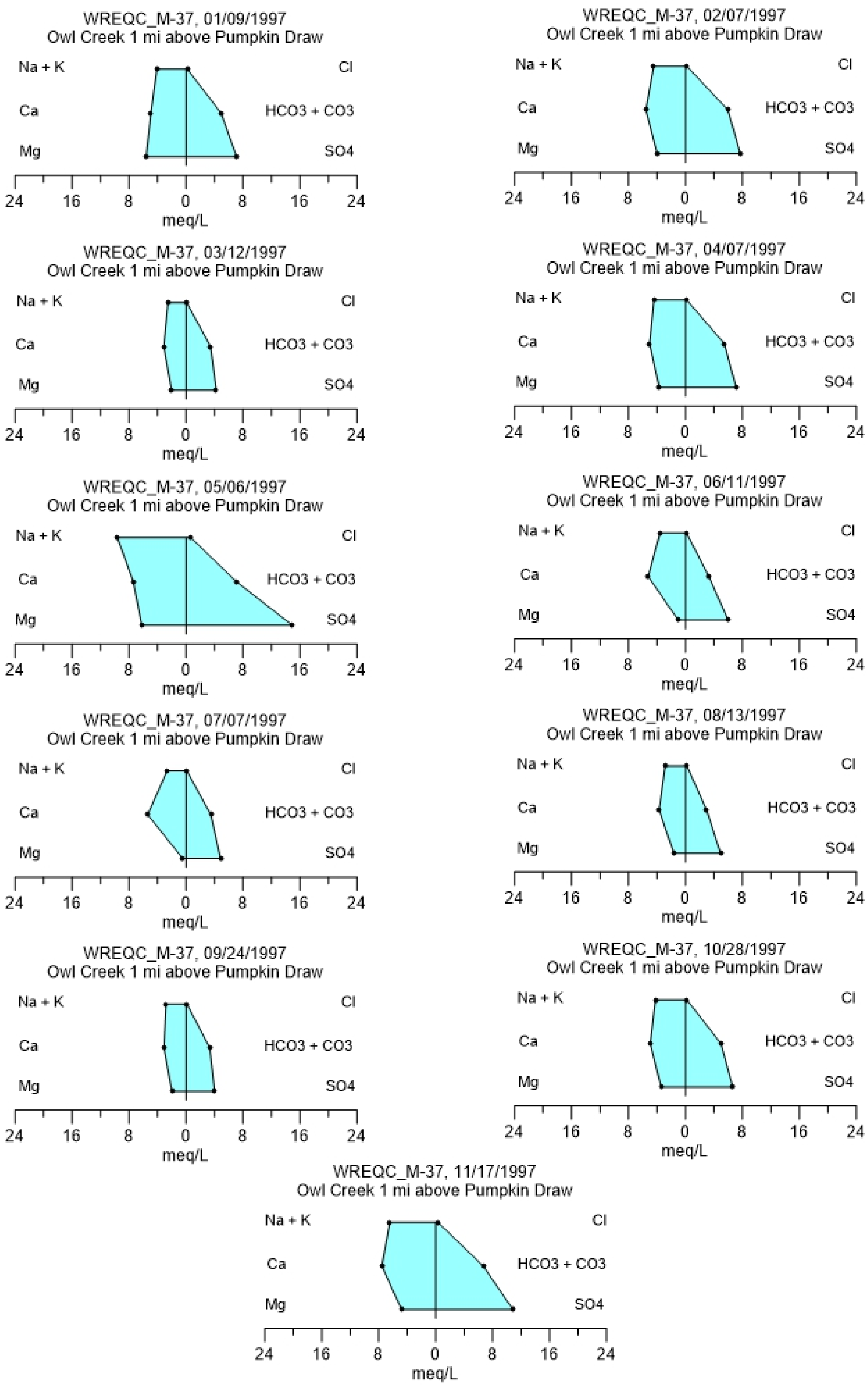

Figure E-16. Stiff Plots for WREQC station M-37 during 1997, arranged by Sample Date.

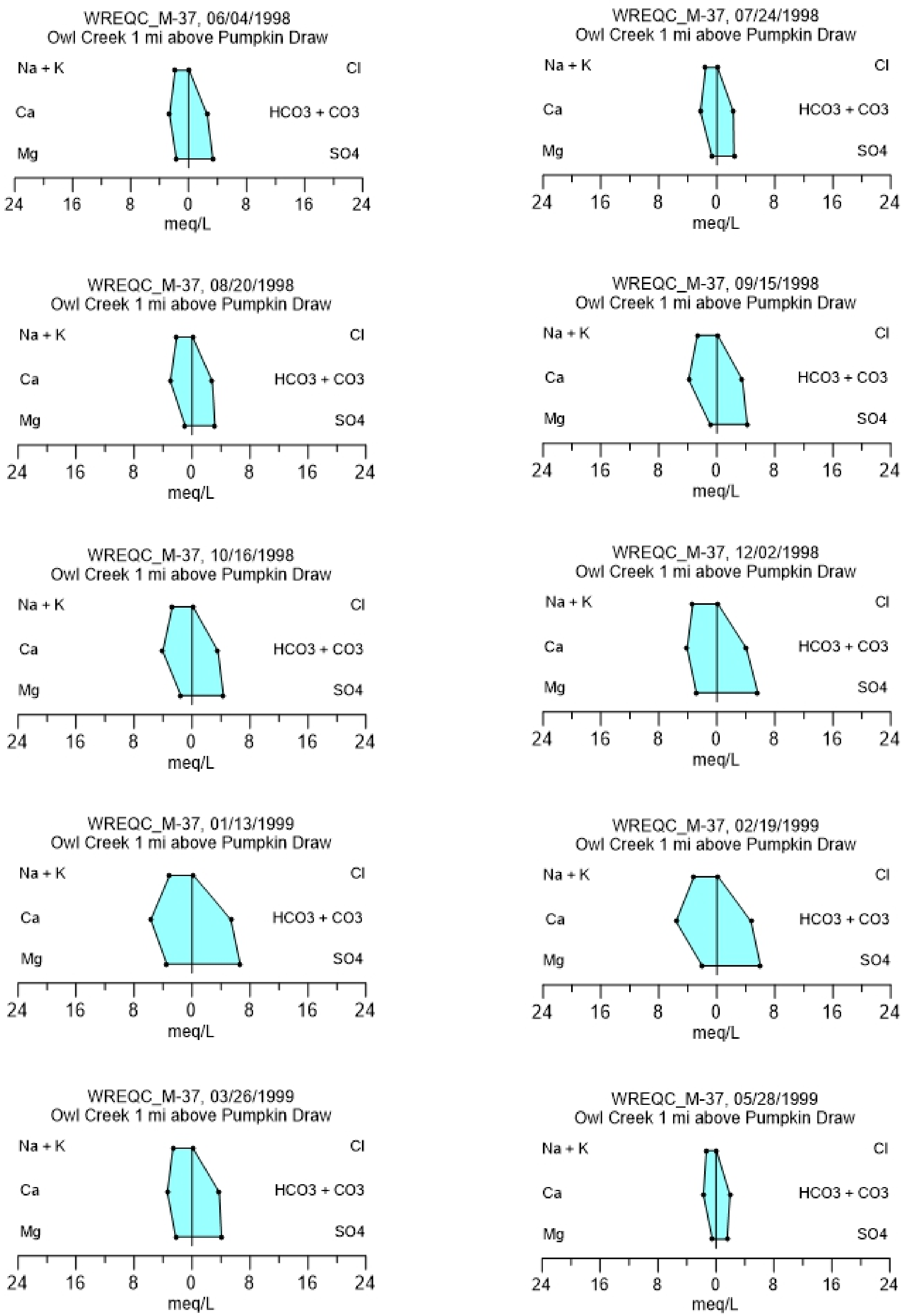

Figure E-16. Stiff Plots for WREQC station M-37 during 1998 – 1999, arranged by Sample Date.

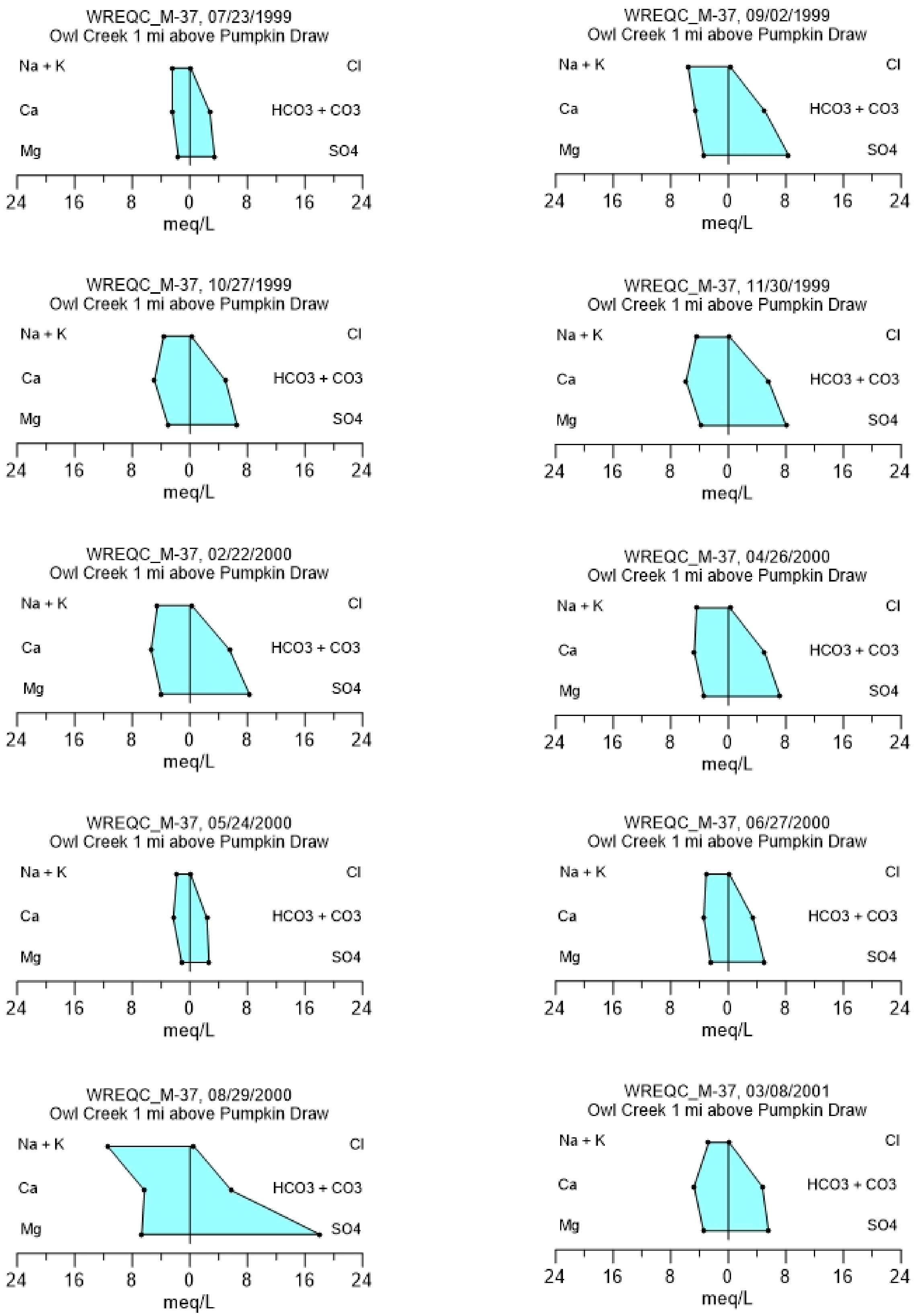

Figure E-16. Stiff Plots for WREQC station M-37 during 1999-2001, arranged by Sample Date.

The two datasets depicted in **Figure E-15** through **Figure E-19** are spatially related, but separated by approximately 6 years from the latest date of the USGS sampling in 1991 to the soonest sample date for the WREQC M-37 station in 1997. The scales of the Stiff plots also differ. The USGS data are plotted on a scale that is almost twice as large as the scale used for the WREQC data due to the larger values measured at the Pumpkin Creek station USGS_434037108225201. Save for the station, the remaining USGS stations could have been scaled similarly to WREQC M-37 due to similar values.

It is not clear why the sample from Pumpkin Creek contain elevated sulfate and sodium (**Figure E-15**). Pumpkin Creek is a relatively short water-course, and the description of the station ("Pumpkin Creek at ditch near Thompson Reservoir near Thermopolis") seems to indicate that is transmitting irrigation water. Aerial imagery indicates that Pumpkin Creek traverses an extensive region of irrigated fields, and thus is probably carrying irrigation return flow back to Owl Creek. This is a possible explanation for the relatively saline character of the water sample as suggested by Stiff plot and the Piper diagram (see **Figure E-1**).

The Stiff plots for the water quality measured at WREQC station M-37 are quite similar for the 1997 to 2001-time period, measured almost regularly on a month basis. There appear to be three minor exceptions to this, including samples obtained 5/6/1997, 11/17/1997, and 8/29/2000. Owl Creek discharge data obtained from SEO gage 0305OC03 (Arapahoe Ranch Bridge) indicates Owl Creek flow at that location on 11/17/1997 and 8/29/2000 was zero Indicating no flow (or gage not operating). Data were not available for on 5/6/1997.

Concluding Remarks

To summarize this extensive array of surface water quality, it is clear that the quality of surface water becomes degraded (as suggested by increased dissolved solids decreased down-basin in Owl Creek and its major tributaries. An overall view of spatially distributed water quality data obtained during November 1991 is presented in **Figure E-19.**

However, other measures of water quality, such as the sodium adsorption ratio (SAR), calculated for these data indicate a relatively low level of hazard for most of the samples, as about 75% of the samples indicate a SAR value of less than 2, about 15% between 2 and 3, 5% between 3 and 4, 5% between 4 and 5, and the remaining 2% (two values) between 5 and 7.5.

Some of the fluctuations in water quality shown in the datasets reviewed in this section are undoubtedly due to low flow conditions during certain times of the year. The observed "flashiness" of the discharge patterns in response to precipitation and snow-melt events underscores these observations. If the basin had a steady supply of surface water year-round, water quality might be more uniform, except perhaps in areas where it is heavily used for agricultural purpose.

Though only a small amount of data is currently available in support, tributary sources of surface water may be worthwhile to evaluate for storage projects based on the possibility of relatively higher quality water (depending on the source area). Red Creek may be ex example of such a tributary stream that drains a relatively undeveloped watershed underlain by favorable geology.

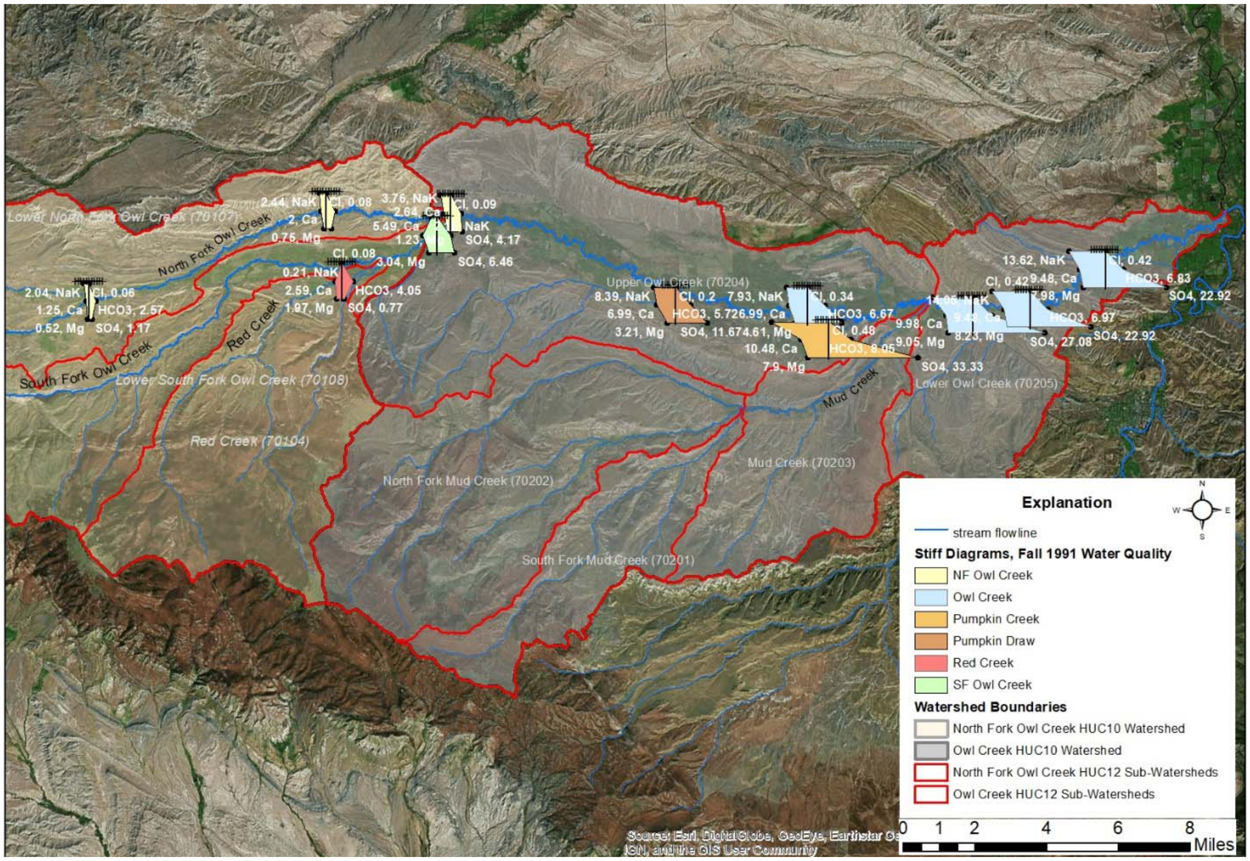

Figure E-19. Map of Synoptically Measured Data from All Available Surface Water Quality Stations during the November 13-17, 1991 time-frame.

APPENDIX F – Reservoir Analysis Details

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WSEO Irrigation Permitted Reservoirs															
WR Number	**Type**	**Capacity (af)**	**Facility Name**	**Notes (2014)**	**Functionality**	**Water Source**	**Status**	**Uses**	**SummaryWRS**	**Twn**	**Rng**	**Sec**	**QQ**	**Longitude**	**Latitude**
P1144.0R	Reservoir	29	RUSH RESERVOIR NO. 2	Wet	Functional	Yes	1/2 capacity	DOM_SW; IRR_SW	Cancelled	043N	096W	24	SW1/4SW1/4	-108.330060	43.675570
P1538.0R	Reservoir	0.16	EMERY RESERVOIR	Wet	Functional	Yes	1/2 capacity	DOM_SW; IRR_SW; STO	Cancelled	042N	095W	02	NE1/4SW1/4	-108.228930	43.633520
P1364.0R	Reservoir	2.4	ERICKSON NO. 3 RESERVOIR	Wet	Functional	Yes	1/2 Capacity	IRR_SW; STO	Cancelled	043N	101W	04	NE1/4NE1/4	-108.974790	43.729050
P13072.0R	Reservoir		HOLDEN RE-REGULATION RESERVOIR	Wet	Functional	Yes	1/4 Capacity	IRR_SW; STO	Complete	043N	096W	06	SE1/4NE1/4	-108.417420	43.724300
P3220.0R	Reservoir	11.01	WEDLOCK RESERVOIR	Wet	Functional	Yes	3/4 capacity	DOM_SW; IRR_SW; STO	Cancelled	044N	095W	11	NE1/4NE1/4	-108.216100	43.803360
P1218.0R	Reservoir	21.6	WHETSTONE RESERVOIR	Wet	Functional	Yes	Full Capacity	IRR_SW	Complete	009N	001E	36	SW1/4SE1/4	-108.704250	43.709080
P6902.0R	Reservoir	17412	ANCHOR RESERVOIR	Wet	Functional	Yes	Full Capacity	IRR_SW	Complete	043N	100W	26	SE1/4NW1/4	-108.824690	43.664300
P1900.0R	Reservoir	4.8	HARDY RESERVOIR NO. 2	Wet	Functional	Yes	Full Capacity	IRR_SW	Complete	044N	101W	28	SE1/4NE1/4	-108.975860	43.754470
P1901.0R	Reservoir	1.2	HARDY RESERVOIR NO. 3	Wet	Functional	Yes	Full Capacity	IRR_SW	Complete	044N	101W	28	SW1/4NE1/4	-108.977620	43.754010
P9435.0R	Reservoir	2.67	LEGION NO. 1 RESERVOIR	Wet	Functional	Yes	Full Capacity	IRR_SW	Fully Adjudicated	043N	095W	25	SW1/4SW1/4	-108.213030	43.661650
CR CR36/181	Reservoir	21.6	Whetstone Reservoir	Wet	Functional	Yes	Full Capacity	IRR_SW		009N	001E	36	SE1/4SW1/4	-108.707290	43.708320
P1674.0R	Reservoir	103.35	ELLIS RESERVOIR	Wet	Functional	Yes	Full Capacity	DOM_SW; IRR_SW	Cancelled	042N	095W	21	SW1/4SW1/4	-108.272990	43.587890
P1233.0R	Reservoir	343.8	HILL-BIERMAN RESERVOIR	Wet	Functional	Yes	Full Capacity	DOM_SW; IRR_SW	Cancelled	008N	003E	11	NW1/4NE1/4	-108.484390	43.689590
P1402.0R	Reservoir	8.4	ERICKSON #1 RESERVOIR	Wet	Functional	Yes	Full Capacity	DOM_SW; IRR_SW; STO	Cancelled	044N	101W	35	SE1/4NE1/4	-108.935480	43.739800
P2094.0R	Reservoir	1070.6	DEMPSEY RESERVOIR	Wet	Functional	Yes	Full Capacity	IRR_SW	Cancelled	044N	094W	31	SE1/4SW1/4	-108.188890	43.733000
P1080.0R	Reservoir	39.88	STEWARD RESERVOIR	Wet	Functional	Yes	Full Capacity	IRR_SW	Cancelled	043N	096W	15	NE1/4NW1/4	-108.366740	43.700190
P3681.0R	Reservoir	15.11	MOORE-SODERHOLM NO. 1	Wet	Functional	No	Full Capacity	IRR_SW	Cancelled	044N	101W	31	SW1/4SW1/4	-109.028580	43.731540
P1363.0R	Reservoir	6.24	ERICKSON NO. 2 RESERVOIR	Wet	Functional	Yes	Full Capacity	IRR_SW; STO	Cancelled	043N	101W	04	SE1/4NE1/4	-108.973850	43.725700
P1143.0R	Reservoir	155.75	RUSH RESERVOIR NO. 1	Wet	Functional	Yes	Full Capcity	DOM_SW; IRR_SW	Complete	043N	096W	23	SE1/4NE1/4	-108.338040	43.680550
P1498.0R	Reservoir	63.96	MCELWEE RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW	Complete	008N	003E	14	SE1/4NW1/4	-108.489360	43.671480
P1344.0R	Reservoir	128	ADAMS NO. 2 RESERVOIR	Dry	Functional	Yes		DOM_SW; IRR_SW	Complete	043N	100W	11	SE1/4SW1/4	-108.825460	43.702480
P3363.0R	Reservoir	80.4	SKINNER RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW; STO	Complete	008N	004E	07	NE1/4SW1/4	-108.451690	43.680870
P1500.0R	Reservoir	603.9	THOMPSON NO. ONE RESERVOIR,	Dry	Functional	Yes		IRR_SW	Complete	043N	096W	09	NW1/4SW1/4	-108.389180	43.707790
P830.0R	Reservoir	2.5	FENNERS NO. 2 RESERVOIR	Dry	Non-functional	No		IRR_SW	Complete	043N	096W	17	NE1/4NW1/4	-108.405090	43.700210
P829.0R	Reservoir	4.5	FENNERS NO. 1 RESERVOIR	Dry	Non-functional	No		IRR_SW	Complete	043N	096W	17	SE1/4NW1/4	-108.407310	43.698140
P1761.0R	Reservoir	7.7	SHOOP RESERVOIR	Dry	Non-functional	No		IRR_SW; STO	Complete	009N	002E	25	NE1/4SW1/4	-108.588360	43.727060
P2899.0R	Reservoir	3	MOORE RESERVOIR	Dry	Functional	Yes		IRR_SW; STO	Complete	009N	002E	31	NW1/4SW1/4	-108.691860	43.713390
P1955.0R	Reservoir	58.5	ENL BLONDE RESERVOIR	Dry	Functional	Yes		IRR_SW; STO	Complete	043N	100W	21	NW1/4NE1/4	-108.862660	43.685350
P4492.0R	Reservoir	0.83	FRIX RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW; STO	Expired	042N	095W	02	NW1/4SW1/4	-108.233840	43.633560
P1099.0R	Reservoir	48	JOHNSON RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW	Cancelled	043N	095W	17	NE1/4SW1/4	-108.287870	43.693220
P1032.0R	Reservoir	1036.38	1ST ENL	Dry	Functional	Yes		DOM_SW; IRR_SW	Cancelled	043N	096W	09	SW1/4NE1/4	-108.383520	43.709890
P1145.0R	Reservoir	48.72	THOMPSON NO. 2 RESERVOIR	Dry	Functional	Yes		DOM_SW; IRR_SW	Cancelled	043N	096W	07	NE1/4NE1/4	-108.415350	43.715430
P1370.0R	Reservoir	78	SYLVESTER RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW	Cancelled	008N	004E	30	NW1/4NE1/4	-108.446380	43.644800
P1539.0R	Reservoir	98.3	MOUNTAIN VIEW CANAL CO.'S RESERVOIR #1	Dry	Non-functional	No		DOM_SW; IRR_SW	Cancelled	043N	097W	01	NW1/4SW1/4	-108.450990	43.722030
P832.0R	Reservoir	24	COPE NO. 1 RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW	Cancelled	043N	097W	11	NE1/4NE1/4	-108.454100	43.713110
P984.0R	Reservoir	4370.8	OWL CREEK IRRIGATION CO.'S NO. 2 RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW	Cancelled	009N	003E	31	NE1/4SE1/4	-108.555960	43.713680
P1404.0R	Reservoir	2787	SOUTH SIDE NO. 1 RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW	Cancelled	009N	002E	36	SW1/4NE1/4	-108.582360	43.715640
P983.0R	Reservoir	23266.5	OWL CREEK IRRIGATION COMPANY'S NO. 1 RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW	Cancelled	009N	002E	36	SW1/4NE1/4	-108.584250	43.714410
P1342.0R	Reservoir	90	HEIDEN RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW	Cancelled	043N	099W	06	NW1/4SW1/4	-108.788610	43.720250
P1343.0R	Reservoir	12.67	ADAMS NO. 1 RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW	Cancelled	043N	100W	10	NW1/4SE1/4	-108.839870	43.706380
P1319.0R	Reservoir	25.55	CHANCE RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW; STO	Cancelled	043N	096W	07	NE1/4NE1/4	-108.416380	43.714820
P3917.0R	Reservoir	309.57	SMITH RESERVOIR	Dry	Functional	Yes		DOM_SW; IRR_SW; STO	Cancelled	008N	004E	17	SW1/4NW1/4	-108.435120	43.671450
P2875.0R	Reservoir	19.5	SHERMAN RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW; STO	Cancelled	008N	004E	30	SE1/4NE1/4	-108.438330	43.642060

WSEO Irrigation Permitted Reservoirs															
WR Number	**Type**	**Capacity (af)**	**Facility Name**	**Notes (2014)**	**Functionality**	**Water Source**	**Status**	**Uses**	**SummaryWRS**	**Twn**	**Rng**	**Sec**	**QQ**	**Longitude**	**Latitude**
P4138.0R	Reservoir	5831.78	MOUNTAIN VIEW RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW; STO	Cancelled	044N	098W	35	NW1/4NE1/4	-108.579410	43.741920
P710.0R	Reservoir	696	TIE DOWN RESERVOIR	Dry	Non-functional	No		DOM_SW; IRR_SW; STO	Cancelled	045N	094W	14	NW1/4NE1/4	-108.101150	43.876180
P6493.0R	Reservoir	364.07	THE FIRST	Dry	Non-functional	No		IRR_SW	Cancelled	044N	094W	09	NE1/4SE1/4	-108.138590	43.794760
P67.0R	Reservoir	1440	DEMPSEY CANAL CO. RESERVOIR NO. 1	Dry	Non-functional	No		IRR_SW	Cancelled	044N	095W	36	SW1/4SE1/4	-108.203190	43.733150
P5738.0R	Reservoir	32.64	FREUDENTHAL RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	043N	096W	11	SW1/4SW1/4	-108.352060	43.703240
P1501.0R	Reservoir	137.28	THOMPSON NO. TWO RESERVOIR,	Dry	Functional	Yes		IRR_SW	Cancelled	043N	096W	07	NE1/4NE1/4	-108.416750	43.715020
P48.0R	Reservoir	18	CLOSE & BADER RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	043N	097W	13	SE1/4NE1/4	-108.436880	43.696310
P1339.0R	Reservoir	33.17	WILSON RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	008N	004E	30	SE1/4NE1/4	-108.440090	43.642510
P1540.0R	Reservoir	179.36	MOUNTAIN VIEW CANAL CO.'S RESERVOIR #2	Dry	Functional	Yes		IRR_SW	Cancelled	043N	097W	01	NW1/4SW1/4	-108.450480	43.720780
P833.0R	Reservoir	24.84	COPE NO. 2 RESERVOIR	Dry	Functional	Yes		IRR_SW	Cancelled	043N	097W	12	NW1/4NW1/4	-108.451500	43.713110
P998.0R	Reservoir	129.38	COPE NO. 3 RESERVOIR	Dry	Functional	Yes		IRR_SW	Cancelled	043N	097W	11	NE1/4NE1/4	-108.454220	43.713110
P1320.0R	Reservoir	7.5	LYDICK RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	008N	003E	35	NE1/4SE1/4	-108.480320	43.622840
P1445.0R	Reservoir	38	STAPLES RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	008N	003E	14	NE1/4SW1/4	-108.489360	43.667870
P1079.0R	Reservoir	9	DEWITT RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	043N	097W	09	NE1/4NW1/4	-108.503730	43.713280
P2337.0R	Reservoir	7.15	SKIDMORE RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	007N	003E	21	SE1/4NE1/4	-108.519200	43.570250
P4437.0R	Reservoir	2024.3	THE COMMUNITY RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	009N	002E	36	SW1/4NE1/4	-108.584310	43.714340
P2149.0R	Reservoir	28.2	OWL RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	043N	099W	12	NE1/4NE1/4	-108.675590	43.714640
P2095.0R	Reservoir	5231.1	BASIN RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	043N	100W	13	SE1/4NW1/4	-108.804730	43.695550
P3595.0R	Reservoir	84.38	CROSKEY #4 RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	043N	100W	02	SW1/4SW1/4	-108.831450	43.717150
P2290.0R	Reservoir	114.75	BASIN RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	043N	100W	15	NE1/4SE1/4	-108.835050	43.692010
P3594.0R	Reservoir	80.9	CROSKEY #3 RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	043N	100W	03	SW1/4SE1/4	-108.837130	43.716270
P3592.0R	Reservoir	166.56	CROSKEY #1 RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	043N	100W	03	SW1/4NE1/4	-108.839660	43.724070
P3593.0R	Reservoir	40.41	CROSKEY #2 RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	043N	100W	03	SE1/4SW1/4	-108.847060	43.717240
P4819.0R	Reservoir	127.68	MCCOY NO 2 RESERVOIR	Dry	Non-functional	No		IRR_SW	Cancelled	044N	101W	27	SW1/4NW1/4	-108.969940	43.754940
P3682.0R	Reservoir	25.02	MOORE-SODERHOLM NO. 2	Dry	Non-functional	No		IRR_SW	Cancelled	043N	101W	06	NE1/4SE1/4	-109.016310	43.722770
P3768.0R	Reservoir	5831.78	MOUNTAIN VIEW RESERVOIR	Dry	Non-functional	No		IRR_SW; S&D	Cancelled	044N	098W	35	NW1/4NE1/4	-108.580650	43.741470
P6432.0R	Reservoir	94.72	HENDERSON RESERVOIR	Dry	Non-functional	No		IRR_SW; STO	Cancelled	044N	094W	09	NE1/4SE1/4	-108.138590	43.794760
P2043.0R	Reservoir	29.15	FREEMAN RESERVOIR	Dry	Non-functional	No		IRR_SW; STO	Cancelled	044N	094W	09	SE1/4SW1/4	-108.148690	43.791100
P1078.0R	Reservoir	124.5	WOODBURN RESERVOIR	Dry	Non-functional	No		IRR_SW; STO	Cancelled	043N	094W	06	SW1/4SW1/4	-108.191210	43.717200
P2063.0R	Reservoir	6.39	RED CANYON RESERVOIR	Dry	Non-functional	No		IRR_SW; STO	Cancelled	042N	096W	23	SE1/4NW1/4	-108.347330	43.595170
P1983.0R	Reservoir	4.59	BLONDE NO. 2 RESERVOIR	Dry	Functional	Yes		IRR_SW; STO	Cancelled	043N	100W	15	NE1/4SW1/4	-108.845080	43.690580
P2638.0R	Reservoir	207.9	ENL HARDY RESERVOIR NO. 1	Dry	Functional	Yes		IRR_SW; STO	Cancelled	044N	101W	27	NW1/4NW1/4	-108.971290	43.756310

BLM and SEO Permitted Stock Reservoirs

Type	Project Name	Notes (2014, 2011, 2010)	Functionality	Water Source	Status	Source	Section	Township	Range	Allotment Name	Latitude	Longitude
Reservoir	ANTELOPE RES	Dry in 3 years of imagery, no breaches or sedimentation	Functional	No	Existing	BLM	6	043N	099W	NORTH HART	43.72	-108.78
Reservoir	BILBO RES	Wet in 2014 & 2011, dry in 2010	Functional	Yes	Existing	BLM	26	044N	095W	SOUTH GEBO COMMON	43.75	-108.23
Reservoir	FREEMAN RESERVOIR	Wet in 2014, 2011, & 2010	Functional	Yes	Existing	BLM	7	044N	093W	SAND DRAW	43.8	-108.04
Reservoir	GLOIN RES	Wet in 2014, 2011, & 2010	Functional	Yes	Existing	BLM	8	044N	096W	EAST WAUGH DOME	43.79	-108.39
Reservoir	HUGH VASS RES 1	Wet in 2010 & 2011, dry in 2014	Functional	Yes	Existing	BLM	6	043N	099W	VASS	43.72	-108.77
Reservoir	INDIAN RES	Wet in 2014 & 2011, dry in 2010	Functional	Yes	Existing	BLM	28	044N	095W	LUCERNE	43.74	-108.27
Reservoir	KIRBY SAND DRAW	Wet in 2014 & 2011	Functional	Yes	Existing	BLM	1	044N	095W	NELSON	43.8	-108.21
Reservoir	MOLE RES	Wet in 2014 & 2011, dry in 2010	Functional	Yes	Existing	BLM	10	044N	097W	HAMILTON DOME	43.78	-108.47
Reservoir	NE RES	Wet in 2014, 2011, & 2010	Functional	Yes	Existing	BLM	15	044N	096W	KING DOME	43.78	-108.37
Reservoir	PAULS RESERVOIR	Wet in 2014, 2011, & 2010	Functional	Yes	Existing	BLM	5	044N	093W	SAND DRAW	43.8	-108.04
Reservoir	POWER LINE RES	Wet in 2014, 2011, 2010	Functional	Yes	Existing	BLM	15	044N	093W	ZIMMERMAN BUTTES	43.77	-107.99
Reservoir	ROUGH OUT RES	Dry in 3 years of imagery, no breaches or sedimentation	Functional	No	Existing	BLM	30	045N	095W	NELSON	43.84	-108.29
Reservoir	RUSSELL RES 1	Wet in 2014, 2011, & 2010	Functional	Yes	Existing	BLM	20	044N	093W	RED SPRINGS DRAW	43.76	-108.04
Reservoir	SANFORD NORMAN RES	Wet in 2014, 2011, & 2010	Functional	Yes	Existing	BLM	4	043N	095W	BUCHANAN	43.73	-108.26
Reservoir	SHUMWAY LEONARD RES	Wet in 2014, 2011, & 2010	Functional	Yes	Existing	BLM	24	043N	096W	SHUMWAY INDIVIDUAL	43.67	-108.33
Reservoir	SPRING RESERVOIR	Dry in 3 years of imagery, no breaches or sedimentation	Functional	No	Existing	BLM	24	043N	096W		43.66	-108.33
Reservoir	TOM L SANFORD RES	Dry in 3 years of imagery, no breaches or sedimentation	Functional	No	Existing	BLM	25	043N	096W	RED CANYON	43.66	-108.31
Reservoir	TS CHARCO RES	Dry in 3 years of imagery, no breaches or sedimentation	Functional	No	Existing	BLM	34	044N	097W	BACK OF RIM	43.74	-108.48
Reservoir	WEBER RES	Dry in 3 years of imagery, no breaches or sedimentation	Functional	No	Existing	BLM	9	043N	100W	THREE PEAKS ANCHOR	43.7	-108.86
Reservoir	WEED RES	Wet in 2014, UNK 2011 & 2010	Functional	Yes	Existing	BLM	30	044N	098W	WAGONHOUND	43.74	-108.66
Reservoir	WHITE WILLOW	Dry in 3 years of imagery, no breaches or sedimentation	Functional	No	Existing	BLM	29	044N	098W	WAGONHOUND	43.74	-108.63
Reservoir	HEDGECOCK & DVARISHKIS	Wet in 2014 & 2011, dry in 2010	Functional	Yes	Existing	BLM	17	044N	097W	HAMILTON DOME	43.78	-108.52
Reservoir	WHITE WILLOW	Wet in 2014, 2011, & 2010	Functional	Yes	Existing	BLM	29	044N	098W	WAGONHOUND	43.74	-108.63
Reservoir	DUARISHKIS RES	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	12	044N	097W	WAUGH DOME	43.79	-108.45
Reservoir	EAST GATE RESERVOIR	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	24	044N	094W	SAND DRAW	43.76	-108.07
Reservoir	FREEMAN DRAW RESERVOIR	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	14	044N	094W	SOUTH LUCERNE GROUP	43.78	-108.1
Reservoir	GWYNN RANCH RES	Dry in 3 years of imagery	Non-Functional	No	Existing	BLM	22	044N	095W	SOUTH GEBO COMMON	43.76	-108.23
Reservoir	HUGH VASS RES 2	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	6	043N	099W	VASS	43.72	-108.78
Reservoir	HUGH VASS RES 3	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	6	043N	099W	VASS	43.71	-108.77
Reservoir	JACKMAN RES	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	6	043N	099W	NORTH HART	43.71	-108.79
Reservoir	JAMES BRYSON RES	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	7	044N	096W	EAST WAUGH DOME	43.79	-108.42
Reservoir	JAMES FRED BRYSON RES	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	8	044N	096W	EAST WAUGH DOME	43.79	-108.39
Reservoir	LAKE RES	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	29	044N	098W	WAGONHOUND	43.75	-108.64
Reservoir	MRS TANNER RES 1	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	9	044N	095W	TANNER	43.79	-108.25
Reservoir	N HART RES	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	6	043N	095W	MEETEETSE DRAW	43.72	-108.29
Reservoir	OB RES	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	13	043N	100W	CURTIS	43.69	-108.79
Reservoir	RUSSELL RES 2	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	15	044N	093W	ZIMMERMAN BUTTES	43.78	-108.009
Reservoir	RUSSELL RES 3	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	19	044N	093W	RED SPRINGS DRAW	43.76	-108.06
Reservoir	S HART RES	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	8	043N	095W	MEETEETSE DRAW	43.7	-108.27
Reservoir	SANFORD RES 1	Dry in 3 years imagery	Non-Functional	No	Non-Existing	BLM	30	044N	096W	STEER	43.75	-108.43
Reservoir	SOUTH BASIN RES	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	26	044N	094W	SOUTH LUCERNE GROUP	43.75	-108.1
Reservoir	TANNER RES 1	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	17	044N	095W	TANNER	43.78	-108.28
Reservoir	WALTERS DRAW 1 RES	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	3	044N	094W	CEDAR MOUNTAIN	43.81	-108.11
Reservoir	WEED RES	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	BLM	30	044N	098W	WAGONHOUND	43.74	-108.66
Reservoir	BEDROCK RESERVOIR	Wet in 2011, dry in 2014 & 2010	Potential	Yes	Existing	BLM	23	044N	094W	SOUTH LUCERNE GROUP	43.77	-108.108
Reservoir	BOBBY CHARCO RES	Wet in 2010, dry in 2011 & 2014	Potential	Yes	Existing	BLM	18	042N	095W	RED CANYON	43.6	-108.3
Reservoir	BOBBY SPRING RES	Wet in 2014, dry in 2011 & 2010	Potential	Yes	Existing	BLM	17	042N	095W	RED CANYON	43.61	-108.29
Reservoir	BROKEN LEG RES	Wet in 2014, dry in 2011 & 2010	Potential	Yes	Existing	BLM	5	044N	093W	SAND DRAW	43.87	-108.03
Reservoir	E JONES RES	Wet in 2014, dry in 2011 & 2010	Potential	Yes	Existing	BLM	15	044N	093W	ZIMMERMAN BUTTES	43.78	-108
Reservoir	GWYNN RES	Wet in 2014, dry in 2011 & 2010	Potential	Yes	Existing	BLM	22	044N	095W	SOUTH GEBO COMMON	43.77	-108.24
Reservoir	MRS TANNER RES 2	Wet in 2014, dry in 2011 & 2010	Potential	Yes	Existing	BLM	14	044N	095W	TANNER	43.77	-108.22
Reservoir	MRS TANNER RES 3	Wet in 2014, dry in 2011 & 2010	Potential	Yes	Existing	BLM	14	044N	095W	TANNER	43.78	-108.23
Reservoir	RED DOT RES	Wet in 2014, dry in 2011 & 2010	Potential	Yes	Existing	BLM	27	045N	095W	NELSON	43.83	-108.24
Reservoir	REEDS RESERVOIR	Wet in 2014, dry in 2011 & 2010	Potential	Yes	Existing	BLM	15	044N	094W	FREEMAN DRAW	43.78	-108.13
Reservoir	SANFORD RES 2	Wet in 2010, dry in 2011 & 2014	Potential	Yes	Existing	BLM	3	043N	097W	HEIFER	43.72	-108.47
Reservoir	TANNER RES 2	Wet in 2014, dry in 2011 & 2010	Potential	Yes	Existing	BLM	9	044N	095W	TANNER	43.78	-108.25
Reservoir	YARD RES	Wet in 2014, dry in 2011 & 2010	Potential	Yes	Existing	BLM	8	043N	100W	RATTLESNAKE	43.70	-108.88

BLM and SEO Permitted Stock Reservoirs													
Type	**Project Name**	**Notes (2014, 2011, 2010)**	**Functionality**	**Water Source**	**Status**	**Source**	**Section**	**Township**	**Range**	**Allotment Name**	**Latitude**	**Longitude**
Reservoir	WEBER RES	Wet in 2014, dry in 2011 & 2010	Potential	Yes	Existing	BLM	09	043N	100W	THREE PEAKS ANCHOR	43.70	-108.86
Reservoir	YARD RES	Wet in 2014, dry in 2011 & 2010	Potential	Yes	Existing	BLM	08	043N	100W	RATTLESNAKE	43.71	-108.88
Reservoir	SHOOP RESERVOIR	Dry in 3 years of imagery, no breaches or sedimentation	Functional	No	Non-Existing	IRR_SEO					43.73	-108.59
Reservoir	BOOTS RESERVOIR TANK NO. 2 RESERVOIR	Wet in 2014, 2011, & 2010	Functional	Yes	Existing	IRR_SEO					43.53	-108.16
Reservoir	BAKER #1	Wet in 2014, 2011, & 2011	Functional	Yes	Existing	IRR_SEO					43.70	-108.22
Reservoir	DANIELS #1 STOCK RESERVOIR	Wet in 2014 & 2011, dry in 2010	Functional	Yes	Existing	IRR_SEO					43.69	-108.47
Reservoir	ENL OF CURTIS STOCK RESERVOIR	Wet in 2014, 2011, & 2011	Functional	Yes	Existing	IRR_SEO					43.71	-108.63
Reservoir	DRY COTTONWOOD STOCK RESERVOIR	Wet in 2014, 2011, & 2011	Functional	No	Existing	IRR_SEO					43.70	-108.66
Reservoir	MCCOY RESERVOIR	Wet in 2014, 2011, & 2012	Functional	Yes	Existing	IRR_SEO					43.71	-108.96
Reservoir	DICKIE NO. 2 RESERVOIR	Wet in 2014, 2011, & 2013	Functional	Yes	Existing	IRR_SEO					43.68	-109.03
Reservoir	LUKE MCNEIL #2 STOCK RESERVOIR	Dry in 3 years of imagery, no breaches or sedimentation	Functional	Yes	Existing	IRR_SEO					43.67	-109.04
Reservoir	BIG STOCK RESERVOIR	Wet in 2014, 2011, & 2013	Functional	Yes	Existing	IRR_SEO					43.67	-108.36
Reservoir	STEWART RESERVOIR	Wet in 2014, 2011, & 2012	Functional	Yes	Existing	IRR_SEO					43.73	-108.16
Reservoir	DOUGLAS KIMSEY STOCK	Wet in 2014, 2011, & 2012	Functional	Yes	Existing	IRR_SEO					43.61	-108.21
Reservoir	DANIELS NO. 2 STOCK RESERVOIR	Dry in 3 years of imagery, no breaches or sedimentation	Functional	Yes	Existing	IRR_SEO					43.69	-108.48
Reservoir	JANE #1	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	IRR_SEO					43.69	-108.39
Reservoir	SKINNER RESERVOIR	Dry in 3 years of imagery	Non-Functional	No	Existing	IRR_SEO					43.68	-108.45
Reservoir	MOORE RESERVOIR	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	IRR_SEO					43.71	-108.69
Reservoir	FRIX RESERVOIR	Dry in 3 years of imagery	Non-Functional	No	Existing	IRR_SEO					43.63	-108.23
Reservoir	JANE NO. 1	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	IRR_SEO					43.69	-108.38
Reservoir	SKINNER RESERVOIR	Dry in 3 years of imagery	Non-Functional	No	Non-Existing	IRR_SEO					43.68	-108.45
Reservoir	HOLDEN RE-REGULATION RESERVOIR	Wet in 2010, dry in 2011 & 2014	Potential	Yes	Existing	IRR_SEO					43.72	-108.42
Reservoir	ENL BLONDE RESERVOIR	Wet in 2010, dry in 2011 & 2014	Potential	Yes	Existing	IRR_SEO					43.69	-108.86
Reservoir	COLLINS RESERVOIR	Wet in 2010, dry in 2011 & 2014	Potential	Yes	Existing	IRR_SEO					43.66	-108.40
Reservoir	HOLDEN RE-REGULATION RESERVOIR	Wet in 2014, dry in 2010 & 2011	Potential	No	Existing	IRR_SEO					43.72	-108.42
Reservoir	HOLDEN STOCK RESERVOIR	Wet in 2014, dry in 2011 & 2010	Potential	No	Existing	IRR_SEO					43.72	-108.45
Reservoir	BELTZ STOCK	Wet in 2014, dry in 2011 & 2010	Potential	No	Existing	IRR_SEO					43.72	-108.61
Reservoir	NEIBER GOOSEBERRY NO. 1 RESERVOIR	Wet in 2014, dry in 2011 & 2010	Potential	No	Existing	IRR_SEO					43.92	-108.09
Reservoir	DON MERRILL NO. 1 STOCK RESERVOIR		Unk	Unk	Unk	IRR_SEO					43.73	-108.64

APPENDIX G – Conceptual Designs

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DESIGN CRITERIA

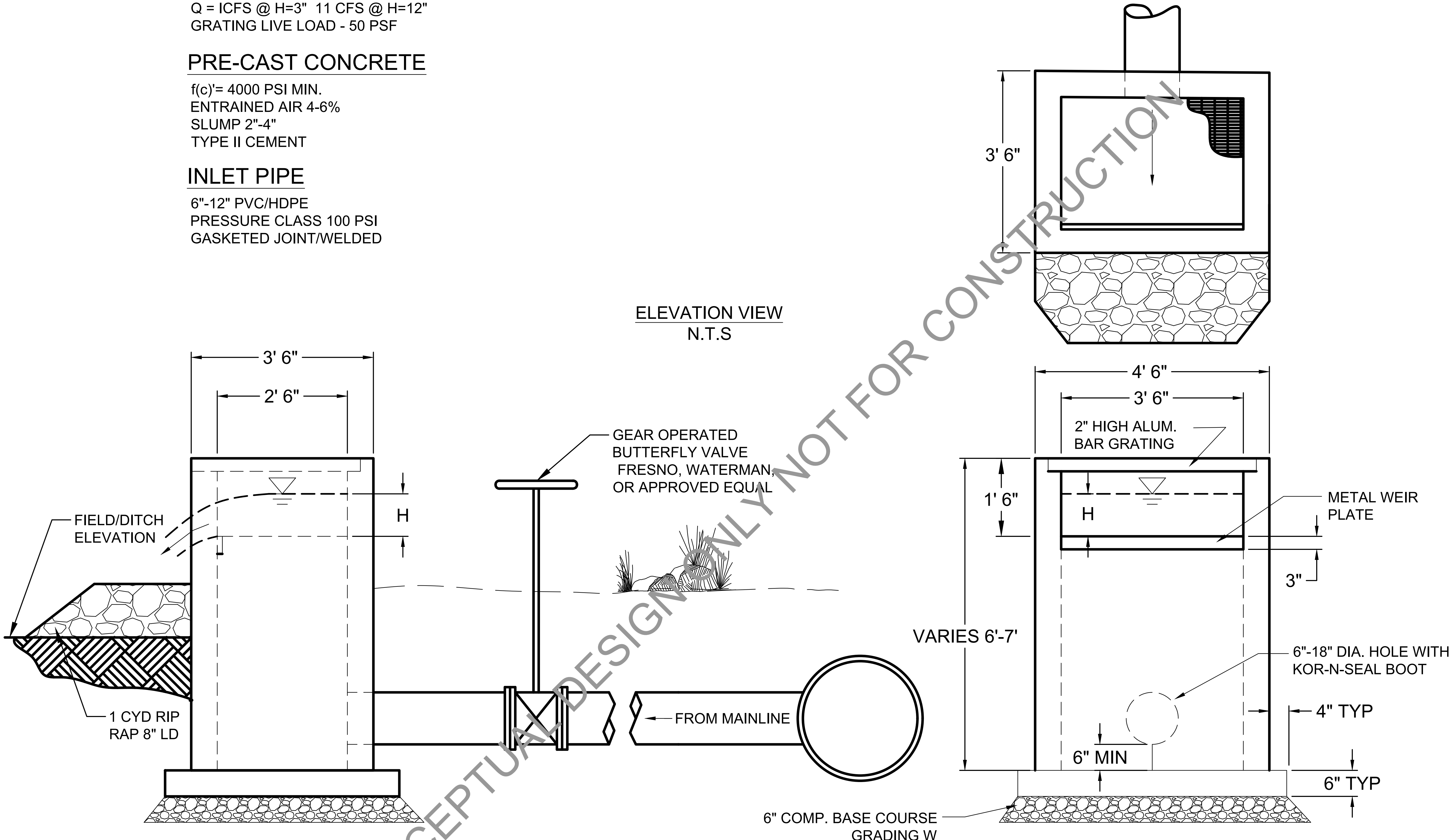
Q = ICFS @ H=3" 11 CFS @ H=12"
GRATING LIVE LOAD - 50 PSF

PRE-CAST CONCRETE

f(c)'= 4000 PSI MIN.
ENTRAINED AIR 4-6%
SLUMP 2"-4"
TYPE II CEMENT

INLET PIPE

6"-12" PVC/HDPE
PRESSURE CLASS 100 PSI
GASKETED JOINT/WELDED



PRE-CAST CONCRETE FARM TURNOUT

LOWHAM WALSH LLC
Engineering & Environmental Services
205 S. Third St
Lander, WY 82520
(307)335-8466

WWDC OWL CREEK LEVEL 1
WATERSHED STUDY

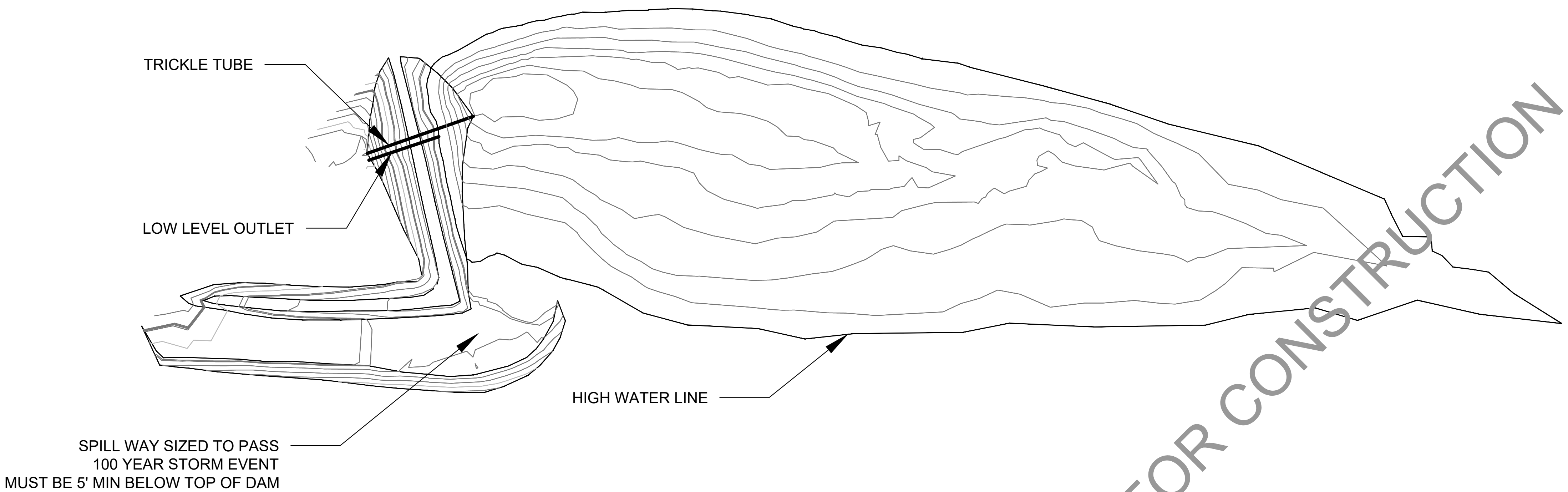
DES	DRN	CHK	APPD
	DGC	FG	

NO.	REVISIONS	BY	DATE

Sheet 1 of 3

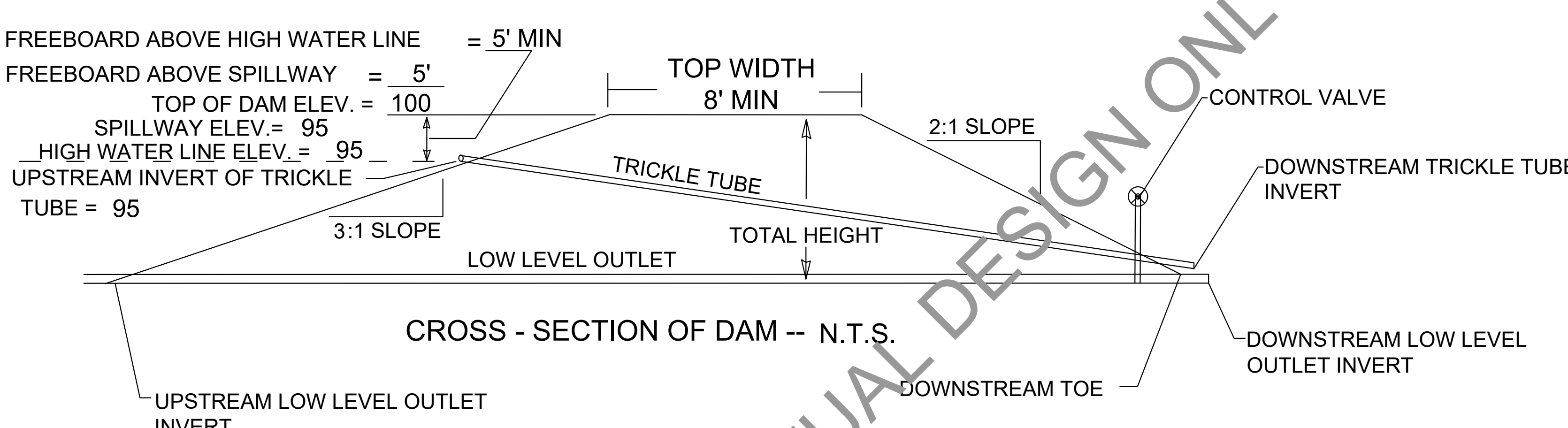
DATE
11-28-16

PLAN VIEW
N.T.S



LOCATION
ELEVATION DATUM:____________
_____1/4, ____1/4
SECTION______
T______N, R______W 6TH P.M.
_________ COUNTY, WYOMING

DETAILS OF DAM
N.T.S



CROSS - SECTION OF DAM -- N.T.S.

DESIGN CRITERIA

1. SEE WSEO REQUIREMENTS PART 1, CHAPTER 5, PAGE 33
2. RESERVOIR TO BE CONSTRUCTED ON OR OFF CHANNEL
3. DAM HEIGHT TO BE UNDER 20' TALL AND CAPACITY NO MORE THAN 20 ACRE-FT. WSEO SW4 CLASSIFICATION
4. COMPACT EMBANKMENT TO MAX DENSITY ASTM D-1557
5. RIP RAP PROTECTION AT OUTLET PIPING > 12" LD
6. EMBANKMENT MUST BE PROTECTED FROM WAVE ACTION WITH VEGETATION OR RIP RAP
7. OFF-CHANNEL RESERVOIR MUST SHOW AND NAME SUPPLY DITCH. SEPARATE RIGHT APPLICATION IS REQUIRED

TYPICAL STOCK RESERVOIR

LOWHAM WALSH LLC
Engineering & Environmental Services
205 S. Third St
Lander, WY 82520
(307)335-8466

WWDC OWL CREEK LEVEL 1 WATERSHED STUDY

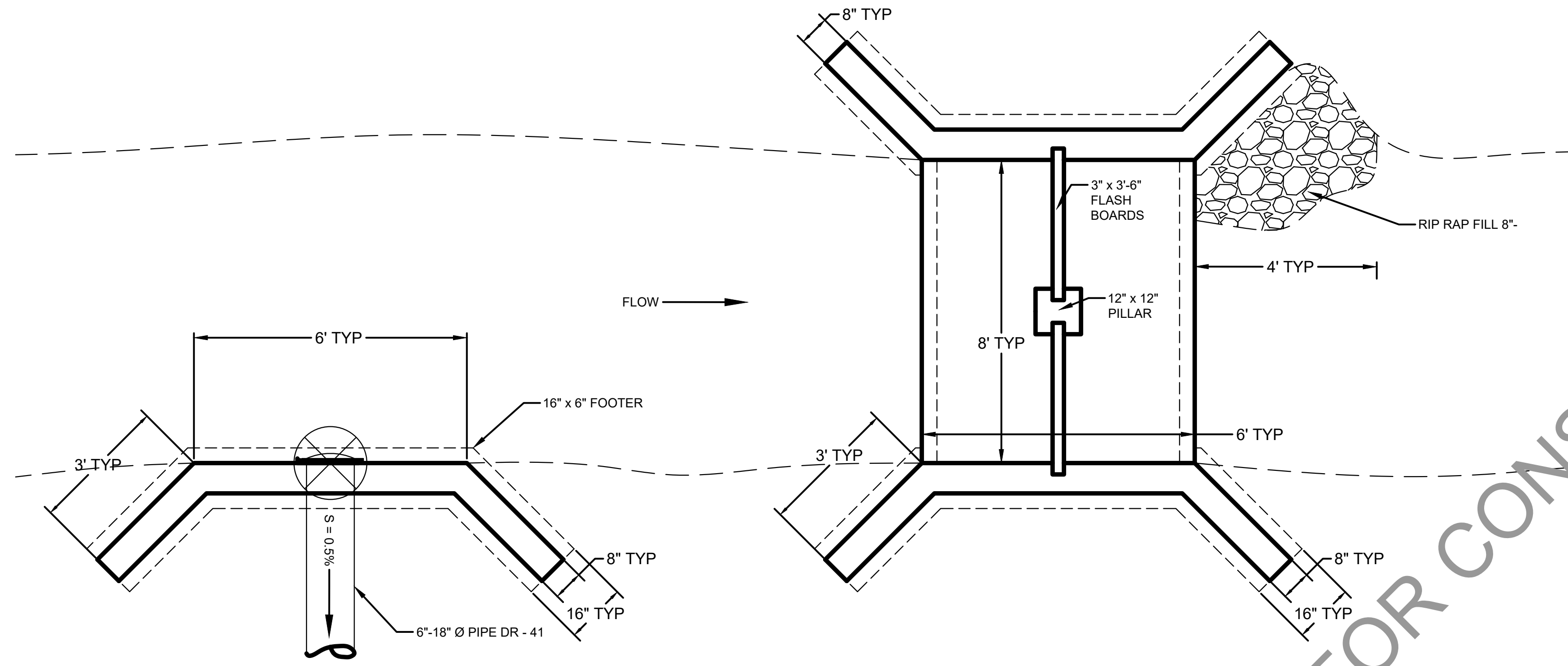
NO.	REVISIONS	BY	DATE

DES
DRN DGC
CHK FG
APPD

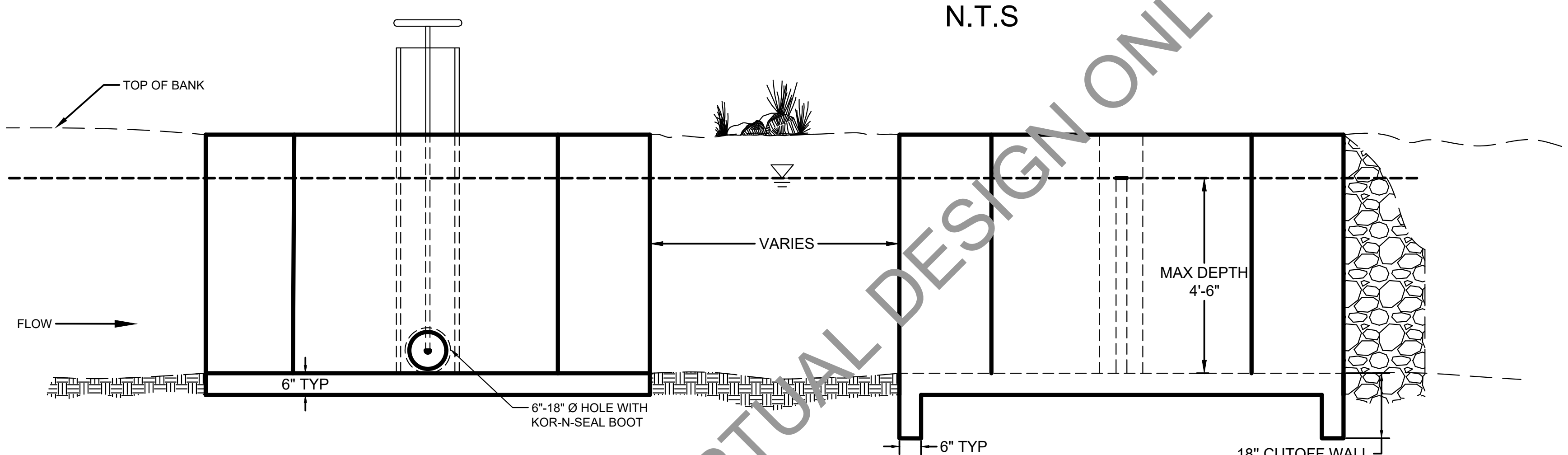
Sheet 3 of 3

DATE
11-28-16

PLAN VIEW
N.T.S



ELEVATION VIEW
N.T.S



DESIGN CRITERIA

1. SOIL BEARING PRESSURE
2. CONCRETE COMPRESSIVE STRENGTH f'(c) 4000psi
3. RECOMPACT SUBGRADE TO 90% MAX DENSITY ASTM D-698
4. RIP RAP >8" L.D.
5. MAX WATER DEPTH 4'-6"

NO.	REVISIONS	BY	DATE

NEW DIVERSION & CHECK STRUCTURE

LOWHAM WALSH LLC
Engineering & Environmental Services
205 S. Third St
Lander, WY 82520
(307)335-8466

WWDC OWL CREEK LEVEL 1
WATERSHED STUDY

DES
DRN DGC
CHK FG
APPD

Sheet 2 of 3

DATE
11-28-16

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APPENDIX H – NED Diagrams

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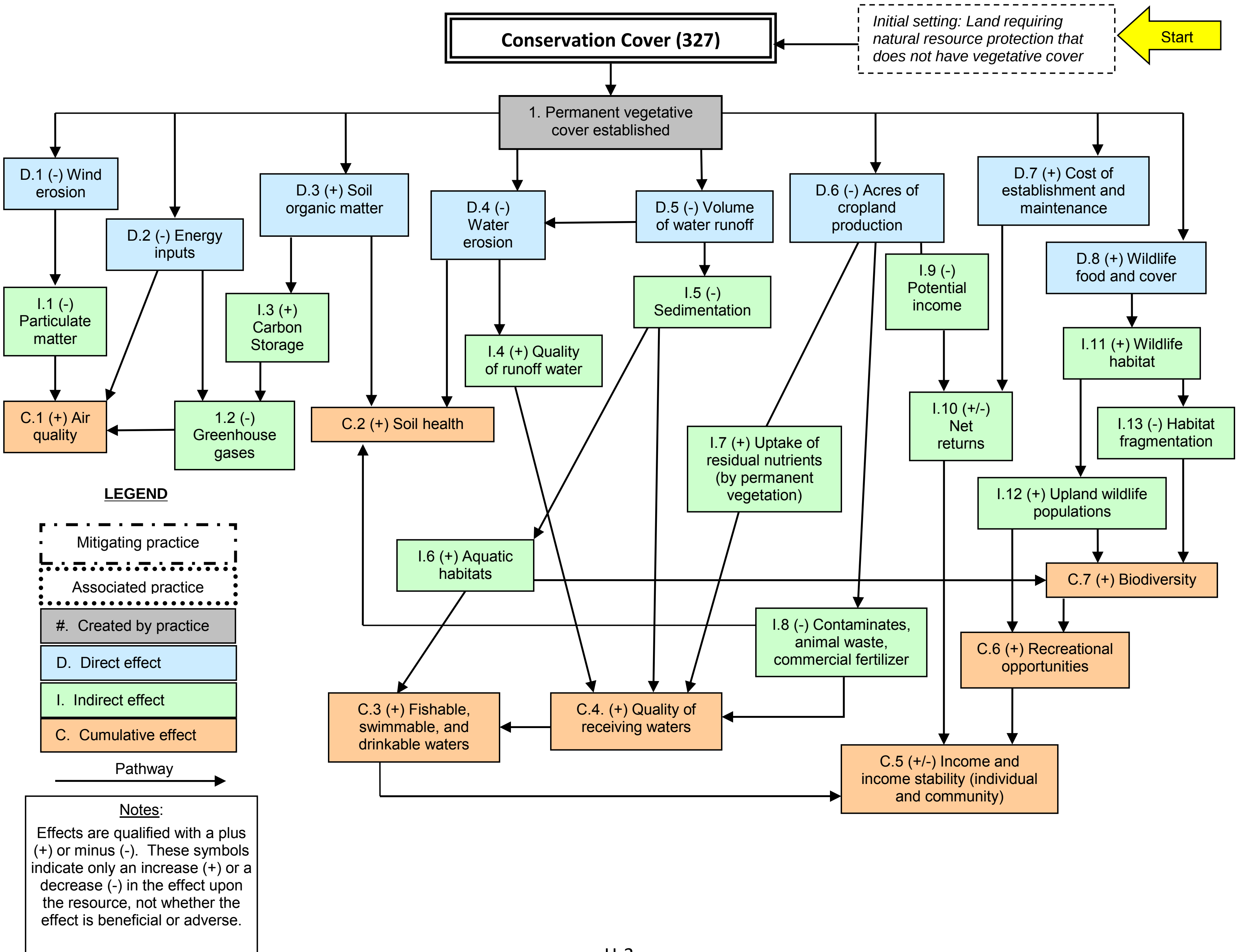
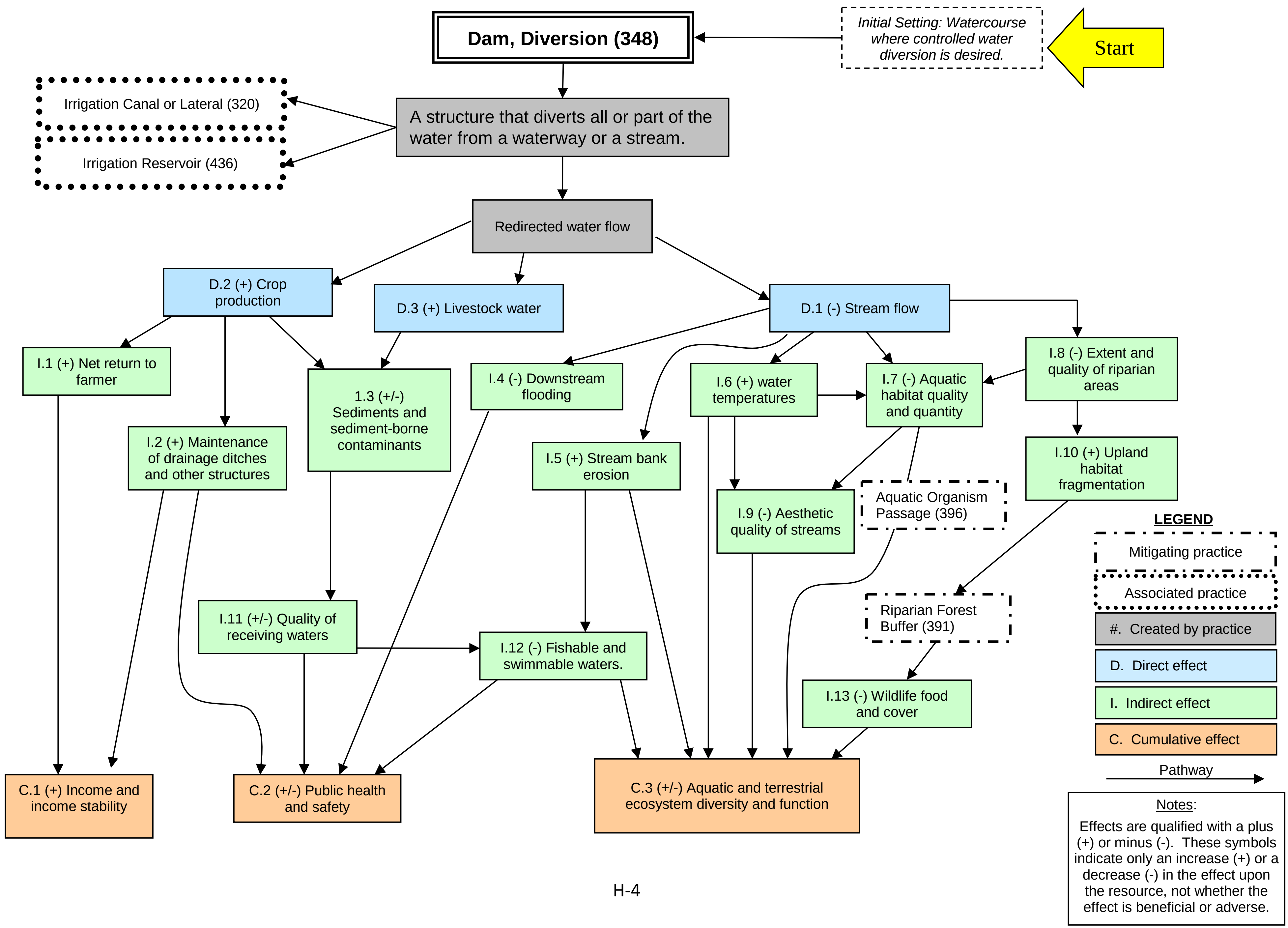
NRCS CONSERVATION PRACTICE EFFECTS- NETWORK DIAGRAM

September 2014



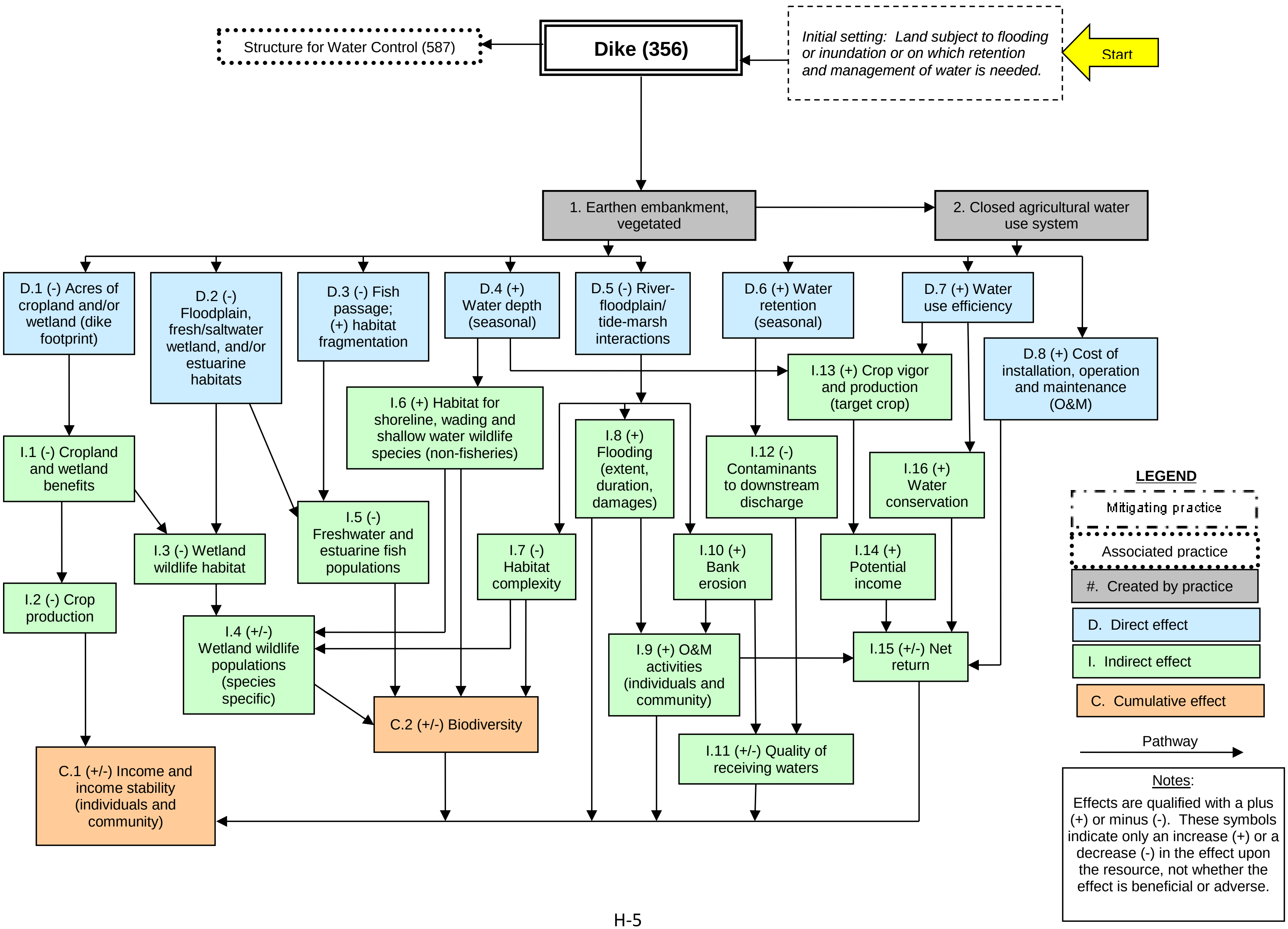
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

March 2014



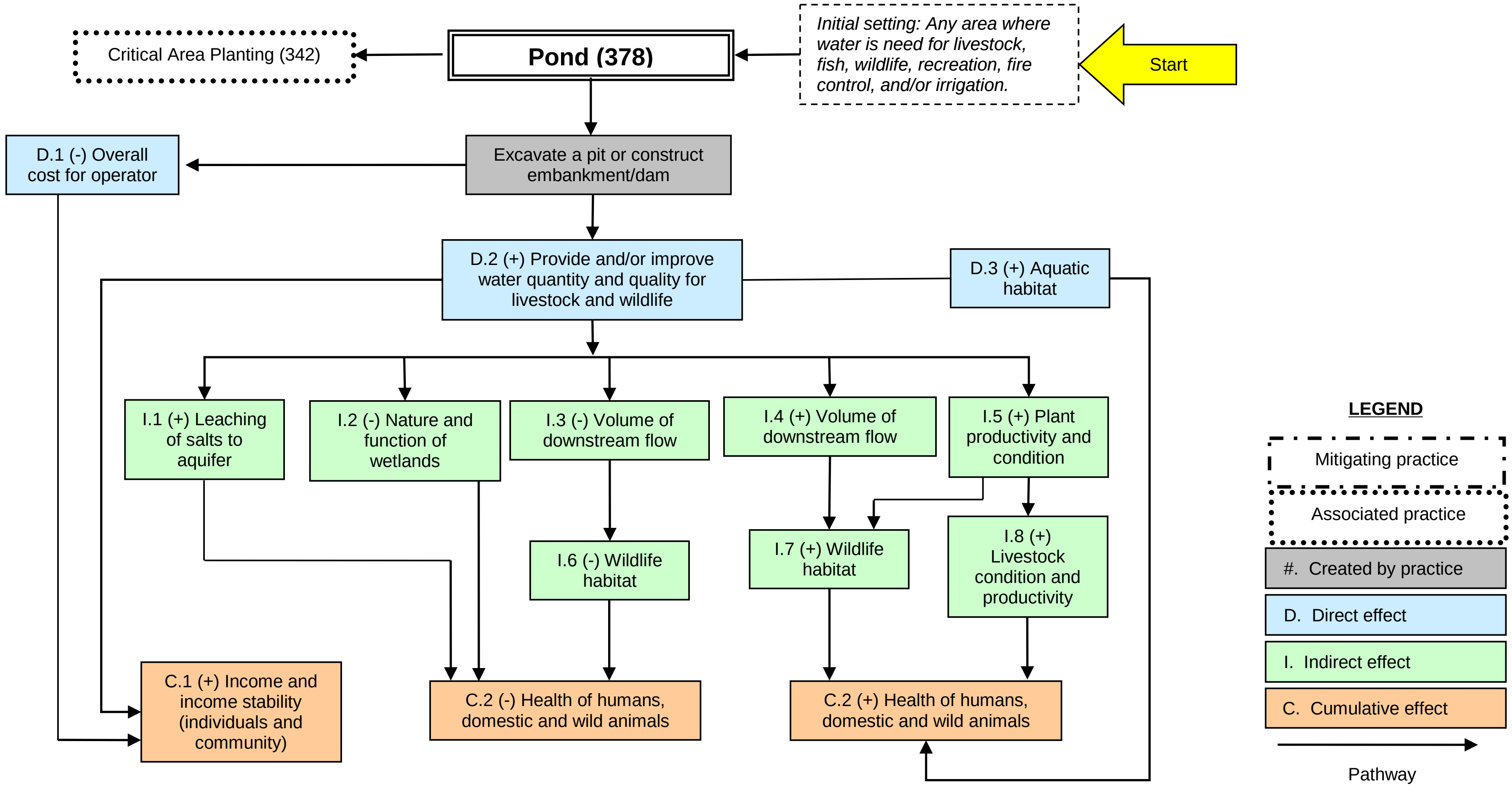
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

March 2014



NRCS CONSERVATION PRACTICE EFFECTS- NETWORK DIAGRAM

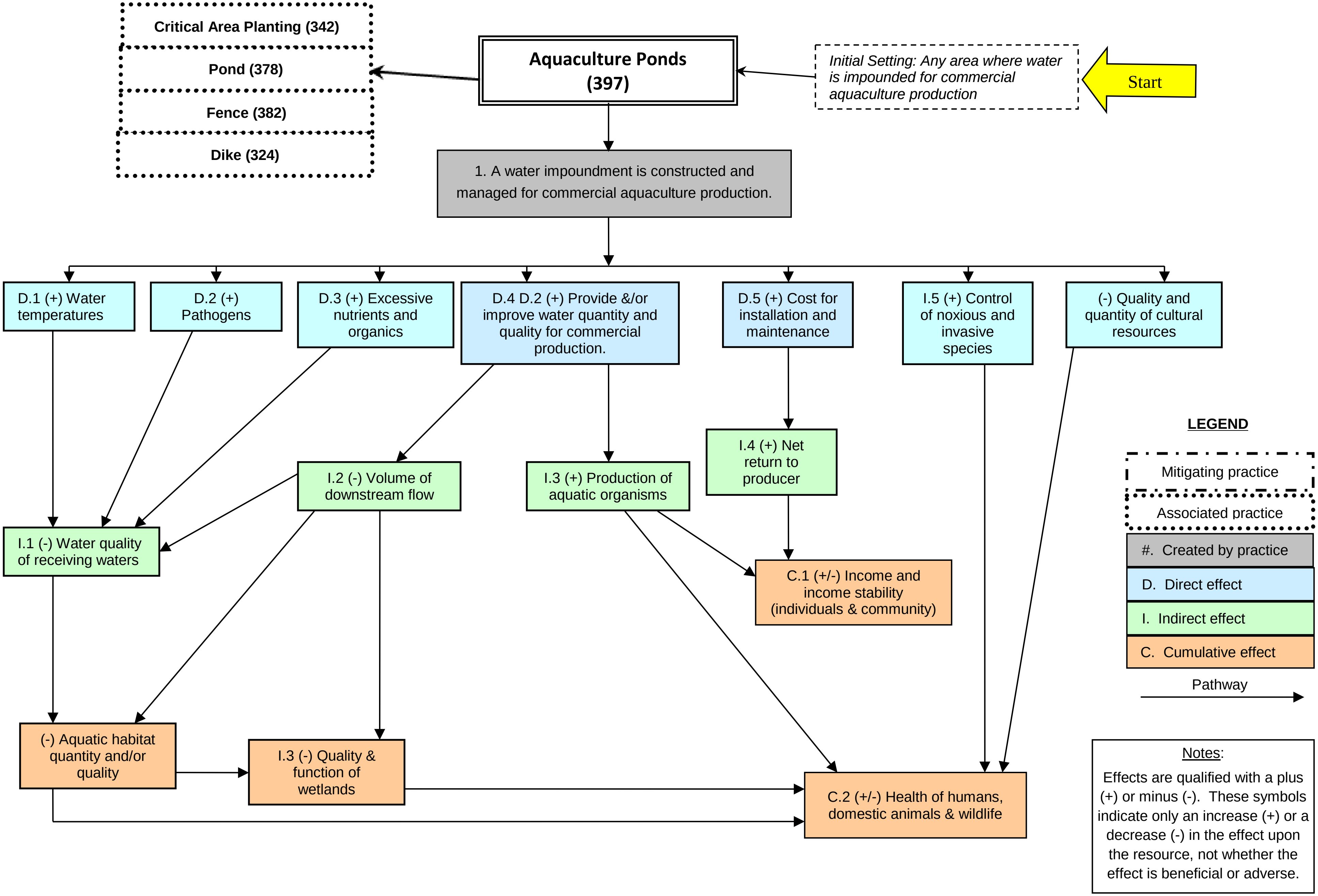
September 2015



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.

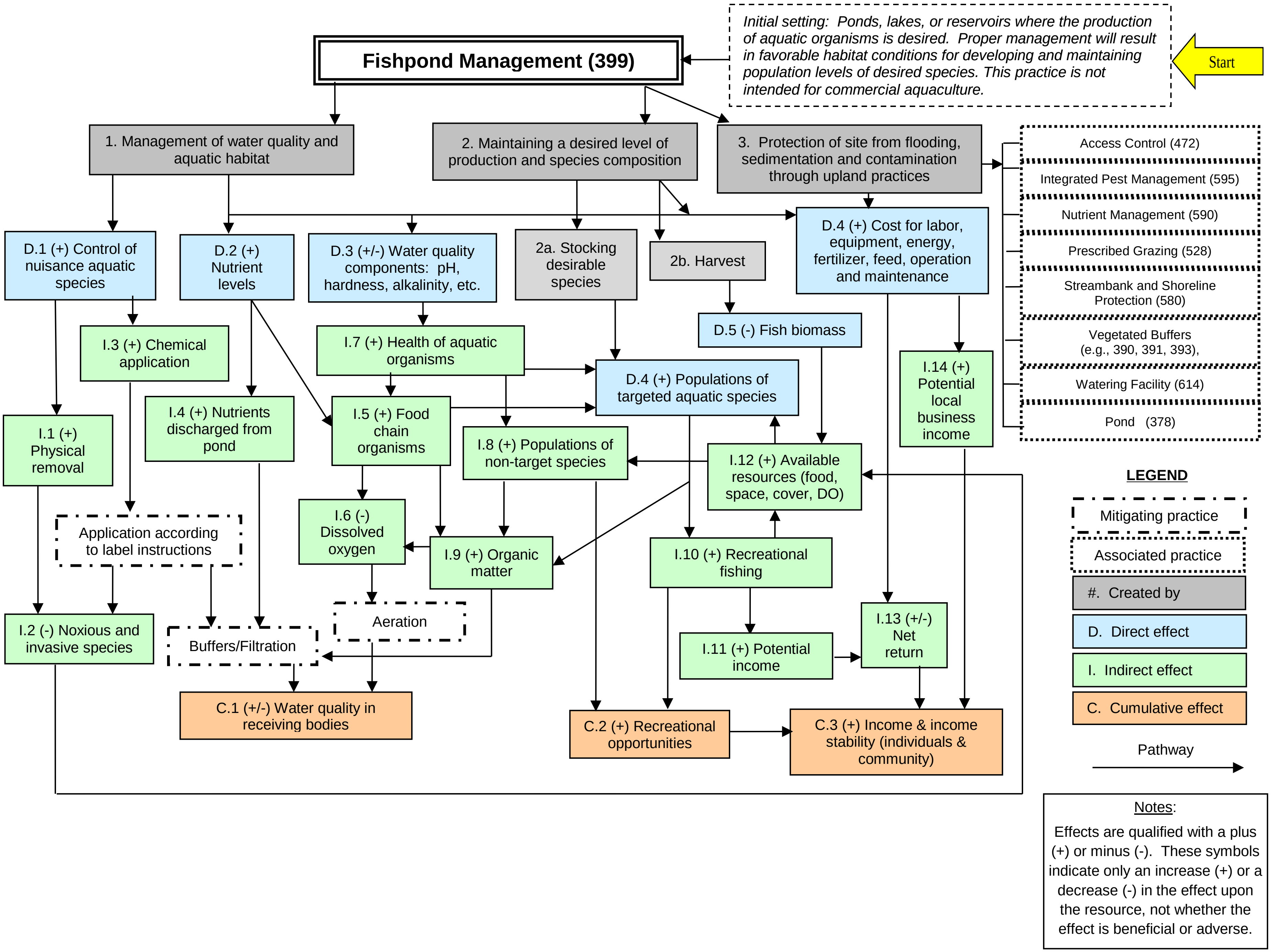
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

March 2014



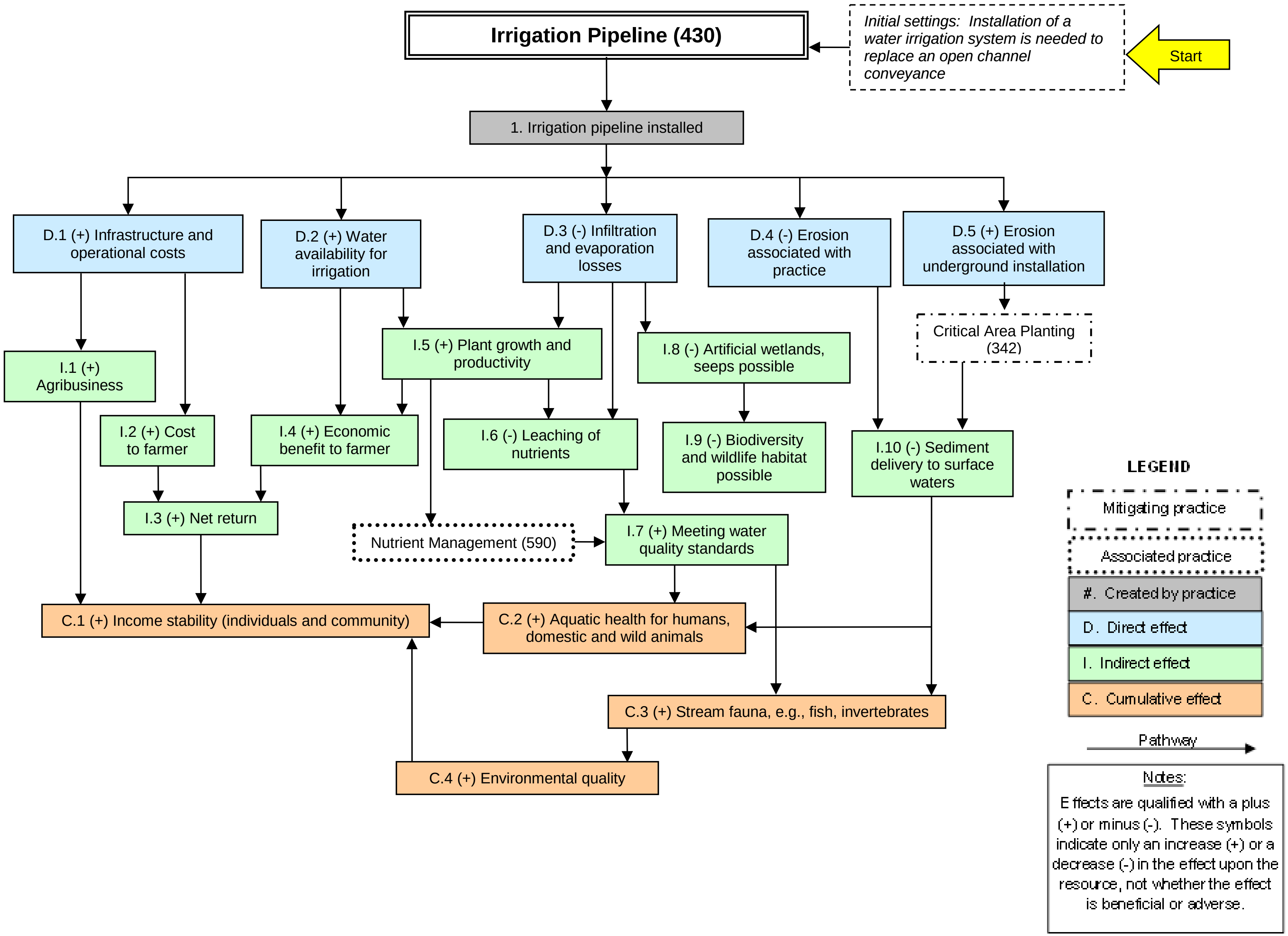
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

March 2014



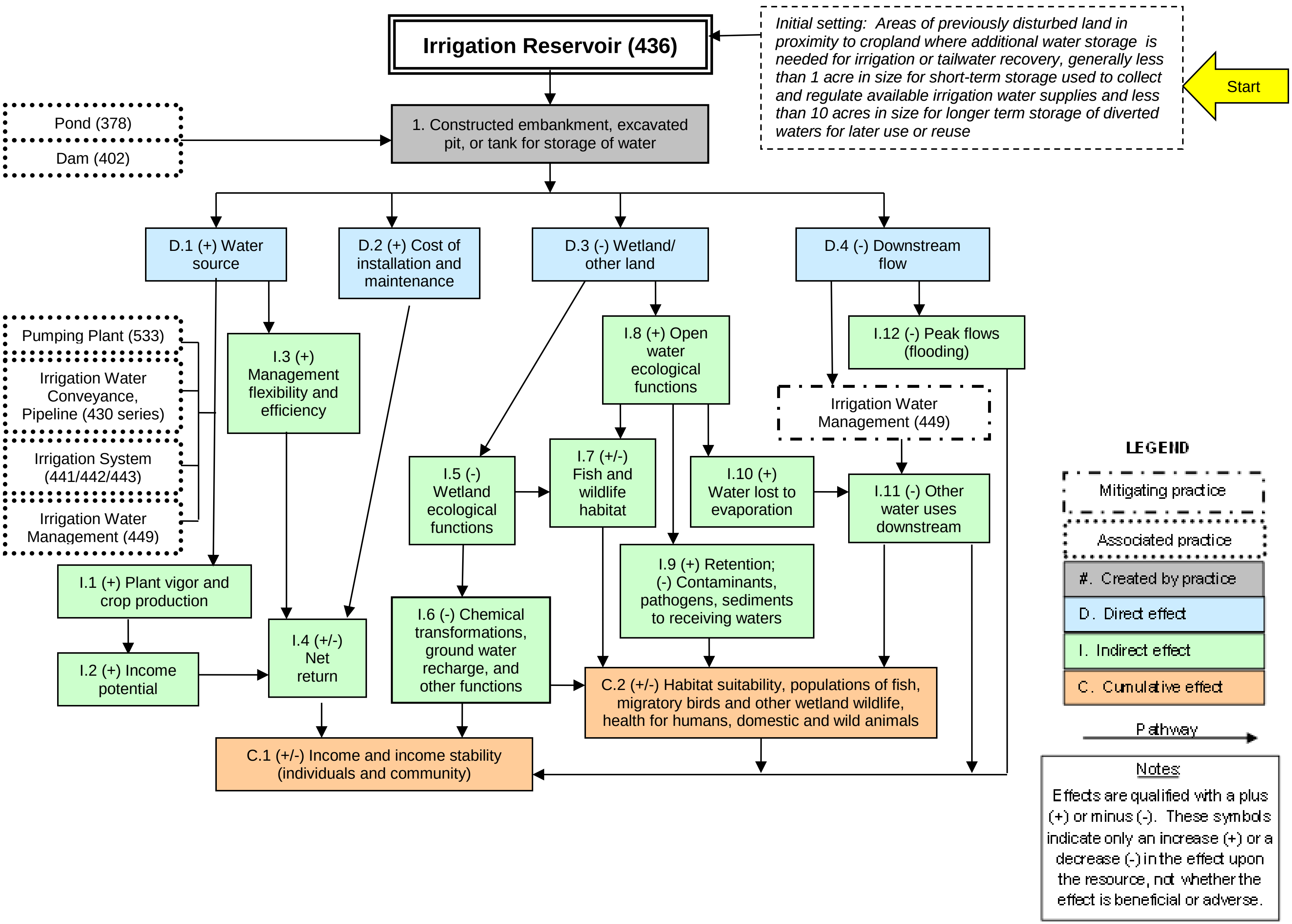
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

March 2014



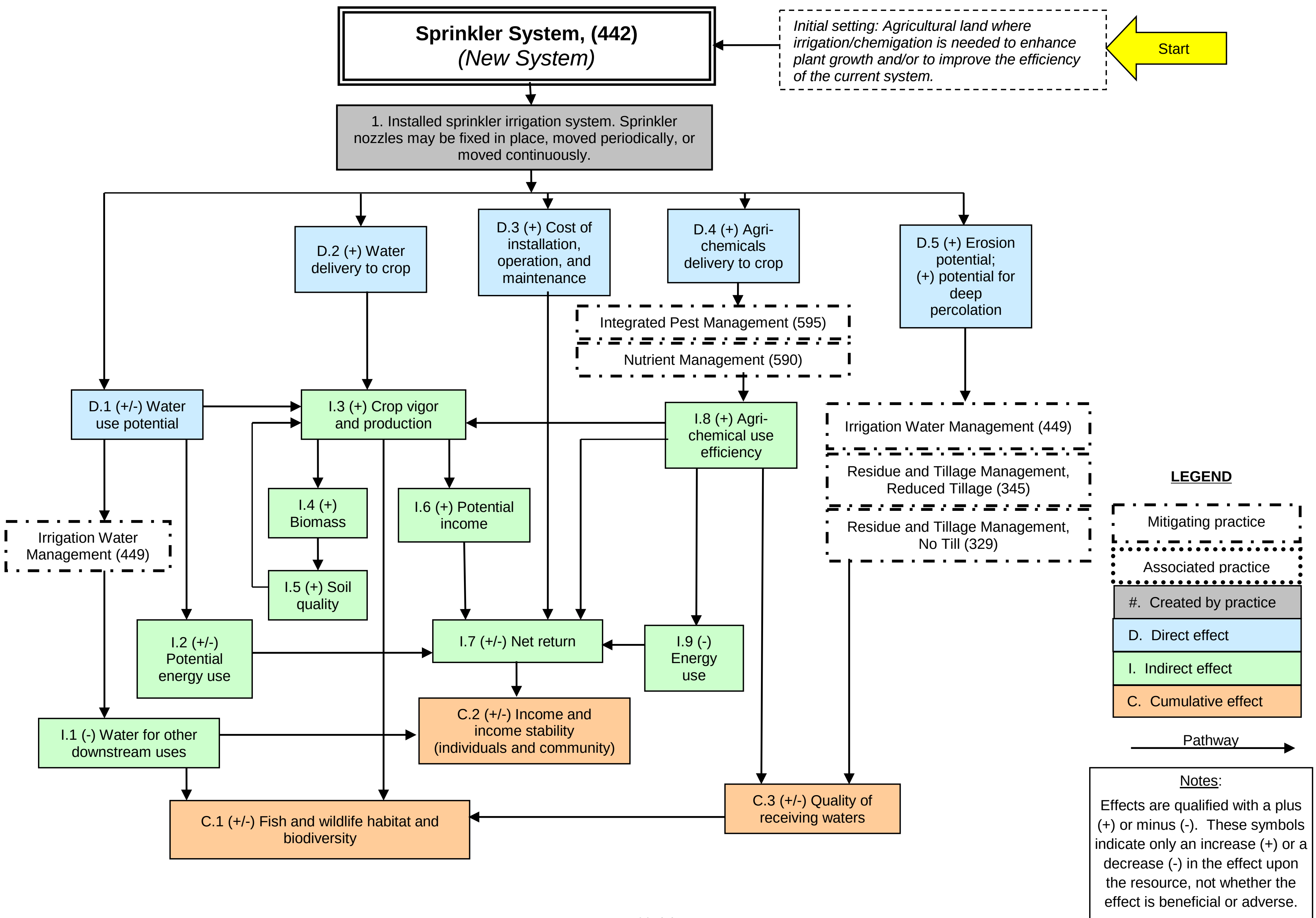
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

March 2014



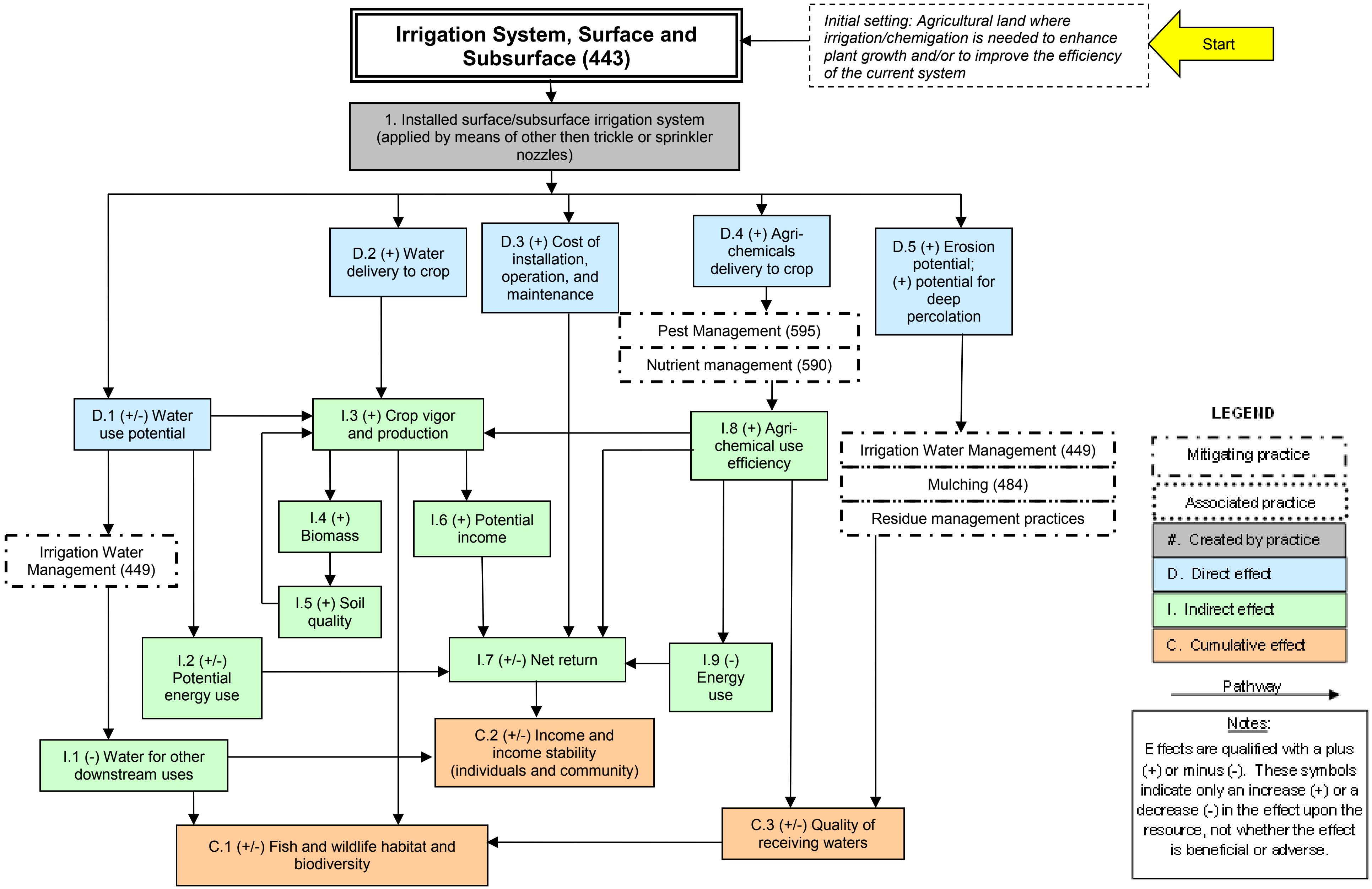
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

September 2015



NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

September 2016



United States Department of Agriculture

Conservation Practice Standard Overview

Irrigation System, Tailwater Recovery (447)

An irrigation tailwater recovery system is an irrigation system in which all facilities utilized for the collection, storage, and transportation of irrigation tailwater for reuse have been installed.

Practice Information

Tailwater recovery involves the collection of recoverable irrigation runoff flows and is applied to conserve irrigation water supplies and/or improve offsite water quality. It applies to systems where recoverable irrigation runoff flows can be anticipated under current or expected management practices.

Facilities are needed to store the collected water and to convey water from the storage facility to a point of entry back into the irrigation system. Additional storage may be required to provide adequate retention time for the breakdown of chemicals in the runoff waters or to provide for sediment deposition. Allowable retention times are specific to the particular chemical used. Seepage from a storage facility is controlled through natural soil or commercial liners, soil additives, or other approved methods when chemical-laden waters are stored. Protection of system components from storm events and excessive sedimentation are also considered in the planning and design of a system.

The irrigation tailwater recovery systems will require maintenance over the expected life of the practice.

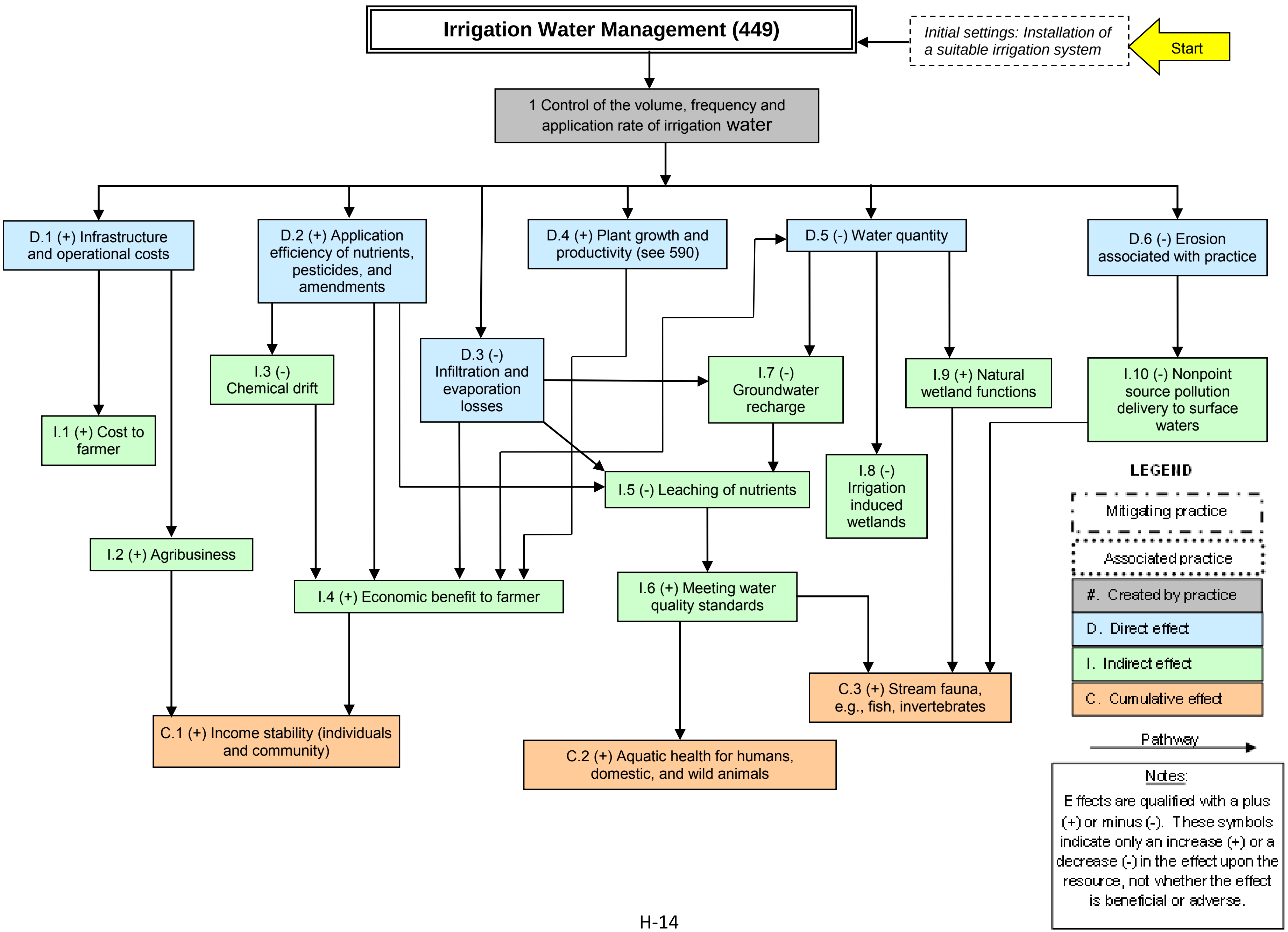
Common Associated Practices

Irrigation System, Tailwater Recovery (447) is commonly applied with conservation practices such as Pumping Plant (533), Irrigation Ditch Lining (428), Pond Sealing or Lining (521), and Irrigation Water Management (449).

For further information, contact your local NRCS field office.

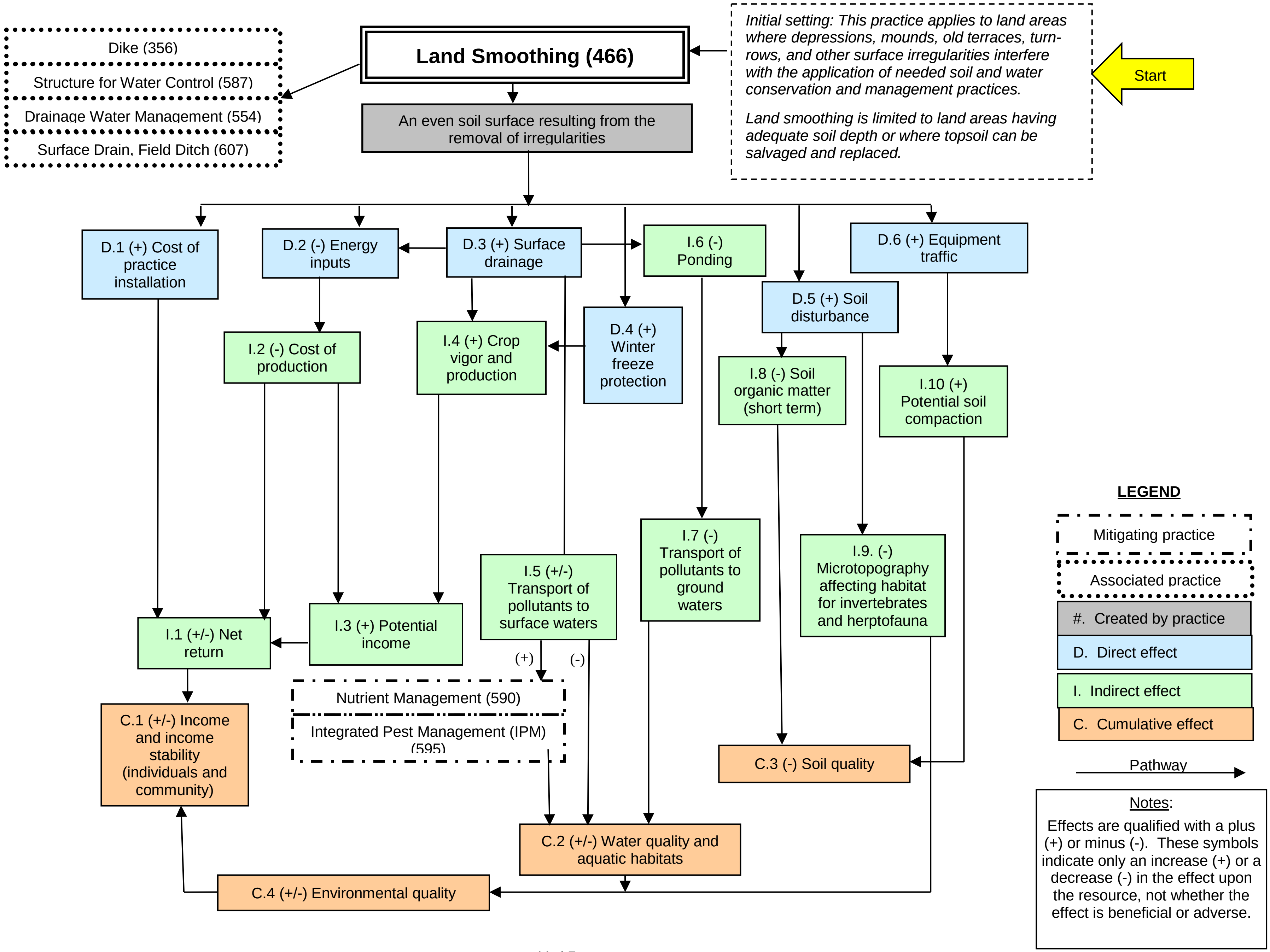
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

September 2014



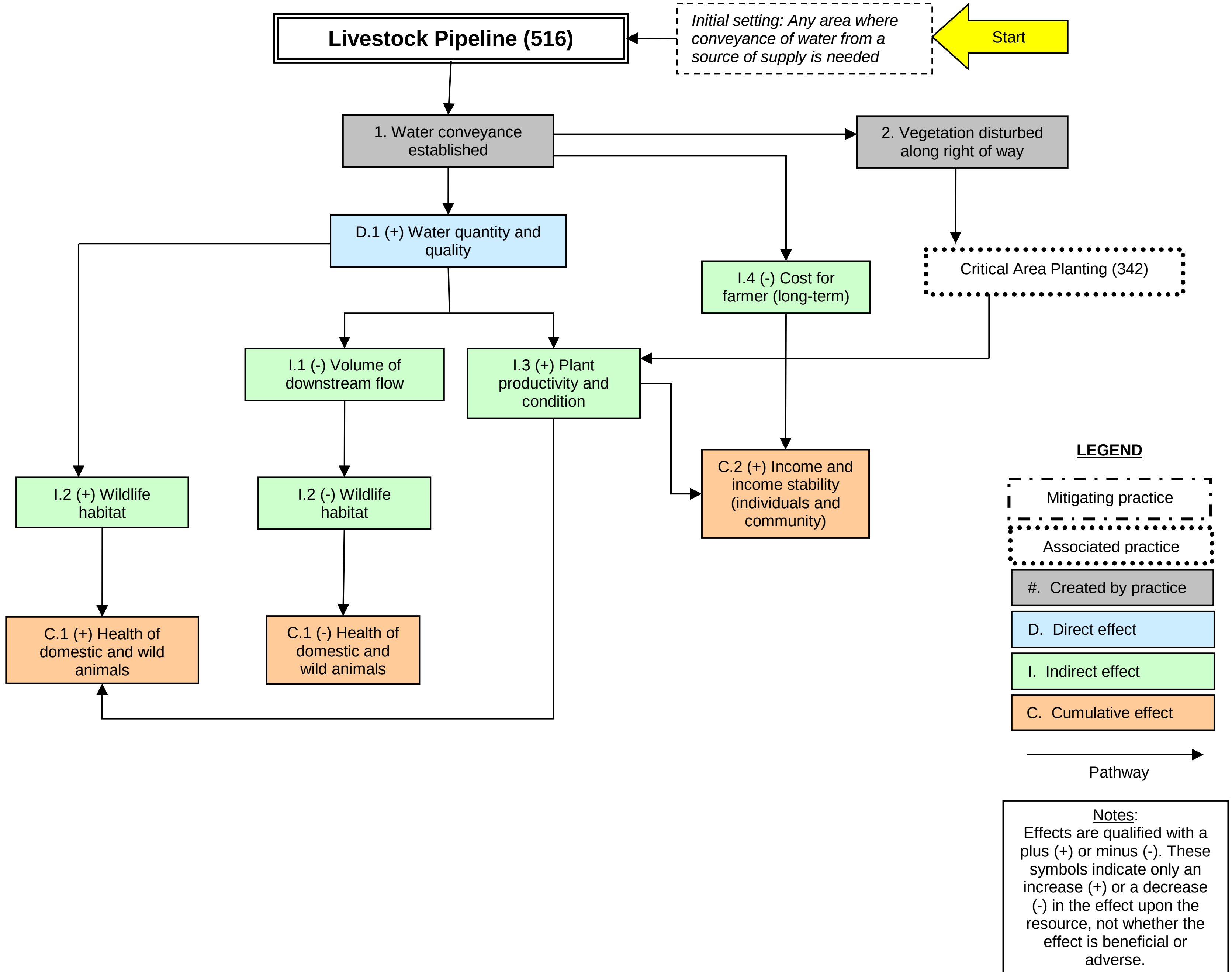
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

May 2014



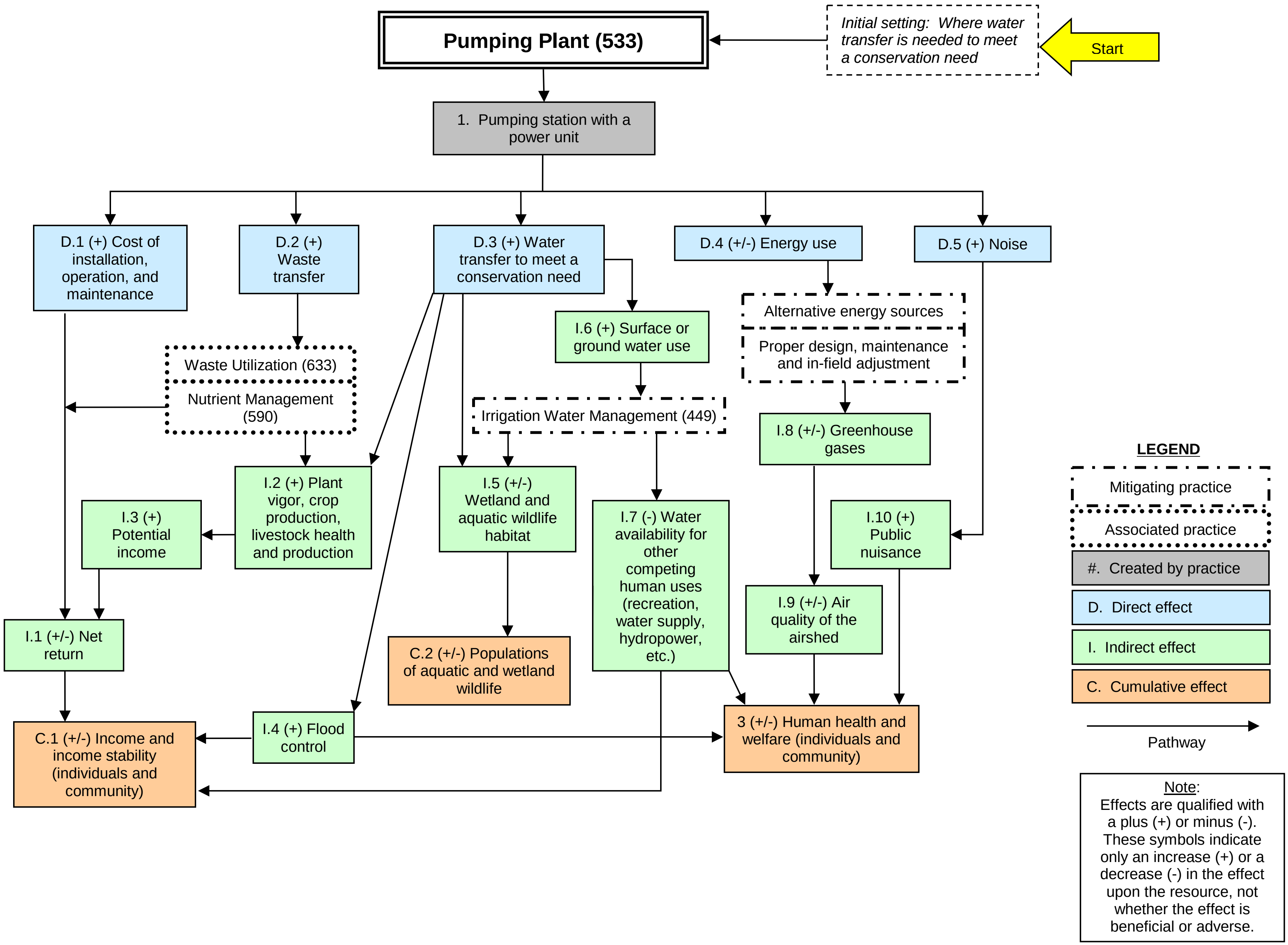
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

March 2014



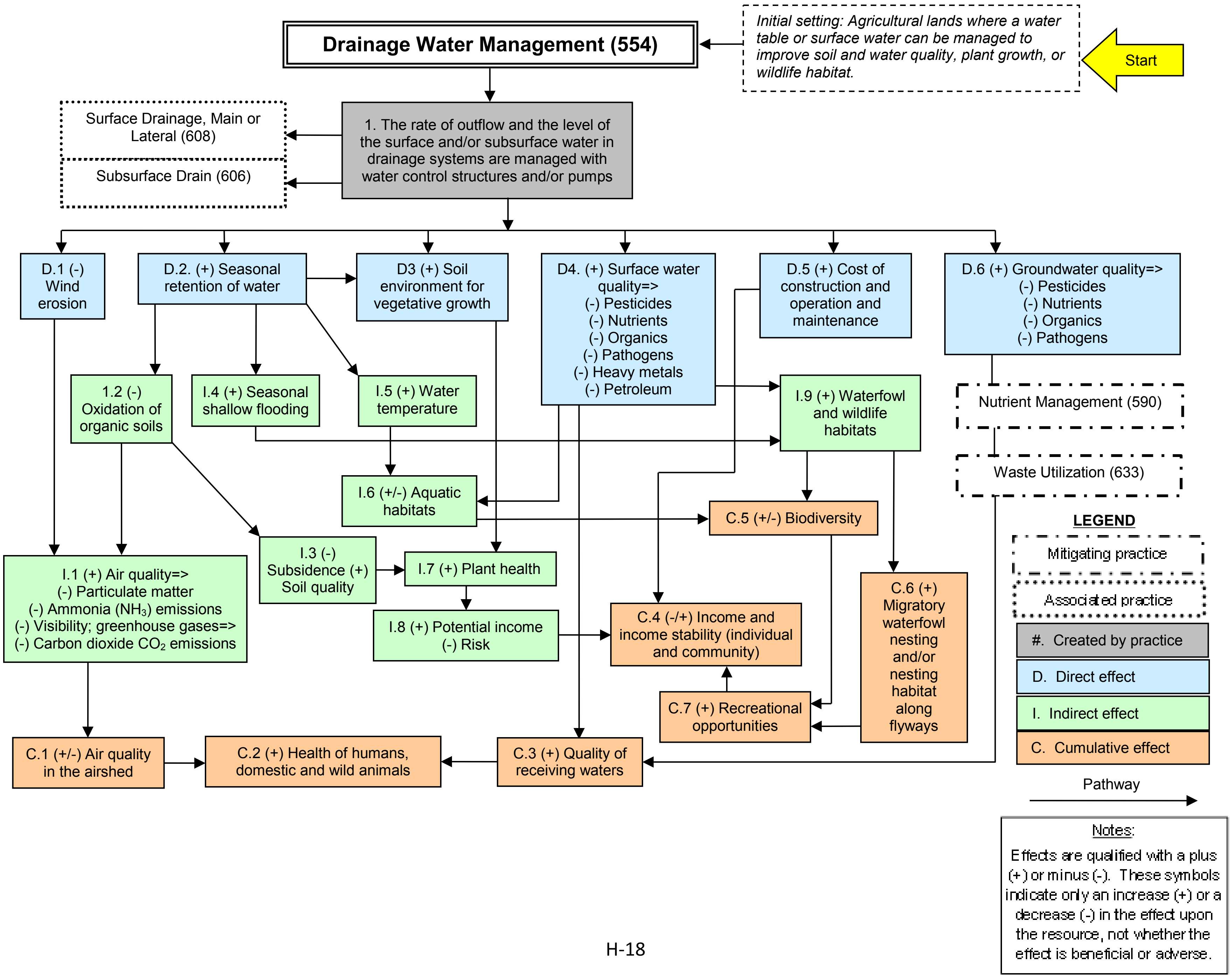
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

March 2014



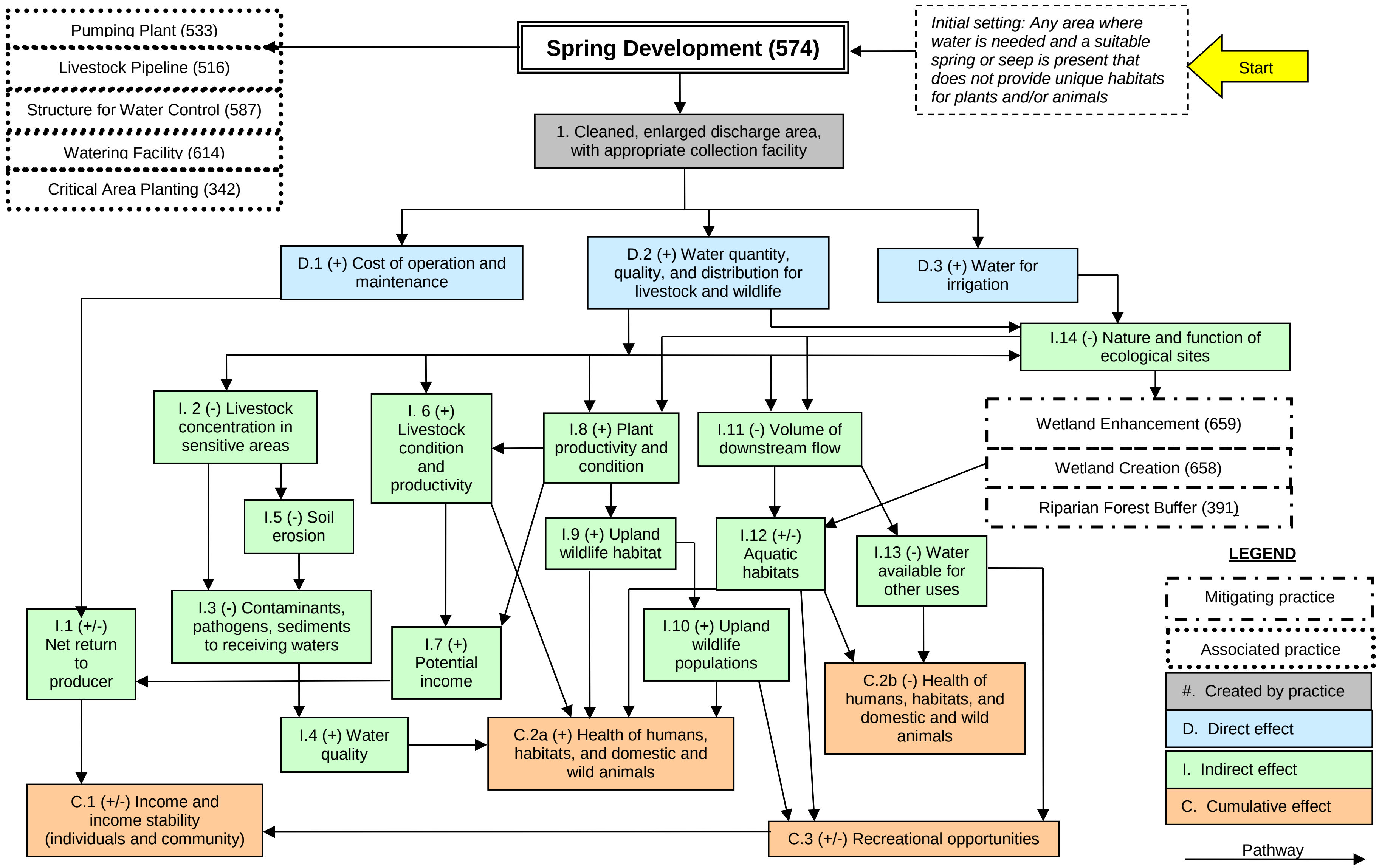
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

September 2016



NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

March 2014

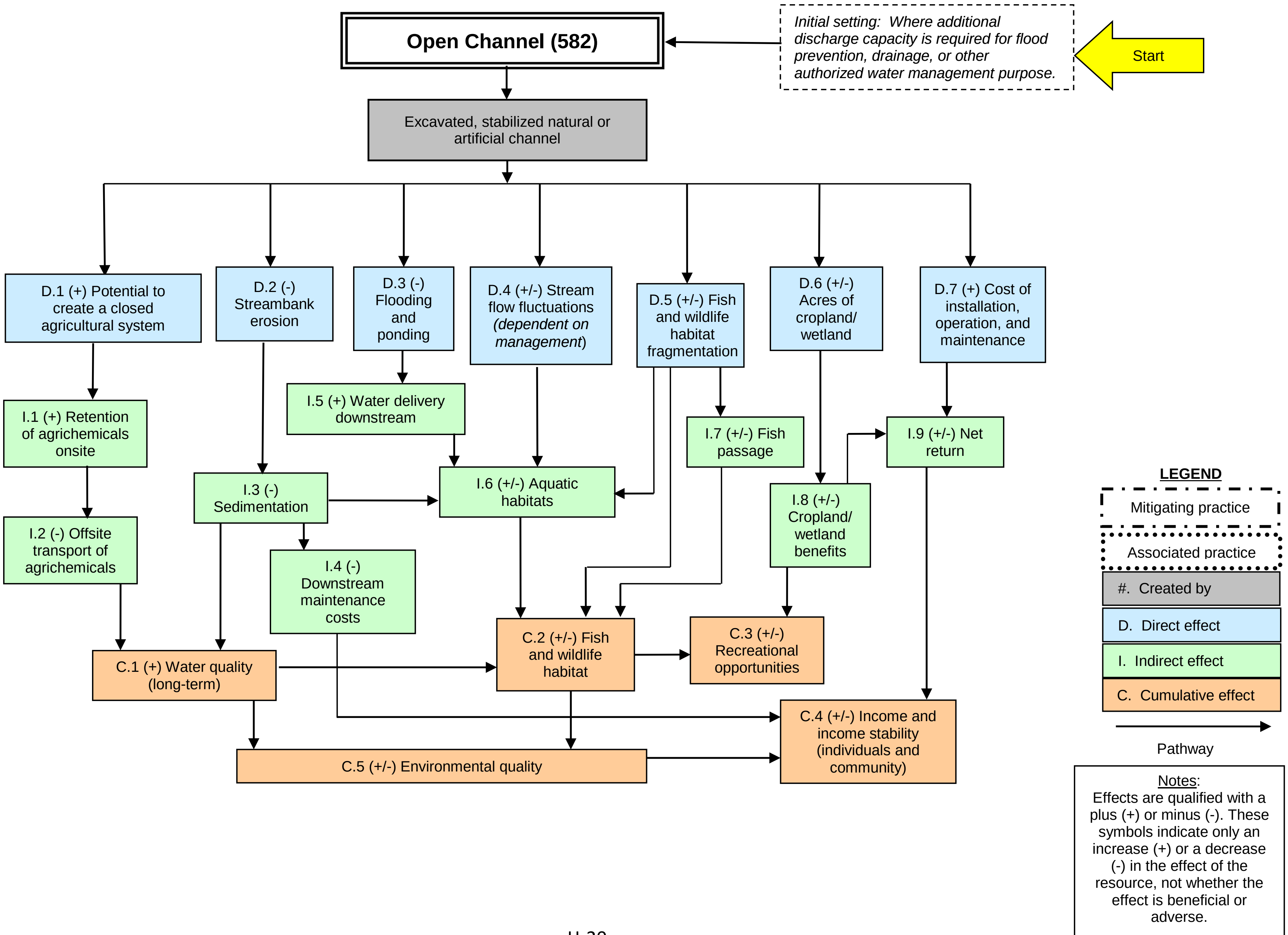


Notes:

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

September 2015



NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

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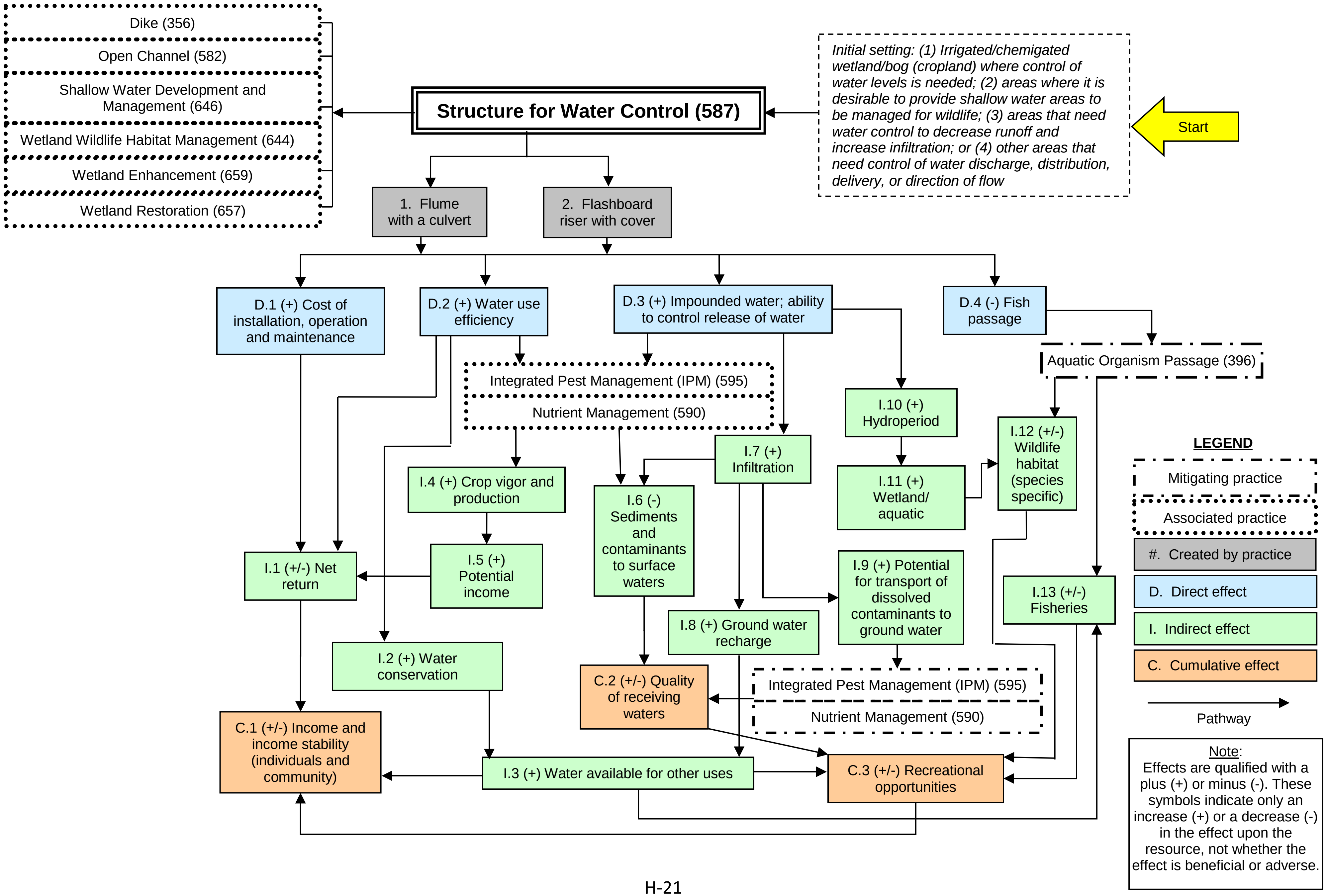

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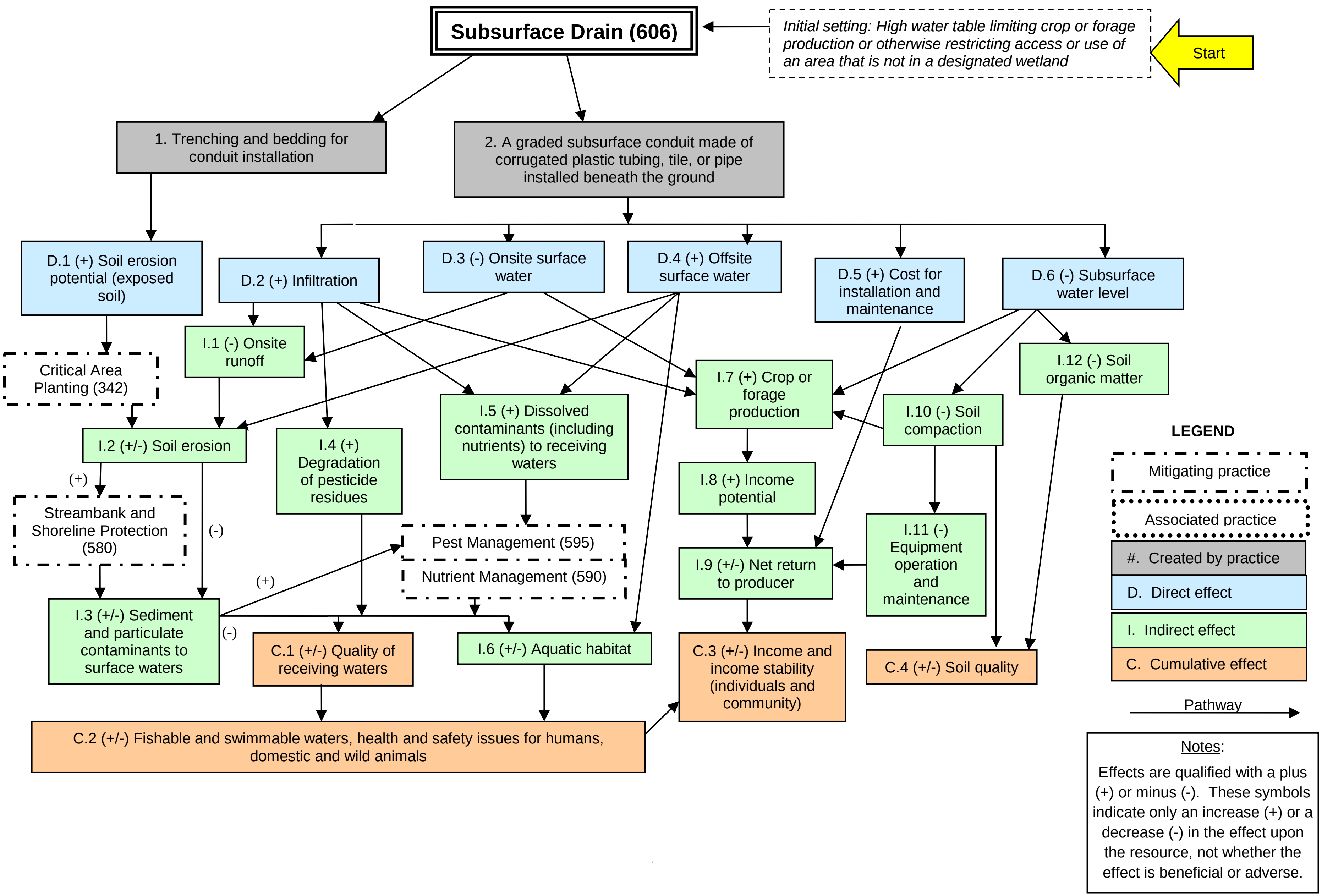

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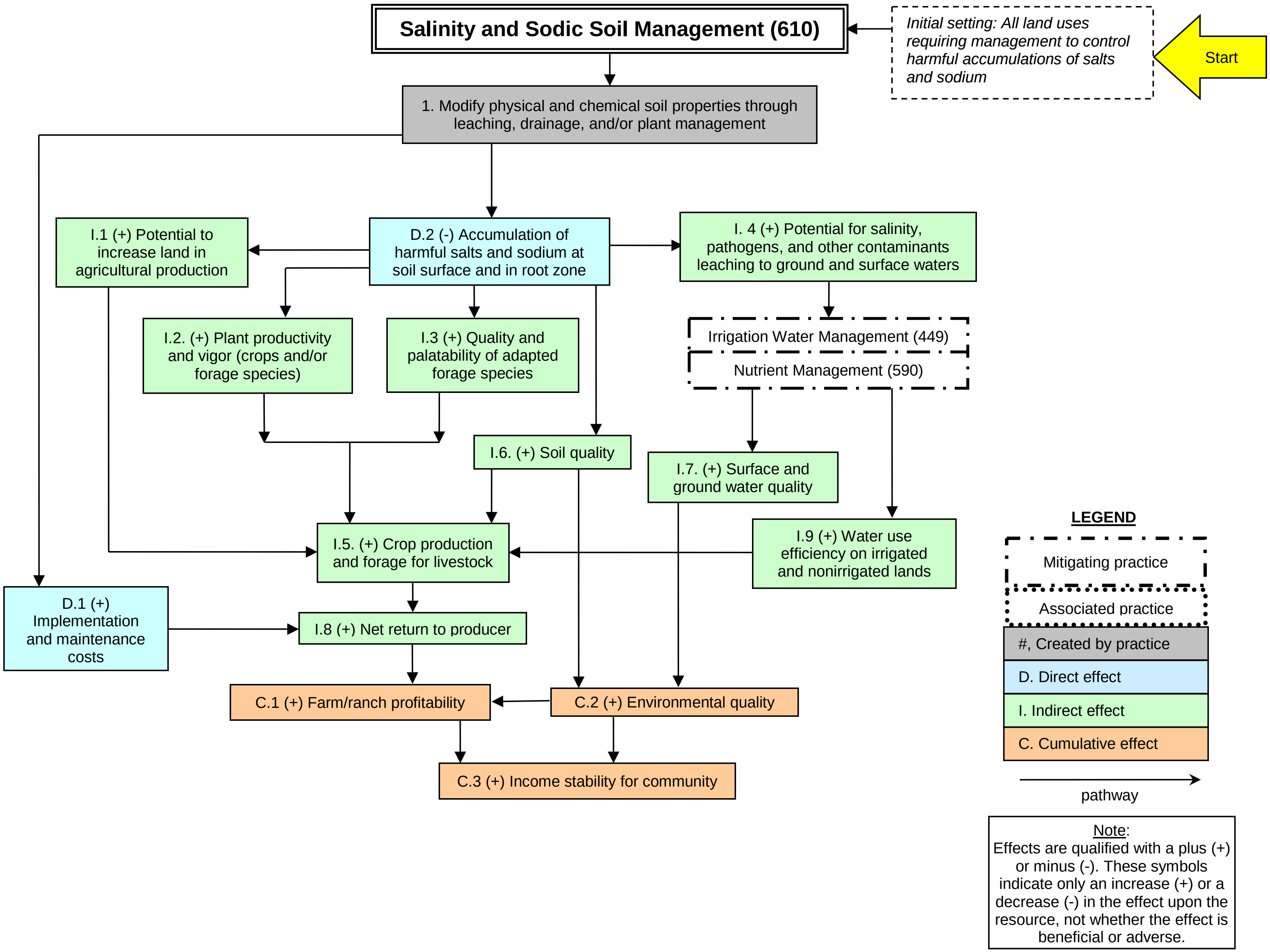

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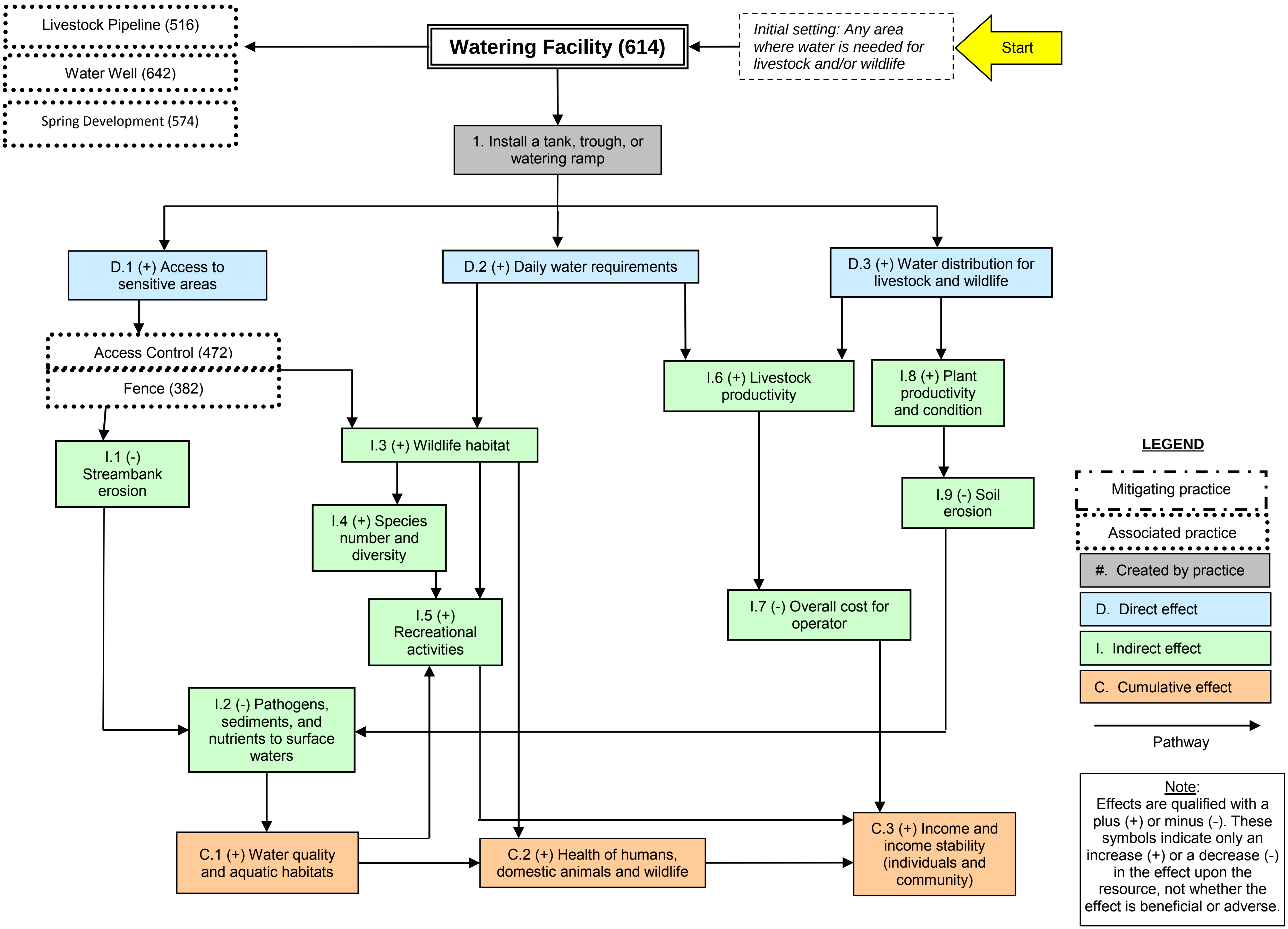

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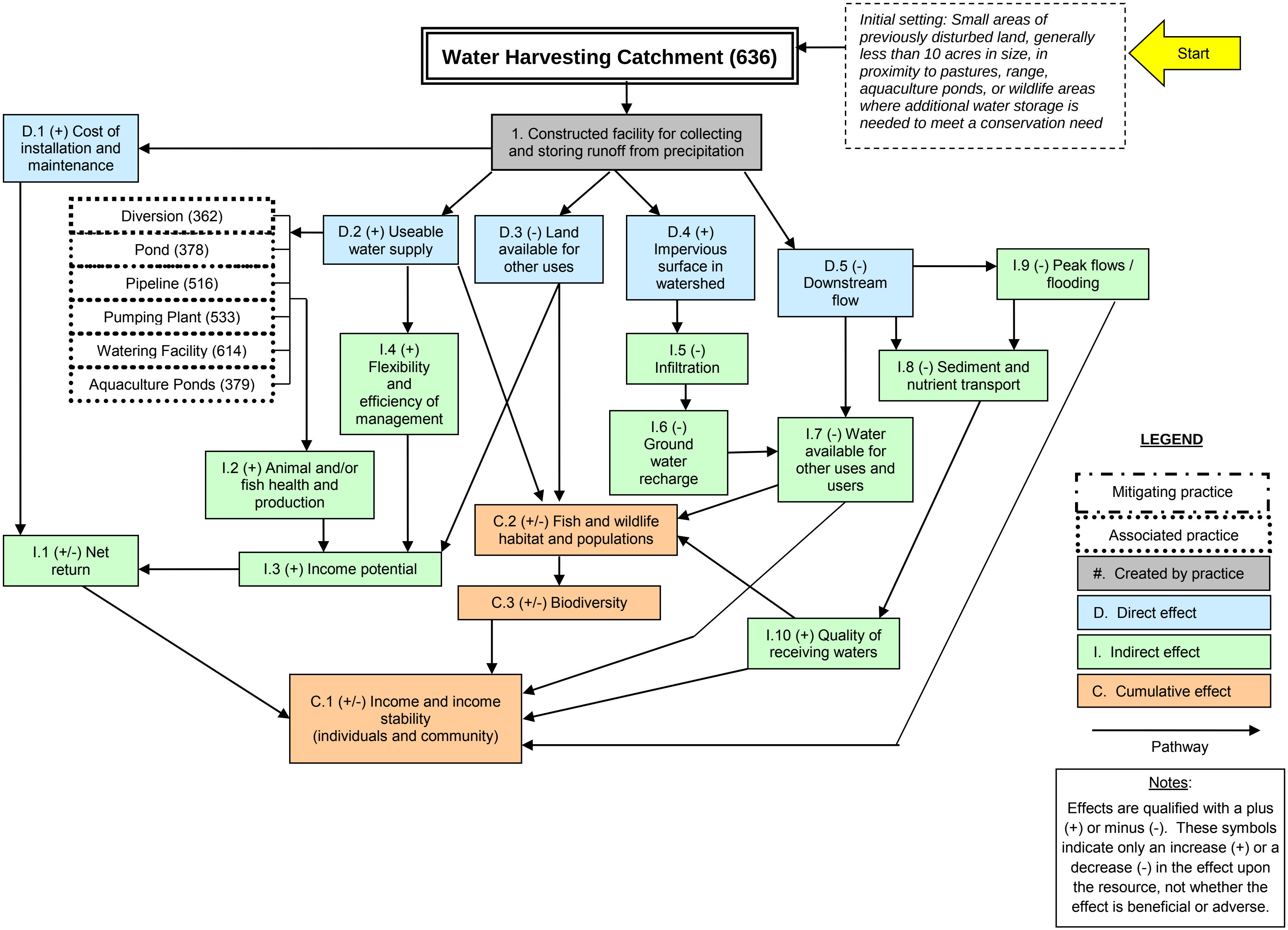

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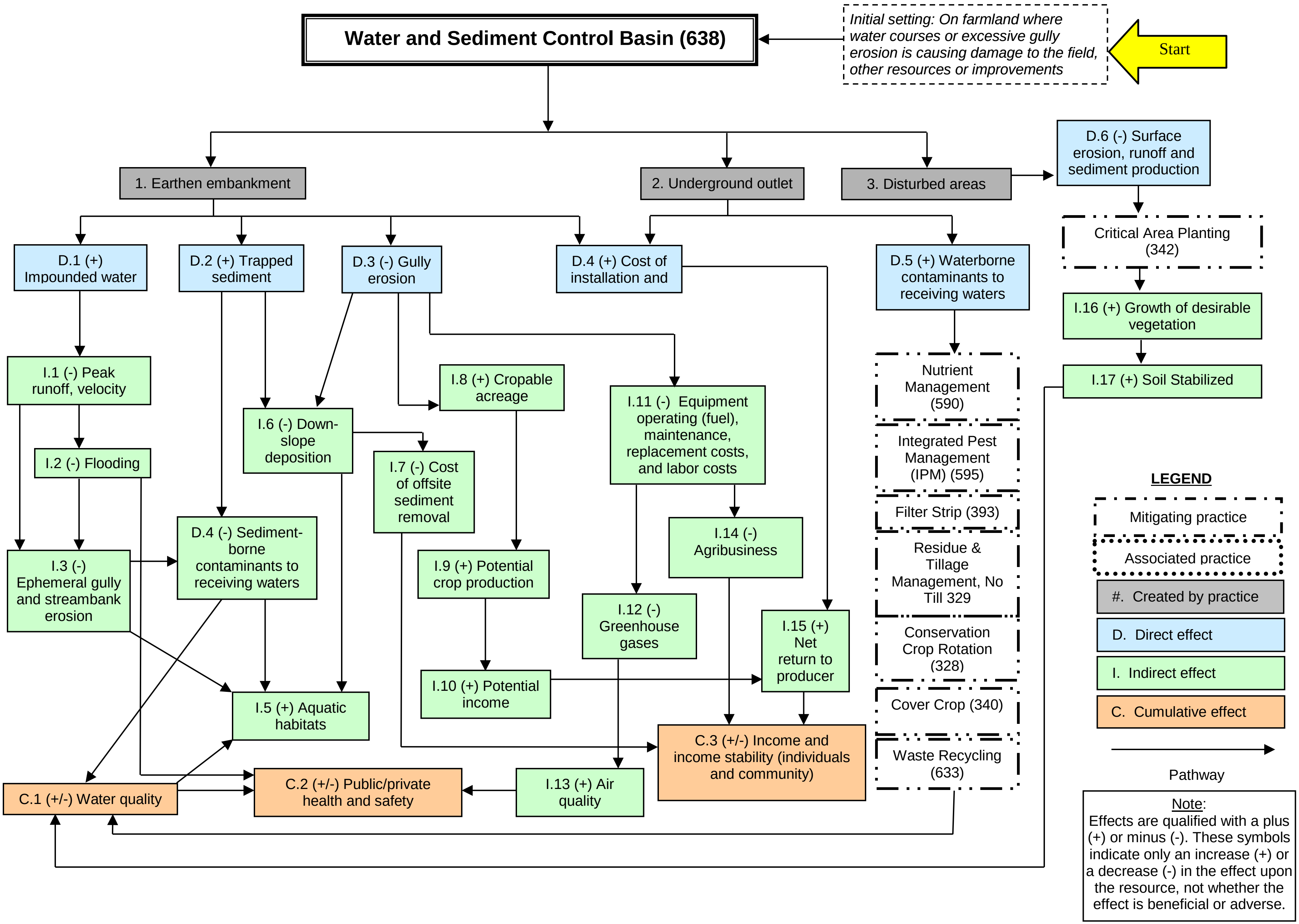
March 2014



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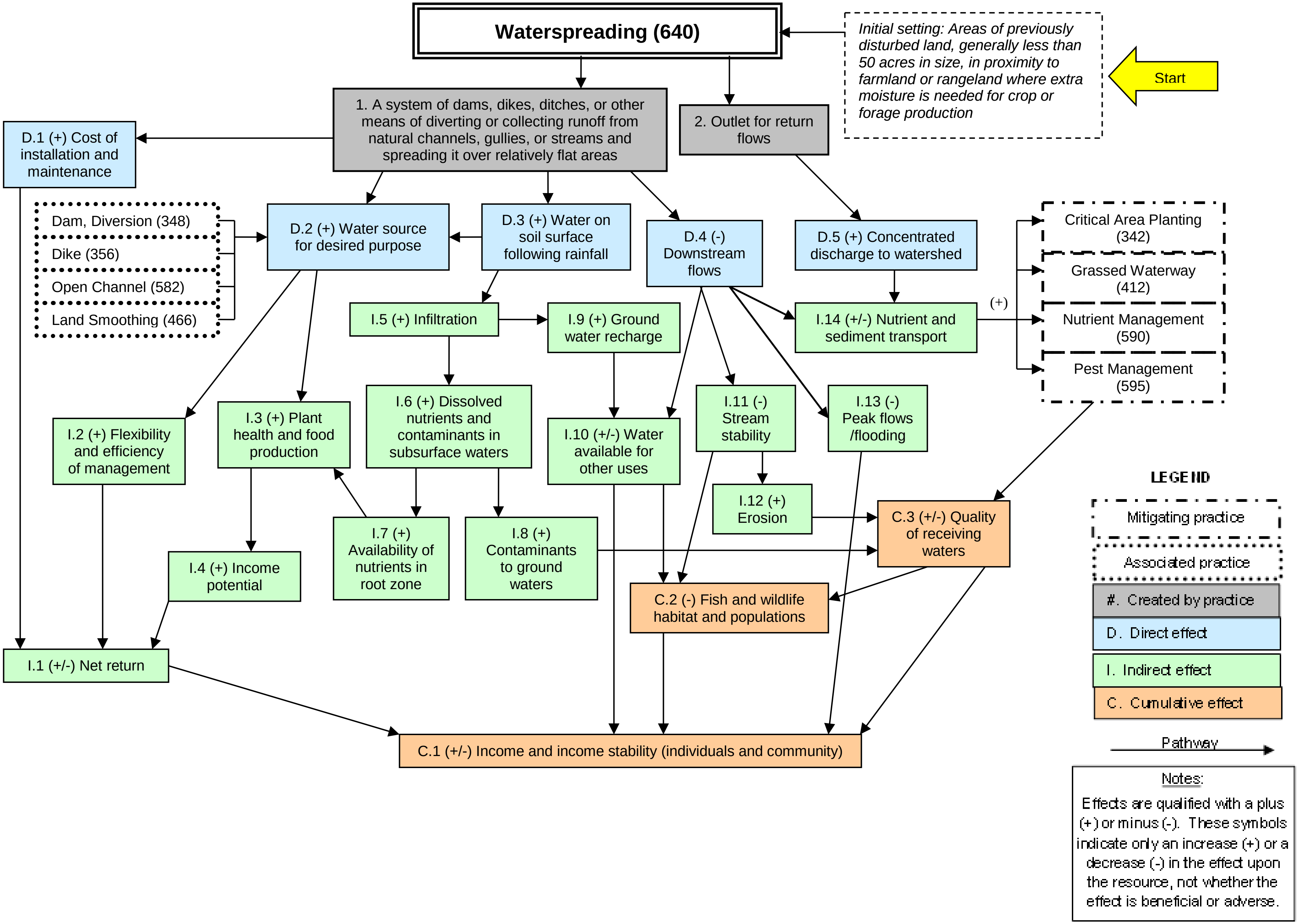

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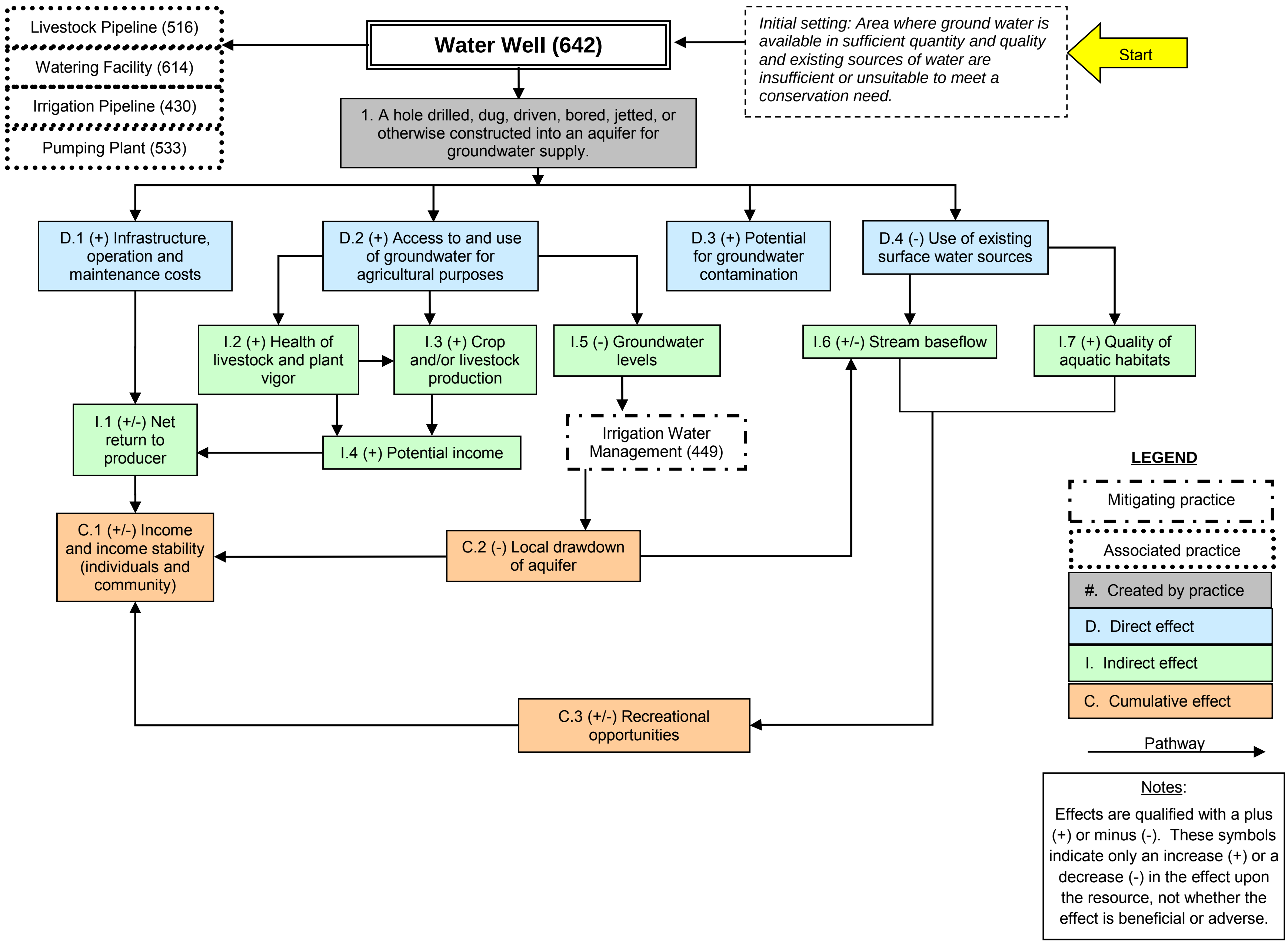
September 2014



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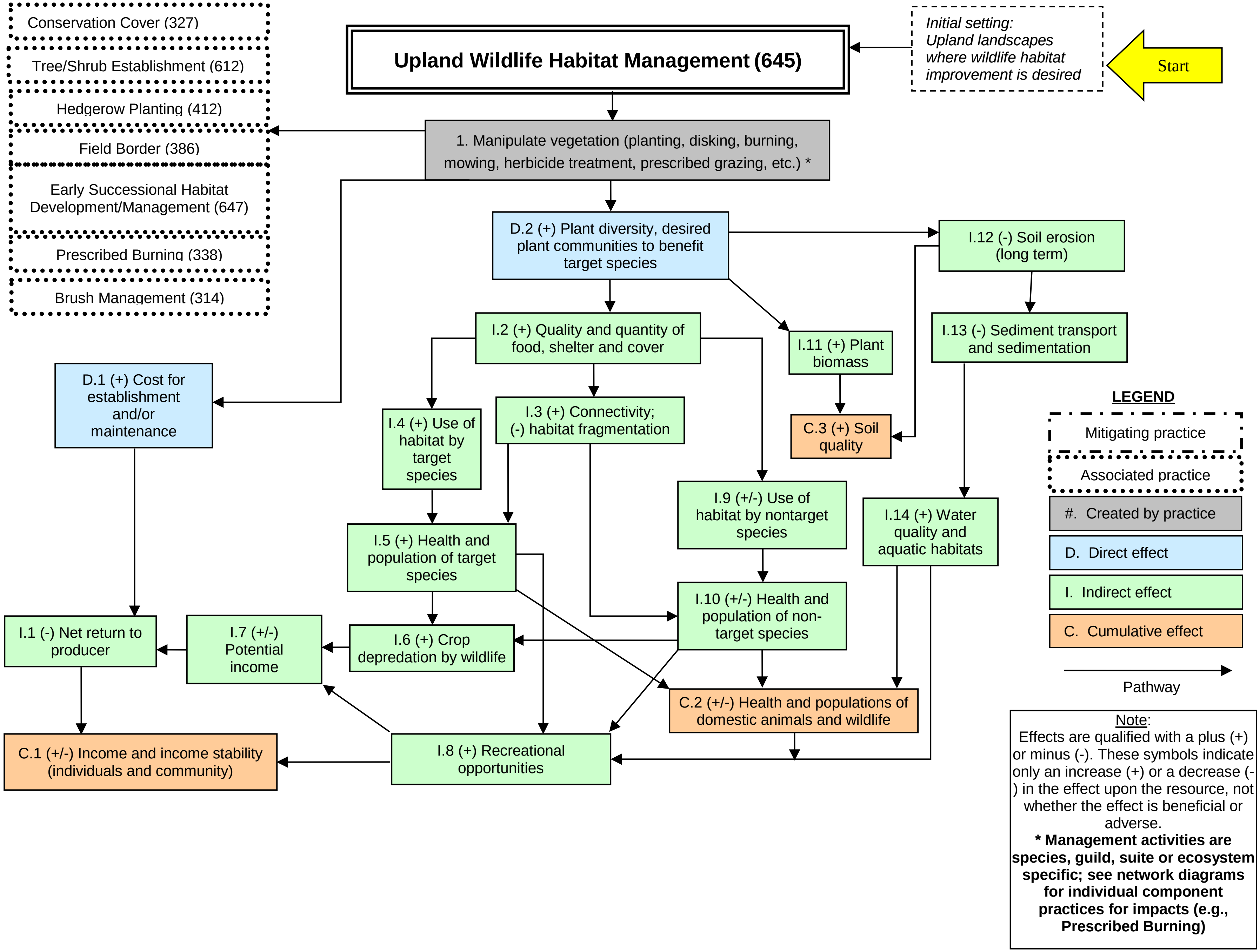
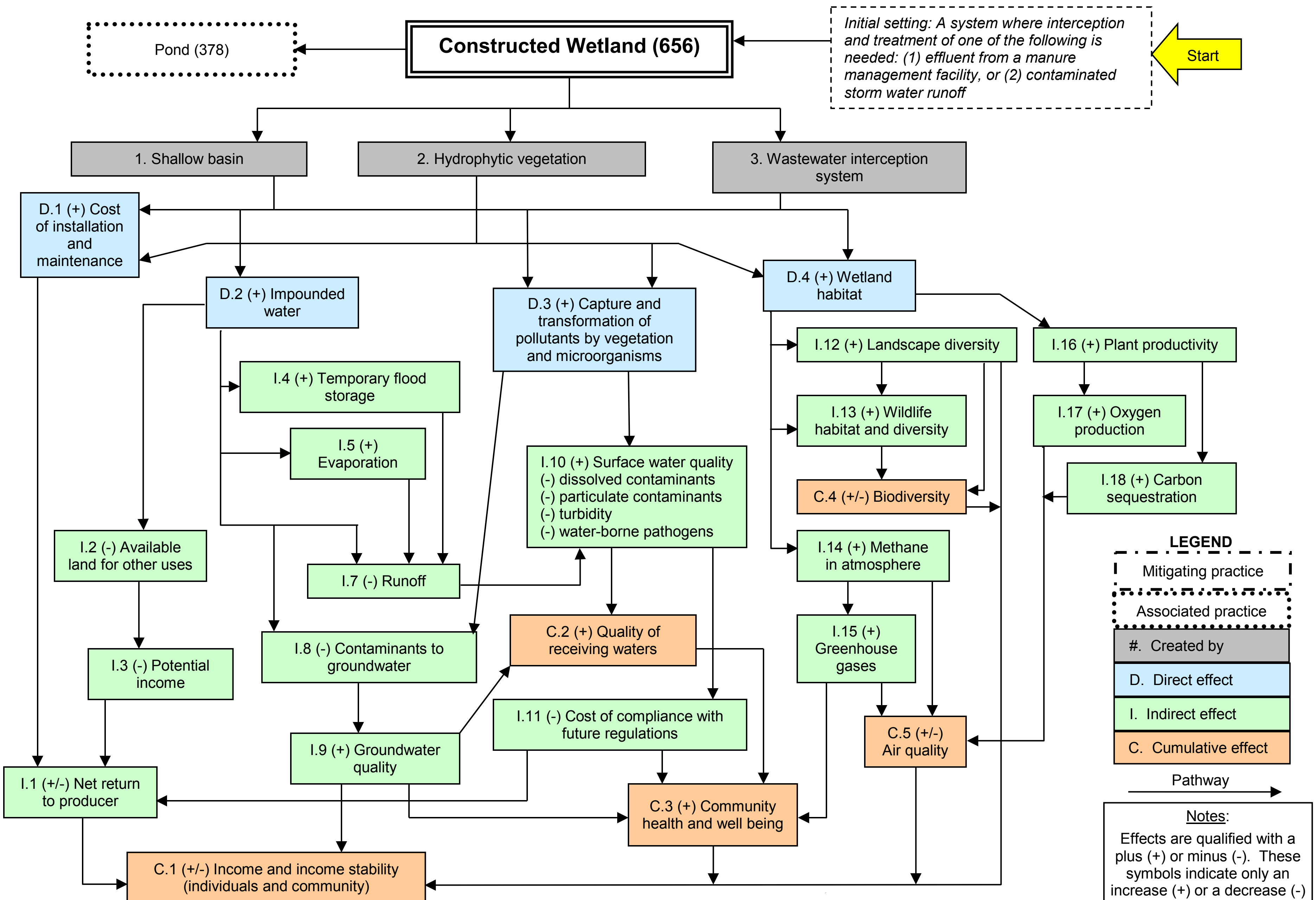


NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

September 2016



Notes:
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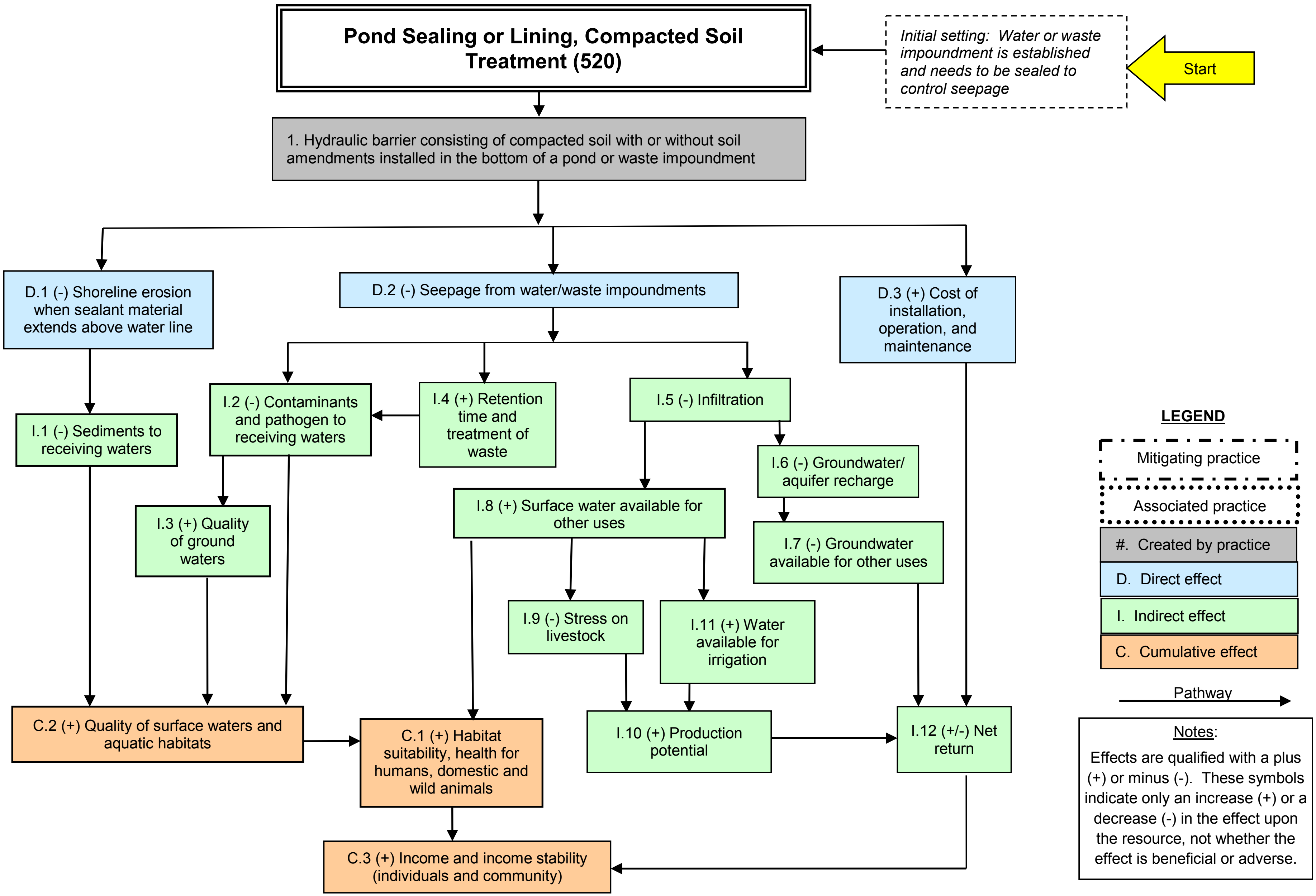
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

May 2016



NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

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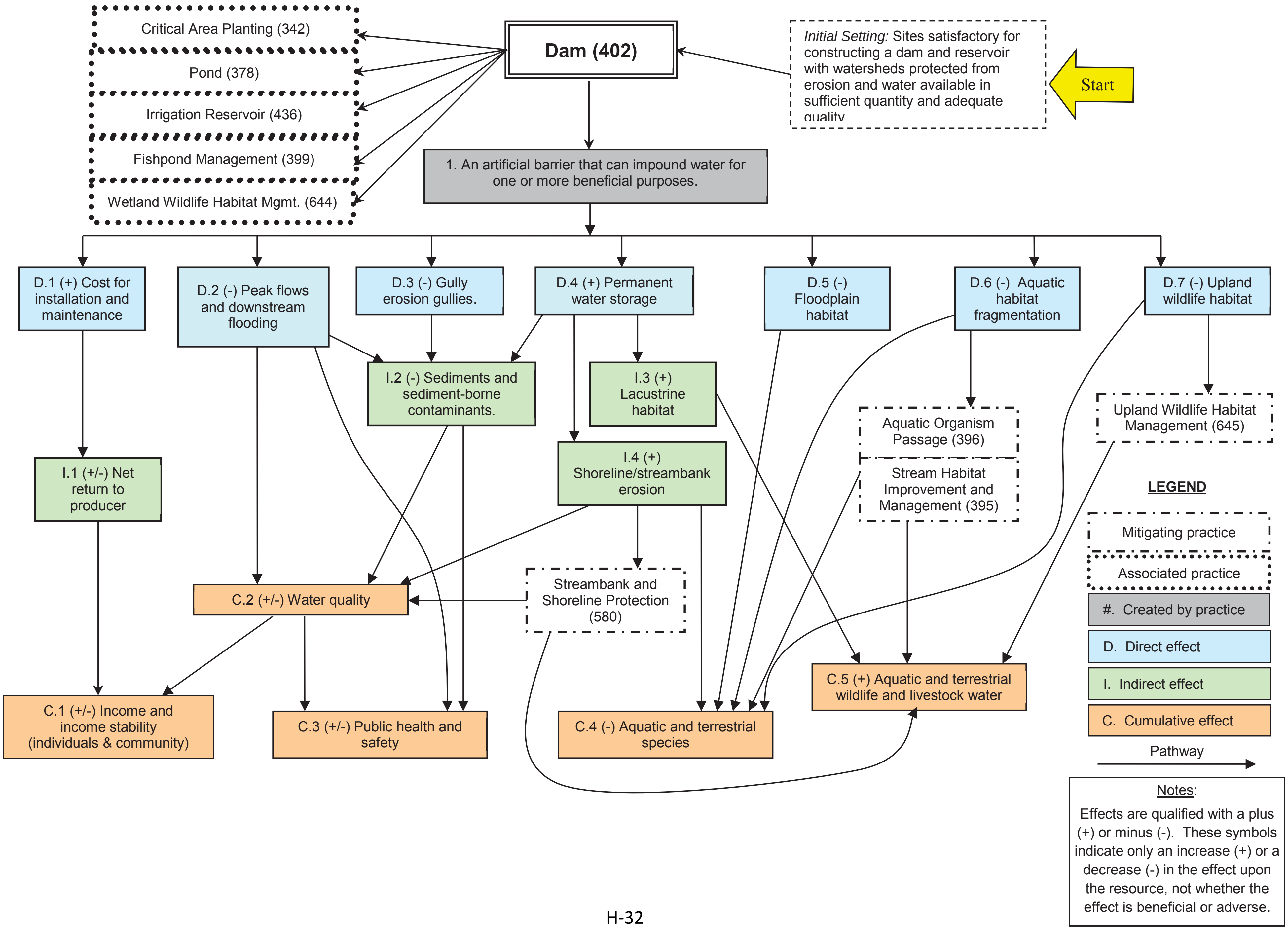

APPENDIX I – Detailed Project Cost Estimates

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ISTO-001							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Pond	HU-Embankment Pond with Corrugated Metal Pipe (CMP) OR High Density Polyethylene (HDPE) Pipe	CuYd	5.28	462	$2,439	50*50*5	Plug to fix wash out
Pond	HU-Embankment Pond with Corrugated Metal Pipe (CMP) Riser and High Density Polyethylene (HDPE) Barrel (includes Polyvinyl Chloride (PVC) Sheet Pile)	CuYd	5.8	370	$2,146	50*25*8	Wedge to fix reservoir
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	1318	$2,649	13.18	*Added line item to add cost for 100' drainage pipe.
Structure for Water Control	HU-Concrete Turnout Structure	Ea	3144.54	2	$6,289		Turnout at washout
	Sub-total				$13,524		Repair reservoir discharge
	HU 10% Increase				$14,876		
	Mobilization/Demobilization 10% of Total				**$16,364**		
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**							

ISTO-002						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Pond	HU-Embankment Pond with Corrugated Metal Pipe (CMP) OR High Density Polyethylene (HDPE) Pipe	CuYd	5.28	1000	$5,280	10'hx150'lx8' w emb
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	10	$592	
	Sub-total				$5,872	
	HU 10% Increase				$6,460	
	Mobilization/Demobilization 10% of Total				**$7,106**	

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISTO-003							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Pond	HU-Embankment Pond with Corrugated Metal Pipe (CMP) OR High Density Polyethylene (HDPE) Pipe	CuYd	5.28	1800	$9,504	140'lx15'hx8' w	
Obstruction Removal	HU-Removal and Disposal of Steel and/or Concrete Structures	SqFt	12.97	196	$2,542	14 x 14	Rehab of old well.
Pumping Plant	HU-Photovoltaic-Powered Pump, less than or equal to 250 ft total head	Ea	4469.4	1	$4,469		
Heavy Use Area Protection	HU-Rock and Gravel on Geotextile	SqFt	1.29	392	$506		
Watering Facility	HU-Storage Tank	Gal	1.07	1200	$1,284	10' Diameter (2ft) Deep	
Water Well	HU-Typical Well, 100- to 600-foot depth with 4-inch Casing	LnFt	36.28	100	$3,628		New well
	Sub-total				$21,933		
	HU 10% Increase				$24,127		
	Mobilization/Demobilization 10% of Total				**$26,539**		
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**							

ISTO-004							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Pond	HU-Embankment Pond with Corrugated Metal Pipe (CMP) Riser and High Density Polyethylene (HDPE) Barrel (includes Polyvinyl Chloride (PVC) Sheet Pile`	CuYd	5.8	400	$2,320	12*40*20	Wedge to install outlet works
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01		$0	13.18	
Bentanite (Call with Wyo-Ben)	rn 30 (5lbs/sqft) 1" thick mat. $98/Ton-$500/truck load (23to	SqFt	0.245	300000	$73,500		6.8 acres of Bentonite
	Install Open Channel Ditch	LnFt	3	700	$2,100		Install 700 ft of dithc from proposed diversion to reservoir
Structure for Water Control	HU-Concrete Turnout Structure	Ea	3144.54	2	$6,289		
	Sub-total				$84,209		
	HU 10% Increase				$92,630		
	Mobilization/Demobilization 10% of Total				**$101,893**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-001							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	20000	$40,200	5	PVC 10" SDR 41
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	3	$178		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	2	$1,814		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	18	$2,852	2-9" Parshall Flume	
	Sub-Total				$45,044		
	HU 10% Increase				$49,548		
	Mobilization/Demobilization 10% of Total				**$54,503**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-002							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	1357	$2,728	2.61	10" PVC (50 psi) Surface Pipe
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	550	$1,106	5	PVC 10" SDR 41. Buried Line
Irrigation Pipeline	HU-Alfalfa Valve, greater than or equal to 10 inch	Ea	552.98	1	$553		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	1	$907		
Structure for Water Control	HU-Concrete Turnout Structure	Ea	3144.54	1	$3,145	Riser Box	
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	9	$1,426	9" Parshall Flume	
	Sub-total				$9,864		
	HU 10% Increase				$10,851		
	Mobilization/Demobilization 10% of Total				**$11,936**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-003							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	14997	$30,144	7.21	PVC 12" SDR 41
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	3	$178		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	2	$1,814		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	9	$1,426	9" Parshall Flume	
	Sub-total				$33,561		
	HU 10% Increase				$36,918		
	Mobilization/Demobilization 10% of Total				**$40,609**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-004						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch (PVC 100 psi)	Lb	2.01	54188	$108,918	23.56
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	10	$592	
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	1	$907	
Structure for Water Control	HU-Concrete Turnout Structure	Ea	3144.54	1	$3,145	
	Reclaim Existing earhen Ditch	LnFt	3	3300	$9,900	
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	15	$2,377	15" Parshal Flume
	Sub-total				$125,839	
	HU 10% Increase				$138,423	
	Mobilization/Demobilization 10% of Total				**$152,265**	

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-005							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	283290	$569,413	29.82	24" PVC (PIP) SDR 41
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	6	$5,442		
	Sub-total				$574,855		
	HU 10% Increase				$632,340		
	Mobilization/Demobilization 10% of Total				**$695,574**		
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**							

ISYS-006							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	7908	$15,895	13.2	24" PVC
Structure for Water Control	HU-Concrete Turnout Structure	Ea	3144.54	1	$3,145		
	Sub-total				$19,040		
	HU 10% Increase				$20,944		
	Mobilization/Demobilization 10% of Total				**$23,038**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-007							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Pond	HU-Excavated Pit	CuYd	8	74	$592	20*20*5	
Irrigation Pipeline	Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP) (10" PVC (50 psi) Surface Pipe), greater than or equal to 10 inch	Lb	2.01	3132	$6,295	2.61	
Irrigation Pipeline	HU-Alfalfa Valve, greater than or equal to 10 inch	Ea	552.98	1	$553		
Pumping Plant	HU-Windmill-Powered Pump	Ft	899.52	12	$10,794		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	1	$907		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	9	$1,426	9" Parshal Flume	
	Sub-total				$20,568		
	HU 10% Increase				$22,624		
	Mobilization/Demobilization 10% of Total				**$24,887**		
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**							

ISYS-008						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Irrigation System, Sprinkler	HU-Pod System	Ea	223.26	15	$3,349	
Pumping Plant	HU-Electric-Powered Pump, less than or equal to 3 Horse Power	BHP	1338.15	1	$1,338	
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	1	$907	
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	9	$1,426	9" Parshal Flume
	Sub-total				$7,020	
	HU 10% Increase				$7,722	
	Mobilization/Demobilization 10% of Total				**$8,494**	
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**						

ISYS-009/009A							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	5400	$10,854	5	10"
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	187302	$376,477	23.56	21" PVC
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	10	$592		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	3	$2,721		
Structure for Water Control	HU-Concrete Turnout Structure	Ea	3144.54	1	$3,145		
	Reclaim Existing Earthen ditch	LnFt	3	4700	$14,100		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	15	$2,377	15" Parshal Flume	
	Sub-total				$410,266		
	HU 10% Increase				$451,292		
	Mobilization/Demobilization 10% of Total				**$496,422**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-010							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	20000	$40,200	5	PVC 10" SDR 41
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	3	$178		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	1	$907		
	Construct Earthen Ditch	LnFt	3	2300	$6,900		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	9	$1,426	9" Parshall Flume	
	Sub-total				$49,611		
	HU 10% Increase				$54,572		
	Mobilization/Demobilization 10% of Total				**$60,029**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-011							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	12711	$25,549	2.61	10" PVC (50 psi) Surface
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	12257	$24,637	7.21	PVC 12" SDR 41
Irrigation Pipeline	HU-Alfalfa Valve, greater than or equal to 10 inch	Ea	552.98	4	$2,212		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	2	$1,814		
Structure for Water Control	HU-Flow Meter with Electronic Index	In	300.92	10	$3,009	Inline Pipe Flow Measurement	
	Sub-total				$57,220		
	HU 10% Increase				$62,942		
	Mobilization/Demobilization 10% of Total				**$69,236**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-012							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	3250	$6,533	5	PVC 10" SDR 41. This is for supply line to pivot
Irrigation System, Sprinkler	HU-Center Pivot System	LnFt	63.73	650	$41,425		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	1	$907		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	9	$1,426	9" Parshall Flume	
	Sub-total				$50,290		
	HU 10% Increase				$55,319		
	Mobilization/Demobilization 10% of Total				**$60,851**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-013							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	3132	$6,295	2.61	10" PVC (50 psi) Surface Pipe
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	1947	$3,913	7.21	PVC 12" SDR 41. This is for siphon under drainage ditch
Irrigation Pipeline	HU-Alfalfa Valve, greater than or equal to 10 inch	Ea	552.98	1	$553		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	1	$907		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	9	$1,426	9" Parshall Flume	
	Sub-total				$13,094		
	HU 10% Increase				$14,404		
	Mobilization/Demobilization 10% of Total				**$15,844**		
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**							

ISYS-014						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Irrigation Pipeline	Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	1.42	9000	$12,780	5
Livestock Pipeline	HU-Surface High Density Polyethylene (HDPE), Iron Pipe Size (IPS) and Tubing	LnFt	1.99	1000	$1,990	2" Discharge
Pumping Plant	HU-Photovoltaic-Powered Pump, less than or equal to 250 ft total head	Ea	4469.4	1	$4,469	
	Sub-total				$19,239	
	HU 10% Increase				$21,163	
	Mobilization/Demobilization 10% of Total				**$23,280**	

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-015							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	60442	$121,489	11.34	15" PVC SDR 41
Heavy Use Area Protection	HU-Rock and Gravel on Geotextile	SqFt	1.29	392	$506		
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	3	$178		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	2	$1,814		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	12	$1,902	12" Parshall Flume	
	Sub-total				$125,888		
	HU 10% Increase				$138,476		
	Mobilization/Demobilization 10% of Total				**$152,324**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-016/016A							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	7000	$14,070	5	10" PVC SDR 41
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	1	$907		
Structure for Water Control	HU-Concrete Check Structure	Ea	3144.54	1	$3,145		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	9	$1,426	9" Parshall Flume	
	Sub-total				$19,548		
	HU 10% Increase				$21,502		
	Mobilization/Demobilization 10% of Total				**$23,653**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-017-023						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	6	$5,442	
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	54	$8,557	6-9" Flume
Structure for Water Control	HU-Flow Meter with Electronic Index	In	300.92	10	$3,009	
	Sub-total				$17,008	
	HU 10% Increase				$18,709	
	Mobilization/Demobilization 10% of Total				**$20,580**	
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**						

ISYS-024							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	10445	$20,995	58.03	42" PVC SDR 41 (slip lining for siphon)
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	20	$1,185		
	Sub-total				$22,180		
	*HU 20% Increase				$26,616		
	Mobilization/Demobilization 10% of Total				**$29,278**		
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**							

ISYS-025							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	29484	$59,263	11.34	15" PVC SDR 41
Heavy Use Area Protection	HU-Rock and Gravel on Geotextile	SqFt	1.29	392	$506		
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	3	$178		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	5	$4,535		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	45	$7,131	5-9" Parshall Flume	
	Sub-total				$71,612		
	HU 10% Increase				$78,773		
	Mobilization/Demobilization 10% of Total				**$86,650**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-026							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	1360	$2,734	1.7	8" PVC (50 psi) Surface Pipe
Irrigation Pipeline	HU-Alfalfa Valve, less than or equal to 8 inch	Ea	366.77	1	$367		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	9	$1,426	9" Parshall Flume	
	Sub-total				$4,527		
	HU 10% Increase				$4,979		
	Mobilization/Demobilization 10% of Total				**$5,477**		
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**							

ISYS-027

Description	Component	Unit Type	Unit Cost	Units Planned	Cost Estimate	Notes	
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	6500	$13,065	5	PVC 10" SDR 41. This is for supply line to pivot
Irrigation System, Sprinkler	HU-Center Pivot System	LnFt	63.73	1000	$63,730		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	1	$907		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	9	$1,426	9" Parshall Flume	
					$79,128		
	HU 10% Increase				$87,041		
	Mobilization/Demobilization 10% of Total				**$95,745**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-028							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	2610	$5,246	2.61	10" PVC
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	17500	$35,175	5	PVC 10" SDR 41
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	1	$907		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	9	$1,426	9" Parshall Flume	
	Sub-total				$42,754		
	HU 10% Increase				$47,030		
	Mobilization/Demobilization 10% of Total				**$51,733**		
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**							

ISYS-029&030

Description	Component	Unit Type	Unit Cost	Units Planned	Cost Estimate	Notes	
Irrigation Pipeline	Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	2610	$5,246	2.61	10" PVC (50 psi) Surface Pipe
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	9000	$18,090	5	PVC 10" SDR 41. This is for supply line to pivot
Irrigation System, Sprinkler	HU-Center Pivot System	LnFt	63.73	1560	$99,419		
Irrigation Land Leveling	HU-Irrigation Land Leveling, less than or equal to 50 acres	Ac	733.94	30	$22,018		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	2	$1,814		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	18.0	$2,852	2-9" Parshall Flume	
	Sub-total				$149,439		
	HU 10% Increase				$164,383		
	Mobilization/Demobilization 10% of Total				**$180,822**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-031							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	2349	$4,721	2.61	10" PVC (50 psi) Surface Pipe
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	9250	$18,593	5	PVC 10" SDR 41
Irrigation Pipeline	HU-Alfalfa Valve, greater than or equal to 10 inch	Ea	552.98	4	$2,212		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	2	$1,814		
Structure for Water Control	HU-Flow Meter with Electronic Index	In	300.92	10	$3,009	Inline Pipe Flow Measurement	
	Sub-total				$30,349		
	HU 10% Increase				$33,384		
	Mobilization/Demobilization 10% of Total				**$36,722**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

ISYS-032							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Irrigation Pipeline	HU- Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	3263	$6,558	2.61	10" PVC (50 psi) Surface Pipe
Irrigation Pipeline	HU-Polyvinyl Chloride (PVC), Plastic Irrigation Pipe (PIP), greater than or equal to 10 inch	Lb	2.01	8400	$16,884	5	PVC 10" SDR 41
Irrigation Land Leveling	HU-Irrigation Land Leveling, less than or equal to 50 acres	Ac	733.94	10	$7,339		
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	3	$178		
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	1	$907		
Structure for Water Control	HU-Flow Meter with Mechanical Index	In	158.46	9	$1,426	9" Parshall Flume	
	Sub-total				$33,292		
	HU 10% Increase				$36,621		
	Mobilization/Demobilization 10% of Total				**$40,283**		
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**							

	SCS-001						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Streambank and Shoreline Protection	HU-Structural, Toewood w/Vegetation (large wood members w/root wads-bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	LnFt	84.25	100	$8,425	50' on both sides	100*10*1.5
Structure for Water Control	HU-In-Stream Structure for Water Surface Profile (WSP)	LnFt	195.11	100	$19,511	100' Cross vane	
	Sub-total				$27,936		
	HU 10% Increase				$30,730		
	Mobilization/Demobilization 10% of Total				**$33,802.56**		

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

SCS-002						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Obstruction Removal	HU-Removal and Disposal of Rock and/or Boulders	CuYd	110.53	40	$4,421	
Structure for Water Control	HU-Slide Gate	Ft	1660.22	3	$4,981	
Structure for Water Control	HU-Concrete Turnout Structure - Small	Ea	906.99	1	$907	
Structure for Water Control	HU-Miscellaneous Structure, Large	Ea	12000	1	$12,000	
Flow measurement	HU-Flow Meter with mechanical index	In	158.46	9	$1,426	Need to add measurement device
24" CMP		LF	35	40	$1,400	
	Sub-total			45	$25,135	
	HU 10% Increase				$27,648	
	Mobilization/Demobilization 10% of Total				**$30,413**	

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

SCS-003						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Streambank and Shoreline Protection	HU-Structural, Toerock w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	LnFt	105.77	50	$5,289	
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	133	$7,879	15x40x1.5
	Sub-total				$13,167	
	HU 10% Increase				$14,484	
	Mobilization/Demobilization 10% of Total				**$15,933**	

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

SCS-004						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Obstruction Removal	HU-Removal and Disposal of Rock and/or Boulders	CuYd	110.53	40	$4,421	
Streambank and Shoreline Protection	Structural, Rock Vane w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	LnFt	75.39	50	$3,770	Cross vane
Structure for Water Control	HU-Slide Gate	Ft	1660.22	3	$4,981	
Structure for Water Control	HU-Concrete Turnout Structure	Ea	3144.54	1	$3,145	
Structure for Water Control	HU-Miscellaneous Structure, Large	Ea	17870.04	1	$17,870	
Flow Measurement	HU-Flow meter with mechanical index	1n	158.46	9	$1,426	
	Sub-total			95	$35,612	
	HU 10% Increase				$39,173	
	Mobilization/Demobilization 10% of Total				**$43,091**	

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

OWI-001						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Pond	HU-Excavated Pit	CuYd	3.56	55	$196	Over excavation
Pond	HU-Embankment Pond with Corrugated Metal Pipe (CMP) OR High Density Polyethylene (HDPE) Pipe	CuYd	5.28	500	$2,640	6x5x450 foot additon to Embankment
Livestock Pipeline	HU-Surface High Density Polyethylene (HDPE), Iron Pipe Size (IPS) and Tubing	LnFt	1.99	100	$199	
Bentanite (Call with Wyo-Ben)	Big Horn 30 (5lbs/sqft) 1" thick mat. $98/Ton-$500/truck load (23ton/truck)	SqFt	.48	73000	$35,040	.48/ft2 installed (from aerial)
	Sub-total			655	$38,075	
	HU 10% Increase				$41,882	
	Mobilization/Demobilization 10% of Total				**$46,071**	

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

OWI-002						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Pond	HU-Excavated Pit	CuYd	3.56	55	$196	Stilling basin
Pond	HU-Embankment Pond with Corrugated Metal Pipe (CMP) OR High Density Polyethylene (HDPE) Pipe	CuYd	5.28	4300	$22,704	1acre x8' divided by 3
Livestock Pipeline	HU-Surface High Density Polyethylene (HDPE), Iron Pipe Size (IPS) and Tubing	LnFt	1.99	100	$199	
Pumping Plant	HU-Electric-Powered Pump, less than or equal to 3 Horse Power	BHP	1338.15	1	$1,338	*Line item added to show pump component
	Sub-total				$24,437	
	HU 10% Increase				$26,881	
	Mobilization/Demobilization 10% of Total				**$29,569**	
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**						

OWI-003					
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**
Wetland Creation	HU-Wetland Creation, Wildlife Pond, Includes Foregone Income	Ac	3399.21	1	$3,399
	Construct Leachfield	LS	10,000	1	$10,000
	Sub-total				$13,399
	HU 10% Increase				$14,739
	Mobilization/Demobilization 10% of Total				**$16,213**
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**					

OWI-004						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Pond	HU-Embankment Pond with Corrugated Metal Pipe (CMP) OR High Density Polyethylene (HDPE) Pipe	CuYd	5.28	1200	$6,336	.3acre x2.5'
Wetland Creation	HU-Wetland Creation, Wildlife Pond, Includes Foregone Income	Ac	3399.21		$0	
Bentonite Liner		Ft2	0.5	13100	$6,550	
	Sub-total			1200	$12,886	
	HU 10% Increase				$14,175	
	Mobilization/Demobilization 10% of Total				**$15,592**	
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**						

OWI-005						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Pond	HU-Embankment Pond with Corrugated Metal Pipe (CMP) OR High Density Polyethylene (HDPE) Pipe	CuYd	5.28	3000	$15,840	12'x110' Embankment
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	40	$2,370	
	Sub-total				$18,210	
	HU 10% Increase				$20,031	
	Mobilization/Demobilization 10% of Total				**$22,034**	

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

OWI-006						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Pond	HU-Embankment Pond with Corrugated Metal Pipe (CMP) OR High Density Polyethylene (HDPE) Pipe	CuYd	5.28	3000	$15,840	2acre/ft pool
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	10	$592	
	Sub-total				$16,432	
	HU 10% Increase				$18,076	
	Mobilization/Demobilization 10% of Total				**$19,883**	

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

OWI-007						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Pond	HU-Embankment Pond without Pipe	CuYd	3.36	500	$1,680	4*25*200 Berm
Obstruction Removal	HU-Removal and Disposal of Brush and Trees, less than or equal to 6-inch diameter	Ac	1103.45	1	$1,103	
Livestock Pipeline	HU-Surface High Density Polyethylene (HDPE), Iron Pipe Size (IPS) and Tubing	LnFt	1.99	100	$199	
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	83	$4,917	150*1.5*10
Streambank and Shoreline Protection	Non-woven filter fabric	ft2	3.5	1800	$6,300	12*150
	Sub-total			684	$14,199	
	HU 10% Increase				$15,619	
	Mobilization/Demobilization 10% of Total				**$17,181**	

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

URI-001					
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**
Livestock Pipeline	HU-Surface High Density Polyethylene (HDPE), Iron Pipe Size (IPS) and Tubing	LnFt	1.99	3550	$7,065
Pumping Plant	HU-Photovoltaic-Powered Pump, less than or equal to 250 ft total head	Ea	4469.4	1	$4,469
Heavy Use Area Protection	HU-Rock and Gravel on Geotextile	SqFt	1.29	392	$506
Watering Facility	HU-Storage Tank	Gal	1.07	4670	$4,997
	Sub-total				$17,036
	HU 10% Increase				$18,740
	Mobilization/Demobilization 10% of Total				**$20,614**

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

URI-002						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Livestock Pipeline	HU-Surface High Density Polyethylene (HDPE), Iron Pipe Size (IPS) and Tubing	LnFt	1.99	2900	$5,771	
Pumping Plant	HU-Electric-Powered Pump, less than or equal to 3 Horse Power	BHP	1338.15	1	$1,338	
Heavy Use Area Protection	HU-Rock and Gravel on Geotextile	SqFt	1.29	393	$507	
Watering Facility	HU-Storage Tank	Gal	1.07	4670	$4,997	20'x2' Bottomless tank
Water Well	Shallow Well, 100-foot depth or less	LnFt	36.29	65	$4,000	Rehab of Well. *Well cost is adjusted to reflect an estimated rehabilitation of existing well cost.
	Sub-total				$16,613	
	HU 10% Increase				$18,274	
	Mobilization/Demobilization 10% of Total				**$20,101**	
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**						

URI-003					
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**
Livestock Pipeline	HU-Surface High Density Polyethylene (HDPE), Iron Pipe Size (IPS) and Tubing	LnFt	1.99	4600	$9,154
Pumping Plant	HU-Photovoltaic-Powered Pump, less than or equal to 250 ft total head	Ea	4469.4	1	$4,469
Heavy Use Area Protection	HU-Rock and Gravel on Geotextile	SqFt	1.29	392	$506
Watering Facility	HU-Storage Tank	Gal	1.07	4670	$4,997
	Sub-total				$19,126
	HU 10% Increase				$21,039
	Mobilization/Demobilization 10% of Total				**$23,142**
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**					

URI-004					
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**
Pumping Plant	HU-Photovoltaic-Powered Pump, less than or equal to 250 ft total head	Ea	4469.4	1	$4,469
Heavy Use Area Protection	HU-Rock and Gravel on Geotextile	SqFt	1.29	392	$506
Watering Facility	HU-Storage Tank	Gal	1.07	4670	$4,997
Water Well	HU-Typical Well, 100- to 600-foot depth with 4-inch Casing	LnFt	36.28	100	$3,628
	Sub-total				$13,600
	HU 10% Increase				$14,960
	Mobilization/Demobilization 10% of Total				**$16,456**
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**					

URI-005					
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**
Livestock Pipeline	HU-Surface High Density Polyethylene (HDPE), Iron Pipe Size (IPS) and Tubing	LnFt	1.99	1800	$3,582
Pumping Plant	HU-Photovoltaic-Powered Pump, less than or equal to 250 ft total head	Ea	4469.4	1	$4,469
Heavy Use Area Protection	HU-Rock and Gravel on Geotextile	SqFt	1.29	392	$506
Watering Facility	HU-Storage Tank	Gal	1.07	4670	$4,997
	Sub-total				$13,554
	HU 10% Increase				$14,909
	Mobilization/Demobilization 10% of Total				**$16,400**

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

URI-006					
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**
Livestock Pipeline	HU-Surface High Density Polyethylene (HDPE), Iron Pipe Size (IPS) and Tubing	LnFt	1.99	4700	$9,353
Pumping Plant	HU-Photovoltaic-Powered Pump, greater than 400 ft total head	Ea	8341.68	1	$8,342
Heavy Use Area Protection	HU-Rock and Gravel on Geotextile	SqFt	1.29	392	$506
Watering Facility	HU-Storage Tank	Gal	1.07	4670	$4,997
	Sub-total				$23,197
	HU 10% Increase				$25,517
	Mobilization/Demobilization 10% of Total				**$28,069**
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**					

URI-007						
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**
Streambank and Shoreline Protection	HU-Structural, Rock Riprap w/Vegetation (bankfull bench construction/bank shaping/riparian-corridor revegetation/rock riprap)	CuYd	59.24	3.0	$178	
Structure for Water Control	HU-Concrete or Steel Pipe, greater than or equal to 30-inch diameter	DiaInFt	2.79	240.0	$670	24"- 10' Long
	Sub-total				$847	
	HU 10% Increase				$932	
	Mobilization/Demobilization 10% of Total				**$1,025**	

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

URI-008							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Livestock Pipeline	HU-Surface High Density Polyethylene (HDPE), Iron Pipe Size (IPS) and Tubing	LnFt	1.99	8150	$16,219		
Pumping Plant	HU-Photovoltaic-Powered Pump, less than or equal to 250 ft total head	Ea	4469.4	1	$4,469		
Heavy Use Area Protection	HU-Rock and Gravel on Geotextile	SqFt	1.29	1176	$1,517	392	
Watering Facility	HU-Storage Tank	Gal	1.07	14010	$14,991	4670	Three tanks
Water Well	HU-Shallow Well, 100-foot depth or less	LnFt	46.66	100	$4,666	New Well	
	Sub-total				$41,862		
	HU 10% Increase				$46,048		
	Mobilization/Demobilization 10% of Total				**$50,653**		
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**							

URI-008A							
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**	**Notes**	
Livestock Pipeline	HU-Surface High Density Polyethylene (HDPE), Iron Pipe Size (IPS) and Tubing	LnFt	1.99	10000	$19,900	Revised footage	
Pumping Plant	HU-Electric-Powered Pump, less than or equal to 3 Horse Power with Pressure Tank	BHP	1705.46	2	$3,411	2 Horse Power	
Pumping Plant	HU-Photovoltaic-Powered Pump, less than or equal to 250 ft total head	Ea	4469.4	1	$4,469		
Heavy Use Area Protection	HU-Rock and Gravel on Geotextile	SqFt	1.29	784	$1,011	392	
Watering Facility	HU-Storage Tank	Gal	1.07	9340	$9,994	4670	Two tanks
	Sub-total				$38,785		
	HU 10% Increase				$42,664		
	Mobilization/Demobilization 10% of Total				**$46,930**		
****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**							

URI-009					
Description	**Component**	**Unit Type**	**Unit Cost**	**Units Planned**	**Cost Estimate**
Livestock Pipeline	HU-Surface High Density Polyethylene (HDPE), Iron Pipe Size (IPS) and Tubing	LnFt	1.99	1200	$2,388
Heavy Use Area Protection	HU-Rock and Gravel on Geotextile	SqFt	1.29	393	$507
Watering Facility	Automatic or Winter, No Storage, less than 450 Gallons	Ea	869.05	2	$1,738
	Sub-total				$4,633
	HU 10% Increase				$5,096
	Mobilization/Demobilization 10% of Total				**$5,606**

****This cost estimate is based on a conceptual design. Cost includes the total estimated cost of materials and labor for the entire project. On-field components such as surface pipe and sprinkler systems are not fundable through the WWDC.**

APPENDIX J - WDO Operating Criteria for SWPP and Conventional Projects

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November 6, 2015

Operating Criteria of the Small Water Project Program of the Wyoming Water Development Program

A. Introduction:

The purpose of the Small Water Project Program (SWPP) is to participate with land management agencies and sponsoring entities in providing incentives for improving watershed condition and function. Projects eligible for SWPP grant funding assistance include the construction or rehabilitation of small reservoirs, wells, pipelines and conveyance facilities, springs, solar platforms, irrigation works, windmills and wetland developments. Projects should improve watershed condition and function and provide benefit for wildlife, livestock and the environment. Projects may provide improved water quality, riparian habitat, habitat for fish and wildlife and address environmental concerns by providing water supplies to support plant and animal species or serve to improve natural resource conditions.

These criteria provide the Wyoming Water Development Commission (WWDC) and the Wyoming Water Development Office (WWDO) with general standards for evaluating and prioritizing applications for funding from the SWPP. In addition, the criteria serve as a tool to coordinate with the public and other state and federal agencies.

B. Legal and Institutional Constraints:

1. Sponsoring Entity: Pursuant to W.S. 99-3-1903(k)(i)and W.S. 99-3-1904(m)(i)[1], funding is available only to eligible public entities.

2. Eligible public entities are defined by state statute and include conservation districts, watershed improvement districts, water conservancy districts, irrigation districts, municipalities, the Joint Business Council of the Eastern Shoshone and Northern Arapaho Indian Tribes, the Business Council of the Eastern Shoshone Indian tribe, the Business Council of the Northern Arapaho Indian tribe, or other approved assessment districts formed in accordance with Wyoming law.

3. Project Description: Pursuant to W.S. 99-3-1903(k)(iii)and W.S. 99-3-1904(m)(iii), the SWPP may provide for construction or rehabilitation and replacement of small dams, windmills, spring development, pipelines, etc., to impound, develop and convey water for livestock, wildlife, irrigation, environmental and recreational purposes.

4. Project Funding: Pursuant to W.S. 99-3-1903(k)(vii) and 99-3-1904(m)(vii), a small project is a project where estimated construction or rehabilitation costs, permit procurement, construction engineering and project land procurement are one hundred thirty-five thousand dollars ($135,000.00) or less and where the maximum financial contribution from the commission is thirty-five thousand dollars ($35,000.00) or less.

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[1] For reference and identification only special statute numbers [appearing in Title "99" of the Wyoming Statutes] have been assigned to selected water projects by the legislative service office.

C. Small Water Project Program Definitions:

1. Small Reservoir: A small reservoir is any water storage facility up to twenty feet (20') of dam height and twenty acre-feet (20 AF) of capacity.

2. Well: A well may be eligible for funding depending on the depth of the well and scope of the project. Projects that propose to drill into unproved aquifers, as determined by the WWDC, may be eligible for the SWPP at the discretion of the WWDC. Discretion of the WWDC will be exercised in cases including but not limited to cases where the applicant is willing to reimburse the WWDC if the well does not meet the minimum requirements of the project in terms of quality and quantity.

3. Solar Platforms: Construction of solar platforms may be eligible for funding through the SWPP.

4. Pipelines and conveyance facilities: Rehabilitation of existing pipelines or conveyance facilities or construction of new pipelines or conveyance facilities may be eligible for funding through the SWPP.

5. Springs: Improving flows of existing springs and installation of collection facilities associated with springs may be eligible for funding through the SWPP.

6. Wetland Development: Development of wetlands where multiple benefits accrue may be eligible for funding through the SWPP.

7. Environmental: Projects that provide for stream bank stability, water quality improvements, or erosion protection may be eligible for funding through the SWPP.

8. Irrigation: Irrigation projects may be eligible for funding through the SWPP.

9. Windmill: Rehabilitation of existing windmills or construction of new windmills may be eligible for funding through the SWPP.

D. Application and Evaluation Process:

1. Planning for small water projects will be generated by a WWDC watershed study or equivalent as determined by the WWDC.

2. Applications shall be received by January 1 of each calendar year. Applications meeting criteria requirements will be considered during the regularly scheduled WWDC meeting in March. Applications shall include a project application, detailed project description, description of public benefit, outline of financial and technical contributions, project location map, project cost estimates and any letters of authorization or commitment of participation that may be available from other funding sources.

3. Projects that improve watershed condition and function, provide multiple benefits, and meet the funding criteria specified in W.S. 99-3-1903(k)(vii) or W.S. 99-3-1904(m)(vii), as described in B.4 herein, are eligible for consideration.

4. The sponsoring entity will be required to address the WWDC and provide testimony and other additional supporting evidence that justifies SWPP funding whenever the public benefit documentation, as required in W.S. 99-3-1903(k)(viii)(c) and W.S. 99-3-1904(m)(viii)(c), submitted with the application is deemed to be insufficient by the WWDO.

5. In order to establish priorities for both New Development and Rehabilitation projects, and to utilize available program funds effectively and efficiently, it is necessary to develop priorities. A project's priority will be assigned based the projects primary purpose, secondary benefits may be considered at the Commission's discretion. Project priorities in order of preference, are defined as follows.

   (1.) Source Water Development
   (2.) Storage
   (3.) Pipelines, Conveyance Facilities, Solar Platforms, and Windmills
   (4.) Irrigation
   (5.) Environmental

6. Projects that have completed the following requirements prior to application will be classified as "Shovel Ready", and may be considered as a funding priority at the Commission's discretion.
   - Permit procurement
   - State and Federal Agency Notifications
   - Land procurement, Right of Way, or Easement Acquisition
   - Have finalized all other financial agreements

   To establish completion of the above listed requirements, the project applicant may be asked to submit additional documentation as determined by the Commission at the time of application.

7. In the case of limited funding for this program the WWDC may only fund a portion of the applications submitted by any one Sponsor.

8. The Commission may take into consideration a Sponsor's existing back log of previously funded projects that are not completed, when awarding grants for new projects.

E. Project Development:

1. The sponsoring entity shall adhere to design standards for small water projects that are provided by the NRCS, an appropriate land management agency or the State Engineer.

2. Project water rights shall be in good standing with the State of Wyoming prior to construction of the project.

3. If the sponsoring entity initiates the construction process without prior written notification by the Commission, the sponsoring entity shall bear all costs resulting from said action.

F. Program Expenditures:

1. Project Description: Projects that develop unused and/or unappropriated water will be considered SWPP New Development Projects and will be funded from SWPP Account I, which is funded by appropriations from Water Development Account I [W.S. 41-2-124(a)(i)]. Projects that improve completed water projects, decrease operation and maintenance costs, and/or improve efficiency of use of existing water supplies will be considered SWPP Rehabilitation Projects and will be funded from SWPP Account II , which is funded by appropriations from Water Development Account II [W.S. 41-2-124(a)(ii)].

2. Project Funding: W.S. 99-3-1903(k)(vii) and W.S. 99-3-1904(m)(vii)as described in B.4 herein, establish the funding limitations for the SWPP.

3. Activities eligible for SWPP funding include design, permit procurement, project land procurement, construction engineering (design and construction inspections), project materials and invoiced contractor expenses. In-kind contributions are only eligible for installation of project materials that were purchased specifically for the project as documented by invoices.

4. Required permits and clearances shall be obtained prior to construction of the project. Copies of the final permits and clearances must be submitted to the WWDO before the WWDO will issue the notice to proceed for construction. WWDC funds may be used as necessary to secure the technical assistance required to complete permitting activities before construction commences.

5. The sponsoring entity shall provide the WWDO an operation and maintenance plan for the estimated life of the project.

6. SWPP funds shall not be used to refinance projects that have already been completed. SWPP funds shall not be used to augment the operating budget of a sponsor or any other entity. Maintenance costs, as determined by the WWDO, are not eligible expenditures under the SWPP. SWPP funding is limited to a one-time construction of a new project or a single rehabilitation of an existing project.

7. A Project Agreement between the WWDC and the sponsoring entity, which documents the roles and responsibilities of the project participants, must be finalized prior to expenditure of SWPP funds. Changes, modifications, revisions or amendments to the Project Agreement may be granted by the WWDC.

8. Construction contractors shall be selected using a competitive bid process.

9. Upon project completion, WWDC funds will be disbursed when a certified bill is received from the sponsoring entity including statement of completion, before and after photographs, project longitude/latitude coordinates and the affidavit of publication documenting the required notices of final settlement were published pursuant to W.S. 16-6-116.

10. If the sponsoring entity submits a certified bill, WWDC funds can be disbursed for a component of a project upon receipt of a certification by the project engineer that the component provides a beneficial use and functions in the manner intended. Retainage on the cost of the component may be held until conditions described in F.9 are met.

11. Upon receipt of WWDC funds, the sponsoring entity shall promptly pay outstanding obligations.

12. Unexpended funds allocated under the Project Agreement will revert to SWPP Account I or SWPP Account II, as appropriate, upon the expiration date of the Project Agreement. Expiration dates may be extended in writing by the WWDC.

APPLICATION FOR THE SMALL WATER PROJECT PROGRAM

Wyoming Water Development Commission
6920 Yellowtail Road
Cheyenne, WY 82002
(307)777-7626

PROJECT NAME: ____

____
(Applicant – Name of Entity)

____
(Contact Name)

______________________ ______________ ______ ________
(P.O. Box or Street Address) (City) (State) (Zip)

______________ ______________ ______________________
(County) (Phone) (Email)

Type*	Quantity	New Development	Rehabilitation	Latitude (Required)	Longitude (Required)
Small Reservoir		☐	☐		
Well		☐	☐		
Solar Platforms		☐	☐		
Pipeline		☐	☐		
Tank		☐	☐		
Spring Development		☐	☐		
Wetland		☐	☐		
Environmental		☐	☐		
Irrigation		☐	☐		
Windmill		☐	☐		

* The project types listed in the above table will be considered eligible as defined by the Small Water Projects Program Criteria. Environmental projects are defined as those that provide for stream bank stability, water quality improvements, or erosion protection.

Legal Description (Optional)

______________ ______________ ______________ ______________
(Township) (Range) (Section) (Quarter Section)

______________ ______________ ______________ ______________
(Township) (Range) (Section) (Quarter Section)

______________ ______________ ______________ ______________
(Township) (Range) (Section) (Quarter Section)

______________ ______________ ______________ ______________
(Township) (Range) (Section) (Quarter Section)

Project Description:

Planning for small water projects will be generated by a WWDC watershed study or equivalent as determined by the Wyoming Water Development Office. Provide all information necessary to accurately describe the proposed project and its eligibility per operating criteria. Additional information may be attached to this application as necessary.

____
____
____
____
____
____
____
____

Public Benefit:

Wyoming statute 99-3-1903(k)(viii)(c) and 99-3-1904(m)(viii)(c) requires all small water project sponsors to substantiate the public benefit that is to be derived from the proposed project. Please provide all information necessary to accurately document public benefit from the proposed project. Additional information may be attached as necessary.

____
____
____
____
____
____
____
____
____
____
____

Project Participants:

Please list all project participants (District, NRCS, WWNRT, BLM, Landowner, etc.), and their type of participation (Technical, Financial, project oversight, etc.).

____
____
____
____
____
____

Who is the owner of the project? ____

Who owns the land that the project is to be built on? ___________________________________

Which WWDC Watershed Study Boundary is this project within? _________________________
____

How many acres will be benefited by this project? ______________________________________

What is the total estimated project cost? ____

Project Readiness:
Projects that have completed the following requirements prior to application may request a "Shovel Ready" designation, and may be considered as a funding priority at the Commission's discretion.

- Certified project design and specifications
- Permit procurement
- State and Federal Agency Notifications
- Land Procurement, Right of Way, or Easement acquisition
- Have finalized all other financial agreements

To indicate an interest in seeking a Shovel Ready Designation please complete the Project Sponsor Checklist, well evaluation and hydrologic evaluation forms available at http://wwdc.state.wy.us/small_water_projects/small_water_project.html and attach to this application. Additionally, please list below all supporting documentation that is being attached.

(If the Sponsor is not seeking a Shovel Ready Designation then following section may be left blank.)

____
____
____
____
____
____
____
____
____

The Sponsor understands and agrees with the conditions set forth in the operating criteria of the Small Water Project Program.

APPROVED: ____
(Sponsor Representative)

DATE: ____________________

THE STATE OF WYOMING

Water Development Commission

6920 YELLOWTAIL ROAD TELEPHONE: (307) 777-7626 CHEYENNE, WY 82002

HYDROLOGIC EVALUATION FORM

SMALL WATER PROJECT PROGRAM

Project Name

Sponsor County

Prepared By Date

Signature

Hydrologic Evaluation Form Checklist

Description	Check As Applicable			Notes
	Yes	No	N/A	
Hydrologic Factors				
Quad Map(s) of Project Site	☐	☐	☐	
Delineation of Entire Drainage Area	☐	☐	☐	
Delineation of Dam Site	☐	☐	☐	
Soil Analysis of Area	☐	☐	☐	
Precipitation Information	☐	☐	☐	
Runoff Analysis	☐	☐	☐	
Yardage to Remove to Rehab.	☐	☐	☐	
Ditch Information	☐	☐	☐	
Pond/Reservoir Plans	☐	☐	☐	
Dam Design Plans	☐	☐	☐	
Spillway Design Plans	☐	☐	☐	
Storage Amount	☐	☐	☐	
Plan (Map) View of Pipe Alignment	☐	☐	☐	
Profile View of Pipe Alignment	☐	☐	☐	
Appurtenances Design & Quantities	☐	☐	☐	
Hydraulic Model Input and Output	☐	☐	☐	
Modeling Data or Information	☐	☐	☐	
Contingencies or Unusual Uses (Elaborate)	☐	☐	☐	
Special Features	☐	☐	☐	
Other (Specify)	☐	☐	☐	
Other (Specify)	☐	☐	☐	

THE STATE OF WYOMING
Water Development Commission
6920 YELLOWTAIL ROAD TELEPHONE: (307) 777-7626 CHEYENNE, WY 82002

PROJECT SPONSOR CHECKLIST FORM

SMALL WATER PROJECT PROGRAM

Project Name

Sponsor County

Prepared By Date

Signature

Project Sponsor Checklist[1]

Description	Check As Applicable			Notes
	Yes	No	N/A	
Construction Factors				
WWDC Project Application	☐	☐	☐	
Project Description	☐	☐	☐	
Designs and Specifications	☐	☐	☐	
Operation and Maintenance Plan	☐	☐	☐	
Budget and Cost Estimates	☐	☐	☐	
Funding Participation (Identify)	☐	☐	☐	
Project Location Information:				
Photographs (Before, During, After)	☐	☐	☐	
Longitude/Latitude Coordinates	☐	☐	☐	
Legal, Design, and Permitting Factors				
Public Benefit (Submit with Application)	☐	☐	☐	
Right-of-Way/Access Agreement	☐	☐	☐	
Easements/Option Agreement	☐	☐	☐	
Agency Commitment:				
NRCS	☐	☐	☐	
BLM	☐	☐	☐	
USFS	☐	☐	☐	
Notifications:				
Wyoming Game and Fish Dept.	☐	☐	☐	
U.S. Fish and Wildlife Service	☐	☐	☐	
Utility Owners	☐	☐	☐	
Land Procurement	☐	☐	☐	
State/County/Local Requirements	☐	☐	☐	
Wyoming SEO Water Right(s)	☐	☐	☐	

Legal, Design, and Permitting Factors *(Continued)*				
Environmental Evaluation	☐	☐	☐	
Cultural Resources Review	☐	☐	☐	
CWA Section 401 Certification	☐	☐	☐	
CWA Section 404 Permit	☐	☐	☐	
DEQ Permit to Construct	☐	☐	☐	
Wetlands Delineation	☐	☐	☐	
Hydrologic Evaluation	☐	☐	☐	
Other (Specify)	☐	☐	☐	
Other (Specify)	☐	☐	☐	

1. This checklist is intended to be used as a guideline and should not be considered an exhaustive list. Additional items may be required for final approval. The signature and supporting documentation discussed below are required to receive notice to proceed.

To Be Completed by Project Sponsor

(Conservation District, Irrigation District, etc.)

Name

Organization

Address

Phone Email

Acquisition of all permits, designs, certificates, and approvals is the responsibility of the project Sponsor. Please review the checklist above and sign below to indicate your agreement that all necessary permits, approvals, and certificates have been obtained:

Signature Date

Please list the attachments included with this package provided that document the necessary approvals:

THE STATE OF WYOMING

Water Development Commission

6920 YELLOWTAIL ROAD TELEPHONE: (307) 777-7626 CHEYENNE, WY 82002

SAGE GROUSE ANALYSIS SHEET

SMALL WATER PROJECT PROGRAM

Project Name

Sponsor County

Prepared By Date

Signature

Sage Grouse Analysis Sheet

Description	Check As Applicable			Notes
	Yes	No	N/A	
Project Location				
Is the project located in Sage Grouse Core Area?	☐	☐		
If yes, provide the distance from the nearest lek.	_________ Miles		☐	
If no, provide the distance to the nearest lek that is either inside or outside of Sage Grouse Core.	_________ Miles		☐	
Institutional Considerations				
If the project is within Sage Grouse Core Area and less than 0.6 of a mile from a lek, a habitat evaluation is required. Has a habitat evaluation been completed?	☐	☐	☐	
If yes, has the habitat evaluation been provided to the Water Development Office?	☐	☐	☐	
For wetland and Small Reservoir Projects within Sage Grouse Core Area, provide the number of wetland or water surface acres created.	_________ Acres		☐	
For spring developments within Sage Grouse Core Area, will the project leave enough water after construction to sustain mesic (wet) vegetation?	☐	☐	☐	

*Sage Grouse Core Location information can be at the following website: https://nrex.wyo.gov/ . For assistance with Habitat Evaluation forms, please call your local Game and Fish Office.

THE STATE OF WYOMING

Water Development Commission

6920 YELLOWTAIL ROAD TELEPHONE: (307) 777-7626 CHEYENNE, WY 82002

WELL EVALUATION FORM

SMALL WATER PROJECT PROGRAM

Project Name

Sponsor County

Prepared By Date

Signature

Well Evaluation Form Checklist

Description	Check As Applicable			Notes
	Yes	No	N/A	
Hydrogeologic Factors				
Quad Map(s) of Project Site	☐	☐	☐	
Geologic Mapping of Project Site	☐	☐	☐	
Hydro-Stratigraphy of Project Site	☐	☐	☐	
Previous Geologic Studies (USGS, etc.)	☐	☐	☐	
Proven Aquifer Development:				
Well Logs (SEO, WOGCC, etc.)	☐	☐	☐	
Water Quality (Analysis Reports, etc.)	☐	☐	☐	
Other Characteristics (Specify)	☐	☐	☐	
Well Site Factors				
Existing Well:				
Workover/Rehab. Requirements	☐	☐	☐	
Proposed New Well:				
Estimated Total Depth	☐	☐	☐	
Minimum Casing/Screen Diameter	☐	☐	☐	
Completion Design	☐	☐	☐	
Drilling Difficulties	☐	☐	☐	
Site Access:				
Necessary Easements	☐	☐	☐	
Remote from Existing Roads	☐	☐	☐	
All-Weather Access	☐	☐	☐	
Power Requirements	☐	☐	☐	
Other Characteristics (Specify)	☐	☐	☐	
Other Characteristics (Specify)	☐	☐	☐	

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