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Final Report

Hopkins Producers Irrigation District Watershed/Water Storage Project, Level I Study

Professional Services No. 05SC0293251

Prepared for:

Wyoming Water Development Commission
Cheyenne, Wyoming

Prepared by:
States West Water Resources Corporation – Cheyenne, Wyoming

In Association with:
Hollingsworth Associates Inc. – Sheridan, Colorado
Western EcoSystems Technology, Inc. – Cheyenne, Wyoming

October 2008

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1. INTRODUCTION

1.1 General

This report presents the findings of the Hopkins Producers Irrigation District (HPID) Watershed/Water Storage Project, Level I Study. This study describes the French Creek and upper North Fork of Clear Creek watersheds and develops conceptual designs and cost estimates for the addition of storage reservoirs to the watersheds. The study was conducted for the Hopkins Producers Irrigation District under direction and funding of the Wyoming Water Development Commission (WWDC) by States West Water Resources Corporation in association with Hollingsworth Associates, Inc. and Western EcoSystems Technology, Inc.

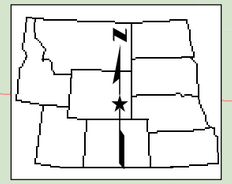
1.2 Description and Scope

The Hopkins Producers Irrigation District submitted a request to the Wyoming Water Development Commission for a Level I study of the French Creek and upper North Fork of Clear Creek watersheds. Figure 1.1 shows a map of the region highlighting the watersheds and irrigated lands in the area. This study assessed, described, and mapped the watershed. The sponsor indicated interest in analyzing and developing surface water within the watershed for irrigation use. This study took an in depth look at the watershed for potential multiuse water storage facilities to supply water and benefit various users including the Hopkins Producers Irrigation District, other irrigators in the watersheds, the City of Buffalo, and other benefits including recreation, environmental, and fishery. The consultant team took a big picture approach to the study to identify potential multipurpose projects that could potentially draw support and funding from multiple sources.

The project required the review of existing information, inventory and description of the watershed, the development of management and rehabilitation plans for the watershed, review of water rights, a plan for public involvement in future studies and projects, and identification of required permits and clearances. An investigation and evaluation of potential water storage sites was completed and conceptual designs, cost estimates, and funding sources were developed for potential reservoir sites and rehabilitation improvements.

1.3 Purpose

The purpose of this study was to develop conceptual designs with cost estimates and make recommendations for the Hopkins Producers ID to assist with the determination of the concepts for reservoir facilities. The study was to evaluate the need for additional storage, identify feasible storage locations, conduct investigations of the alternatives, and present detailed alternatives to the WWDC and sponsor.



1:100,000

R 85 W

R 84 W

R 83 W

UPPER NORTH CLEAR CREEK WATERSHED

Upper Clear Cr

French Cr

FRENCH CREEK WATERSHED

Rock Cr

Johnson Cr

THE HOPKINS PRODUCERS IRRIGATION DISTRICT

BUFFALO

Clear Cr

90

25

16

EXPLANATION

WATERSHED BOUNDARY

LAND OWNERSHIP

FEDERAL AGENCY PROTECTIVE WITHDRAWL (USFS)

PATENTED

STATE OF WYOMING

U.S. BUREAU OF LAND MANAGMENT

U.S. FOREST SERVICE

WATER

WYOMING GAME AND FISH DEPT.

Irrigated Lands

5 4 3 2 1 0 5 Miles

FIGURE 1.1
FRENCH CREEK AND UPPER NORTH CLEAR CREEK WATERSHEDS

2. OVERVIEW

2.1 General

French Creek and the North Fork of Clear Creek are located on the east slope of the Bighorn mountains. Flows in French Creek range from 1 cfs to approximately 30 cfs during spring runoff. Flows in the North Fork of Clear Creek at the point of diversion for the Four Lakes and French Creek Ditch range from 3 cfs to 75 cfs. The French Creek watershed encompasses 27 square miles from its headwaters to the confluence with Clear Creek. The upper North Fork of Clear Creek watershed above the Four Lakes diversion to its headwaters encompasses 15.1 square miles.

Hopkins Producers ID serves approximately 2,100 acres in the French Creek and Sand Creek drainages. The diversions are from the North Fork of Clear Creek through the Four Lakes and French Creek Ditch diversion and on French Creek located in Sections 25, 26, and 27 Township 51 North, Range 83 West and Sections 21 and 30 Township 51 North, Range 82 West, Johnson County, Wyoming. The ditches are presently unlined earth canals. The HPID is currently implementing a plan to pipe the Hopkins Ditch.

The HPID currently has no storage in the basin and relies solely on direct flow irrigation. The diversion flow rate varies with irrigation demand and available flow in the creek, however, under normal conditions (one cfs per 70 acres) HPID typically diverts 30 cfs. The HPID is shown on Figure 2.1.

2.2 Problem Identification

French Creek with its relatively low elevation drainage area typically has good flow in May and June during the early runoff season, but the low elevation snow pack melts out early and flows drop in July and August. The North Fork of Clear Creek draws from a high elevation drainage area and flows are typically sustained through the runoff season. These flows transferred from the North Fork of Clear Creek to French Creek sustain the irrigators on French Creek while in priority. The transfer is reduced by regulation on Clear Creek typically in mid-June during dry years and mid-July during normal years. The irrigators on French Creek typically experience late season irrigation water supply shortages. These shortages usually occur in August and September when flows in French Creek drop and regulation shuts down the transfer from the North Fork of Clear Creek. It would be beneficial to the irrigation district to release water from storage during this time. Several potential reservoirs are presented in this study to solve these water shortage problems.

LEGEND

53.0 Acres	Lands with original supply from the North Fork of Clear Creek, Permit No. 1369 Enl., the Enlarged Four Lakes and French Creek Ditch with priority of April 7, 1905. These same lands have an unadjudicated supplemental supply from French Creek through the Enlarged Hopkins Ditch, Permit No. 5283 Enl. with a priority of January 5, 1931.
135.0 Acres	Lands with original supply from the North Fork of Clear Creek, Permit No. 307 Enl., the Enlarged Four Lakes and French Creek Ditch with a priority of January 28, 1898. These same lands have an unadjudicated supplemental supply from French Creek through the Enlarged Hopkins Ditch, Permit No. 5283 Enl., with a priority of January 5, 1931.
124.9 Acres	Lands with original supply under the Willard Hamptom Appropriation, Territorial Appropriation, diverting from the North Fork of Clear Creek through the Four Lakes and French Creek Ditch with a priority of June 1, 1884. These same lands have a supplemental supply from French Creek through the Enlarged Hopkins Ditch, Permit No. 5283 Enl., with a priority of January 5, 1931.
363.6 Acres	Lands with original supply under the Marie Camino Appropriation, Territorial Appropriation, diverting from the North Fork of Clear Creek through the Four Lakes and French Creek Ditch with a priority of June 1, 1884. These same lands have an unadjudicated supplemental supply from French Creek through the Enlarged Hopkins Ditch, Permit No. 5283 Enl. with a priority of January 5, 1931.
130.0 Acres "blanket description"	Lands with original supply under the Martin J. Whaley Appropriation, Territorial Appropriation, diverting from the North Fork of Clear Creek with a priority of June 1, 1886. These same lands have an unadjudicated supplemental supply from French Creek through the Enlarged Hopkins Ditch, Permit No. 5283 Enl. with a priority of January 5, 1931.
30.0 Acres "blanket description"	Lands with original supply under the John A. Fisher Appropriation, Territorial Appropriation, diverting from French Creek through the John A. Fisher No. 2 Ditch with a priority of May 10, 1883.
18.0 Acres "blanket description"	Lands with original supply under the John A. Fisher Appropriation, Territorial Appropriation, diverting from French Creek through the John A. Fisher No. 1 Ditch with a priority of May 10, 1883.
9.0 Acres	Lands with original supply under the Barker Ditch, Permit No. 22531,. diverting from French Creek with a priority of June 8, 1961.
5.7 Acres	Lands with original supply under the Enlarged Barker Ditch, Permit No. 6434 Enl. diverting from French Creek with a priority of October 18, 1972.
27.6 Acres	Lands with original supply under the Enlarged Moeller No. 1 Ditch, Permit No. 2465 Enl. diverting from French Creek with a priority of May 22, 1911.
53.9 Acres	Lands with original supply under the Joe D. Hall et al Appropriation, Territorial Appropriation, the North Fork French Creek Dtch diverting from North Fork Clear Creek with a priority of October 16, 1886. These same lands have a supplemental supply from French Creek under Permit No. 2465 Enl., the Enlarged Moeller Ditch with a priority of May 22, 1911.
126.1 Acres	Lands with original supply under the Joe D. Hall et al Appropriation, Territorial Appropriation, the North Fork French Creek Dtch, diverting from the North Fork of Clear Creek with a priority of October 16, 1886.
103.6 Acres	Lands with original supply under Permit No. 2464 Enl., the Enlarged Mayhew and Gorgen Ditch diverting from French Creek with a priority of May 22, 1911.
100.88 Acres	Lands with original supply under the Antonio Silva Appropriation, Territorial Appropriation, the Four Lakes and French Creek Ditch diverting from Clear Creek with a priority of June 1, 1884 - Water is conveyed to the lands through the Hopkins Ditch.
144.32 Acres	Lands with original supply under the Antonio Silva Appropriation, Territorial Appropriation, the Four Lakes and French Creek Ditch diverting from Clear Creek with a priority of June 1, 1884. Water is conveyed to the lands through the Gorgen Ditch.
122.8 Acres	Lands with original supply under the Antonio Silva Appropriation, Territorial Appropriation, the Four Lakes and French Creek Ditch diverting from Clear Creek with a priority of June 1, 1884. Water is conveyed to the lands through the Mayhew and Gorgen Ditch.
60.0 Acres	Lands with original supply under the Antonio Silva Appropriation, Territorial Appropriation, the North Fork and French Creek Ditch diverting from Clear Creek with a priority of December 31, 1885. Water is conveyed to the lands through the Moeller No. 3 Ditch.
12.0 Acres	Lands with original supply under the Antonio Silva Appropriation, Territorial Appropriation, diverting from French Creek through the Mayhew and Gorgen Ditch with a priority of May 10, 1883.
118.0 Acres	Lands with original supply under the John Sage Appropriation, Territorial Appropriation, diverting from Clear Creek through the Four Lakes and French Creek Ditch with a priority of June 18, 1884. Water is conveyed to the lands through the Mayhew and Gorgen Ditch.
20.0 Acres	Lands with original supply under the Peter Gorgen Appropriation, Territorial Appropriation, diverting from French Creek through the Gorgen Ditch with a priority of October 31, 1883.
105.0 Acres	Lands with original supply under the John Sage Appropriation, Territorial Appropriation, diverting from Clear Creek through the Four Lakes and French Creek Ditch with a priority of June 1, 1884. Water is conveyed to the lands through the Mayhew & Meyer Ditch.
200.0 Acres "blanket description"	Lands with original supply under the Geo. F. Myers Appropriation, Territorial Appropriation, diverting from Clear Creek through the Four Lakes and French Creek Ditch with a priority of June 1, 1884.
40.0 Acres "blanket description"	Lands with original supply under the Gena Fisher Appropriation, Territorial Appropriation, diverting from Clear Creek through the Four Lakes and French Creek Ditch with a priority of June 1, 1884.

LANDOWNERS WITHIN DISTRICT

MARGARET M. BARKER REVOCABLE TRUST
MARGARET M. BARKER
141 French Creek Road
Buffalo, Wyoming 82834 — **511.92 ACRES**

GREG L. GODDARD AND CONNIE M. GODDARD
234 French Creek Road
Buffalo, Wyoming 82834 — **465.16 ACRES**

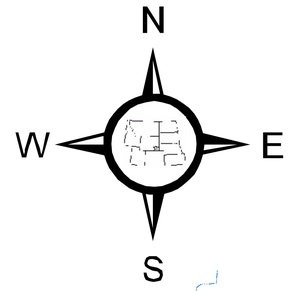
J. CRAIG SMITH AND DONNA M. SMITH
333 French Creek Road
Buffalo, Wyoming 82834 — **73.45 ACRES**

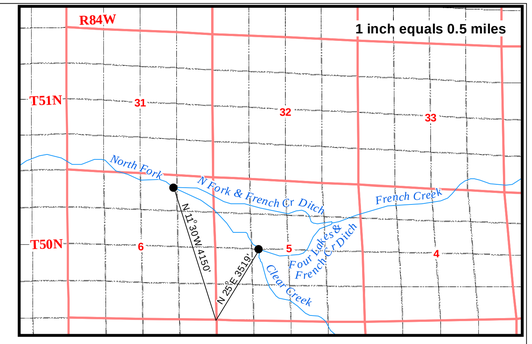
JOHNSON COUNTY RANCH IMPROVEMENT NO. 1, LLC
JOHN G. JENKINS
P.O. Box 818
Buffalo, Wyoming 82834 — **853.48 ACRES**

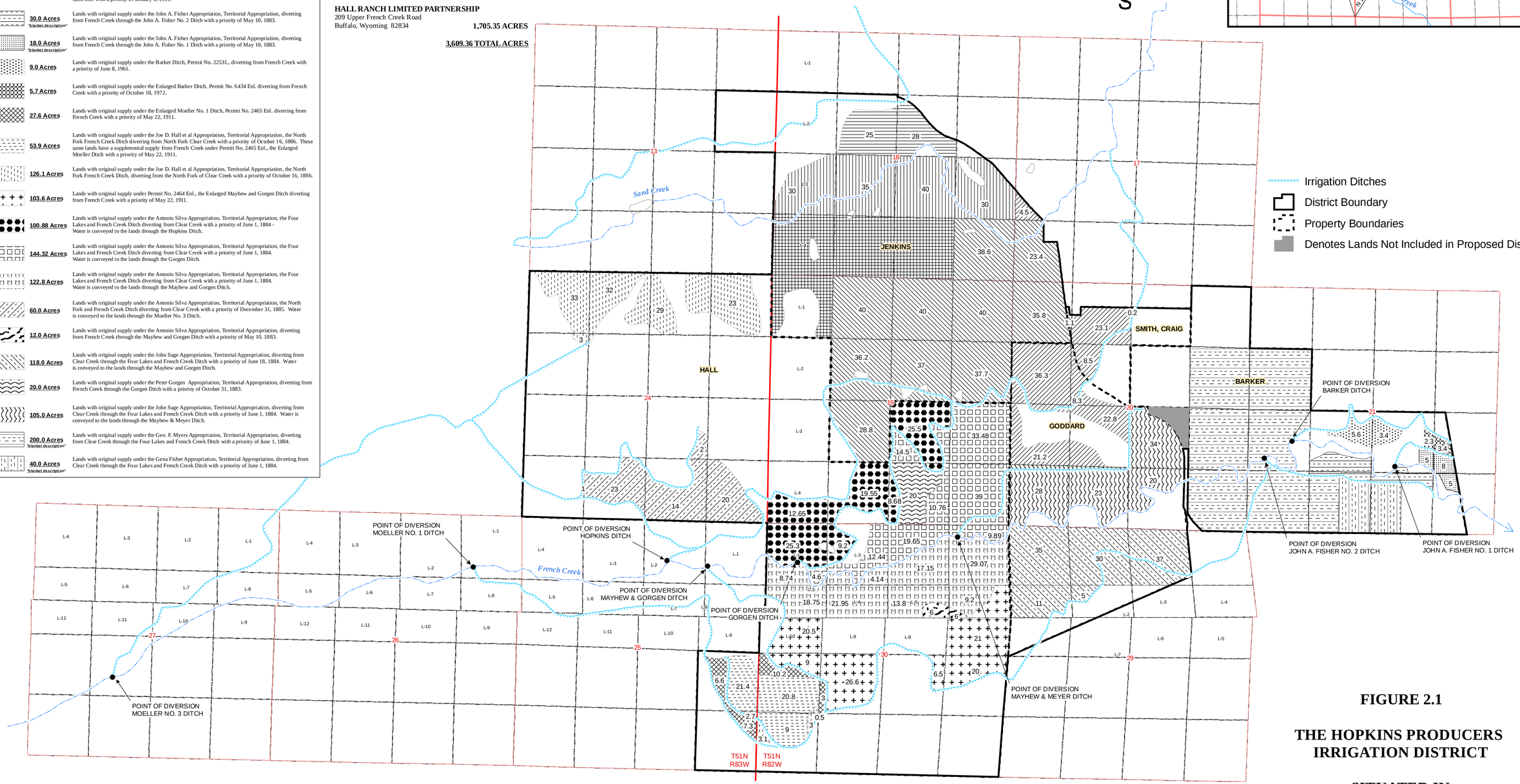
HALL RANCH LIMITED PARTNERSHIP
209 Upper French Creek Road
Buffalo, Wyoming 82834 — **1,705.35 ACRES**

3,609.36 TOTAL ACRES

HOPKINS PRODUCERS IRRIGATION DISTRICT







2,000 1,000 0 2,000 4,000 6,000 Feet

1 inch equals 1,000 feet

CERTIFICATE OF ENGINEER

STATE OF WYOMING)
) SS
COUNTY OF LARAMIE)

I, Gordon W. Fassett, P.E. of Cheyenne, Wyoming, hereby certify that this map was made from records on file in the office of the Wyoming State Engineer and to the best of my knowledge and belief, it accurately represents those water rights.

Wyoming Registration P.E. 3175

FIGURE 2.1

THE HOPKINS PRODUCERS IRRIGATION DISTRICT

SITUATED IN
SECTIONS 13, 24, AND 25,
TOWNSHIP 51 NORTH, RANGE 83 WEST
SECTIONS 17, 18, 19, 20, 21, 29, AND 30,
TOWNSHIP 51 NORTH, RANGE 82 WEST
JOHNSON COUNTY, WYOMING

3. Watershed Description

3.1 Land Uses

Land uses in the lower French Creek watershed include rural development, irrigated land for pasture, grass hay, and alfalfa production, and grazing. Land uses in the upper French Creek watershed include grazing, logging, and recreation. Land uses in the upper North Fork of Clear Creek watershed include grazing, logging, and recreation. Ground water and oil and gas wells are shown on Figures 3.1 & 3.2.

3.2 Geology/Soils/Land Cover/Climatologic Zones

Surface and subsurface geology is mapped by the USGS and is shown on Figures 3.3 & 3.4. Soils are mapped by the NRCS up to the Forest Service boundary and are shown on Figure 3.5. Appendix I contains an explanation of the soil types shown on the map. Major plant communities and land cover is shown on Figure 3.6. The level IV ecoregions of the watershed area mapped by the EPA are shown below in Figure 3.7. The upper North Fork of Clear Creek watershed starts in the alpine zone and continues through the granitic subalpine zone. The French Creek watershed starts in granitic subapline zone and continues through the dry mid-elevation sedimentary mountains zone, the Pryor-Bighorn foothills, and the Mesic dissected plains region. Climate data is available from the Western Regional Climate Center. Data on average monthly temperature and precipitation is included in Appendix H.

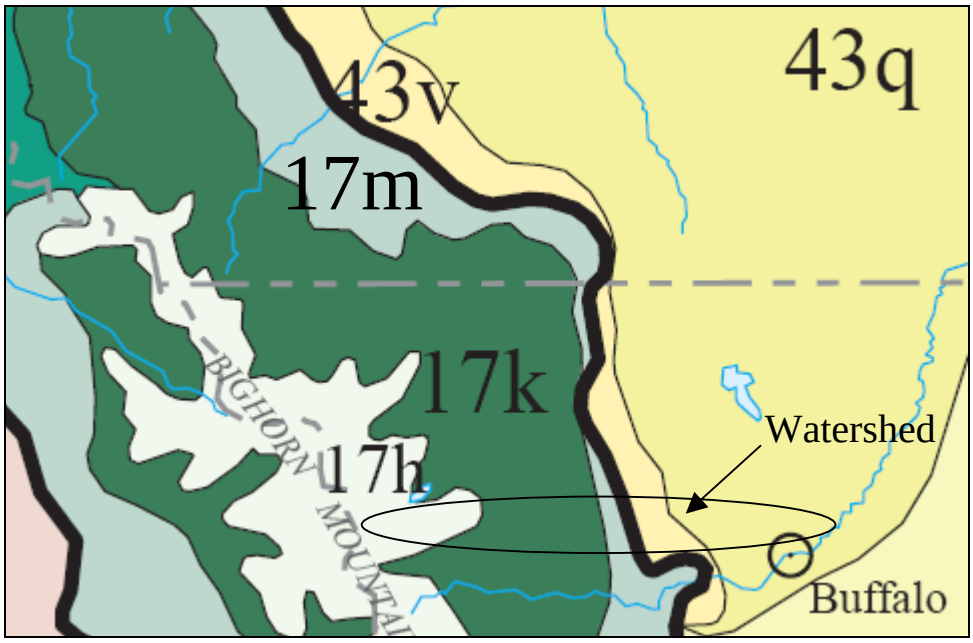


Figure 3.7 Level IV Ecoregions

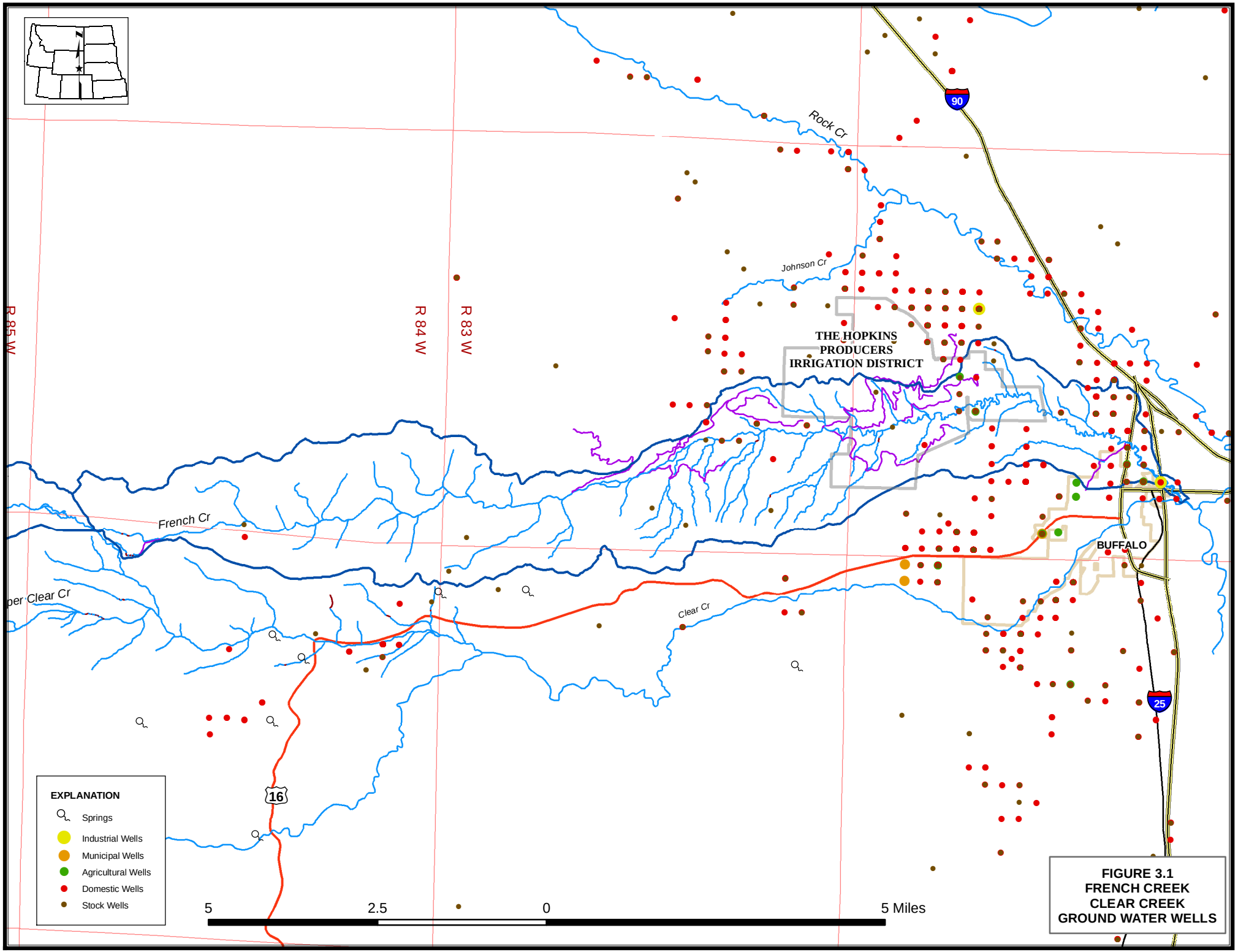
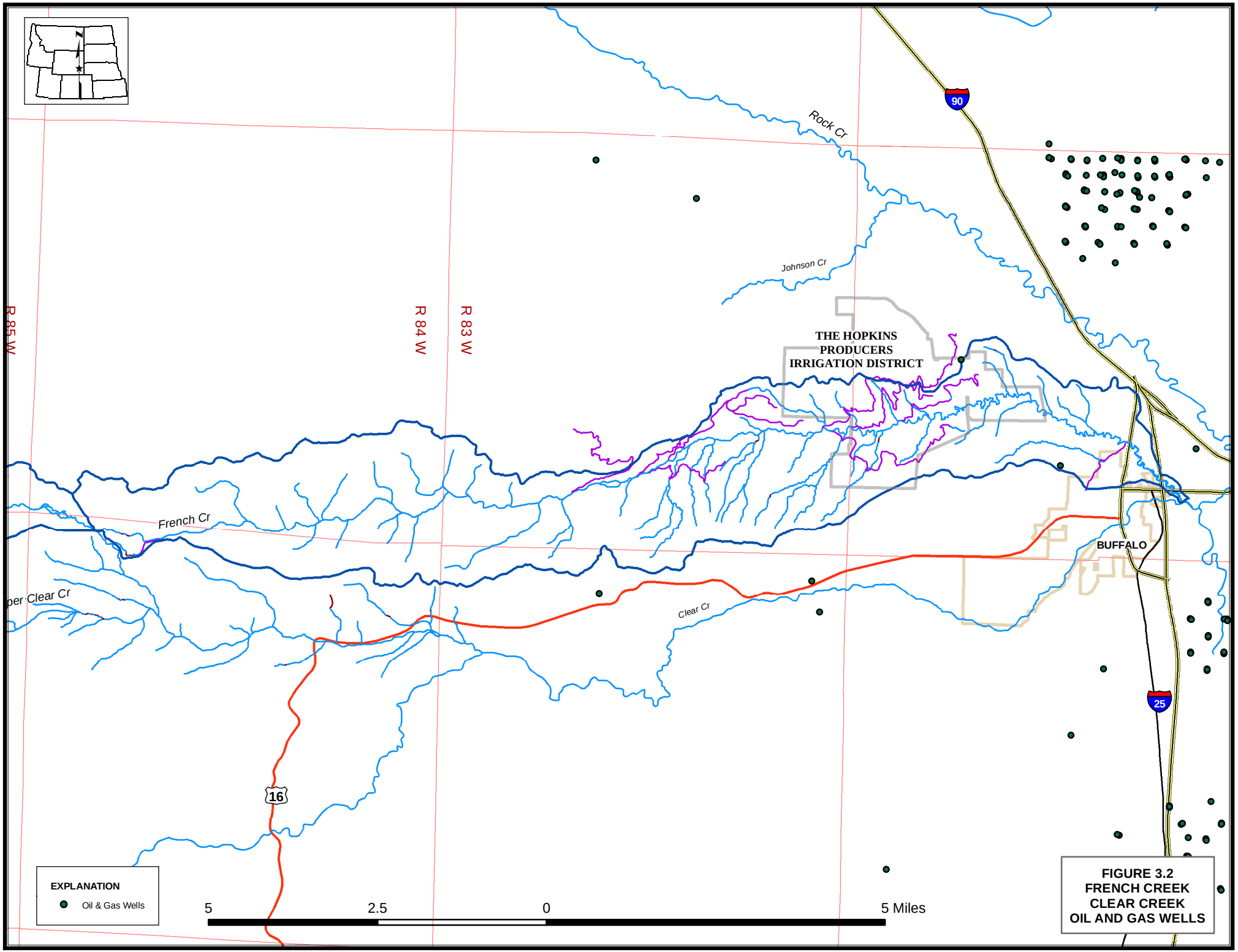
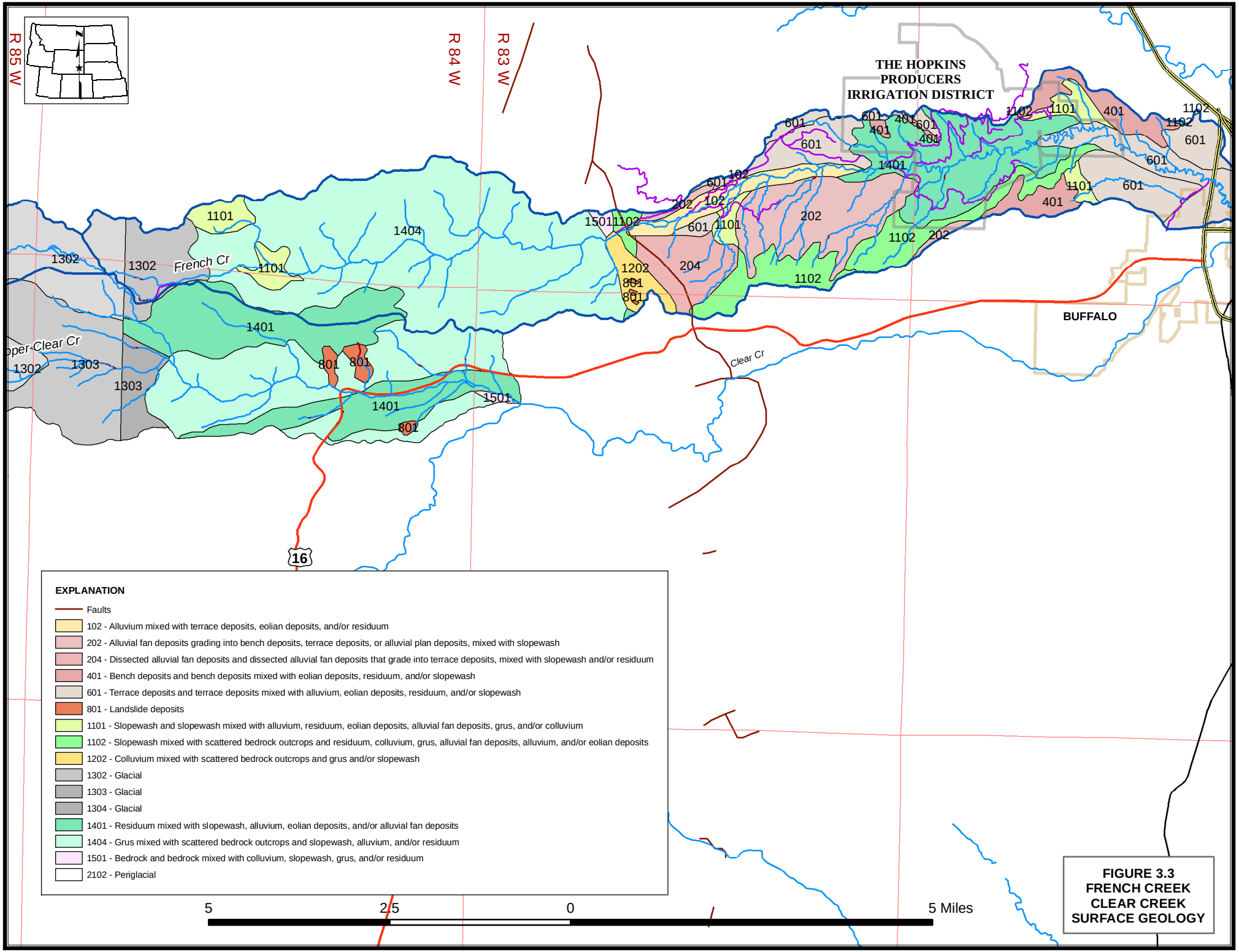
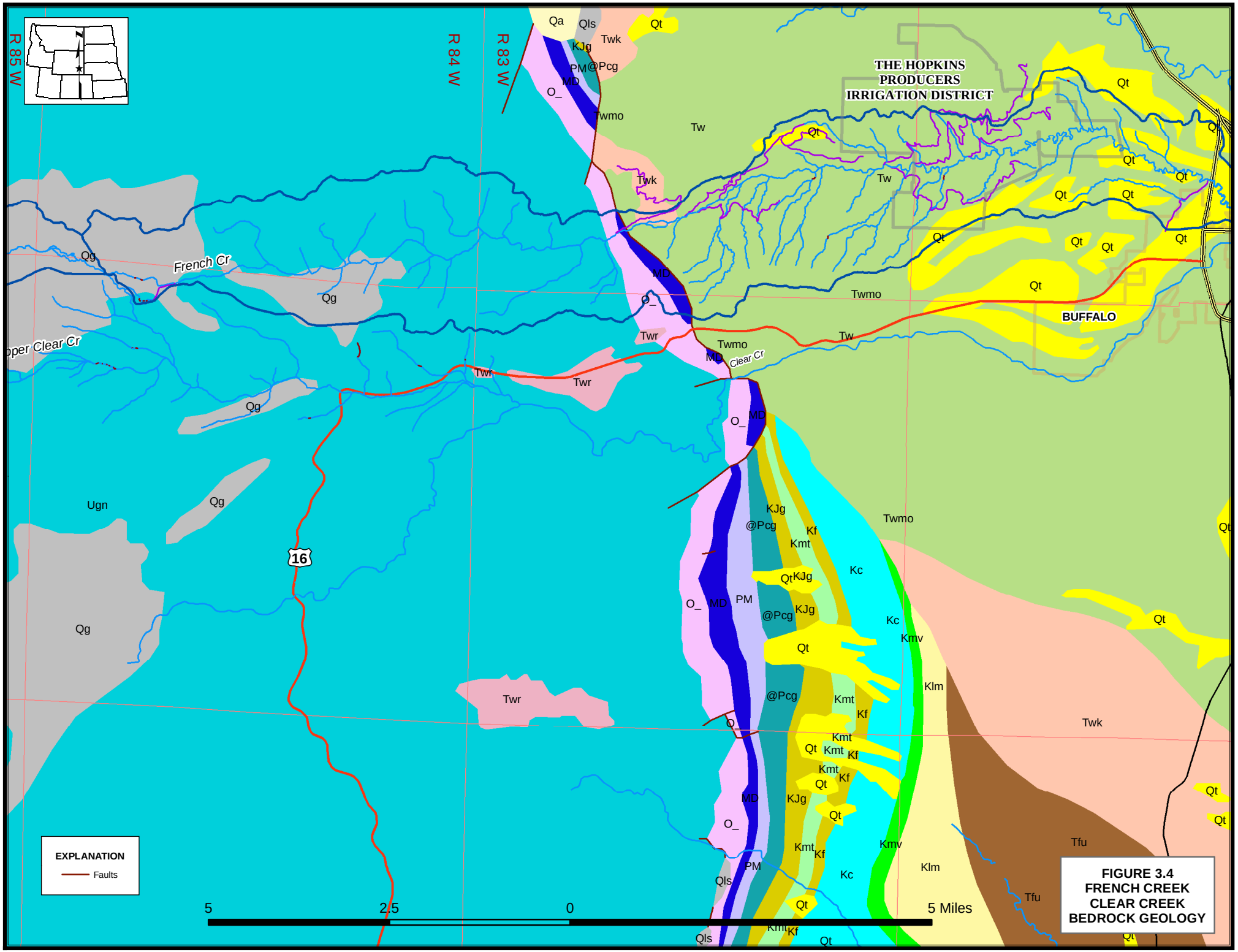
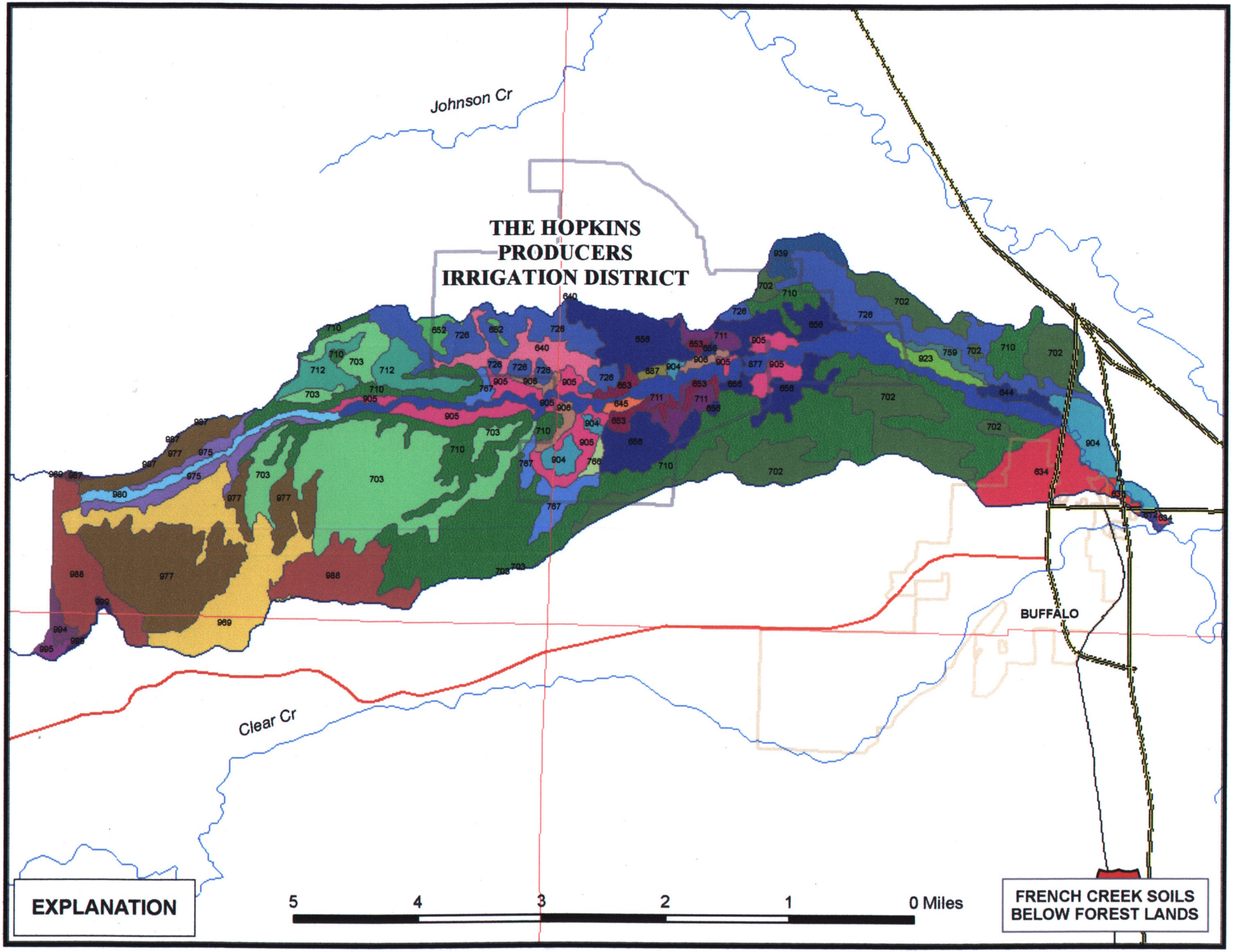


FIGURE 3.1
FRENCH CREEK
CLEAR CREEK
GROUND WATER WELLS


Rock Cr
Johnson Cr
R 85 W
R 84 W
R 83 W
THE HOPKINS
PRODUCERS
IRRIGATION DISTRICT
French Cr
per Clear Cr
Clear Cr
BUFFALO
90
25
16
EXPLANATION
Oil & Gas Wells
5
2.5
0
5 Miles
FIGURE 3.2
FRENCH CREEK
CLEAR CREEK
OIL AND GAS WELLS


R 85 W
R 84 W
R 83 W
THE HOPKINS
PRODUCERS
IRRIGATION DISTRICT
BUFFALO
French Cr
Clear Cr
16
EXPLANATION
Faults
102 - Alluvium mixed with terrace deposits, eolian deposits, and/or residuum
202 - Alluvial fan deposits grading into bench deposits, terrace deposits, or alluvial plan deposits, mixed with slopewash
204 - Dissected alluvial fan deposits and dissected alluvial fan deposits that grade into terrace deposits, mixed with slopewash and/or residuum
401 - Bench deposits and bench deposits mixed with eolian deposits, residuum, and/or slopewash
601 - Terrace deposits and terrace deposits mixed with alluvium, eolian deposits, residuum, and/or slopewash
801 - Landslide deposits
1101 - Slopewash and slopewash mixed with alluvium, residuum, eolian deposits, alluvial fan deposits, grus, and/or colluvium
1102 - Slopewash mixed with scattered bedrock outcrops and residuum, colluvium, grus, alluvial fan deposits, alluvium, and/or eolian deposits
1202 - Colluvium mixed with scattered bedrock outcrops and grus and/or slopewash
1302 - Glacial
1303 - Glacial
1304 - Glacial
1401 - Residuum mixed with slopewash, alluvium, eolian deposits, and/or alluvial fan deposits
1404 - Grus mixed with scattered bedrock outcrops and slopewash, alluvium, and/or residuum
1501 - Bedrock and bedrock mixed with colluvium, slopewash, grus, and/or residuum
2102 - Periglacial
5
2.5
0
5 Miles
FIGURE 3.3
FRENCH CREEK
CLEAR CREEK
SURFACE GEOLOGY


R 85 W
R 84 W
R 83 W
THE HOPKINS PRODUCERS IRRIGATION DISTRICT
BUFFALO
French Cr
Clear Cr
16
Qa
Qls
Qt
KJg
Twk
@Pcg
PM
MD
O_
Twmo
Tw
Qg
Twr
Ugn
Kf
Kmt
Kc
Kmv
Klm
Tfu
EXPLANATION
Faults
5
2.5
0
5 Miles
FIGURE 3.4
FRENCH CREEK
CLEAR CREEK
BEDROCK GEOLOGY


Johnson Cr
THE HOPKINS
PRODUCERS
IRRIGATION DISTRICT
BUFFALO
Clear Cr
EXPLANATION
5
4
3
2
1
0 Miles
FRENCH CREEK SOILS
BELOW FOREST LANDS

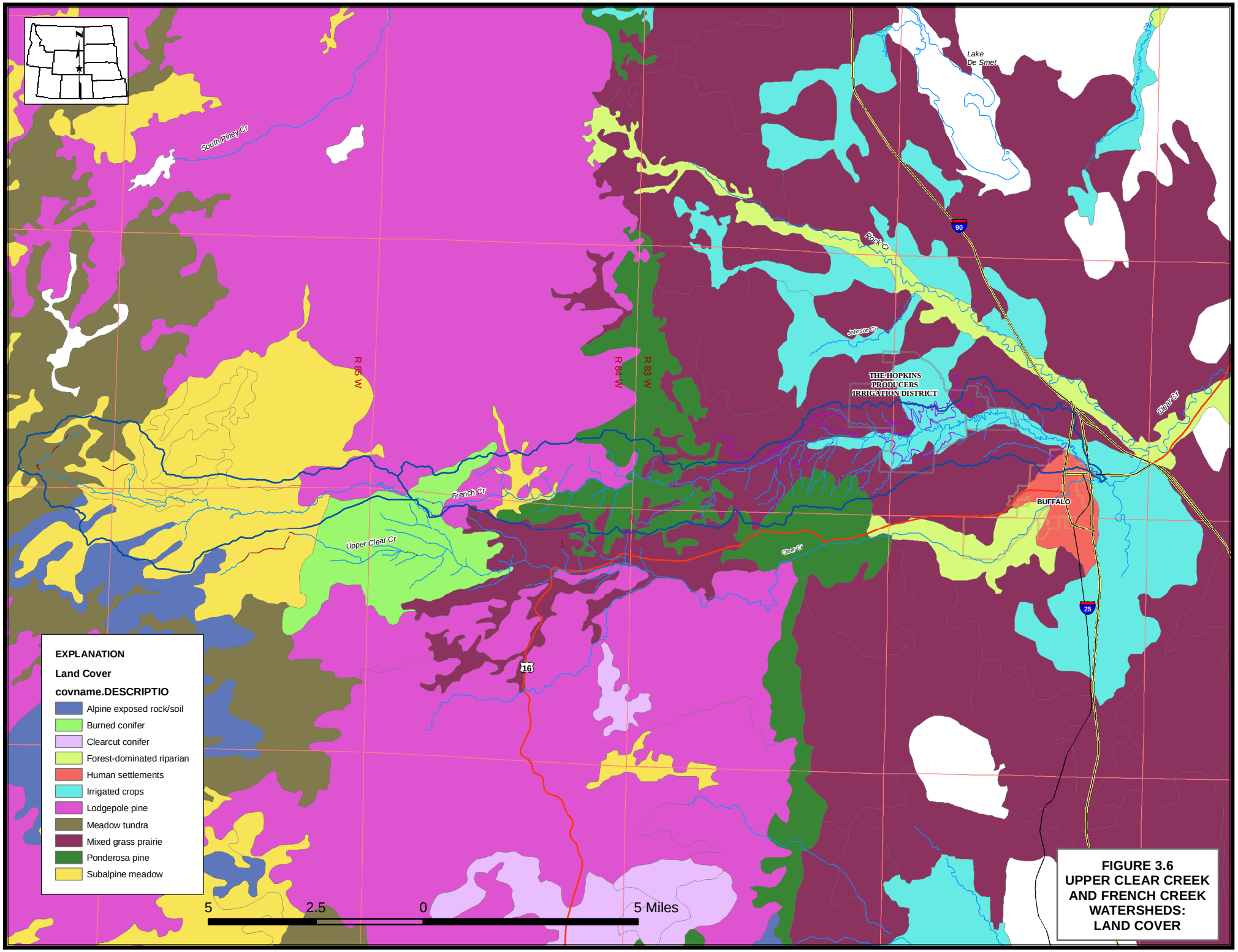


FIGURE 3.6
UPPER CLEAR CREEK AND FRENCH CREEK WATERSHEDS: LAND COVER

3.3 Channel Structure/Morphology

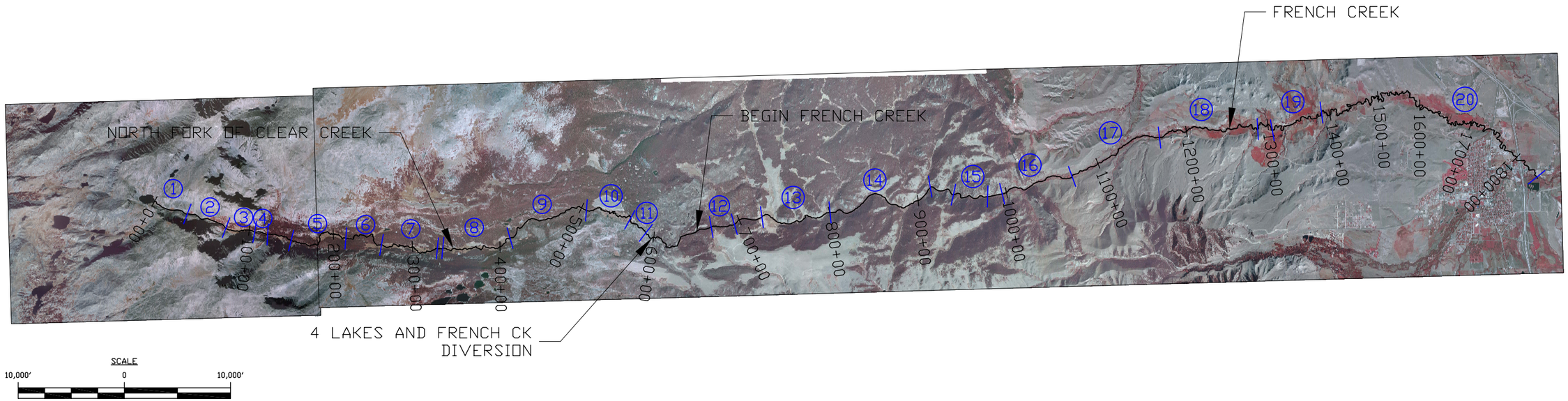
All of French Creek and the reaches of North Clear Creek above the Four Lakes and French Creek Ditch diversion were examined in a desktop level stream morphology effort. The watershed was analyzed from a water development perspective. The approach was to identify current issues and opportunities and how the stream morphology would affect and be affected by the development of a reservoir facility in the watershed.

French Creek has been influenced by the introduction and development of irrigation. The additional flows transferred into the French Creek basin from the North Fork of Clear creek have influenced the stream structure. The additional flow has widened and straightened the stream causing bank erosion and downcutting in areas. These transfers have occurred since 1884. Given the length of time since the transfers first began influencing the stream morphology, the stream has likely stabilized in most reaches. The channel slope and sinuosity was determined for the study reaches and are shown on Figure 3.8 and Table 3.1. Additional transfers as presented in this study would likely cause additional instability in some reaches of the stream. These locations of potential instability could be reaches 13, 14, 17, 18, 19 and 20.

Peak monthly average flow in French Creek in a normal year without import water is approximately 30 cfs. The peak monthly average flow in French Creek including current import from the North Fork of Clear Creek is approximately 62 cfs. Additional transfers as described in this study of 3500 AF in normal years during the month of May is a monthly average flow rate of 57 cfs. Current import monthly average flow for May in a normal year is 4 cfs. The average monthly flow in French Creek with current import water from the North Fork of Clear Creek in May is 31 cfs. With the addition of 57 cfs from the North Fork of Clear Creek, the flow in French Creek would be approximately 88 cfs. This is 26 cfs more water than the current average monthly peak flow. This additional flow will likely cause additional erosion and instability on some reaches of French Creek.

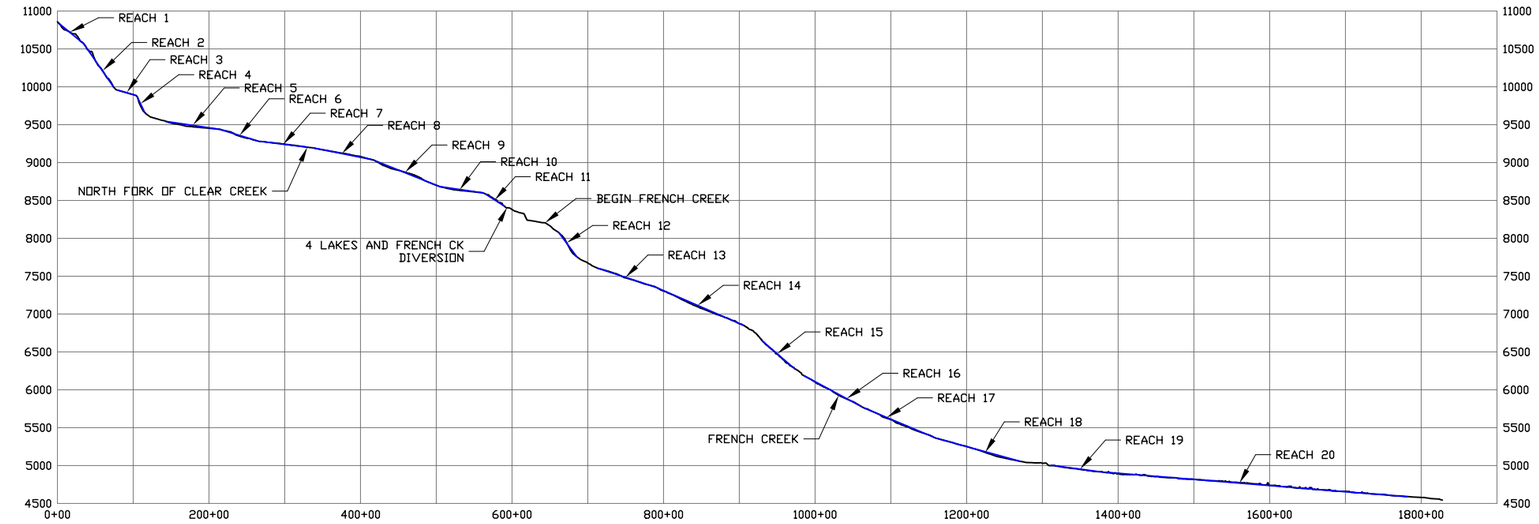
LEGEND

(1) REACH



SCALE

10,000′ 0 10,000′



VERT. SCALE

2,000′ 0 2,000′

HORIZ. SCALE

20,000′ 0 20,000′

NORTH CLEAR CREEK AND FRENCH CREEK
CHANNEL SLOPE

REV	DESCRIPTION OF REVISION	BY	DATE
1	PRELIMINARY DESIGN	DWW	07/08

FILE NAME: STREAM
SCALE: VARIES
OPERATOR: DWW
DATE: 07/08
PROJECT NO: 522-WY
TASK NO: 001-263
LOCATION: BUFFALO, WY
PROJECT: HOPKINS STORAGE
SEND TO: VICTOR E. ANDERSON
PHONE: (307) 634-7848

STATES WEST WATER RESOURCES CORPORATION
1904 E. 15th STREET
CHEYENNE, WYOMING 82001
(307) 634-7848
FAX: (307) 634-7851

WARNING

IF THIS BAR DOES NOT MEASURE 1/2" THEN DRAWING IS NOT TO SCALE

DESIGNED	DWW
DRAWN	DWW
CHECKED	VEA
PEER REVIEWED	VEA
PROJECT MANAGER	VEA
DATE	07/08

HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 3.8
NORTH CLEAR CK & FRENCH CK
CHANNEL SLOPE AND SINUOSITY

REVISION	1
PROJECT	522-WY
DRAWING	3-9

Table 3.1 - North Clear Creek and French Ck Stream Slope and Sinuosity				
Reach No.	Begin Station	End Station	Stream Slope ft/ft	Sinuosity
1	0	3500	0.083	1.00
2	3500	7500	0.145	1.01
3	8000	10300	0.029	1.06
4	10500	11500	0.211	1.03
5	14300	21500	0.015	1.18
6	21500	26500	0.031	1.16
7	26500	33100	0.012	1.17
8	33700	41500	0.020	1.17
9	41900	50500	0.040	1.06
10	50500	56200	0.015	1.37
11	56500	59000	0.064	1.10
12	66200	68500	0.134	1.06
13	71300	79000	0.033	1.25
14	79000	90500	0.043	1.03
15	93000	97300	0.086	1.02
16	98500	106100	0.054	1.06
17	106500	115700	0.042	1.07
18	116000	127000	0.028	1.20
19	130700	138200	0.013	1.69
20	138200	182806	0.008	1.95

3.4 Water Quality

French Creek is a Class 2AB stream and upper North Fork of Clear Creek is a Class 1 stream. The stream classifications are defined as follows:

- Class 1, Outstanding Waters. Class 1 waters are those surface waters in which no further water quality degradation by point source discharges other than from dams will be allowed. In designating Class 1 waters, water quality, aesthetic, scenic, recreational, ecological, agricultural, botanical, zoological, municipal, industrial, historical, geological, cultural, archaeological, fish and wildlife, the presence of significant quantities of developable water, and other values of present and future benefit to the people are considered.

- Class 2AB. Class 2AB waters are those waters, and all their perennial tributaries and adjacent wetlands, that are known to support game fish populations or spawning and nursery areas at least seasonally and where a game fishery and drinking water use is otherwise attainable. Unless it is shown otherwise, these waters are presumed to have sufficient water quality and quantity to support drinking water supplies and are protected for that use.

Currently, French Creek and the North Fork of Clear Creek are not on the Wyoming Department of Environmental Quality Section 303(d) list. Assessment by DEQ indicated French Creek is impacted by flow augmentation, however, it is meeting the aquatic life uses. A watershed plan was completed by the Lake DeSmet Conservation District to improve water quality in the French Creek watershed. The report is attached in Appendix G. There are currently no active National Pollution Discharge Elimination System permits in the French Creek or upper North Fork of Clear Creek watersheds.

Water quality testing stations are shown on Figure 3.9. Water quality data for French Creek from the Wyoming Water Resources Data Center from 1976 and data for Clear Creek from the USGS from 1975 to 1991 is presented in graphical form on Figures 3.10 and 3.11.

3.5 Big Game Habitat & Sensitive Species

Figures 3.12 through 3.20 show big game habitat classifications in the French Creek watershed and observations of sensitive species within a township buffer of the potential reservoir sites in the French Creek watershed.

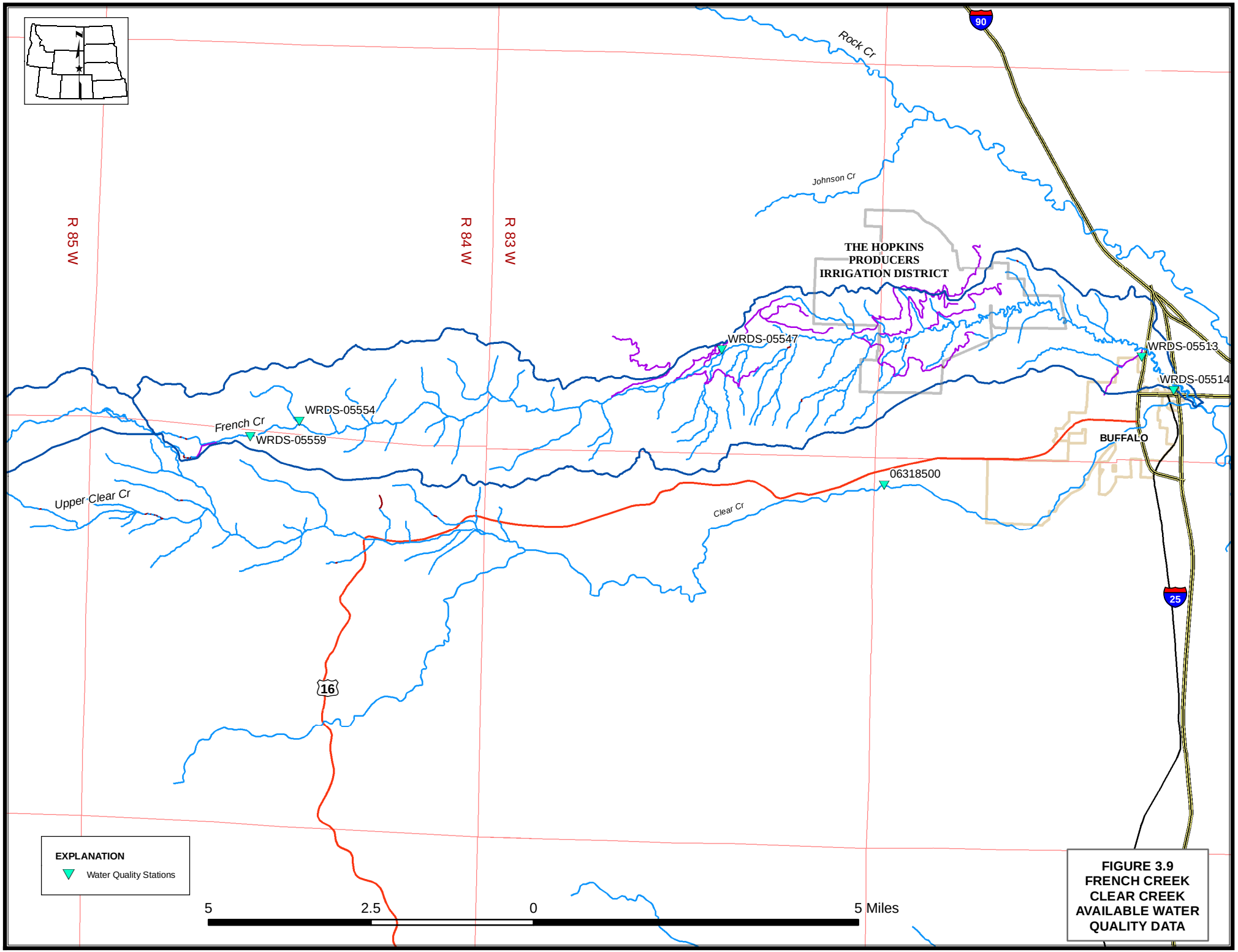


FIGURE 3.9
FRENCH CREEK
CLEAR CREEK
AVAILABLE WATER
QUALITY DATA

Figure 3.10

CLEAR CREEK BELOW ROCK CREEK NEAR BUFFALO, WY - 06320200

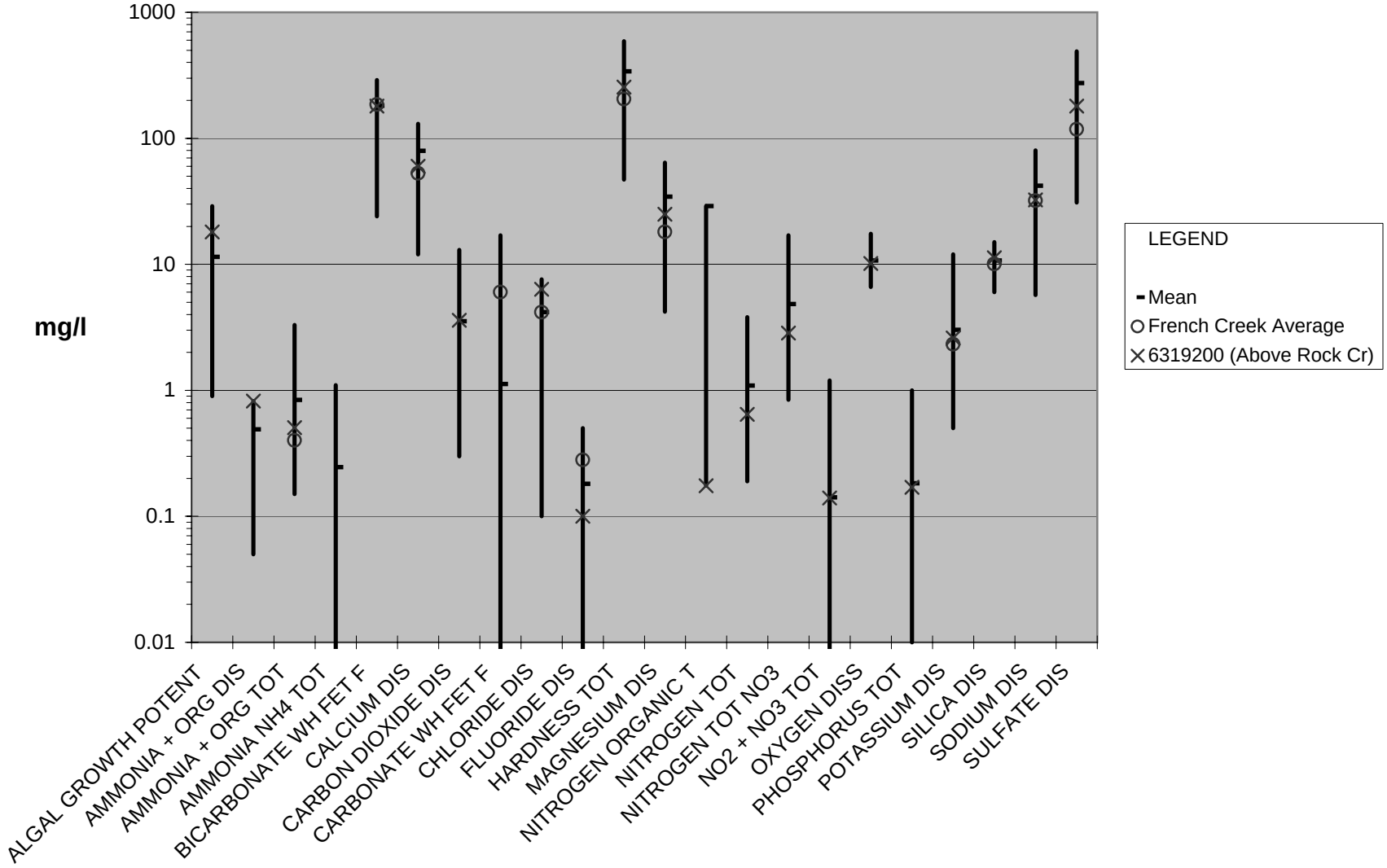
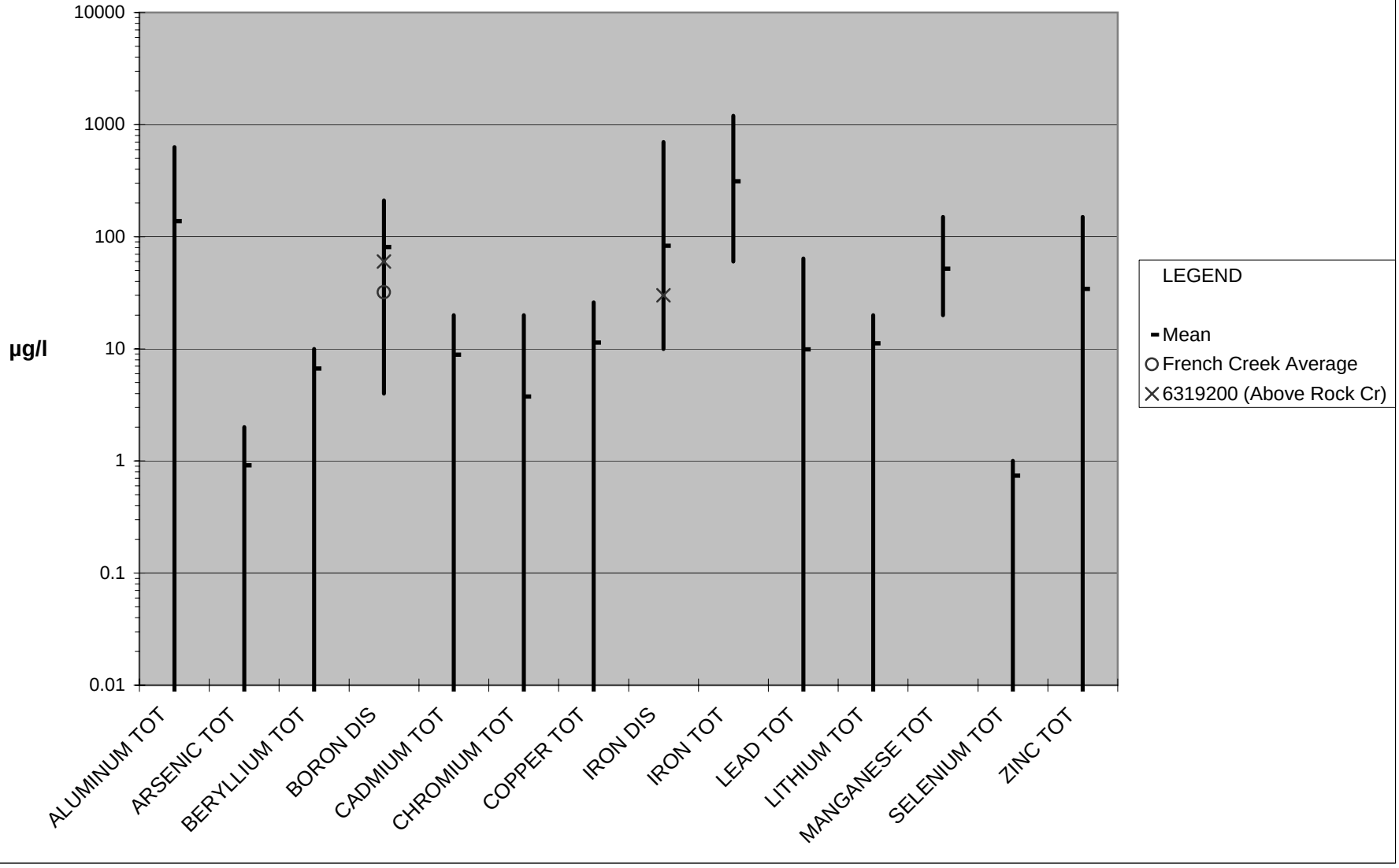


Figure 3.11
CLEAR CREEK BELOW ROCK CREEK NEAR BUFFALO, WY - 06320200



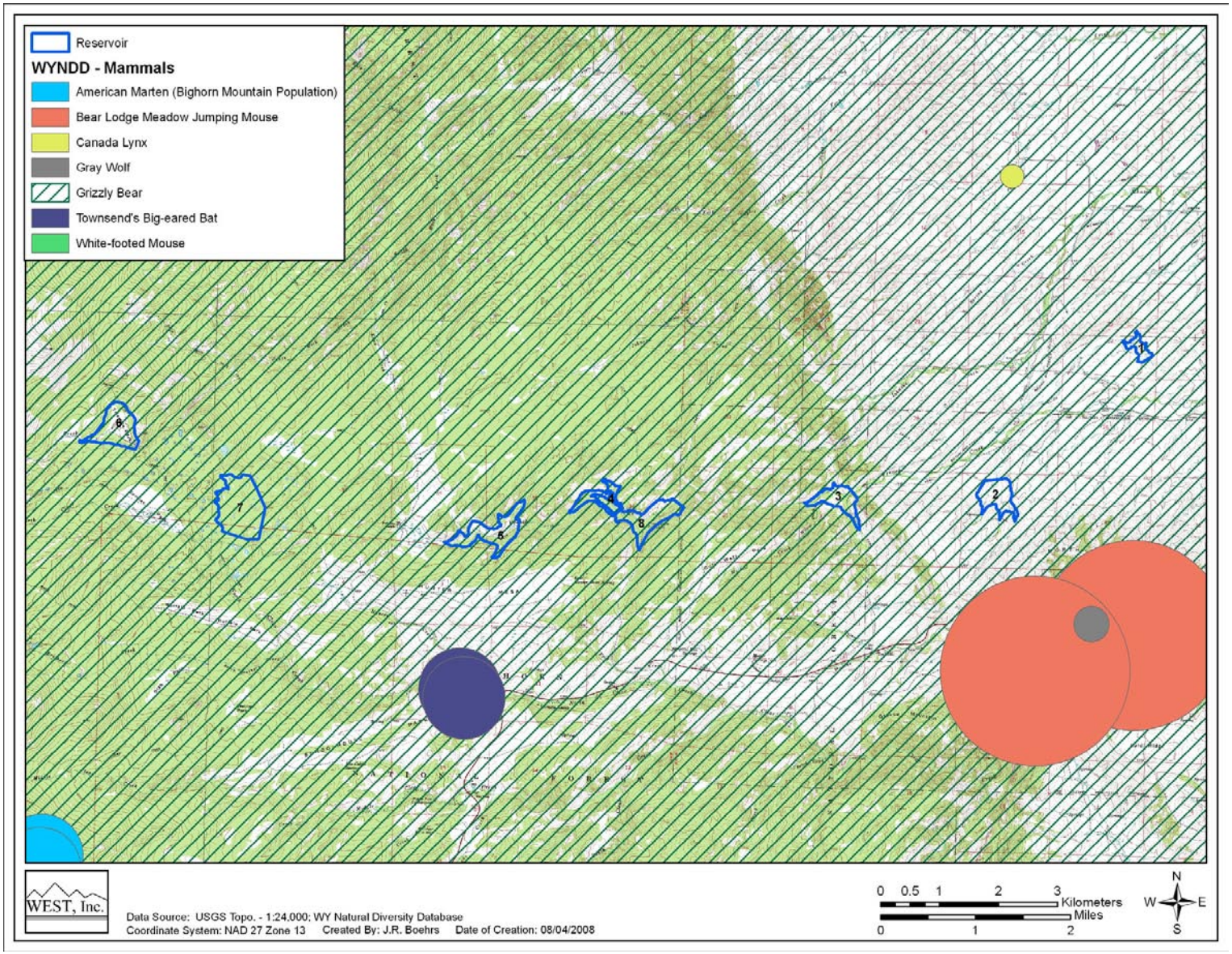


Figure 3.12 Observations of sensitive species within a township buffer of the Hopkins Producers reservoir sites

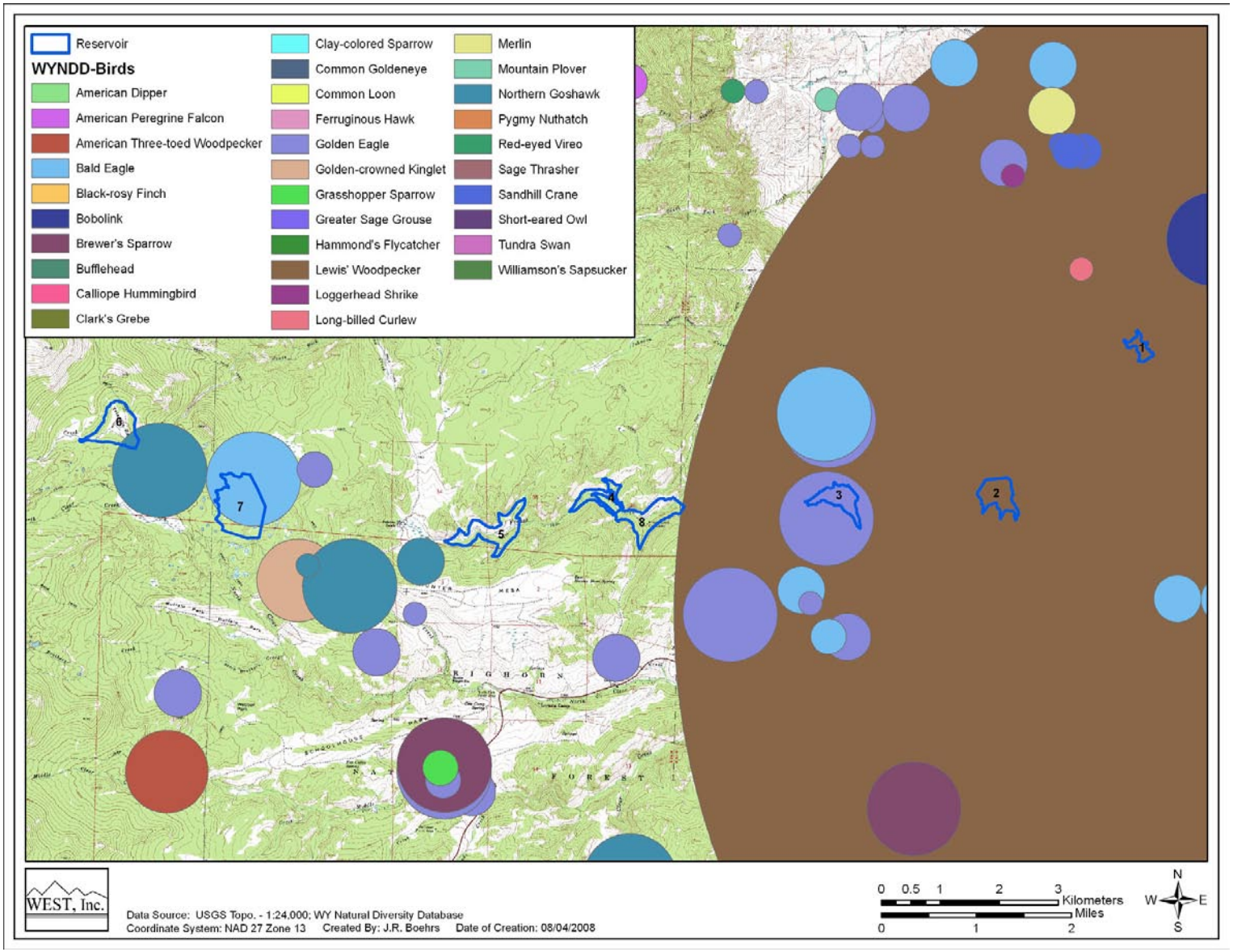


Figure 3.13 Observations of sensitive species within a township buffer of the Hopkins Producers reservoir sites

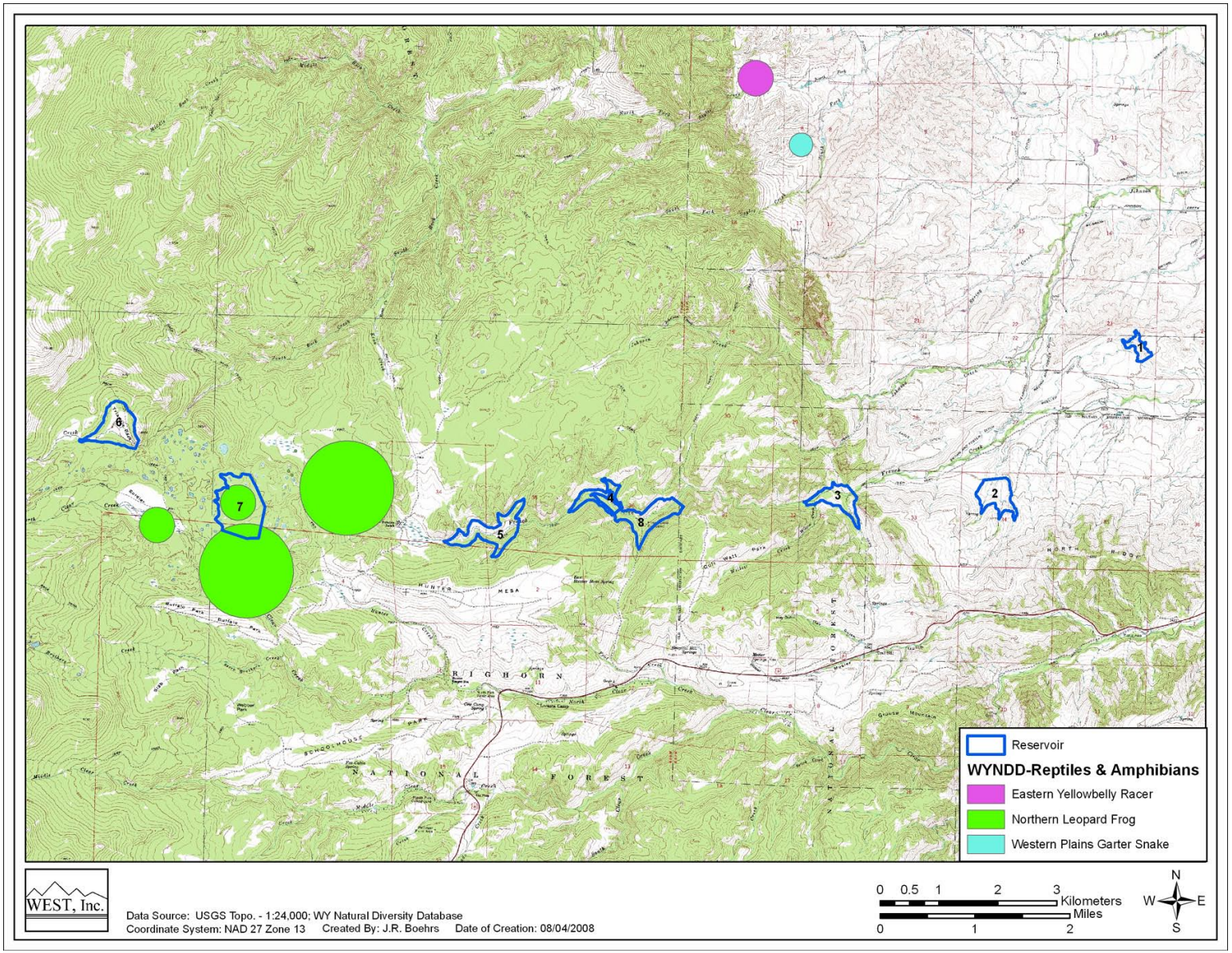


Figure 3.14Observations of sensitive species within a township buffer of the Hopkins Producers reservoir sites

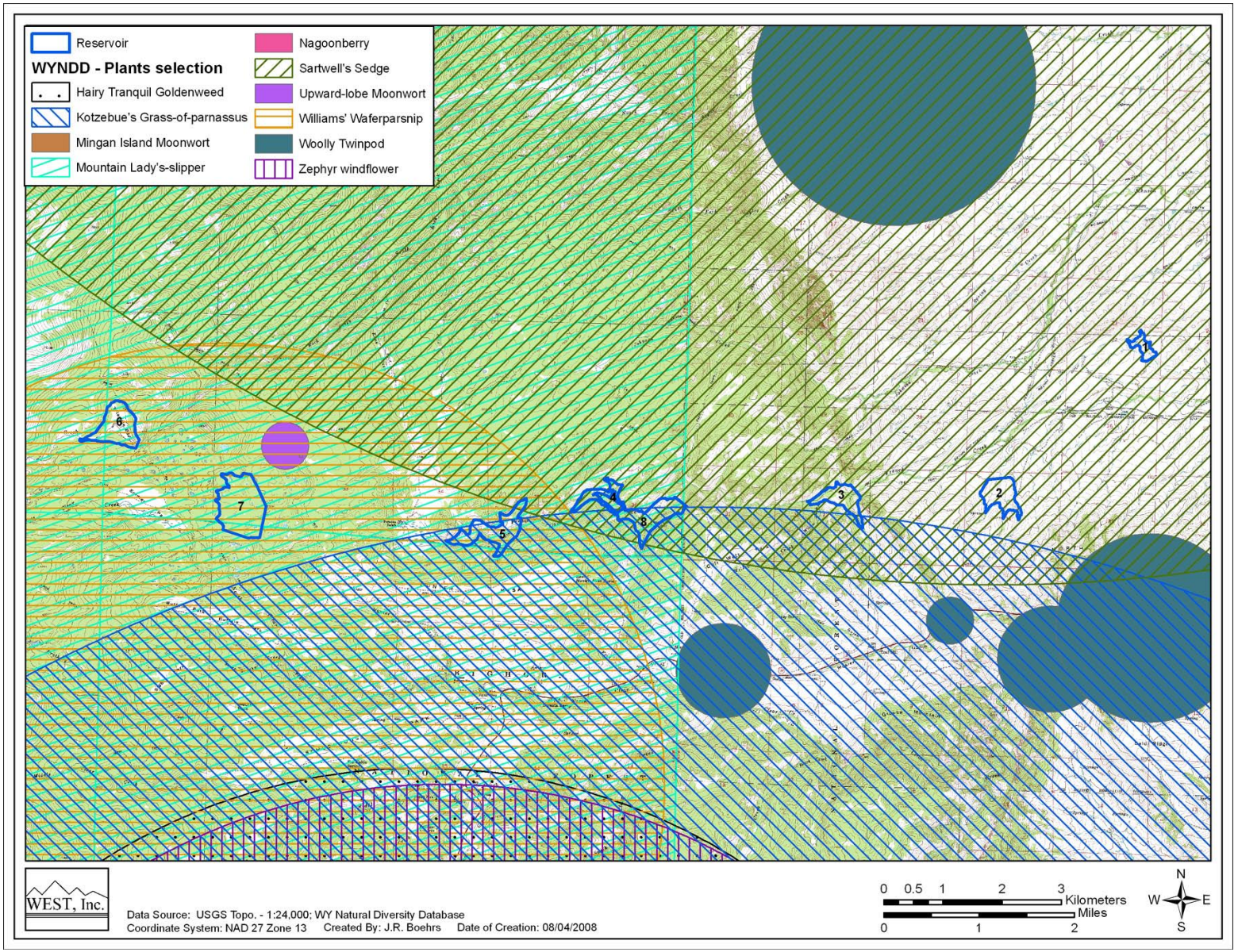


Figure 3.15 Observations of sensitive species within a township buffer of the Hopkins Producers reservoir sites

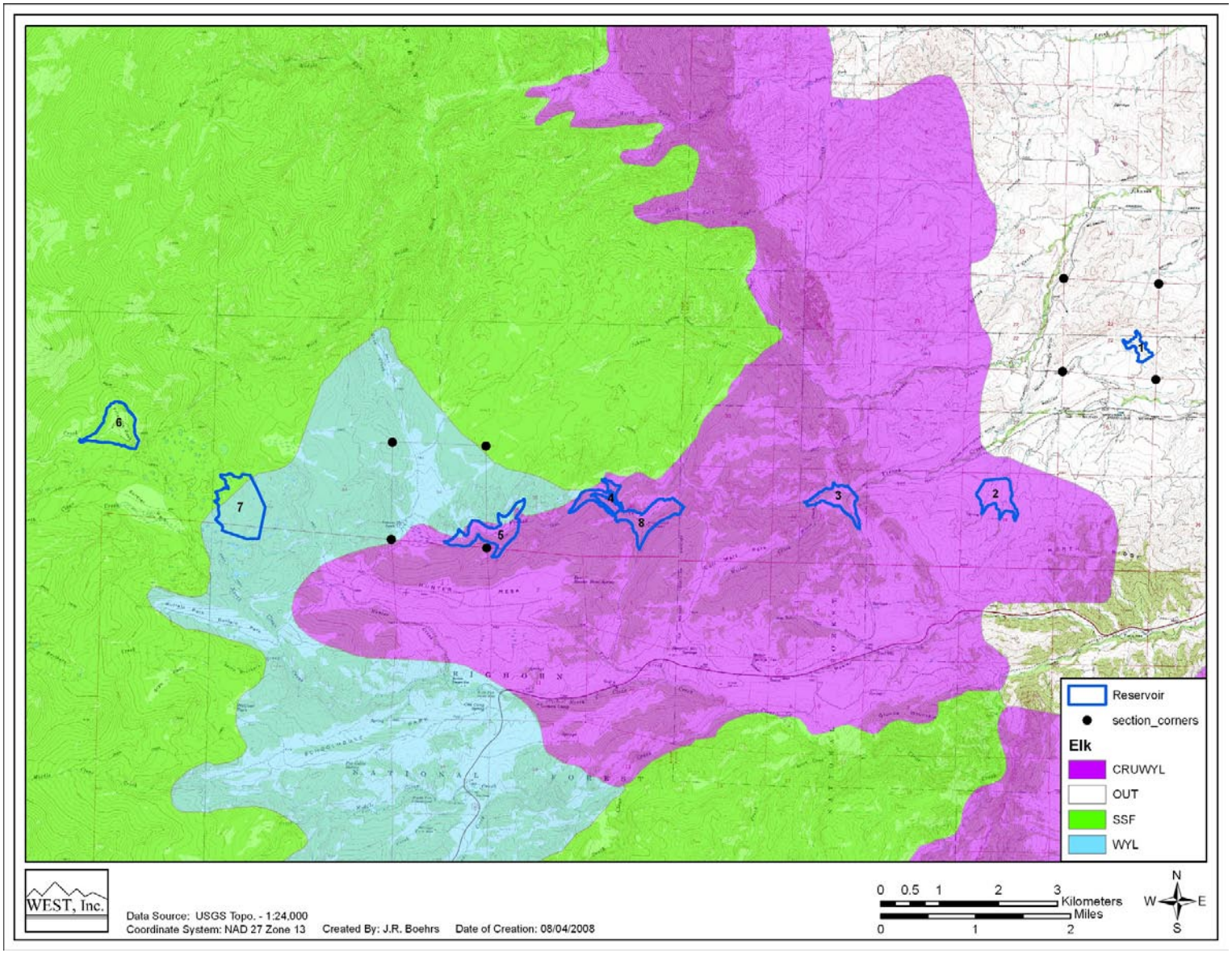


Figure 3.16 Big game habitat classifications at the Hopkins Producers reservoir sites

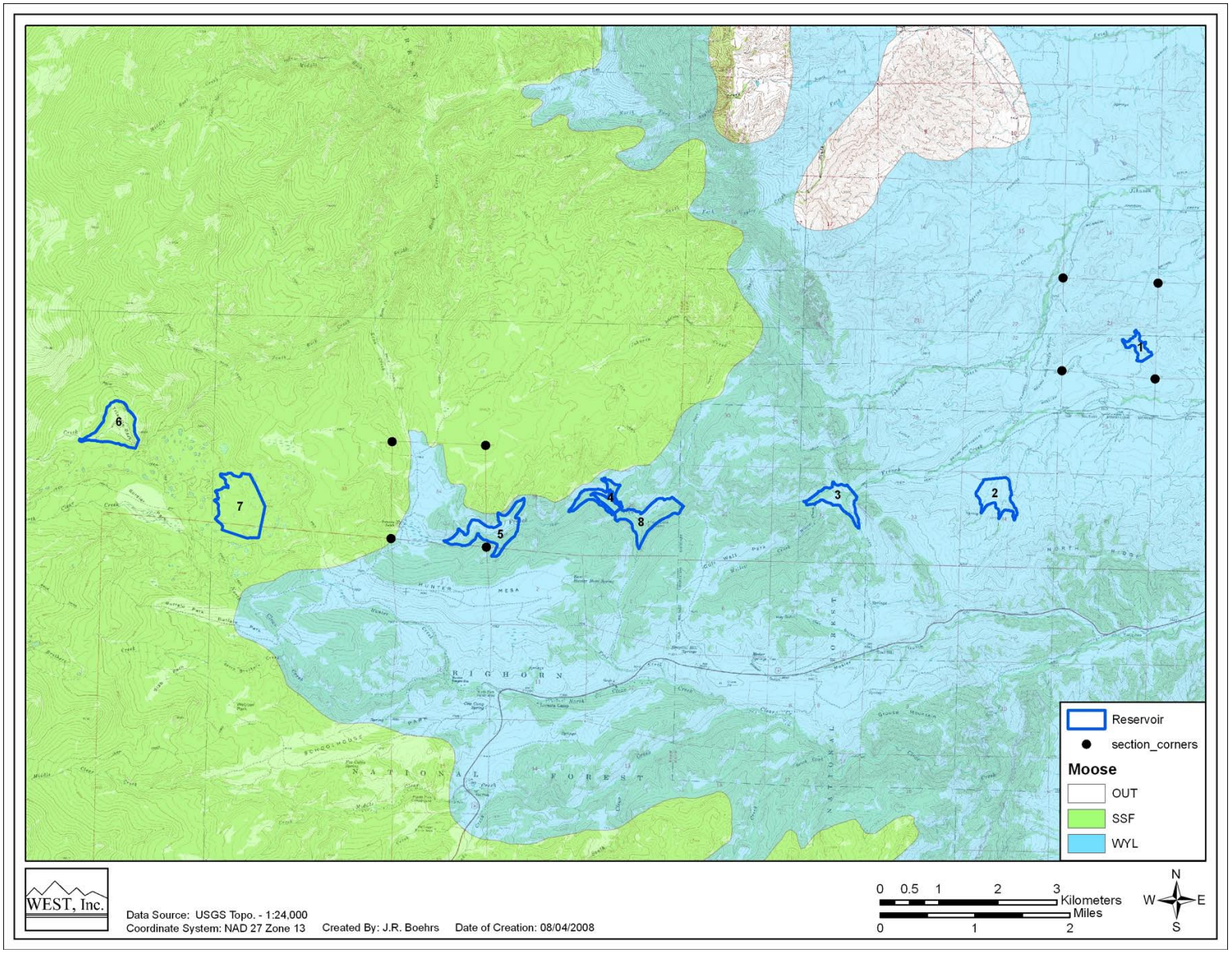


Figure 3.17 Big game habitat classifications at the Hopkins Producers reservoir sites

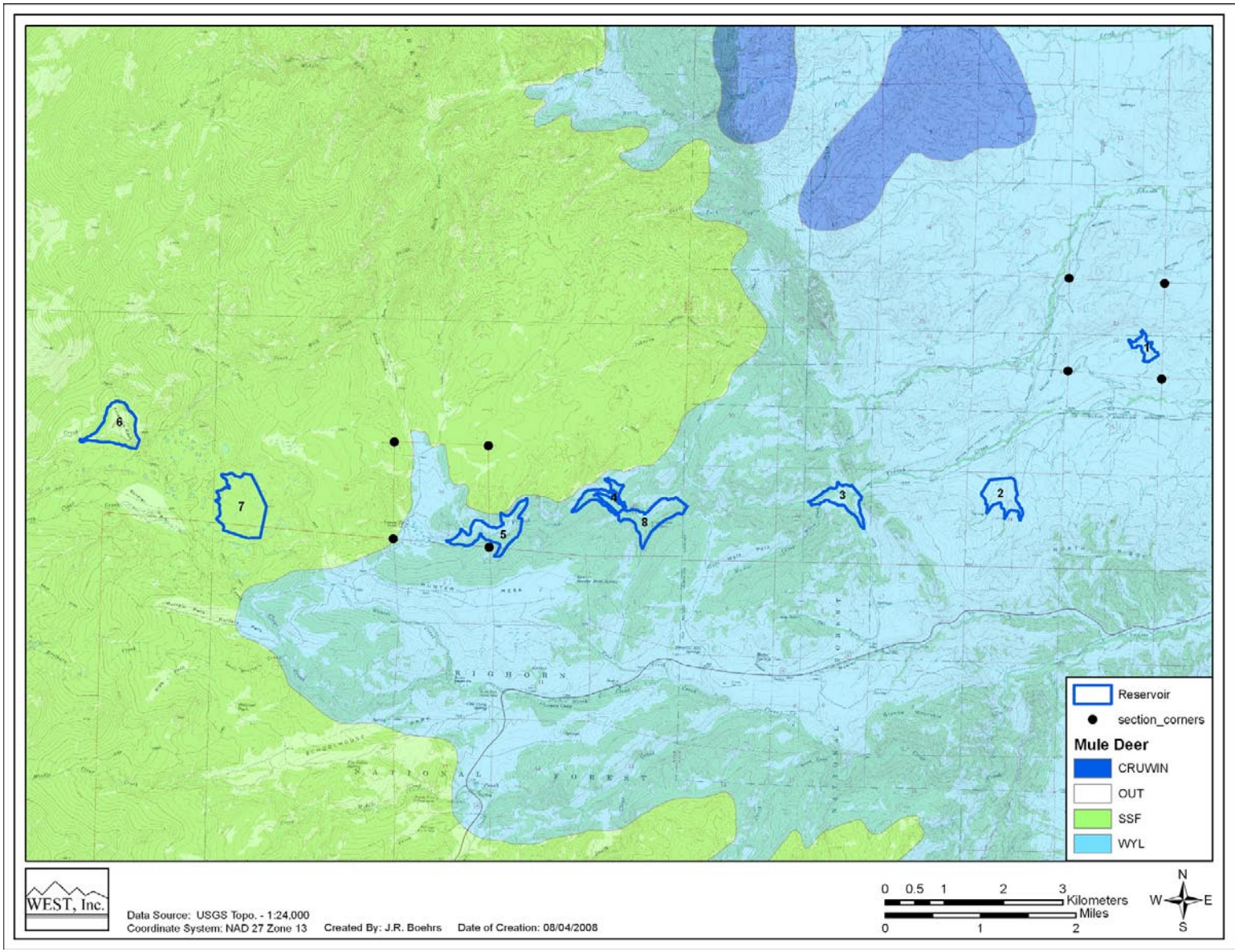


Figure 3.18 Big game habitat classifications at the Hopkins Producers reservoir sites

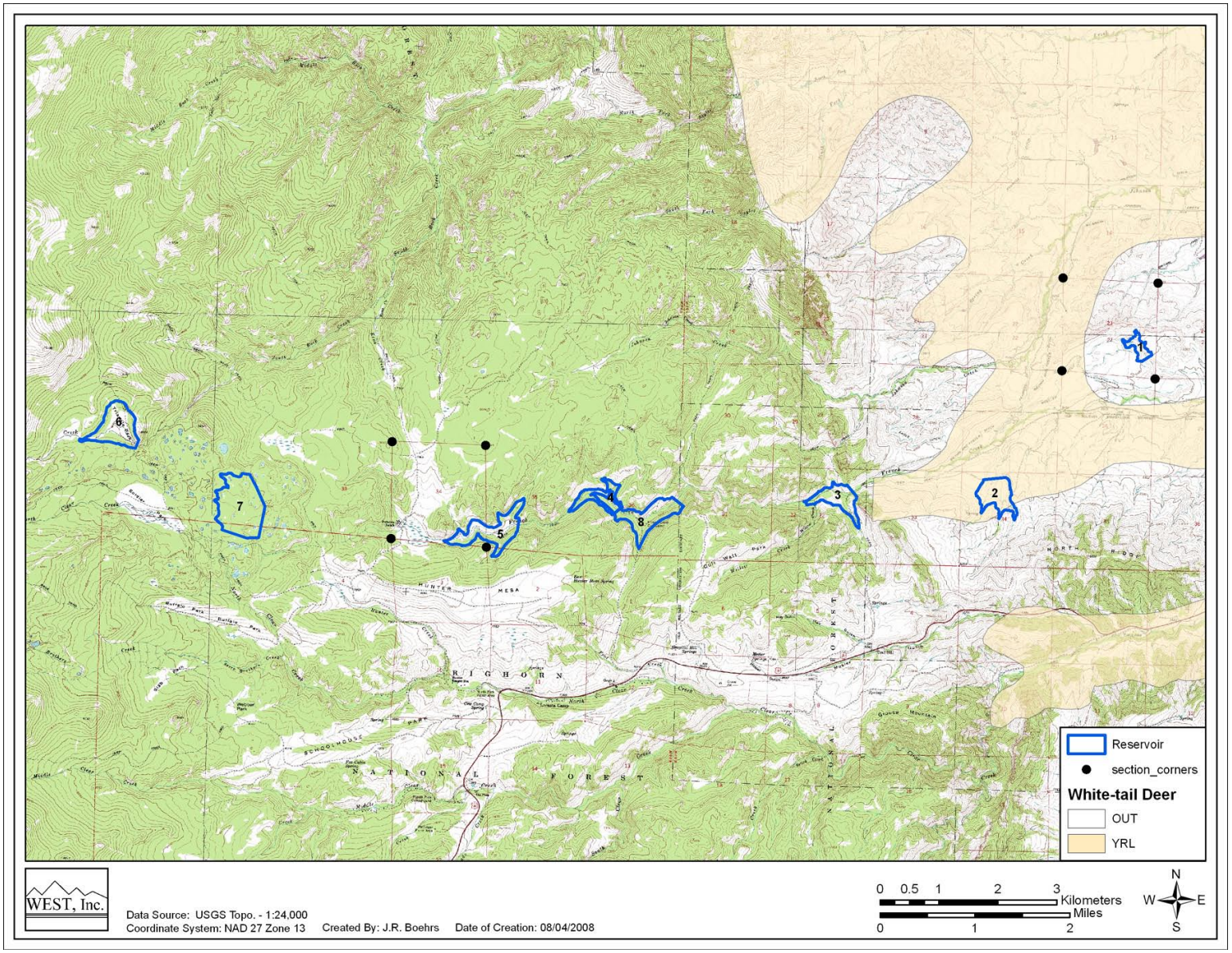


Figure 3.19 Big game habitat classifications at the Hopkins Producers reservoir sites

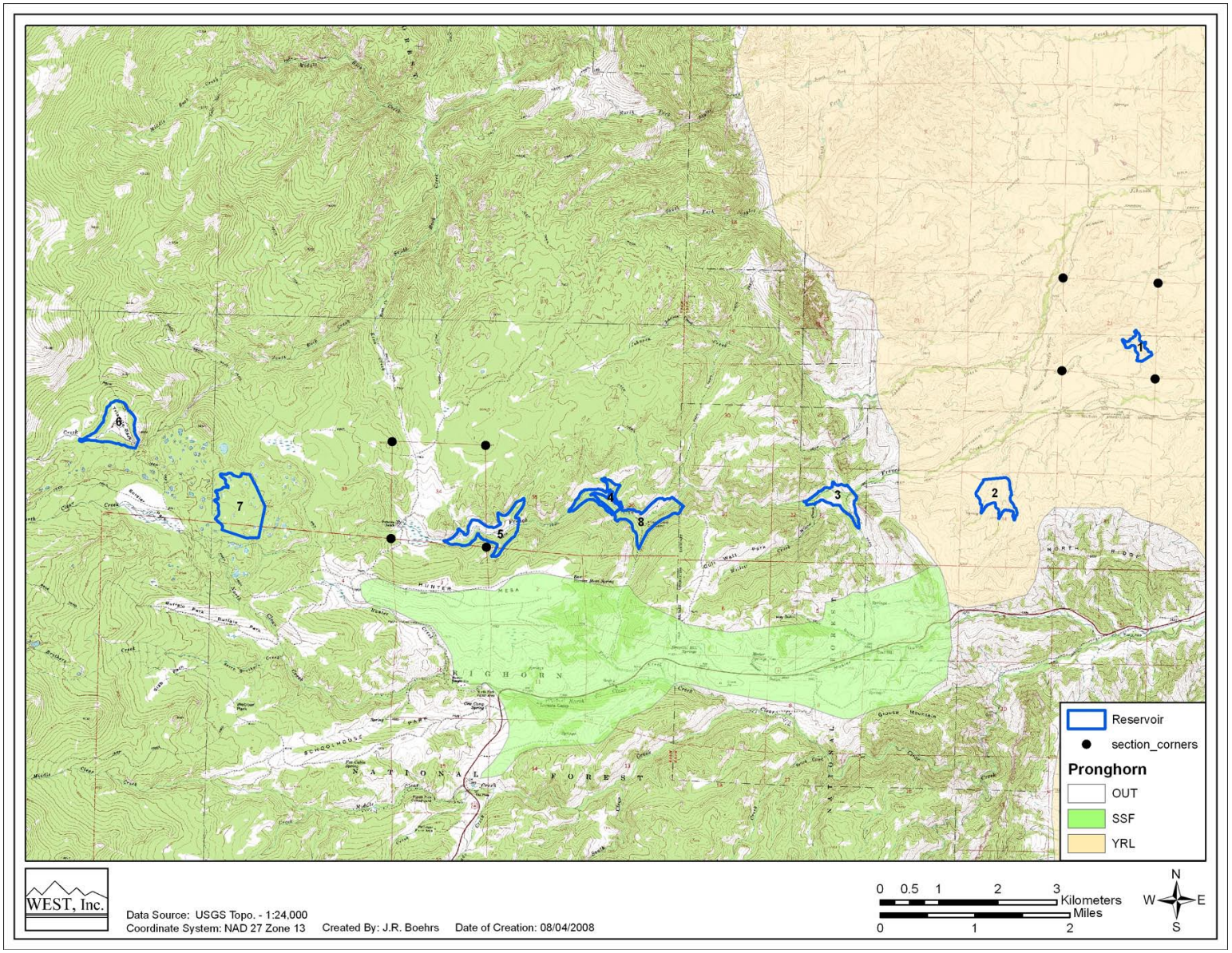


Figure 3.20 Big game habitat classifications at the Hopkins Producers reservoir sites

4. Hydrology

4.1. Introduction

Watershed hydrology was developed for the French Creek, upper North Fork of Clear Creek and upper South Rock Creek drainages in effort to determine water availability for storage in the proposed reservoir facilities. Stream discharge for wet, normal, and dry year scenarios was developed.

There are no streamflow gauging stations in the French Creek drainage, therefore estimated streamflows were based on streamflow records at hydrologically similar gaging station locations. This section describes the approaches and techniques for developing streamflow data in the study area.

4.2 Approach

USGS gaging station 06320500 South Piney Creek at Willow Park, WY was selected for use as a representative gage of annual basin discharge volume. This gage was selected because the drainage basin has similar characteristics to that of the drainage basin in the study area. Both basins have similar elevations, land cover, and precipitation zones. USGS gage 06320500 is located downstream of Willow Park reservoir and has streamflow data from 1947 to present. The streamflow at this gage is not considered natural flow due to the influence of releases from Willow Park (built 1959) and Cloud Peak (built 1896) reservoirs. USGS gage 06320500 has 10 years of streamflow data between 1947 and 1957 that was before Willow Park reservoir was constructed. After construction, the timing of releases has influenced the stream flow and gage data. USGS gage 06320500 has 33.6 square miles of drainage area contributing to it and is located at 8540 feet above sea level. Monthly mean streamflow data was analyzed. First, the monthly mean flow rate was divided by the area of the contributing watershed to result in a unit runoff (cfs/acre of drainage area). For each of the proposed reservoir sites, this unit runoff per acre value was multiplied by the drainage area of the proposed reservoir site to result in the average monthly flow at each proposed reservoir site. Next, the average monthly flow values were adjusted for average basin elevation using Loham's regression equation elevation term (Streamflows in Wyoming, USGS WRIR 88-4045, Loham). After 1971, winter flow data is not available. The missing data was filled by first calculating the percentage of annual flow discharged each month for existing data. Then, the missing monthly data was interpolated based on the known summer month discharges. The synthetic data correlates very well with the original data. The monthly average streamflow was summed to result in annual runoff volume for each reservoir's drainage basin as shown in Table 4.1. These mean annual volumes correlate very well with the regression equations developed in the USGS WRIR 88-4045. This annual volume was distributed monthly by correlating with a natural flow gage. The Powder/Tongue River Basin Water Plan selected USGS gage 06319480 South Rock Creek above Red Canyon Near Buffalo, WY to model monthly ungaged flows in French Creek at the Penrose Ditch diversion. USGS gage 06319480 has two years of data from November 1974 through September 1976. The Powder/Tongue River Basin Water Plan extended this data from 1970 to 1999. See the Power/Tongue River Basin Water Plan for a complete description of the data extension. This extended data was used to distribute annual flows on a monthly basis by multiplying the

extended monthly gaged flows from USGS 06319480 by the percentage of ungaged basin annual volume to gaged basin annual volume. This monthly distribution was used for Sites 1, 2, 3, 4, 5, and 8 and for upper North Fork of Clear Creek and South Rock Creek. Wet, normal and dry years were delineated using extended USGS gage 06319480 as an indicator gage for Sites 1, 2, 3, 4, 5, and 8 and for upper North Fork of Clear Creek and South Rock Creek. The driest 20% of years were classified as dry years, the wettest 20% of years were classified as wet years, and the remaining 60% of years were considered normal years.

Table 4.1 - Estimated Average Annual Flow at Ungaged Model Nodes

Basin	Site	Drainage Area	Mean Basin Elevation	Estimated Average Annual Runoff		USGS Regression Equ.
		sq. mi.	ft	AF	AF/sq.mi.	AF
French Ck	2	1.2	6172	260	220	243
French Ck	3	11.9	7571	4710	397	4498
French Ck	4,8	6.2	7901	2800	448	2659
French Ck	5	5.0	7982	2320	461	2200
French Ck	Penrose div	13.1	7438	4920	377	4705
South Rock Ck	6	7.1	10066	6370	901	6054
Upper N. Clear Ck	4 Lakes div	15.1	10396	14900	987	14285

4.3 Water Availability

A meeting held March 17, 2008 with the Board of Control, Water Division II in Sheridan, WY resulted in anecdotal information on water availability in the study area. In general, French Creek and South Rock Creek are not prolific sources of additional water. There could be some water available for storage in French Creek in April and May before irrigation starts. South Rock Creek is usually regulated around June 1st. Some water could be available in April and early May. There is additional water available in the North Fork of Clear Creek early in the runoff season. Snow and ice in the Four Lakes and French Creek Ditch Diversion preclude delivery of early runoff water to French Creek. If a method of delivery was installed, additional water could be delivered to French Creek for storage. The lack of streamflow gauging stations in the French Creek and upper North Fork of Clear Creek drainages induces uncertainty in the water availability determination. The analysis presented is an approximation of water availability.

Water availability was estimated using the watershed hydrology developed in the study. Water availability was developed at each potential reservoir site in effort to determine reservoir yield. Initially, irrigation depletions estimates from the spreadsheet model developed in the Powder/Tongue River Basin Water Plan were used when determining water availability at each reservoir site. The irrigation depletions were subtracted from the available water at each node. The results of this analysis indicated water availability at times we know anecdotally were not reasonable. It was then determined to estimate water availability based on historic irrigation and regulation timing. Irrigation on French Creek historically begins mid May in dry years and the beginning of June in normal years. Regulation is historically imposed the second week of June in dry years and the second week of July in normal years. Based on these timelines, water was assumed to be available for storage on French Creek in dry years during the month of April and

half of May and in normal years during the month of May. The estimated average monthly discharge of the reservoir's drainage basin less a minimum flow was assumed to be the water available for storage. Minimum flow was assumed to be the average annual flow in the reach at the reservoir site. This gives an estimate of water available for storage at each reservoir location. Additional water availability was also estimated on the North Fork of Clear Creek at the Four Lakes and French Creek Ditch Diversion and at Triangle Park on South Rock Creek. Additional water in the North Fork of Clear Creek was estimated by subtracting the current water transfer to French Creek plus a minimum flow from the estimated flow in North Fork of Clear Creek. The minimum flow was assumed to be the average annual flow in the reach at the point of diversion. The same estimates and assumptions were made on water availability in South Rock Creek. The results of the analyses are shown in Figures 4.1 though 4.16.

4.4 Site No. 3 Water Availability

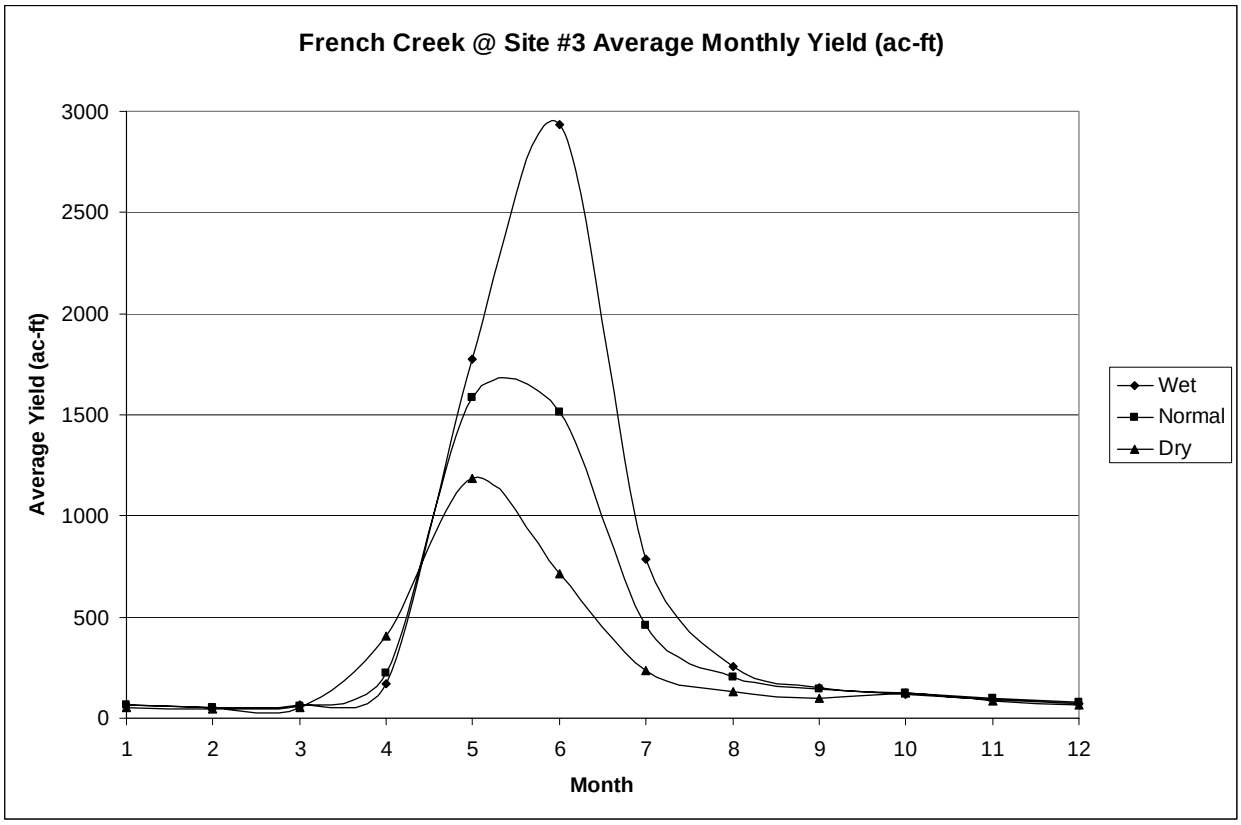


Figure 4.1 Estimated Average Monthly Yield of French Creek Drainage @ Site #3

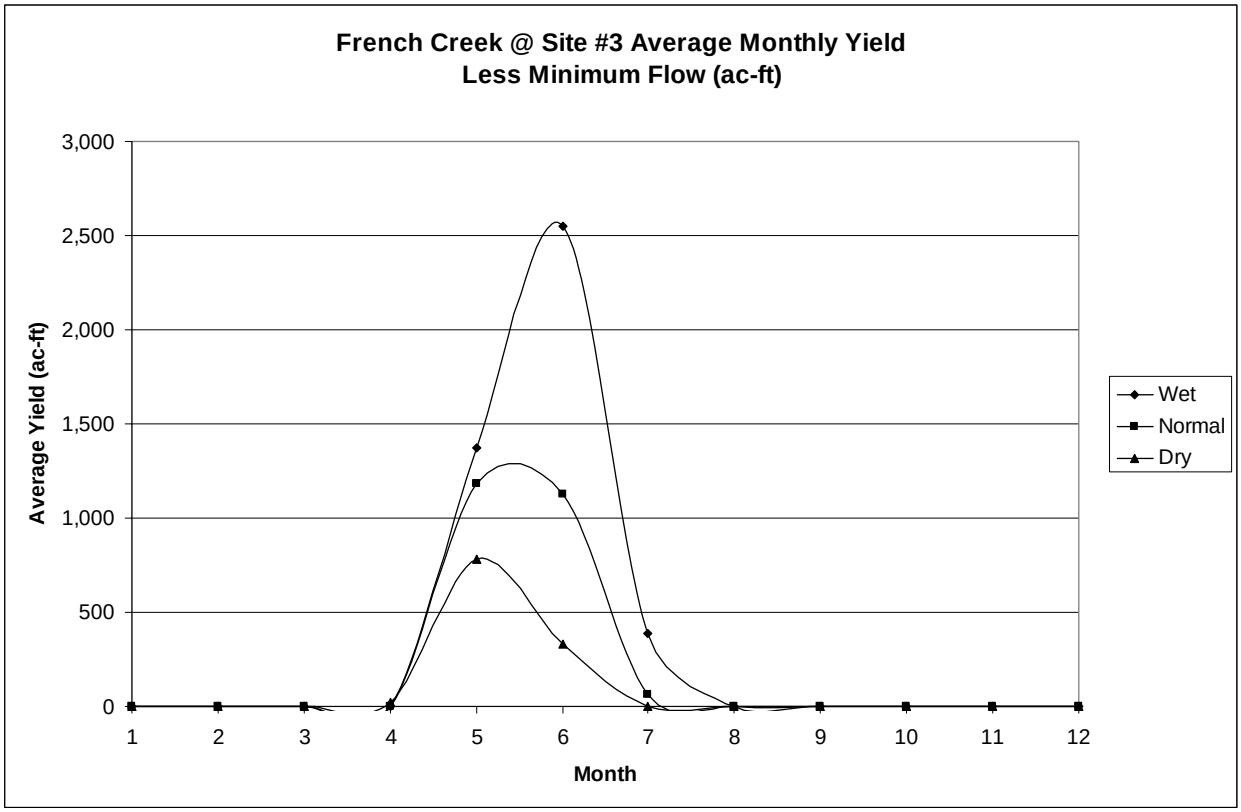


Figure 4.2 Est. avg. monthly yield of French Ck drainage @ Site #3 less minimum flow

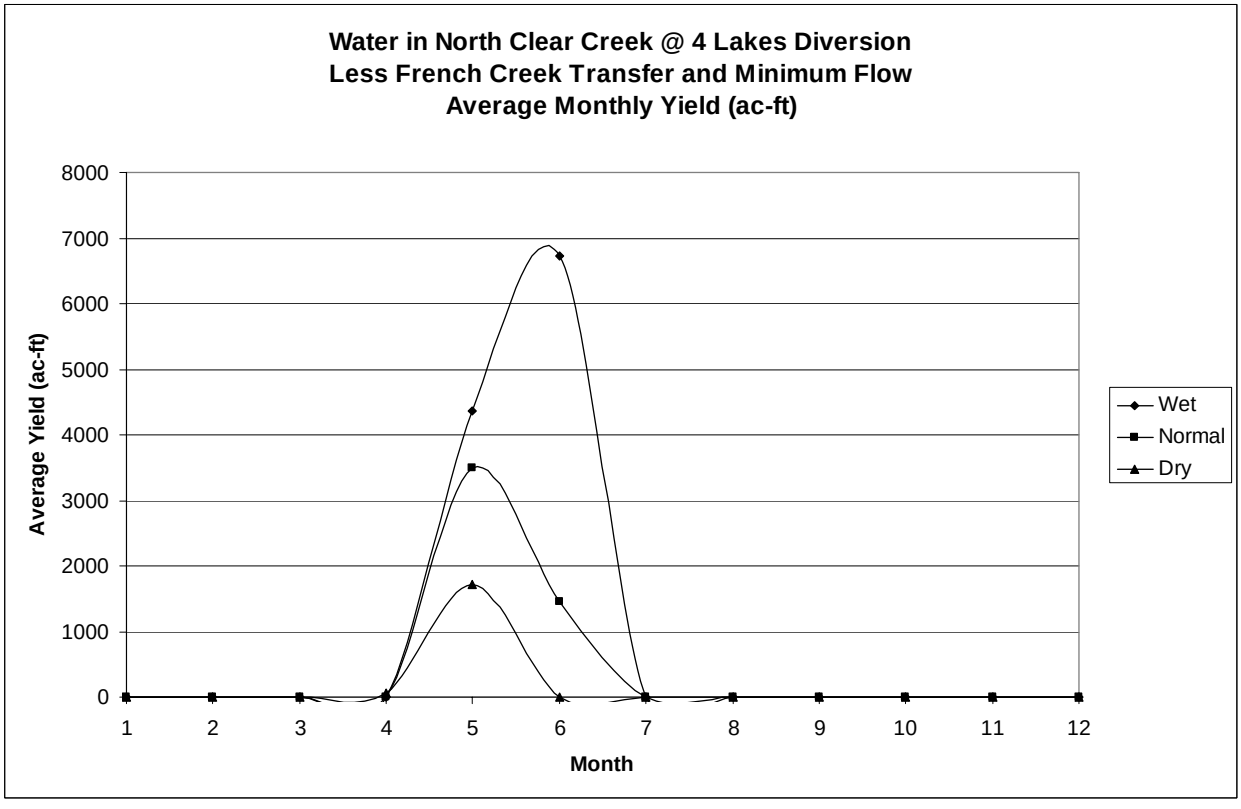


Figure 4.3 Est. avg. yield of North Clear Ck drainage @ 4 Lakes div less transfer and min. flow

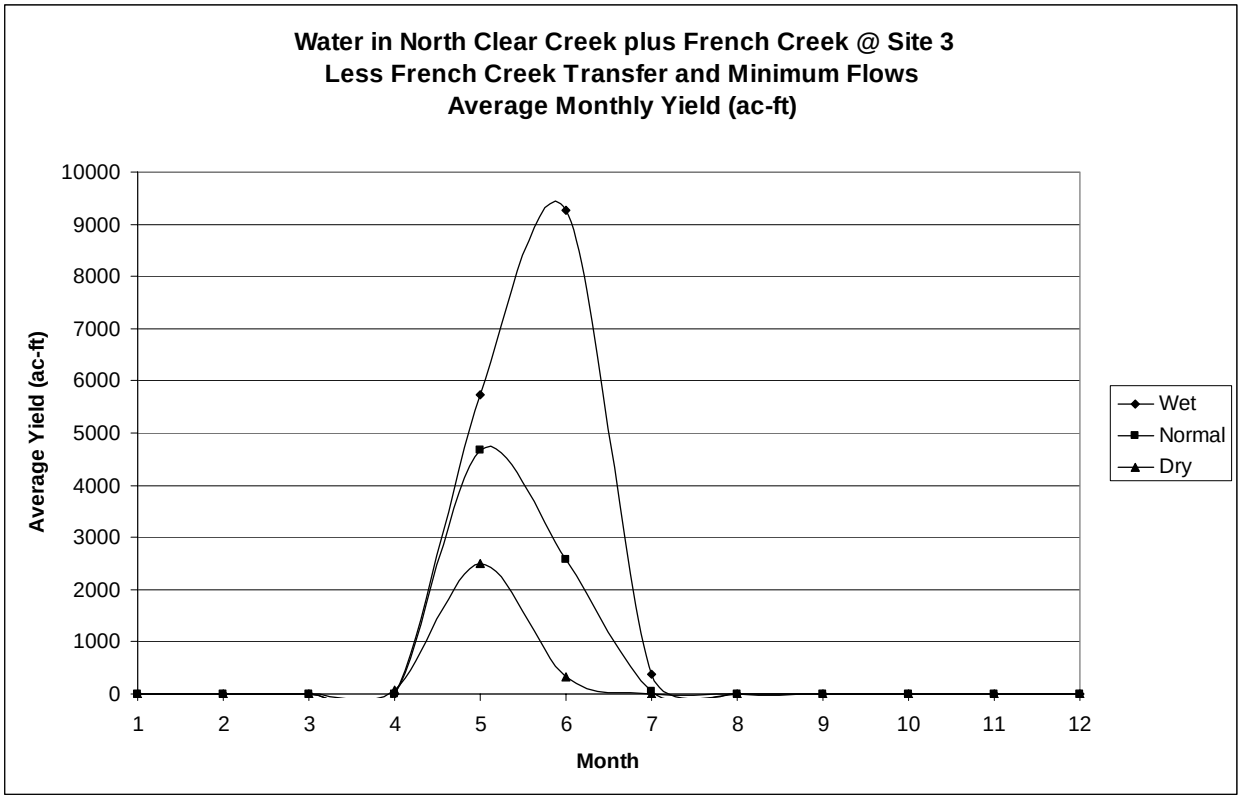


Figure 4.4 Est. avg. yield of French Ck @ Site #3 plus N. Clear Ck less min. flows and current French Ck transfer.

As shown on the previous figures, it is estimated that 1200 AF of water from French Creek could be available and stored in Site #3 during May in a normal year and 3500 AF of additional water from North Clear Creek could be available and could be transferred and stored. Approximately 400 AF of water from French Creek could be available and stored in Site #3 during April and the first half of May in a dry year, and 900 AF of additional water from North Clear Creek could be available and could be transferred and stored in a dry year.

4.5 Site No. 1 Water Availability

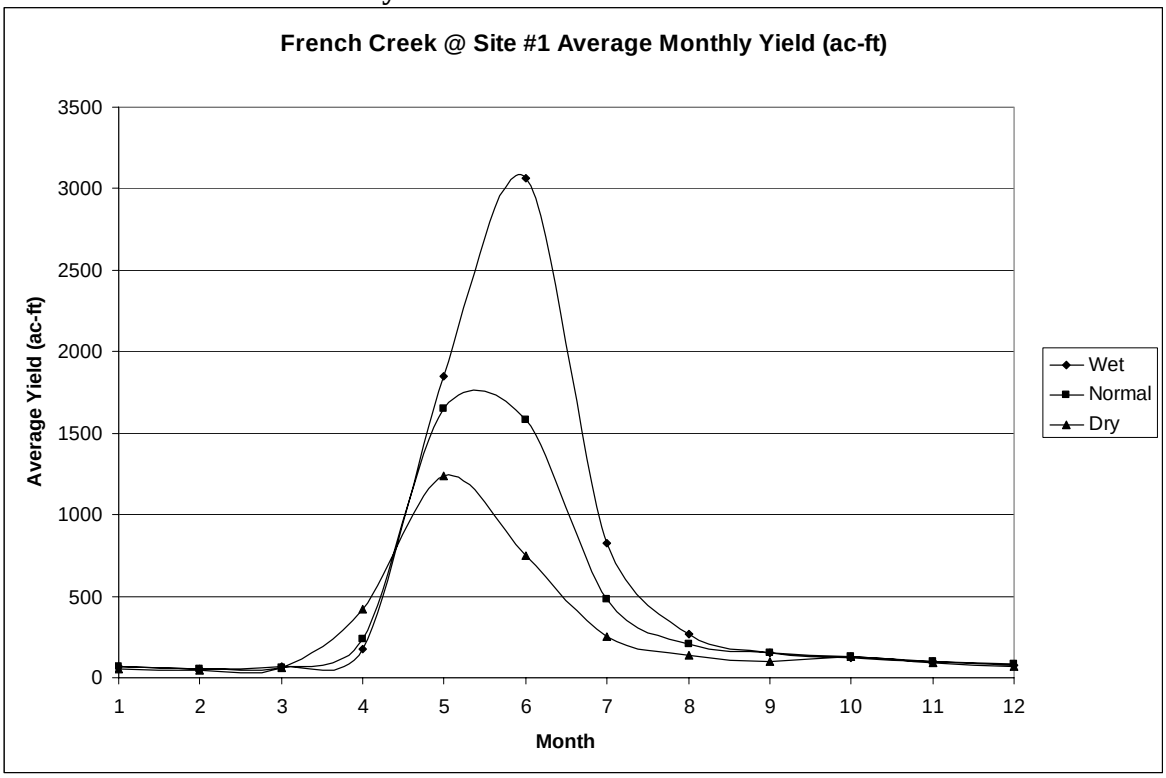


Figure 4.5 Estimated Average Monthly Yield of French Creek Drainage @ Site #1

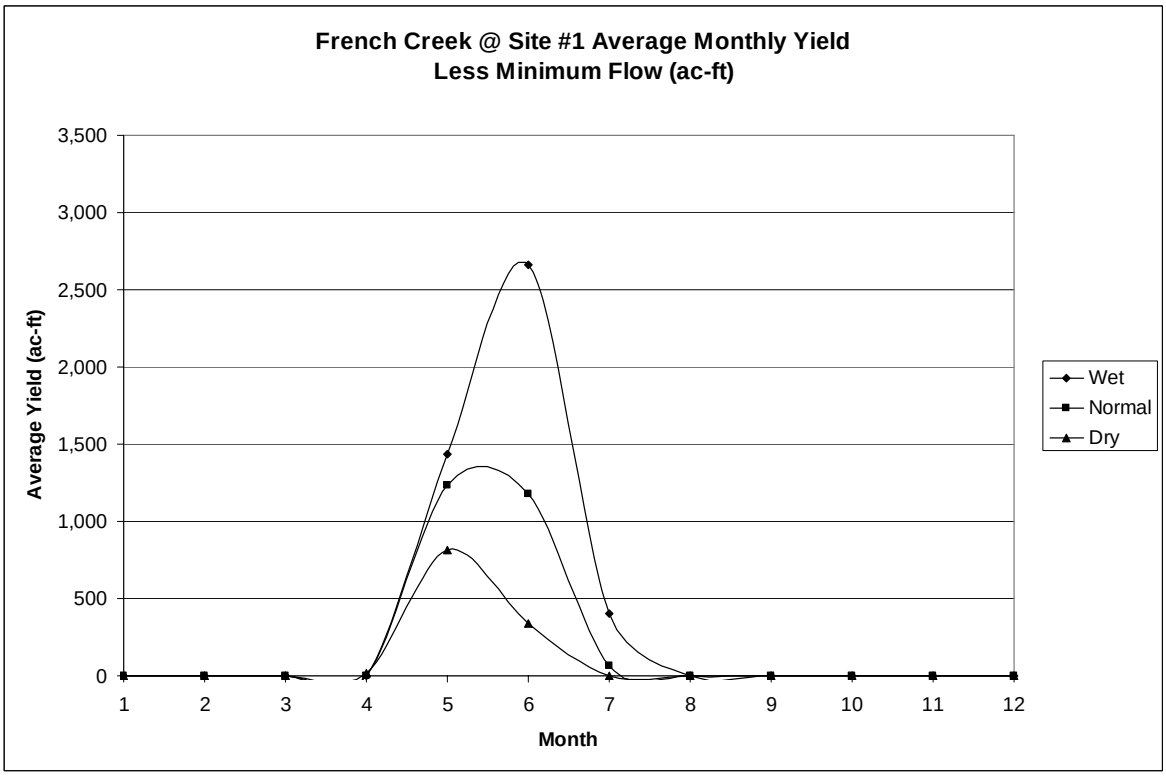


Figure 4.6 Est. avg. monthly yield of French Ck drainage @ Site #1 less minimum flow

As shown on the previous figures, approximately 1250 AF of water from French Creek could be available and stored in Site #1 during May in a normal year and approximately 450 AF of water from French Creek could be available and stored in Site #1 during April and the first half of May in a dry year.

4.6 South Rock Creek (Site 6) Water Availability

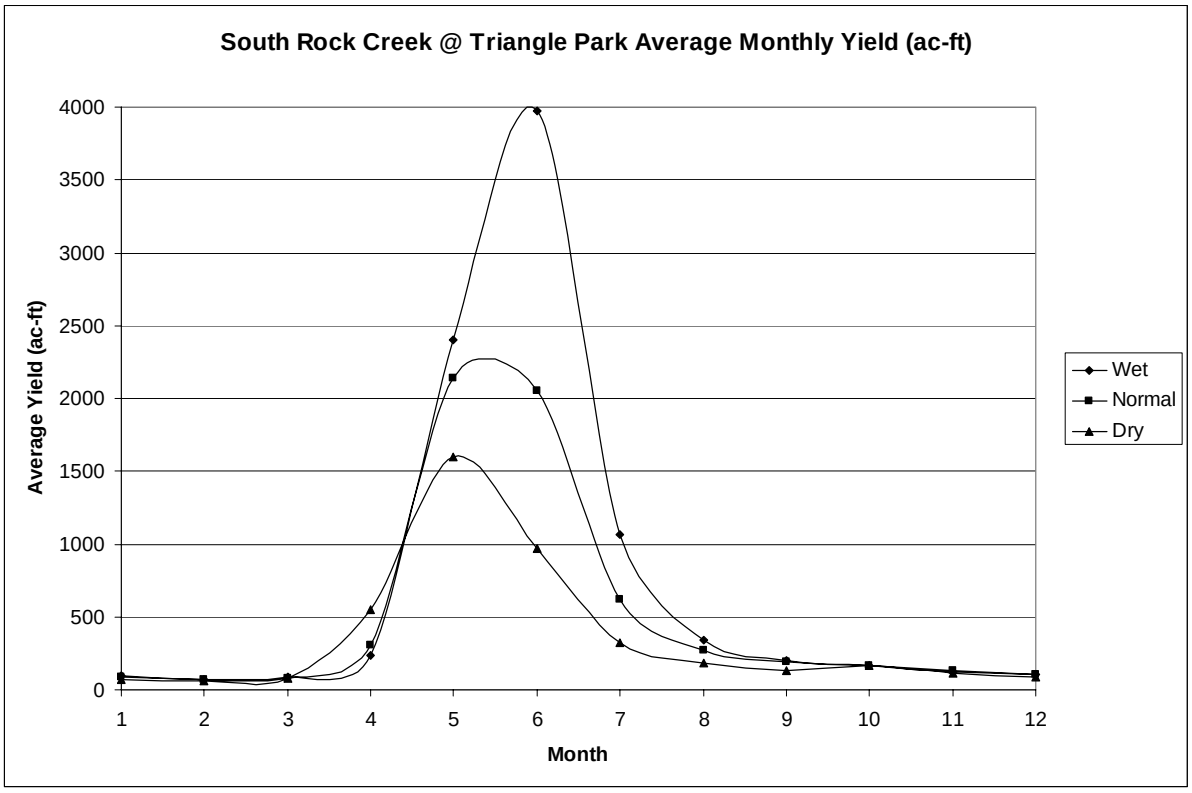


Figure 4.7 Estimated Average Monthly Yield of South Rock Creek Drainage @ Triangle Park

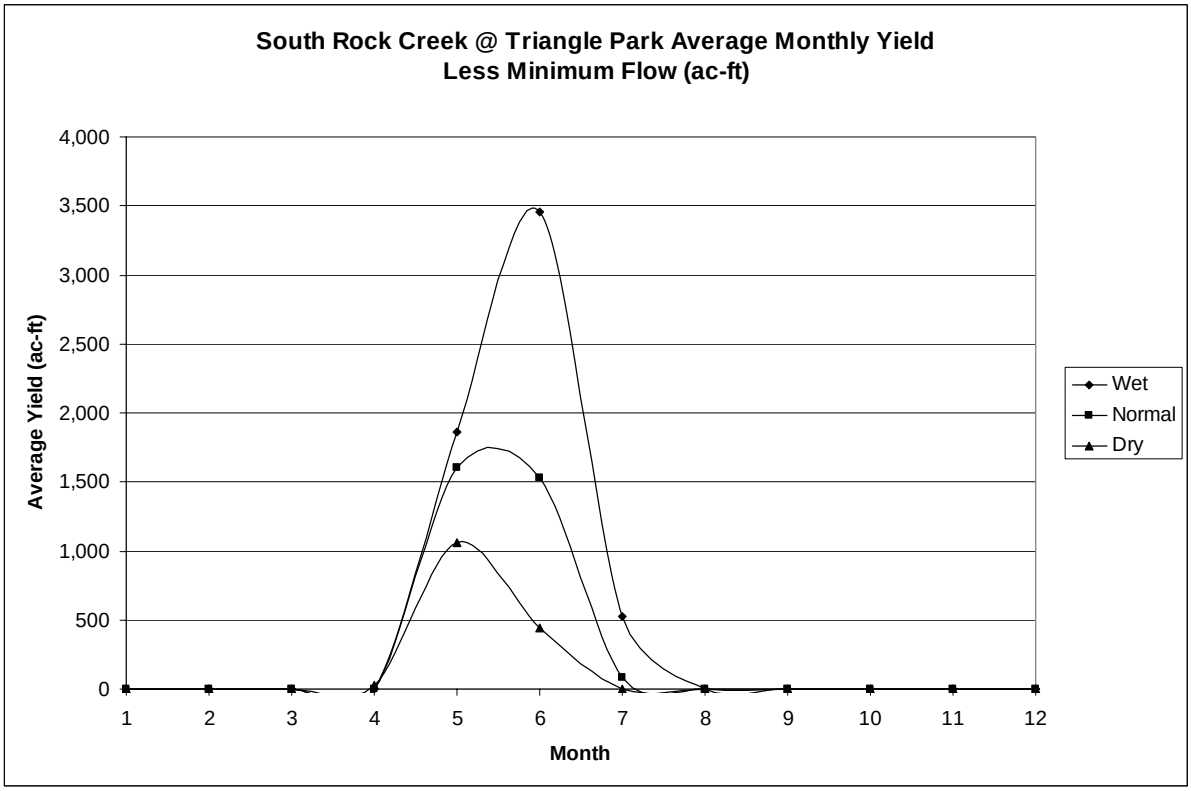


Figure 4.8 Est. avg. monthly yield of South Rock Ck drainage @ Triangle Park less minimum flow

As shown on the previous figures, approximately 1600 AF of water from South Rock Creek could be available and transferred to North Clear Creek and transferred to French Creek during May in a normal year and approximately 550 AF of water from South Rock Creek could be available and transferred during April and the first half of May in a dry year. Anecdotally, the Board of Control, Water Division II indicated there was not much water available in South Rock Creek.

4.7 North Fork of Clear Creek @ Four Lakes Diversion Water Availability

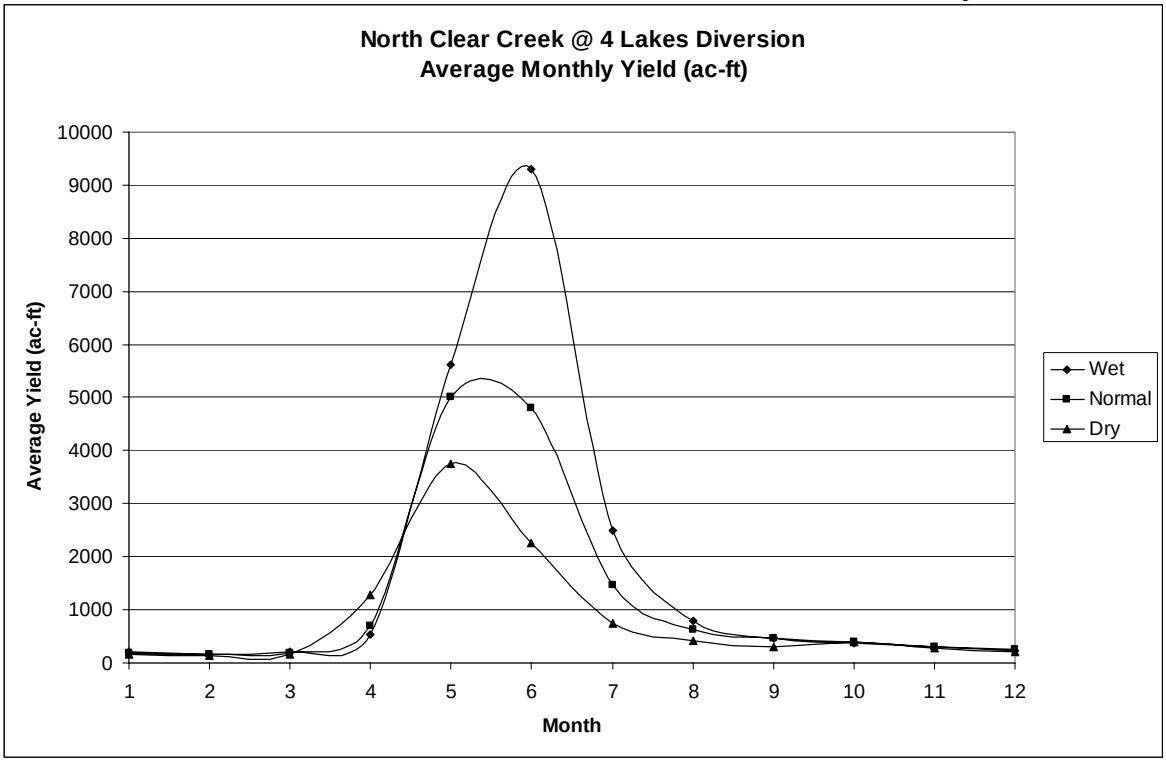


Figure 4.9 Estimated Average Monthly Yield of North Clear Ck Drainage @ 4 Lakes Div

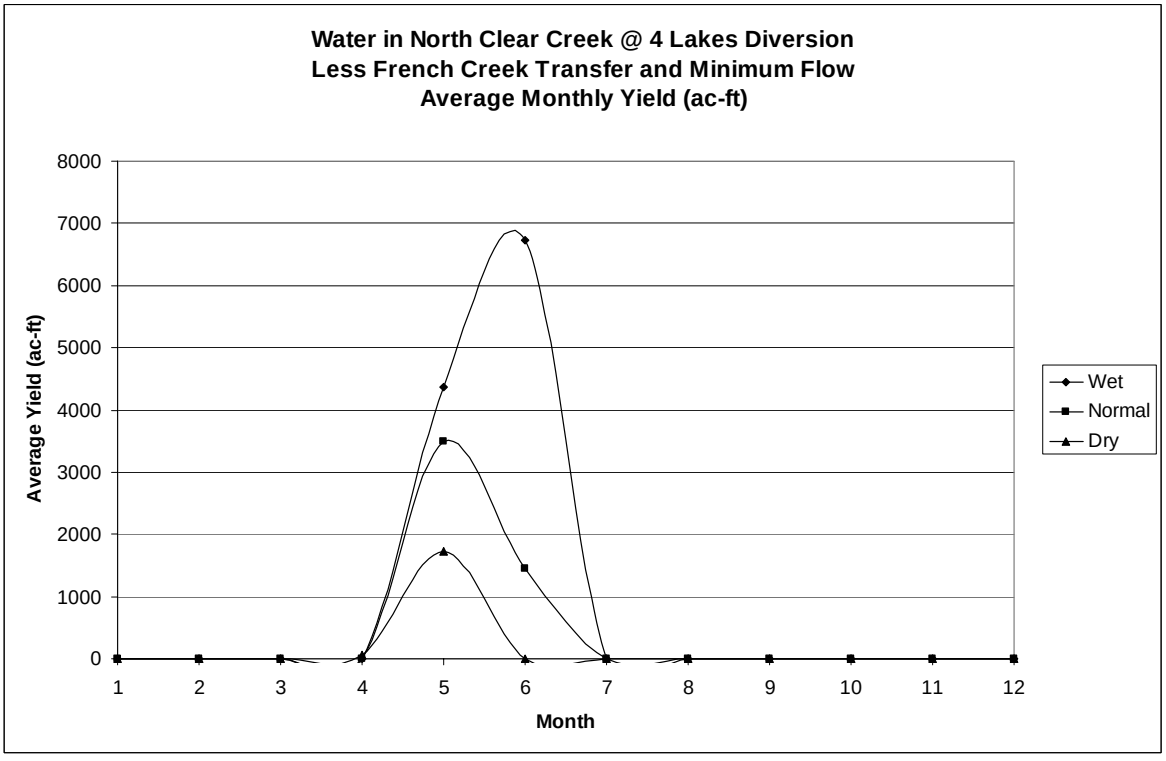


Figure 4.10 Est. avg. yield of North Clear Creek drainage @ 4 Lakes diversion less transfer to French Ck and minimum flow

As shown on the previous figures, approximately 3500 AF of water from the North Fork of Clear Creek could be available and transferred to French Creek during May in a normal year and approximately 900 AF of water from the North Fork of Clear Creek could be available and transferred during April and the first half of May in a dry year.

4.8 Site No. 5 Water Availability

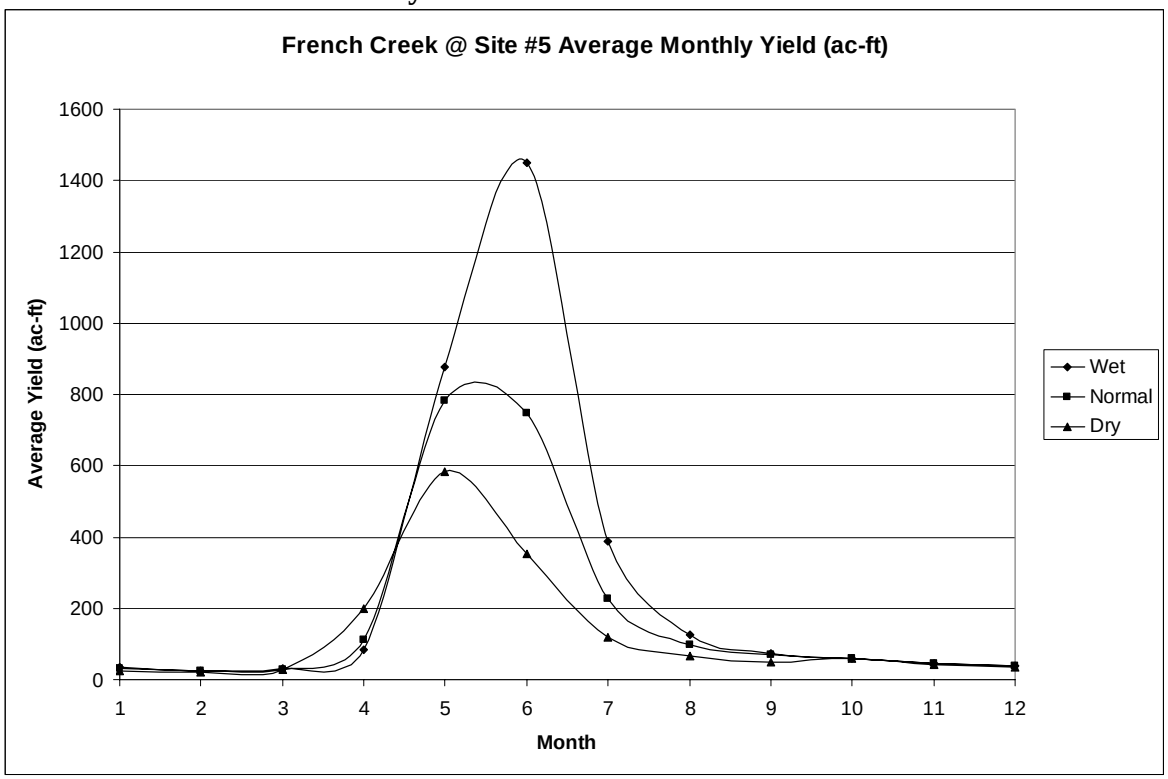


Figure 4.11 Estimated Average Monthly Yield of French Creek Drainage @ Site #5

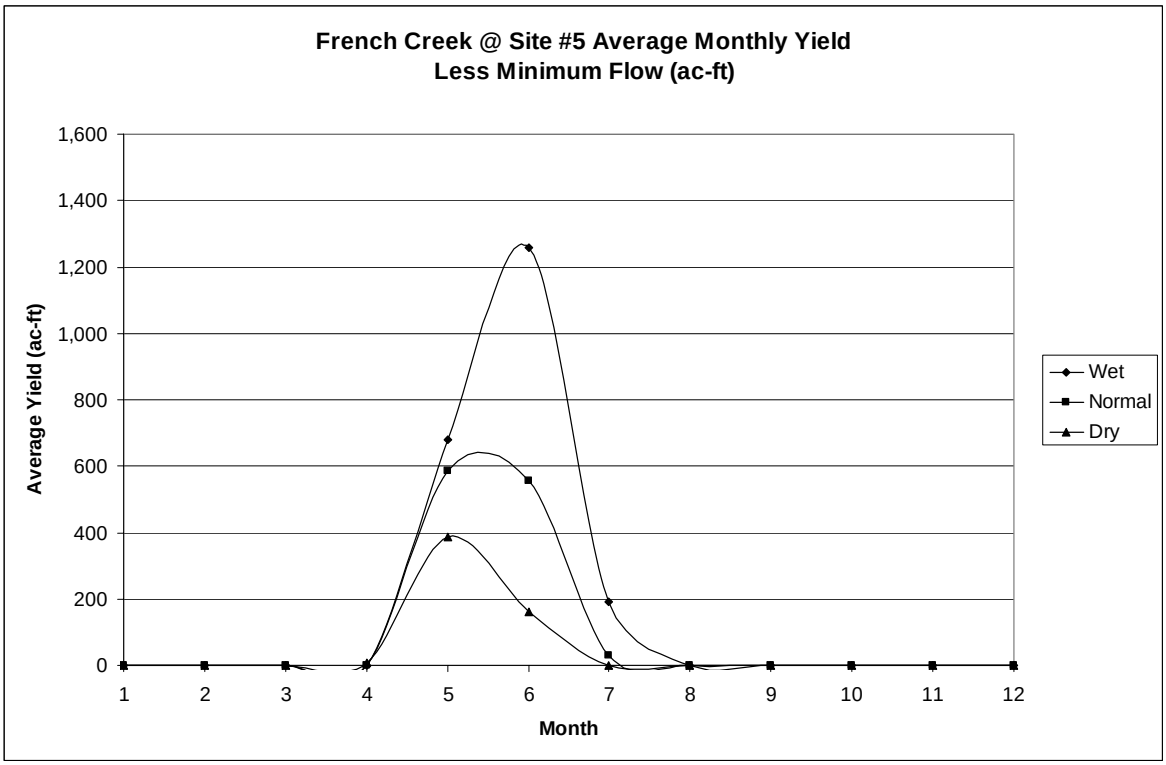


Figure 4.12 Est. avg. monthly yield of French Ck drainage @ Site #5 less minimum flow

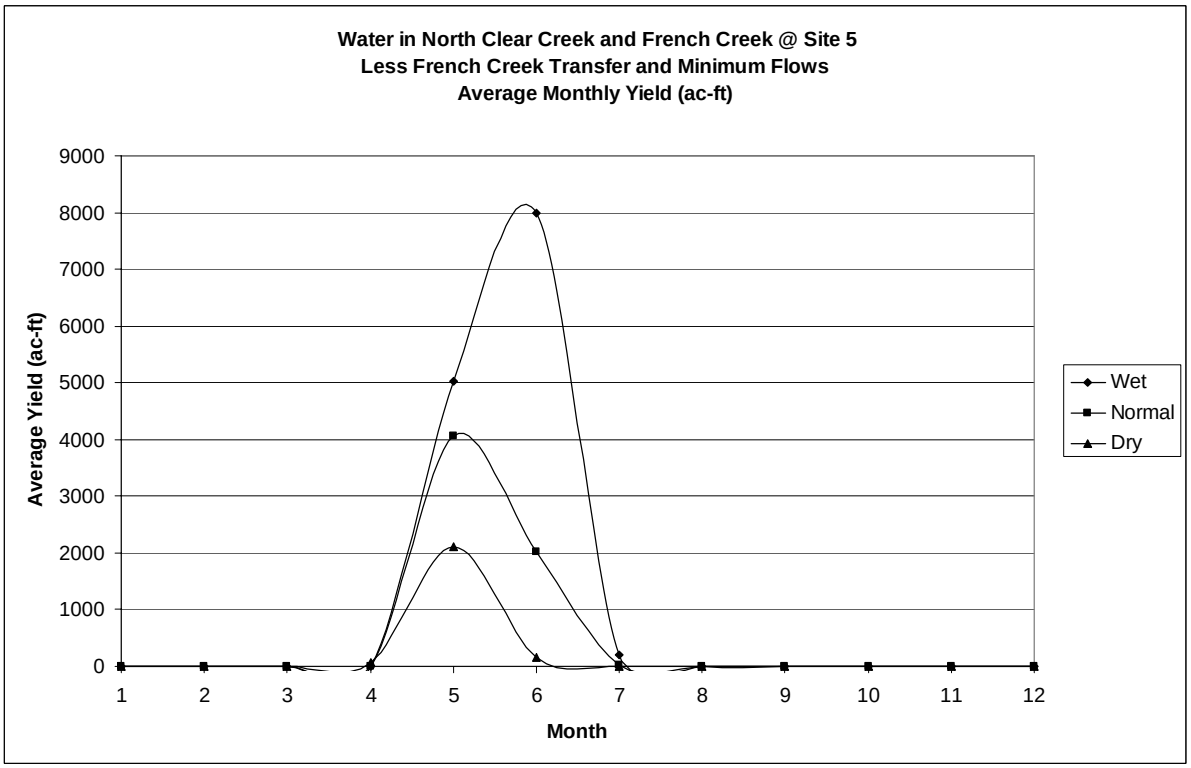


Figure 4.13 Est. avg. yield of French Ck @ Site #5 plus N. Clear Ck less min. flows and current French Ck transfer.

As shown on the previous figures, 600 AF of water from French Creek could be available and stored in Site #5 during May in a normal year and 3500 AF of additional water from North Clear Creek could be available and could be transferred and stored. Approximately 200 AF of water from French Creek could be available and stored in Site #5 during April and the first half of May in a dry year, and 900 AF of additional water from North Clear Creek could be available and could be transferred and stored in a dry year.

4.9 Site No. 4 & 8 Water Availability

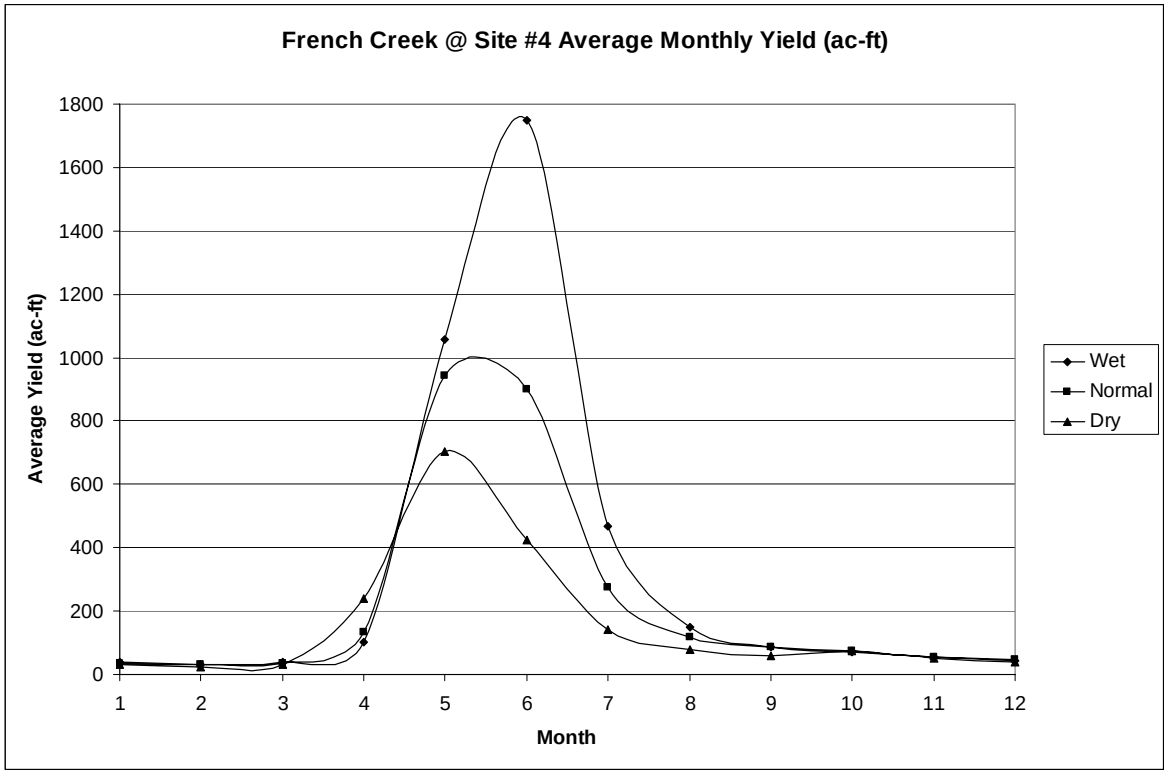


Figure 4.14 Estimated Average Monthly Yield of French Creek Drainage @ Site #4

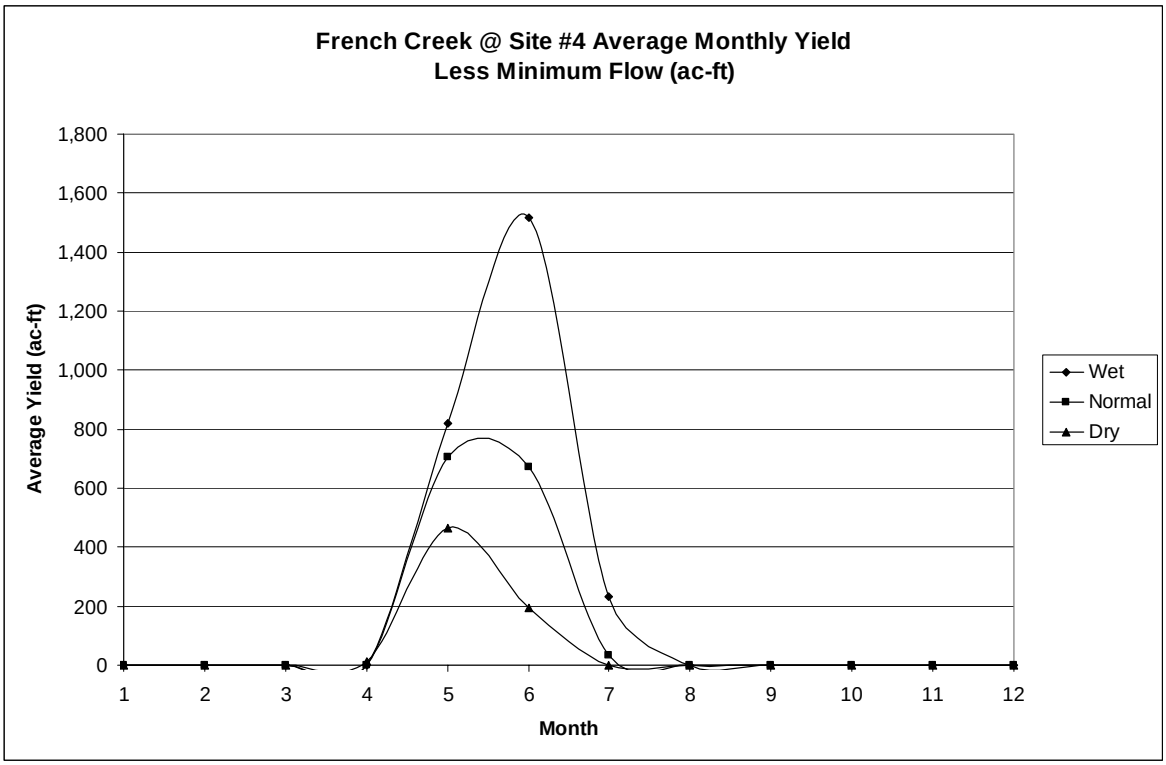


Figure 4.15 Est. avg. monthly yield of French Ck drainage @ Site #4 less minimum flow

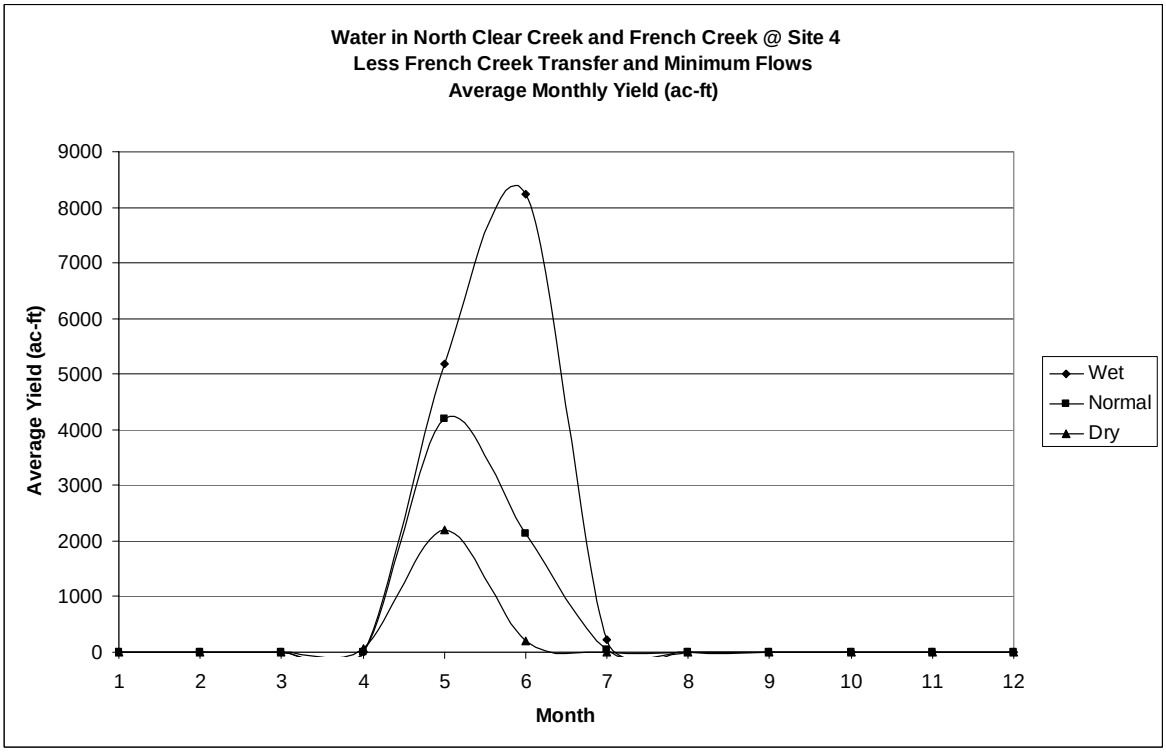


Figure 4.16 Est. avg. yield of French Ck @ Site #4 plus N. Clear Ck less min. flows and current French Ck transfer.

As shown on the previous figures, 700 AF of water from French Creek could be available and stored in Site #4 or Site #8 during May in a normal year and 3500 AF of additional water from North Clear Creek could be available and could be transferred and stored. Approximately 250 AF of water from French Creek could be available and stored in Site #4 or Site #8 during April and the first half of May in a dry year, and 900 AF of additional water from North Clear Creek could be available and could be transferred and stored in a dry year.

The lack of streamflow gauging stations in the French Creek and upper North Fork of Clear Creek drainages induces uncertainty into the water availability analysis; therefore a range of water availability is given for dry, normal, and wet years as shown in Table 4.2. The upper end of the range of water availability estimates were determined based on the previously described assumptions and correlations with gage data from other basins, and the lower end of the range of water availability estimates were determined based on uncertainty in the analysis.

Table 4.2 - Water Availability (Acre-Feet per year)

Yield (AF)	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6 (South Rock Creek)	Site 7	Site 8	North Clear Creek
Dry Year	200-450	200-400	200-400	100-250	100-200	300-550	300-550	100-250	500-900
Normal Year	900-1250	900-1200	900-1200	300-700	300-600	1000-1600	1000-1600	300-700	2800-3500
Wet Year	1100-1450	1100-1400	1100-1400	400-800	400-700	1100-1850	1100-1850	400-800	3500-4300

4.10 Needs

Anecdotally, the Hopkins Producers ID indicated a need in dry years for 13cfs for 45 days. This computes to 1160 AF of water. The Powder/Tongue River Basin Water Plan indicates shortages during dry, normal, and wet year hydrologic conditions. The basin plan indicates shortages on French Creek at 1200, 430, and 200 AF for dry, normal, and wet years respectively. The basin plan indicates shortages on Johnson Creek at 4839, 3003, 2217 AF for dry, normal, and wet years respectively. The basin plan indicates shortages on Clear Creek above Buffalo at 4839, 3003, 2217 AF for dry, normal, and wet years respectively. Estimates of need should be further defined with additional stream flow gauging. With additional stream flow gauging, modeling can further the refinement of shortages estimates. Storage on French Creek could supply water to supplement these needs. Site #1 could help supplement the needs of irrigators on French Creek and the Hopkins Producers Irrigation District. Sites #2,3,4,5, and 8 could help supplement the needs of not only the irrigators on French Creek but also needs in the greater Clear Creek watershed.

4.11 Future Stream Gaging

To advance a potential reservoir site in the French Creek basin, stream flow data would need to be collected and refinements would need to be made to the reservoir hydrology. Stream flow gages on the North Fork of Clear Creek near the Four Lakes and French Creek diversion and on French Creek at the Forest Service boundary would be two logical locations for further study of water availability and needs.

5. North Fork of Clear Creek Diversion Rehabilitation

5.1 Introduction

The existing Four Lakes and French Creek Ditch Diversion diverts water by gravity from the North Fork of Clear Creek to French Creek. This system diverts an average of 7773 AF per year with historic maximum of 12,409 AF and minimum of 2088 AF. The average first diversion is June 7 with historic extremes of May 7 to July 13. The system has an approximate capacity of 75 cfs. The average shut off date is September 23 with historic extremes of August 1 to September 30.

The diversion system consists of the head gate with two steel gates, a parshall measurement flume, and an approximately 5000 foot long ditch to French Creek.

Preliminary hydrology has indicated the availability of additional water from the North Fork of Clear Creek. This water could be transferred and stored in a reservoir facility on French Creek. This system, to capture additional water, would require modification to the existing facilities including a water right enlargement. Preliminary design and cost estimates of these modifications have been developed.

5.2 Water Supply

Preliminary hydrology has indicated the availability of additional water from the North Fork of Clear Creek. This additional water could be transferred to French Creek and stored in a reservoir facility on French Creek. The hydrological analysis estimated the additional divertable flows in the North Fork of Clear Creek at the Four Lakes Diversion for dry, average, and wet years as shown below:

	North Fork of Clear Creek
Dry Years	500-900 AF
Average Years	2800-3500 AF
Wet Years	3500-4300 AF

5.3 Preliminary Design

A concrete diversion structure, new headgate, wasteway, and flow measurement device could be constructed as shown on Figures 5.1 and 5.2. Snow and ice keeps the existing ditch inoperable until early May when a minimum flow is diverted to clear the ditch. A pipeline from the diversion to French Creek is proposed to allow early diversions if water is available. The system capacity would be increased to take advantage of larger available flows in normal and wet years. The diversion would discharge to a 36” pipeline to convey a maximum of 140 cfs 5000 feet to the French Creek drainage. A stream gauge should be installed on North Clear Creek near the diversion to keep record of flows.

5.4 French Creek Channel Erosion Control / Rehabilitation

The French Creek channel has demonstrated erosion problems currently due to the introduced flows from the North Fork of Clear Creek. With increased flows, the erosion issues would be increased as discussed in Section 3.3. In addition, stream losses at a potential storage facility would require mitigation. It is proposed to rehabilitate and protect the French Creek channel from the North Fork diversions to the reservoir site. Figure 5.3 shows a typical detail of a boulder drop structure used to reduce channel slope, provide stream bed grade control, and create a pool for enhancement of aquatic habitat. Where bank stabilization is required, structural protection may be best suited along the toe of the slopes while bioengineering protection may be more appropriate along the upper slopes of the bank. Long-term stability is often facilitated by the integration and placement of both structural and bioengineered stability measures.

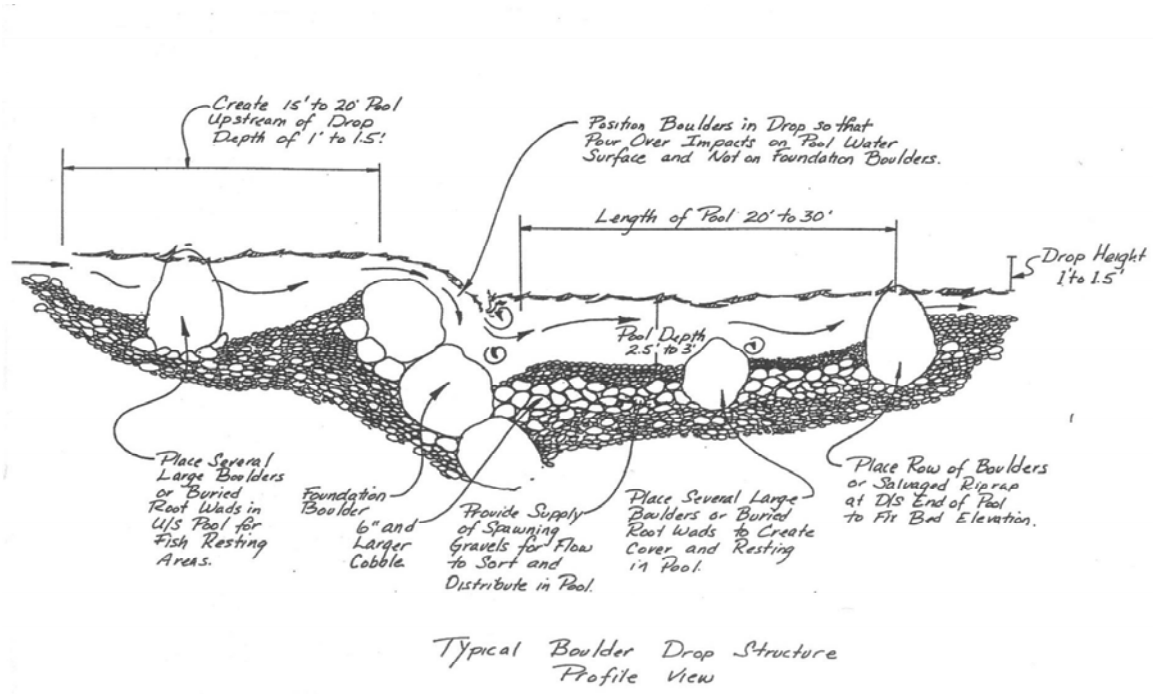


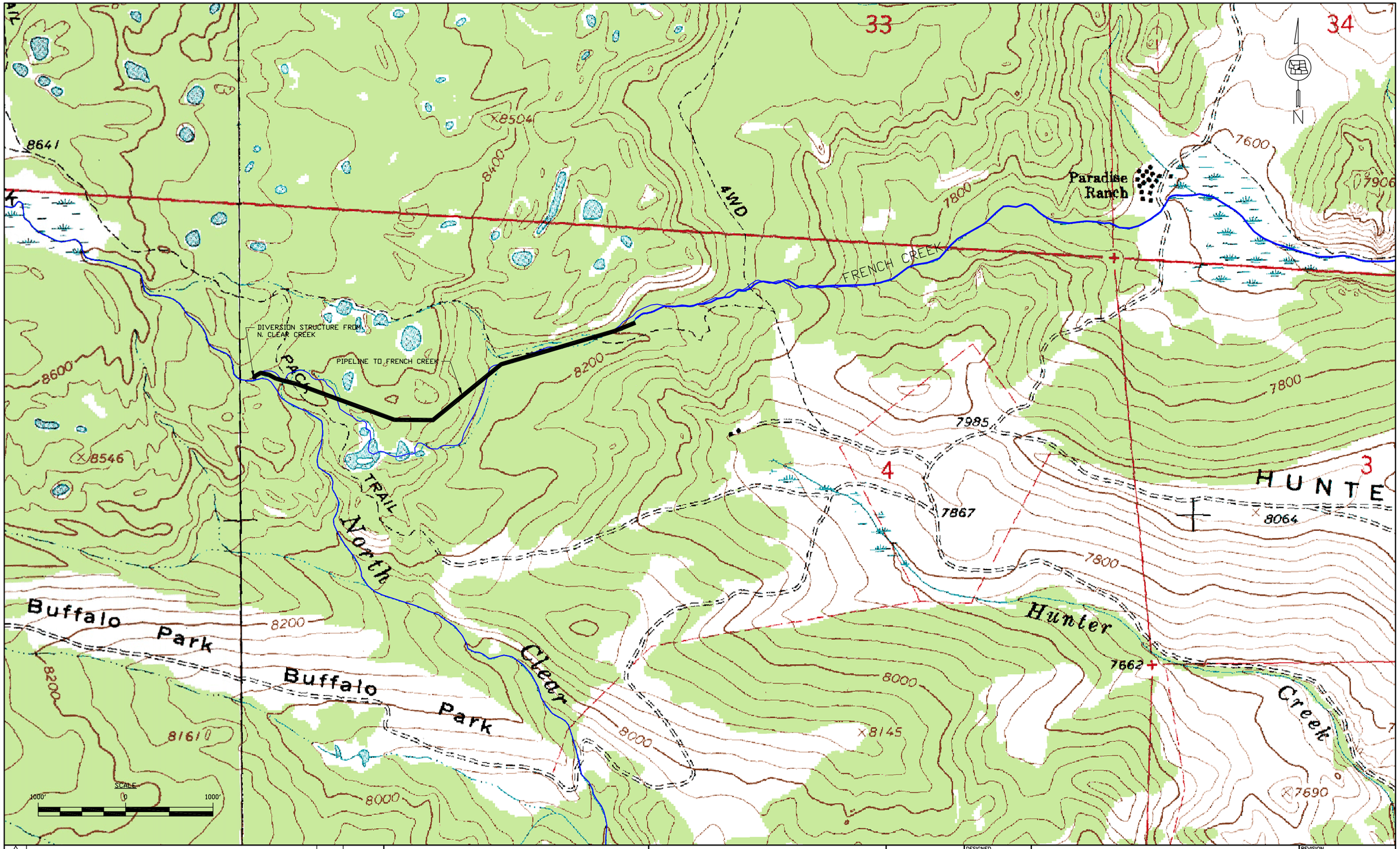
Figure 5.3 – Typical Boulder Drop Structure

5.5 Cost Estimates

A preliminary construction cost estimate was developed for the North Fork of Clear Creek water supply to French Creek. The cost estimate was developed utilizing the standard format and is shown on Table 5.1. The estimated construction cost for the system is approximately $2.4 million.

Table 5.1 - N. Clear to French Creek Pipeline and Diversion

No.	Item	Units	Estimated Quantity	Unit Cost	Cost
1	Clearing	Ac.	10	$2,000.00	$20,000
2	Diversion Structure	L.S.	--	--	$200,000
3	Flow Meter	L.S.	--	--	$50,000
4	Stream Gauge	L.S.	--	--	$50,000
5	36" Pipeline	L.F.	5,000	$200.00	$1,000,000
6	Energy Disipation Structure	L.S.	--	--	$50,000
7	Stream Stabilization on French Ck.	E.A.	40	$25,000.00	$1,000,000
8	Revegetation	Ac.	10	$2,000.00	$20,000
				Construction Cost:	**$2,390,000**



1	PRELIMINARY DESIGN	DWW	07/08
REV	DESCRIPTION OF REVISION	BY	DATE

FILE NAME: SITE 3
SCALE: 1"=300'
OPERATOR: DWW
DATE: 07/08
PROJECT NO.: 522-WY
TASK NO.: 001-263
LOCATION: BUFFALO, WY
PROJECT: HOPKINS STORAGE
SEND TO: VICTOR E. ANDERSON
PHONE: (307) 634-7848

STATES WEST WATER RESOURCES CORPORATION

1904 E. 15th STREET
CHEYENNE, WYOMING 82001
(307) 634-7848
FAX: (307) 634-7851

WARNING

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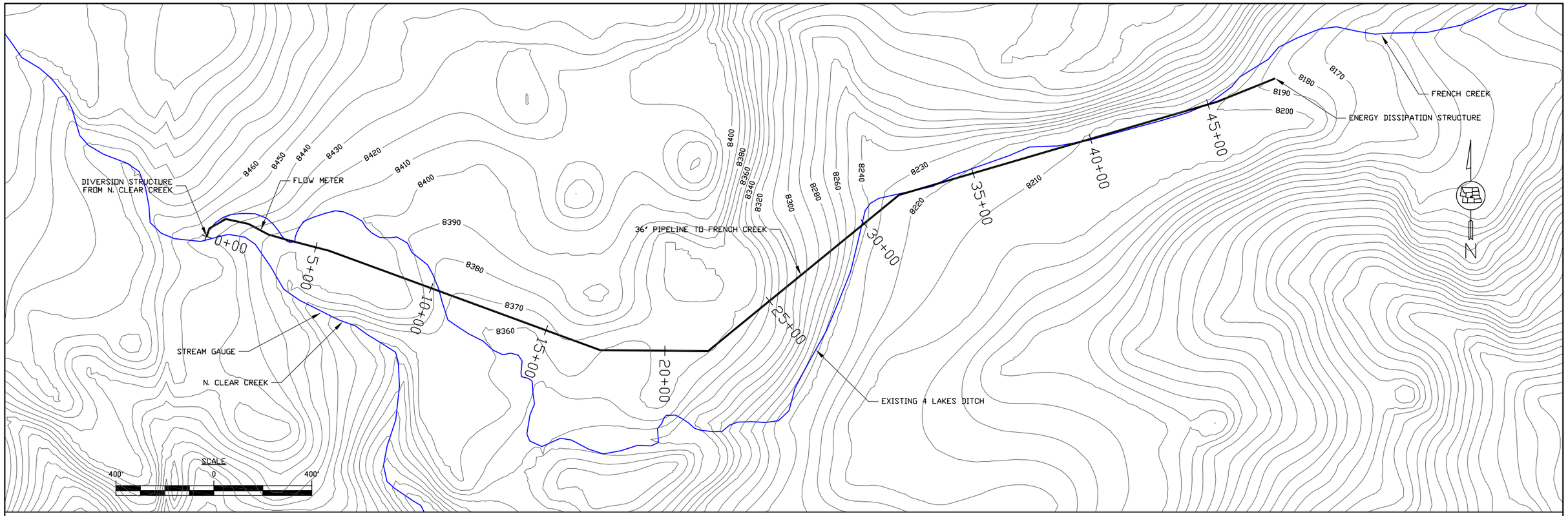
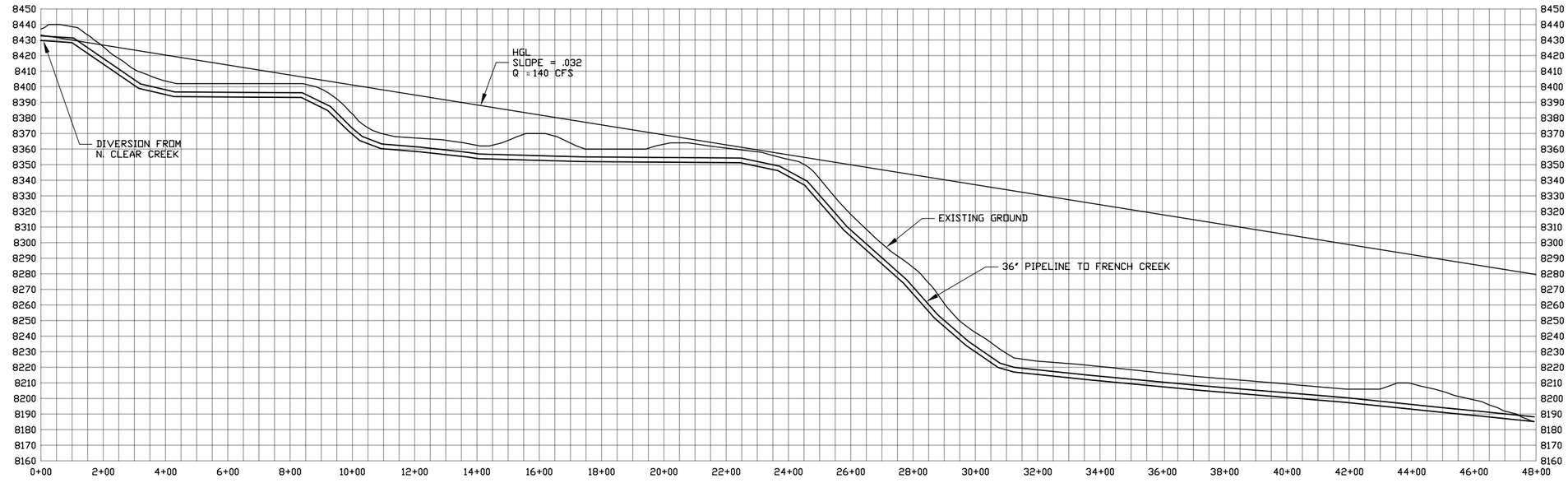
DESIGNED	DWW
DRAWN	DWW
CHECKED	VEA
PEER REVIEWED	VEA
PROJECT MANAGER	VEA
DATE	07/08

HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 5.1
NORTH CLEAR CREEK DIVERSION SITE PLAN

REVISION	1
PROJECT	522-WY
DRAWING	5-3





SCALE
400' 0 400'

DIVERSION AND PIPELINE FROM N. CLEAR CREEK TO FRENCH CREEK

FILE NAME: SITE 3
SCALE: 1"=300'
OPERATOR: DWW
DATE: 07/08
PROJECT NO. 522-WY
TASK NO. 001-283
LOCATION: BUFFALO, WY
PROJECT: HOPKINS STORAGE
SEND TO: VICTOR E. ANDERSON
PHONE: (307) 634-7848

REV	DESCRIPTION OF REVISION	BY	DATE
1	PRELIMINARY DESIGN	DWW	07/08

STATES WEST WATER RESOURCES CORPORATION
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DRAWN	DWW
CHECKED	VEA
PEER REVIEWED	VEA
PROJECT MANAGER	VEA
DATE	07/08

HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 5.2
NORTH CLEAR CREEK
DIVERSION AND PIPELINE

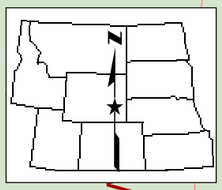
REVISION 1
PROJECT 522-WY
DRAWING 5-4

6. Water Storage Site Evaluation

Potential reservoir sites were identified and evaluated in the French Creek, upper North Clear Creek, and South Rock Creek watersheds. Field reconnaissance investigations were conducted August 21 and 22, 2007. Greg Johnson with Western EcoSystems Technologies evaluated wetland and riparian impacts and other environmental concerns associated with each reservoir site. Harold Hollingsworth with Hollingsworth Associates evaluated the geotechnical aspects of each reservoir site. Estimates were made based on visual assessment of foundation conditions and borrow material availability. Other party members of the field reconnaissance were Victor Anderson and Dylan Wade with States West Water Resources Corp., Steve Muth with the Wyoming Water Development Commission, George Mathes and Dave Hall with the Hopkins Producers Irrigation District, and Dan Scaife with the National Forest Service.

Sites were identified based on their ability to serve the needs of the Hopkins Producers ID and other needs in the watershed. Sites were identified in both on and off channel locations at topographically optimal locations, in locations where water is available for storage, and in locations where environmental impacts could be minimized and environmental improvements could be made. A range of sites were developed. Multiuse projects that promote not only agriculture but also recreation, environmental, and municipal benefits were explored. Sites No. 1 and 2 are single purpose sites that could serve irrigation benefits to the Hopkins Producers ID and other irrigators on lower French Creek. All other sites identified are considered multipurpose projects serving multiple benefits to a range of users.

Eight reservoir sites were identified and are shown on Figure 6.1. Sites No. 1, 3, 4, 5, 6, and 8 were evaluated in this reconnaissance level study and are discussed below. Site No. 2 and No. 7 were dropped from further consideration during the field reconnaissance for reasons discussed below. Tables 6.1 and 6.2 and the end of this section display information about each potential reservoir site.



1:50,000

R 84 W

R 83 W

6

7

French Cr

5

4

8

3

2

1

Upper Clear Cr

Clear Cr

16

EXPLANATION

WATERSHED BOUNDARY

LAND OWNERSHIP

FEDERAL AGENCY PROTECTIVE WITHDRAWL (USFS)

PATENTED

STATE OF WYOMING

U.S. BUREAU OF LAND MANAGMENT

U.S. FOREST SERVICE

WATER

WYOMING GAME AND FISH DEPT.

Irrigated Lands

2.5 1.25 0 2.5 Miles

FIGURE 6.1
POTENTIAL
RESERVOIR SITES

Table 6.1 - Potential Reservoir Storage Sites Matrix

Site Name	1	2	3 RCC	3 Earth	4
Location	Off Channel	Off Channel	On Channel French Ck	On Channel French Ck	On Channel French Ck
Legal Description	23, T51N, R83W	34, T51N, R83W	32, T51N, R83W	32, T51N, R83W	36, T51N, R84W
Size (AF)	230, 500, 965	4000	3500, 6000	3000, 5500, 7500, 10000	3200+
Average Annual Yield	230, 465, 850	2500	2230, 3630	1950, 3350, 4000, 4000	-
Irrigated Acres Supplied	HPID, lower Clear Ck	HPID, lower Clear Ck	HPID, French Ck, Clear Ck, Johnson Ck, lower Rock Creek	HPID, French Ck, Clear Ck, Johnson Ck, lower Rock Creek	HPID, French Ck, Clear Ck, Johnson Ck, lower Rock Creek
Uses	Ag Irrigation	Ag Irrigation	Ag Irri., Municipal, Environmental, Recreation	Ag Irri., Municipal, Environmental, Recreation	Ag Irri., Municipal, Environmental, Recreation
Dam Type	Earth Embankment	-	RCC	Earth Embankment	RCC or Earth Embank
Borrow Material Availability	available onsite	-	available onsite	Rock avail, fine grain unknown	Rock avail, fine grain unknown
Dam Height	60-100	160	170, 210	190, 230, 250, 280	120
Crest Elevation	5358, 5378, 5400	5800	6200, 6240	6200, 6240, 6260, 6290	7200
Crest Length	700	1250	880, 1000	880, 1000, 1100, 1240	740
Crest Width	30	-	20	48, 56, 60, 66	-
Embankment Volume (CY)	175k, 300k, 475k		300k, 470k	2200k, 3500k, 4500k, 5700k	-
Design Flood	-	PMF	PMF	PMF	PMF
Peak Flood Flow (cfs)	-	8000	14150	14150	9100
Flood Volume (AF)	-	550	3050	3050	1650
Drainage Area (sq-mi)	0.1	1.2	11.9	11.9	6.2
Mean Basin Elevation		6172	7571	7571	7901
Reservoir Supply	Rehabed Moeller No. 3 ditch, French Creek	4000' supply canal, French Creek	N. Clear Creek & French Ck enlarge and pipe 4 Lakes div	N. Clear Creek & French Ck enlarge and pipe 4 Lakes div	N. Clear Creek & French Ck enlarge and pipe 4 Lakes div
Outlet Works	control gate on upstream face	-	Multilevel intake	Multilevel inclined intake	-
Spillways	Earth	-	Section in dam	Excavate around left abutment	-
Land Ownership	Private	Private	Forest Service	Forest Service	Forest Service
Cultural/Archaeological impacts	est. minimal	est. minimal	Mining site, historic road	Mining site, historic road	est. minimal
Wetlands impacts (ac)	~0.7	est. minimal	<0.5	<0.5	<1.0
Riparian impacts	none	some	some	some	some
Endangered Species	none	none	none	none	none
Threatened Species	occur in area	occur in area	occur in area	occur in area	occur in area
Big Game impacts	none	elk crucial winter range	elk crucial winter range	elk crucial winter range	elk crucial winter range
Project Cost ($)	3.1M, 4.6M, 6.8M	-	51.7M, 68.3M	44.2M, 59.5M, 71.6M, 86.9M	-
Cost/AF ($/AF)	13.5k, 9.2k, 6.9k	-	14.8k, 11.4k	14.7k, 10.8k, 9.6k, 8.7k	-
Cost/AF Yield ($/AF Yield)	13.5k, 9.9k, 8k	-	23.2k, 18.8k	22.7k, 17.8k, 17.9k, 21.7k	-

Table 6.2 - Potential Reservoir Storage Sites Matrix

Site Name	5 RCC	5 Rockfill	6	7	8 RCC	8 Earth
Location	On Channel French Ck	On Channel French Ck	On Channel South Rock Ck	Off Channel	On Channel French Ck	On Channel French Ck
Legal Description	34&35, T51N, R84W	34&35, T51N, R84W			36, T51N, R84W	36, T51N, R84W
Size (AF)	2500, 5000, 7500	2500, 5000	4900	9700	2500, 6000, 7500, 10000	2500, 5500, 7500
Average Annual Yield	1620, 3020, 3500	1620, 3020	-	-	1630, 3590, 3590, 3590	1630, 3310, 3590
Irrigated Acres Supplied	HPID, French Ck, Clear Ck, Johnson Ck, lower Rock Creek	HPID, French Ck, Clear Ck, Johnson Ck, lower Rock Creek	-	-	HPID, French Ck, Clear Ck, Johnson Ck, lower Rock Creek	HPID, French Ck, Clear Ck, Johnson Ck, lower Rock Creek
Uses	Ag Irri., Municipal, Environmental, Recreation	Ag Irri., Municipal, Environmental, Recreation	Ag Irri., Municipal, Environmental, Recreation	Ag Irri., Municipal, Environmental, Recreation	Ag Irri., Municipal, Environmental, Recreation	Ag Irri., Municipal, Environmental, Recreation
Dam Type	RCC	Earth Embankment	Earth Embankment, RCC?	Earth Embankment	RCC	Earth Embankment
Borrow Material Availability	available onsite	Rock avail, fine grain unknown	Rock avail, fine grain unknown	Rock avail, fine grain unknown	available onsite	Rock avail, fine grain unknown
Dam Height	120, 155, 180	120, 155, 180	80	60-120	180, 210	200, 230
Crest Elevation	7480, 7515, 7540	7480, 7515	8880	8520	7080, 7110, 7125, 7155	7080, 7110, 7130
Crest Length	580, 720, 830	580, 720	550-900	6300	700, 800	700, 800
Crest Width	20	-	26	34	20	50, 56
Embankment Volume (CY)	140k, 250k, 350k	450k, 750k	-	-	110k, 350k, 450k, 620k	900k, 2400k, 3400k
Design Flood	PMF	PMF	PMF	-	PMF	PMF
Peak Flood Flow (cfs)	8050	8050	7950	-	9500	9500
Flood Volume (AF)	1350	1350	1400	-	1800	1800
Drainage Area (sq-mi)	5.0	5.0	7.1	-	6.2	6.2
Mean Basin Elevation	7982	7982	10066	-	7901	7901
Reservoir Supply	N. Clear Creek & French Ck enlarge and pipe 4 Lakes div	N. Clear Creek & French Ck enlarge and pipe 4 Lakes div	South Rock Ck	South Rock Ck & N. Clear Creek	N. Clear Creek & French Ck enlarge and pipe 4 Lakes div	N. Clear Creek & French Ck enlarge and pipe 4 Lakes div
Outlet Works	Multilevel intake	Multilevel inclined intake	-	-	Multilevel intake	Multilevel inclined intake
Spillways	Section in dam	-	-	-	Section in dam	Excavate around left abutment
Land Ownership	Forest Service	Forest Service	Forest Service	Forest Service	Forest Service	Forest Service
Cultural/Archaeological impacts	est. minimal	est. minimal	est. minimal	est. minimal	French Creek cow camp	French Creek cow camp
Wetlands impacts (ac)	1.03 fens, >2.0 total	1.03 fens, >2.0 total	significant ~98	0.75-1.25	<1.0	<1.0
Riparian impacts	some	some	some	some	some	some
Endangered Species	none	none	none	none	none	none
Threatened Species	occur in area	occur in area	occur in area	occur in area	occur in area	occur in area
Big Game impacts	elk crucial winter range	elk crucial winter range	none	none	elk crucial winter range	elk crucial winter range
Project Cost ($)	33.5M, 49.6M, 58.2M	35.6M, 43.7M	-	-	32.1M, 55.2M, 65.4M, 82.0M	21.9M, 39.9M, 52.4M
Cost/AF ($/AF)	13.4k, 9.9k, 7.8k	14.2k, 8.7k	-	-	12.8k, 9.2k, 8.7k, 8.2k	8.8k, 7.3k, 7.0k
Cost/AF Yield ($/AF Yield)	20.7k, 16.4k, 16.6k	22.0k, 14.5k	-	-	19.7k, 15.4k, 18.2k, 22.8k	13.4k, 12k, 14.6k

6.1 Site No. 1 Preliminary Analysis

6.1.1 Introduction

Site No. 1 is an off-channel site located approximately three miles east of the Forest Service boundary and approximately one-half mile north of French Creek in Section 23, Township 51 North, Range 83 West as shown on Figure 6.2. The site is located on private property. The reservoir would be supplied utilizing an enlarged Moeller Ditch. Water would be delivered from the reservoir to the Hopkins ditch by a pipeline. The site could store a maximum of approximately 1000AF. Three alternatively sized reservoirs were analyzed and preliminary designs and cost estimates were developed.

This alternative site would be a single-purpose reservoir with the reservoir yield being utilized for supplementary irrigation water for the Hopkins Irrigation District. The analysis of the reservoir alternatives is discussed in detail in the following sections.

6.1.2 Reservoir Capacity

Elevation-area-capacity data were developed for this site. The summary of information is shown in Table 6.3 and the capacity-elevation curve is shown on Figure 6.3. The maximum storage capacity of the site is approximately 1000AF. For this analysis, alternative sizes of 230AF, 500AF, and 985AF have been addressed.

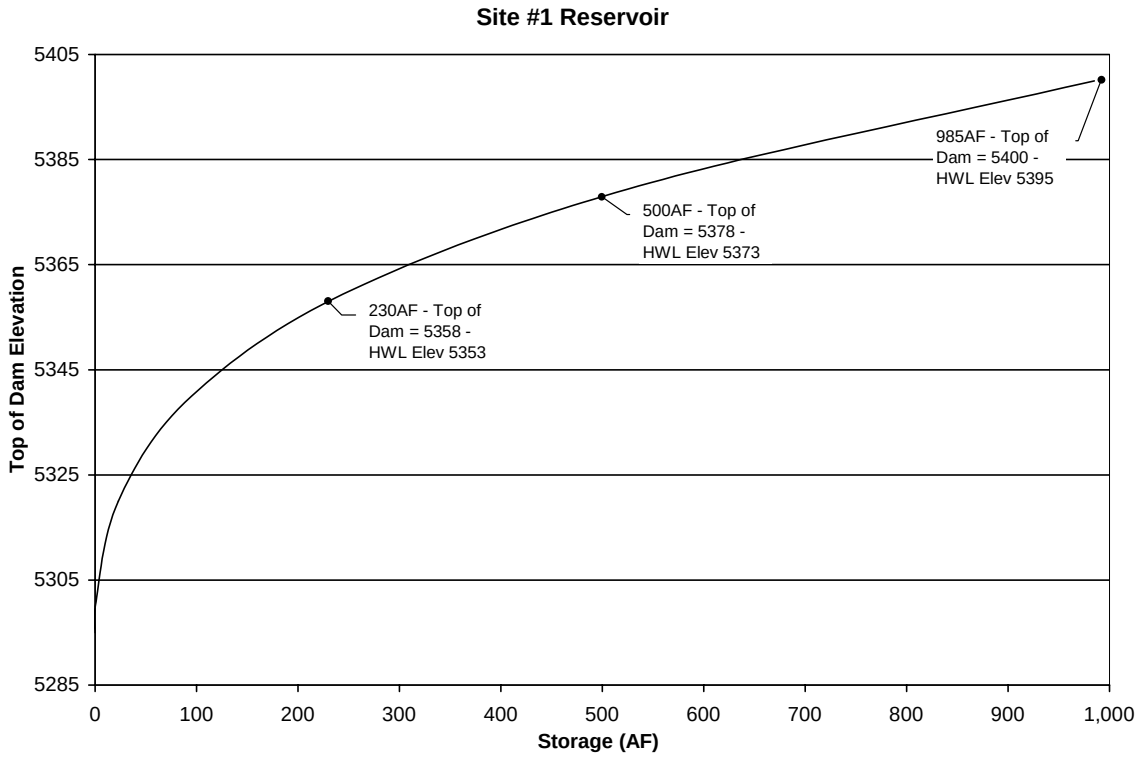


Figure 6.3 Site #1 reservoir stage / storage curve

EXISTING FENCELINE

DELIVERY PIPELINE

RESERVOIR SITE

EXISTING CANAL
TO BE UPGRADED

PROPOSED
DIVERSION
STRUCTURE

OLD MILITARY RESERVATION BOUNDARY

PENROSE DITCH

BROWN AND FOSTER DITCH

MOELLER DITCH

FOSTER DITCH

HOPKINS

French Creek

1000' 0 1000'

REV	DESCRIPTION OF REVISION	BY	DATE
1	CONCEPTUAL DESIGN	JMR	05/27/08

FILE NAME: maines
PLOT SCALE: 1:1
OPER: JMR
DATE: 2008MAY27
PROJ. # 522WY
TASK # CONCEP. DESIGN
LOC: BUFFALO, WY
PROJ. HOPKINS STUDY
SEND TO: JENNIFER RUSSELL
PHONE: (307) 634-7848

STATES WEST WATER
RESOURCES CORPORATION

1904 EAST 15th STREET
CHEYENNE, WYOMING 82001
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PEER REVIEWED	
PROJECT MANAGER	VEA
DATE	MAY 2008

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FIGURE 6.2
SITE 1 PLAN VIEW

REVISION 1
PROJECT 522-WY

Table 6.3 - Site #1 Elevation-Area-Capacity

Top of Dam Elevation	Water Elevation	Water Area (sq.ft.)	Water Area (Ac)	Incr. Volume (AF)	Total Volume (AF)	Dam Height	Crest Width	Reservoir Excavation (CY) *	Net Storage (AF)
5295		0	0.0		0.0				0.0
				0.2					
5300	5295	4,035	0.1		0.2	5	12	100	0.3
				20.5					
5320	5315	85,100	2.0		20.7	25	16	3,800	23.0
				63.9					
5340	5335	193,158	4.4		84.6	45	20	17,300	95.3
				139.6					
5360	5355	414,853	9.5		224.2	65	24	43,400	251.1
				251.2					
5380	5375	679,538	15.6		475.4	85	28	98,000	536.1
				413.8					
5400	5395	1,123,011	25.8		889.2	105	32	154,500	985.0

6.1.3 Reservoir Yield

The average annual yields for the alternative reservoir sizes were estimated and are summarized below.

Reservoir Size	Yield (AF)
230 AF	230
500 AF	465
985 AF	850

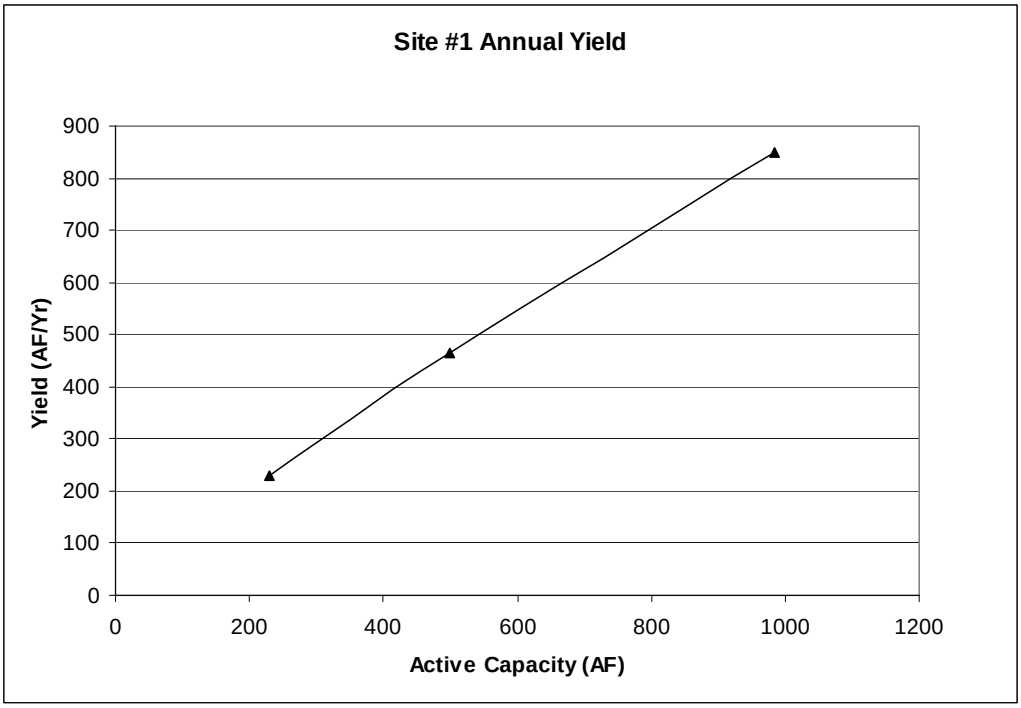


Figure 6.4 Annual yield vs. active capacity at Site No. 1

6.1.4 Water Supply

The water supply for this site would be supplied from available flows from French Creek. The hydrological analysis estimated the available flow for dry, average, and wet years as summarized below. In average and dry years, the available flow usually occurs in April and May, before irrigation demands could utilize the flows.

	Range (AF)	Average (AF)
Dry Years	200-450	325
Average Years	900-1250	1075
Wet Years	1100-1450	1275

6.1.5 Supply Canal

The storable flows would be diverted from French Creek into an enlarged and rehabilitated Moeller Ditch as shown on Figure 6.2. The ditch would be enlarged to divert from 25cfs to 50cfs, depending upon reservoir size. A permanent diversion structure would be constructed on French Creek to insure deliveries to the reservoir. The Moeller Ditch is approximately 11,000 feet in length from the point of diversion to where the ditch would emerge into the reservoir. Erosion is currently a problem in the lower portions of this ditch. Erosion protection and grade control structures should be installed to stabilize the channel.

6.1.5 Irrigation Shortages

Irrigation shortages for the Hopkins Irrigation District were estimated for dry, average, and wet years as shown below. The shortages occur primarily in July, August, and September.

Dry Years	1200 AF
Average Years	400 AF
Wet Years	0

6.1.6 Geological and Geotechnical Investigation

Site No. 1 is located in a well-defined V-shaped valley with a well-defined drainage way that was dry at the time of the field reconnaissance. There is a low saddle on the left abutment through which an irrigation ditch has been routed. The bedrock is interbedded sandstones and claystones of the Wasatch Formation. The right abutment was mantled with sand and gravel with cobble overlying the bedrock for a depth of at least 15 feet. A sluff is present near the right abutment. Silty sands and sandy clays were exposed in the stream cut in the valley bottom. The left abutment had a similar mantle of granular soils as the right abutment except that there were exposures of an uncemented, fairly coarse-grained white sandstone and medium-hard grey and brown claystone. The ditch crossing the saddle on the left abutment had cut at least 20 feet in depth exposing claystone 3 feet to 5 feet thick and interbedded sandstone at least 15 feet thick. The site has a good grass cover with a few small trees in the valley bottom.

A dam approximately 60 feet to 100 feet high has been analyzed. There is a sufficient amount of cohesive and granular soils in the reservoir area to construct a zoned earth embankment dam. The crest width should be at least the height of the dam divided by 5 plus 10 feet. The exterior slopes should be 3H:1V or flatter on the upstream face and 2.5H:1V or flatter on the downstream face. The core should have upstream and downstream slopes of 1H:1V or flatter. The granular soils should be used for the exterior shells and the cohesive materials should be used for the core. Downstream of the core, a 3-foot wide chimney drain and a 5-foot thick blanket drain should be installed. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the right abutment, 10 feet in the valley bottom, and 5 feet on the left abutment. A 5-foot deep cutoff trench should be excavated below the core with a width of at least 10 feet and 1H:1V side slopes.

6.1.7 Dam and Reservoir Preliminary Design

Utilizing the recommendations for the dam cross section, preliminary designs of the alternative reservoir sizes was completed. The preliminary design of the reservoir is shown on Figures 6.2, 6.5, and 6.6. The alternative size projects correspond to 230AF, 500AF, and 985AF.

The reservoir site has very a minimal drainage area so flood flows are not a concern. An earthen overflow should be constructed in case the delivery ditch is not shut off when the reservoir is full.

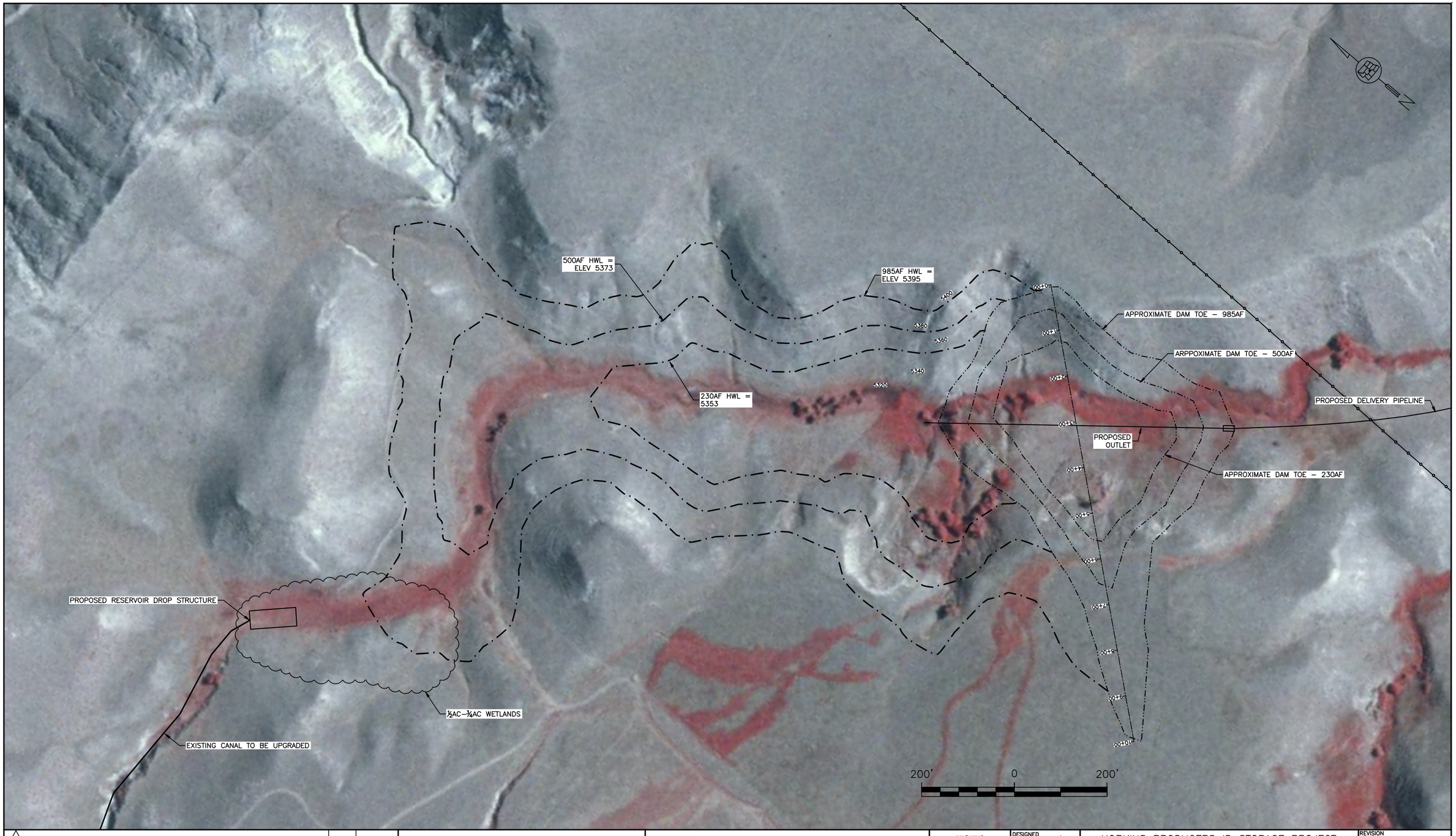
The outlet works would consist of a control gate, outlet pipe, metering, and connection to the pipeline as shown on Figure 6.5. The outlet pipe would be concrete-encased steel pipe. The control gate would be a high-pressure sluice gate with the stem extended to the dam crest for operation. A meter or flume would be installed to measure flow releases.

6.1.8 Water Delivery System To Hopkins Ditch

The storage water released from the reservoir would be delivered in a pipeline as shown on Figure 6.2. The natural drainage below the dam is relatively steep and would erode with sustained flows. The pipeline would be approximately 4500ft long and would incorporate 16- to 18-inch PVC pipe to deliver a minimum of 15cfs to 25cfs with a reservoir depth of ten feet. The discharge point of the pipeline could be at the Hopkins Ditch or it could connect directly to the pipeline being installed by the District.

6.1.9 Wetland Impacts

The proposed dam site for Site 1 is on a channel with wetland fringes, all of which were classified as wet meadow type wetlands. The total area of wetland impact at this site was estimated at approximately 0.7acres. These wetland impacts would have to be mitigated. Where mitigate?



FILE NAME / PLOT SCALE	1:1
OPER. / DATE	JMR / 2008MAY27
PROJ. # / TASK #	522WY / CONCEP. DESIGN
LOC.	BUFFALO, WY
PROJ.	HOPKINS STUDY
SEND TO	JENNIFER RUSSELL
PHONE	(307) 634–7848

REV	DESCRIPTION OF REVISION	BY	DATE
1	CONCEPTUAL DESIGN	JMR	05/27/08

STATES WEST WATER RESOURCES CORPORATION

1904 EAST 15th STREET
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FAX: (307) 634–7851

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DRAWN	JMR
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PEER REVIEWED	
PROJECT MANAGER	VEA
DATE	MAY 2008

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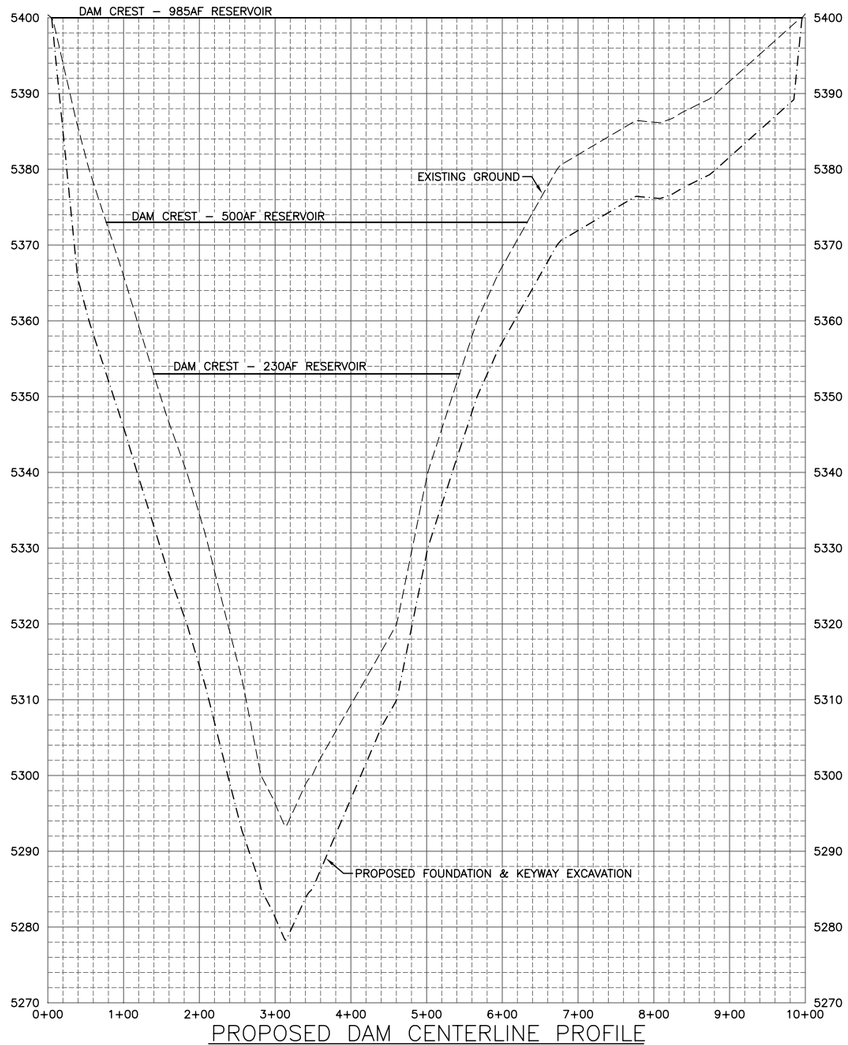
FIGURE 6.5
SITE 1 PLAN VIEW

REVISION 1

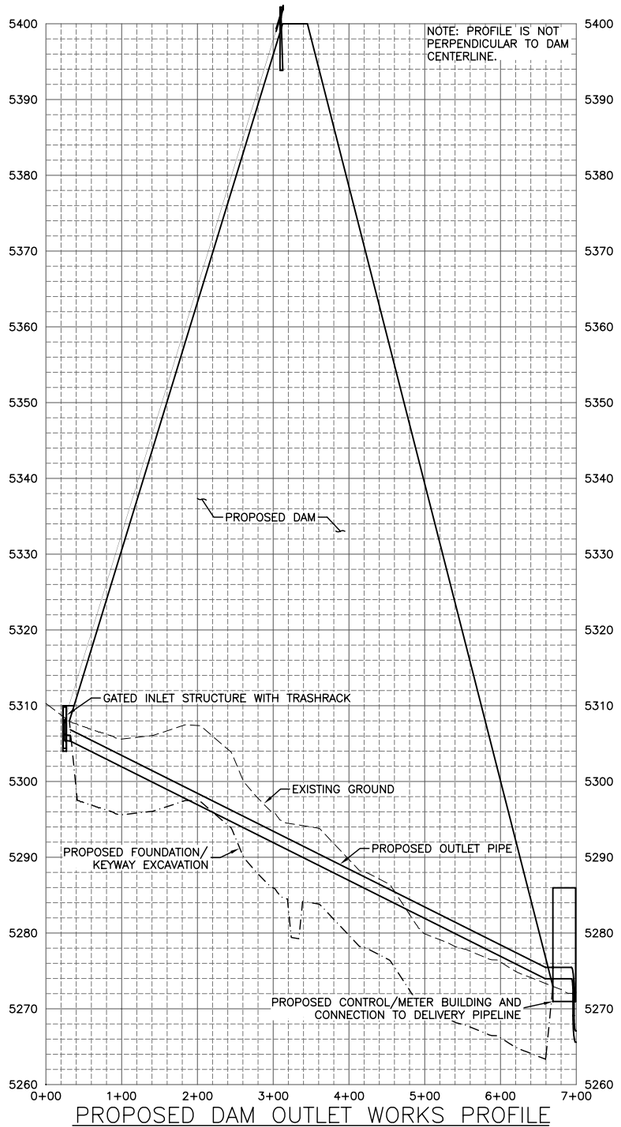
PROJECT 522–WY

6–10



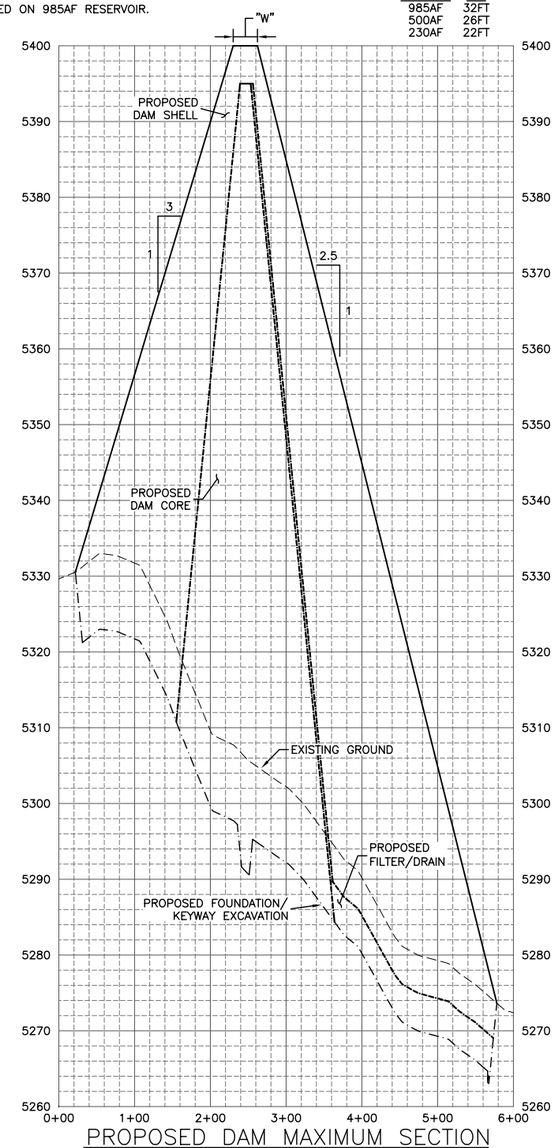
PROPOSED DAM CENTERLINE PROFILE

NOTE: OUTLET PROFILE AND MAXIMUM SECTION BASED ON 985AF RESERVOIR.



PROPOSED DAM OUTLET WORKS PROFILE

STORAGE	"W"
985AF	32FT
500AF	26FT
230AF	22FT



PROPOSED DAM MAXIMUM SECTION

VERT. SCALE
20' 0 20'

HORIZ. SCALE
200' 0 200'

REV	DESCRIPTION OF REVISION	BY	DATE
1	CONCEPTUAL DESIGN	JMR	05/27/08

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1904 EAST 15th STREET
CHEYENNE, WYOMING 82001
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CHECKED	
PEER REVIEWED	
PROJECT MANAGER	VEA
DATE	MAY 2008

HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 6.6
SITE 1 DAM
PROFILES AND SECTION

REVISION 1
PROJECT 522-WY

6-11

FILE NAME: names
PLOT SCALE: 1:1
OPER: JMR
DATE: 2008MAY27
PROJ. # 522WY
TASK # CONCEP. DESIGN
LOC: BUFFALO, WY
PROJ. HOPKINS STUDY
SEND TO: JENNIFER RUSSELL
PHONE (307) 634-7848

6.1.10 Sensitive Species, Riparian Areas, and Big Game Habitat Impacts

Site 1 is within mule deer winter-yearlong range, but not crucial winter range. Site 1 is within pronghorn yearlong range. These impacts should not require mitigation.

6.1.11 Cultural Impacts

A Class I cultural resource survey of the Site No. 1 Reservoir was performed. The purposes of the Class I survey are to document all previously recorded sites and to provide an assessment of the potential for cultural resources in the reservoir area. A file search of the Wyoming State Historical Preservation Office (SHPO), Cultural Records Office database in Laramie, Wyoming, was conducted on September 13, 2007. Previously recorded historical sites at this reservoir site include 48JO1603, the Fort McKinney Wood Reservation Road, which is south of the reservoir site and has been recommended as not eligible to the National Register of Historic Places (NRHP).

6.1.12 Preliminary Cost Estimates

Preliminary cost estimates for Reservoir Site No. 1 were developed for the three alternative sizes of 230AF, 500AF, and 985AF. The cost estimates were developed utilizing the standard WWDC format to estimate the total project costs. The cost estimates are shown in Tables 6.4, 6.5, and 6.6. The information is presented in graphical form in Figure 6.7. This figure allows for cost estimates of other sizes of reservoirs.

Table 6.4 - Site Number 1 - Earth Embankment - 230 ac-ft, Crest Elev: 5358, NHWL: 5353

No.	Item	Unit	Quantity	Unit Cost	Cost
1	Mobilization	LS	--	--	$100,000
2	Reservoir				
3	Foundation Excavation	CY	60,000	$4.00	$240,000
4	Key Trench Excavation	CY	1,750	$10.00	$17,500
5	Dam Embankment	CY	175,000	$6.50	$1,137,500
6	Outlet Works	LS	--	--	$175,000
7	Wetland Mitigation	Ac	1.5	$25,000.00	$37,500
8	Revegetation	Ac	10.0	$2,000.00	$20,000
9	Supply Canal				
10	Diversion Struction	LS	--	--	$40,000
11	Measuring Flume	LS	--	--	$8,000
12	Canal Rehabilitation	LF	10,000	$8.00	$80,000
13	Reservoir Drop Structure	LS	--	--	$50,000
14	Headgate	LS	--	--	$15,000
15	Delivery Pipe				
16	16" PVC	LF	4,500	$45.00	$202,500
17	Outlet Structure	LS	--	--	$5,000
				Construction Cost Sub-Total:	**$2,128,000**
				10% Engineering:	$212,800
				Sub-Total:	**$2,340,800**
				15% Contingency:	$351,120
				CONSTRUCTION COST TOTAL:	**$2,691,920**
				Preparation of Final Designs and Specifications:	$200,000
				Permitting:	$100,000
				Legal Fees:	$50,000
				Acquisition of Access and Rights of Way:	$100,000
				TOTAL PROJECT COST:	**$3,141,920**
				USE:	**$3.1M**

Table 6.5 - Site Number 1 - Earth Embankment - 500 ac-ft, Crest Elev: 5378, NHWL: 5373

No.	Item	Unit	Quantity	Unit Cost	Cost
1	Mobilization	LS	--	--	$160,000
2	Reservoir				
3	Foundation Excavation	CY	80,000	$4.00	$320,000
4	Key Trench Excavation	CY	2,500	$10.00	$25,000
5	Dam Embankment	CY	300,000	$6.50	$1,950,000
6	Outlet Works	LS	--	--	$250,000
7	Wetland Mitigation	Ac	2.0	$25,000.00	$50,000
8	Revegetation	Ac	15.0	$2,000.00	$30,000
9	Supply Canal				
10	Diversion Struction	LS	--	--	$50,000
11	Measuring Flume	LS	--	--	$10,000
12	Canal Rehabilitation	LF	10,000	$9.00	$90,000
13	Reservoir Drop Structure	LS	--	--	$60,000
14	Headgate	LS	--	--	$20,000
15	Delivery Pipe				
16	16" PVC	LF	4,500	$45.00	$202,500
17	Outlet Structure	LS	--	--	$6,000
				Construction Cost Sub-Total:	**$3,223,500**
				10% Engineering:	$322,350
				Sub-Total:	**$3,545,850**
				15% Contingency:	$531,878
				CONSTRUCTION COST TOTAL:	**$4,077,728**
				Preparation of Final Designs and Specifications:	$250,000
				Permitting:	$100,000
				Legal Fees:	$50,000
				Acquisition of Access and Rights of Way:	$100,000
				TOTAL PROJECT COST:	**$4,577,728**
				USE:	**$4.6M**

Table 6.6 - Site Number 1 - Earth Embankment - 985 ac-ft, Crest Elev: 5400, NHWL: 5395

No.	Item	Unit	Quantity	Unit Cost	Cost
1	Mobilization	LS	--	--	$230,000
2	Reservoir				
3	Foundation Excavation	CY	100,000	$4.00	$400,000
4	Key Trench Excavation	CY	3,000	$10.00	$30,000
5	Dam Embankment	CY	475,000	$6.50	$3,087,500
6	Outlet Works	LS	--	--	$460,000
7	Wetland Mitigation	Ac	2.0	$25,000.00	$50,000
8	Revegetation	Ac	20.0	$2,000.00	$40,000
9	Supply Canal				
10	Diversion Struction	LS	--	--	$50,000
11	Measuring Flume	LS	--	--	$15,000
12	Canal Rehabilitation	LF	10,000	$12.50	$125,000
13	Reservoir Drop Structure	LS	--	--	$80,000
14	Headgate	LS	--	--	$25,000
15	Delivery Pipe				
16	16" PVC	LF	4,500	$60.00	$270,000
17	Outlet Structure	LS	--	--	$8,000
				Construction Cost Sub-Total:	**$4,870,500**
				10% Engineering:	$487,050
				Sub-Total:	**$5,357,550**
				15% Contingency:	$803,633
				CONSTRUCTION COST TOTAL:	**$6,161,183**
				Preparation of Final Designs and Specifications:	$350,000
				Permitting:	$100,000
				Legal Fees:	$50,000
				Acquisition of Access and Rights of Way:	$100,000
				TOTAL PROJECT COST:	**$6,761,183**
				USE:	**$6.8M**

6.1.13 Reservoir Alternative Size Comparison

The three alternative size reservoirs analyzed for Site 1 are compared in Table 6.7. As indicated, the 985 AF reservoir has a lower unit cost per acre-foot of storage. The comparison of the unit cost per acre-foot of yield indicates that the 500 to 985 AF reservoirs have the lower unit cost as shown on Figure 6.8. This site would be most economically developed at the larger size alternatives.

Table 6.7 - Site No. 1 Alternatives Comparison

Dam Type	Total Capacity	Est. Cost	Storage Unit Cost	Est. Yield	Unit Cost Yield
	AF	$Mil	$/AF	AF/Yr	$/AF Yield
Earth	230	$3.1	$13,478	230	$13,478
Earth	500	$4.6	$9,200	465	$9,892
Earth	985	$6.8	$6,904	850	$8,000

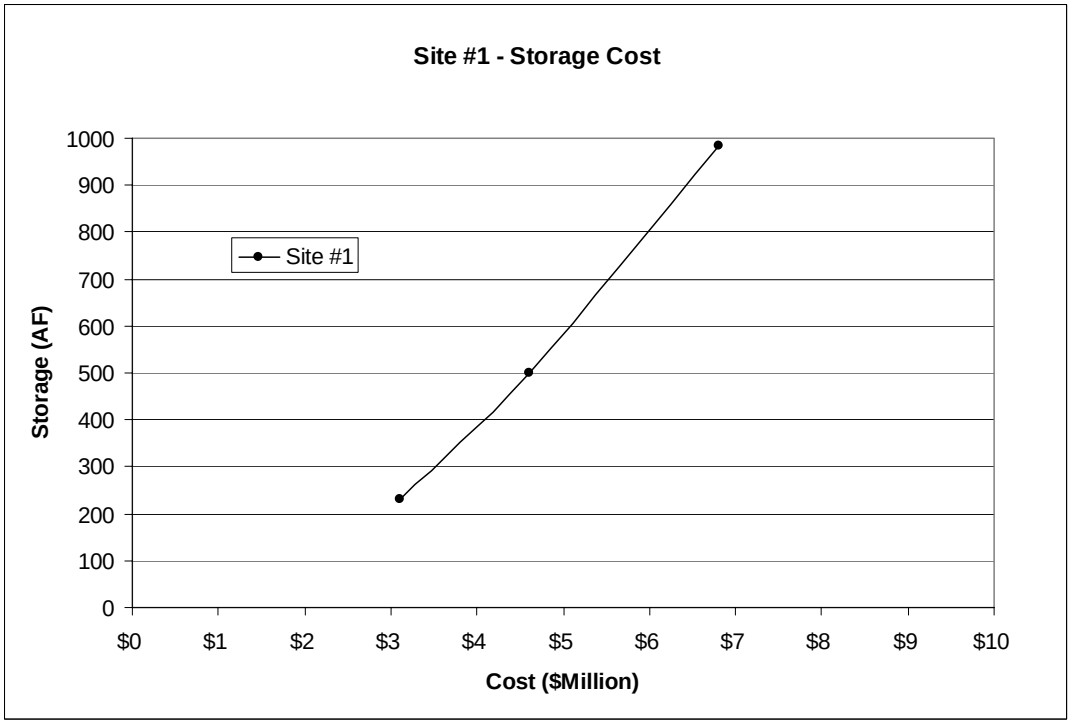


Figure 6.7 Site No. 1 Storage Costs

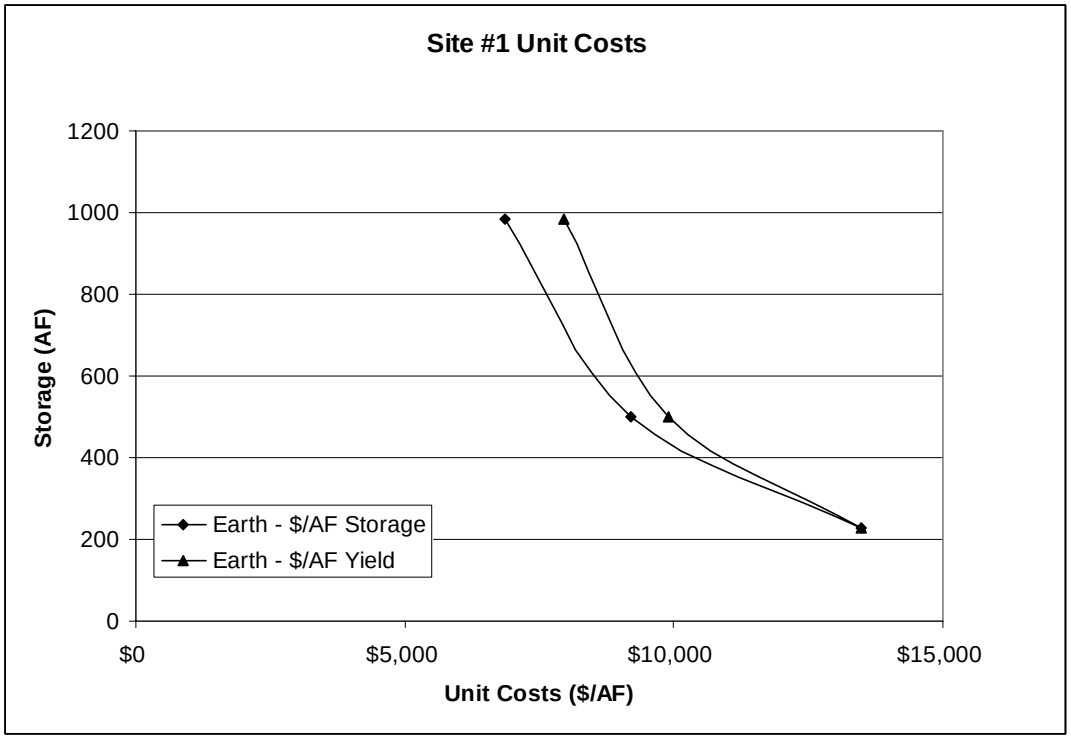


Figure 6.8 Site No. 1 Unit Costs

6.1.14 Project Financing

The current financing package offered by the Wyoming Water Development Commission is 67% grant, 33% loan at 4% for a case specific term not to exceed 50 years. The Commission has the ability in their criteria to grant up to 75%. The Commission has the authority with Wyoming Legislature approval to grant 100% of the total project costs. In order to achieve this level of financing the project would have to give significant benefit to the State of Wyoming. Additional funding sources may include the NRCS.

Assuming a 67% WWDC grant and 33% loan at 4% for 50 years, the annual repayment would be as follows:

Table 6.8 - Site No. 1 Annual Repayment

Dam Type	Total Capacity	Est. Cost	Annual Repayment
	AF	$Mil	$/Yr
Earth	230	$3.1	$48,149
Earth	500	$4.6	$71,446
Earth	985	$6.8	$105,616

6.1.15 Summary

Site No. 1 would be a single purpose facility to supply supplemental irrigation water to the Hopkins Producers ID. Site No. 1 is located off channel on private land. The reservoir could be supplied by improving the existing Moeller ditch. Site No. 1 is most efficient based on the water availability and project cost in the 500-985 AF range. With the anticipated availability of fine grain material, an earth embankment at this location would be the most economical dam. The cultural resources in the vicinity are likely minimal. Wetland impacts at this site are minimal but will likely require mitigation. The design flood at this site is minimal. Access to the site requires improvement of an existing private road. This site is recommended for further study if single purpose alternatives are pursued.

6.2 Site No. 2

6.2.1 Introduction

Site No. 2 is an off channel site located on private land below the Forest Service boundary as shown on Figure 6.9. Site No. 2 is located in the North half of Section 34, Township 51 North, Range 83 West. The reservoir would be supplied through a canal by flows from the North Fork of Clear Creek and French Creek.

This site could be a multiple-use reservoir. The reservoir yield could be utilized in the French Creek and Clear Creek drainages for irrigation supplementary flows, municipal purposes, environmental uses, and recreation. Benefits to the Hopkins Producers ID and other downstream irrigators could be achieved with additional late season water. This water could be transferred to Clear Creek (see section 7) to be utilized for future municipal needs of the City of Buffalo and additional hydropower generation, supplemental irrigation water, instream flows through Buffalo, and could delay regulation on the Clear Creek drainage. A minimum pool could be maintained in the reservoir to promote recreation.

6.2.2 Reservoir Capacity

This reservoir site could potentially store approximately 4000AF. The reservoir was assumed to incorporate a recreation pool of approximately 30% of the total storage. Consequently, the 4000AF reservoir would have 2800AF of active storage.

6.2.3 Water Supply

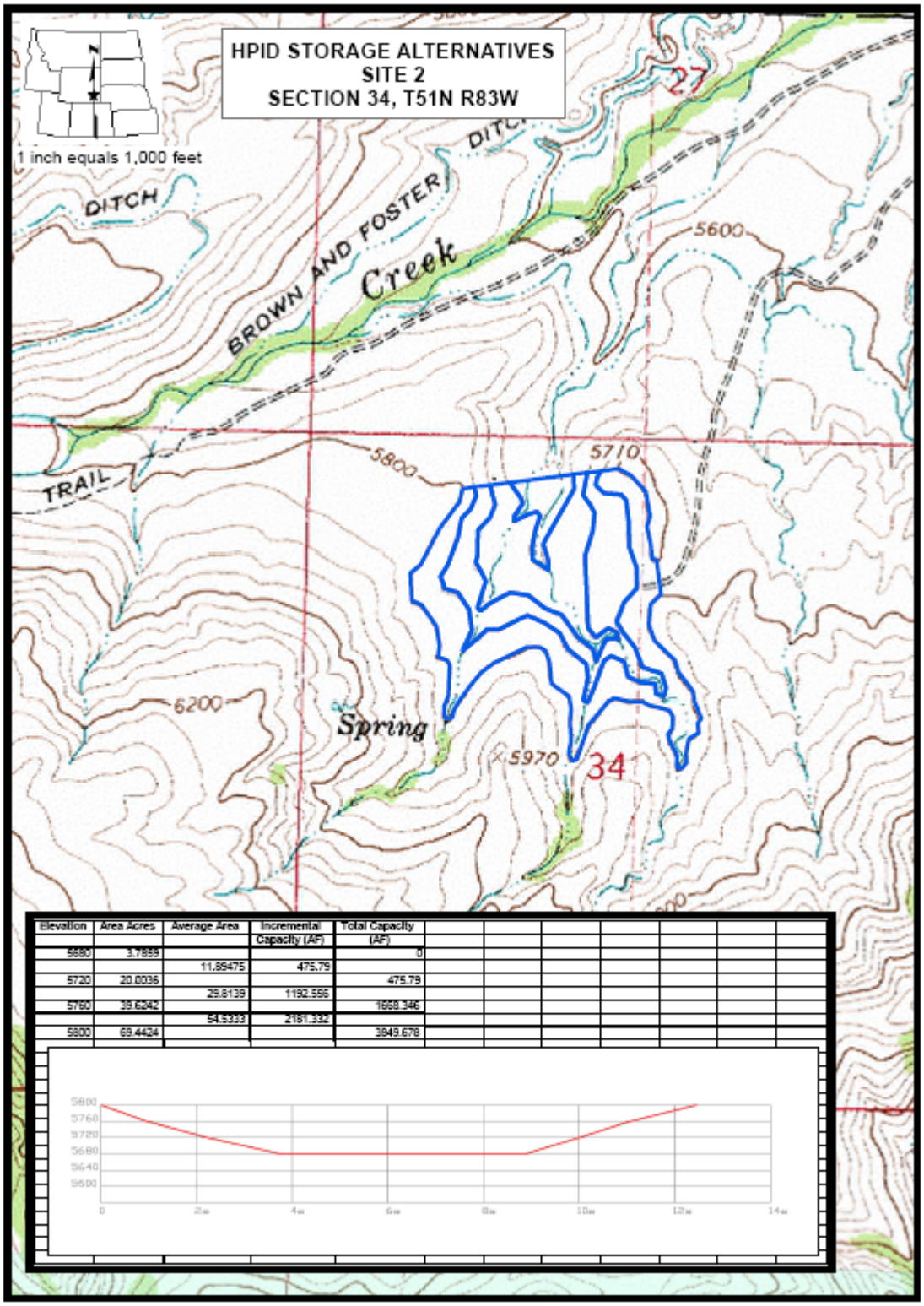
The potential water supply for a reservoir at Site No. 2 would be from available flows on French Creek and available flows from the North Fork of Clear Creek. The North Fork of Clear Creek water supply analysis is discussed in detail in section 6. The hydrological analysis estimated the available storable flows for dry, average, and wet years as shown below:

	French Creek	North Fork Clear Creek	Total
Dry Years	200-400 AF	500-900 AF	700-1300 AF
Average Years	900-1200 AF	2800-3500 AF	3700-4700 AF
Wet Years	1100-1400 AF	3500-4300 AF	4600-5700 AF

A supply canal approximately 4000 feet long would be required to divert flows from French Creek.

6.2.4 Reservoir Yield

The potential yield of the reservoir was estimated in the hydrological analysis. The estimated average annual yield of a 4000 AF reservoir with an active capacity of 2800AF would be approximately 2500AF.



Elevation	Area Acres	Average Area	Incremental Capacity (AF)	Total Capacity (AF)
5680	3.7859			0
		11.89475	475.79	
5720	20.0036			475.79
		29.8139	1192.556	
5760	39.6242			1668.346
		54.5333	2181.332	
5800	69.4424			3849.678

Figure 6.9 Site No. 2

6.2.5 Wetland Impacts

Site No. 2 was not visited during the field reconnaissance. Wetland impacts would likely be minimal as there are only narrow fringe wetlands along the drainage.

6.2.6 Sensitive Species, Migratory Birds, and Big Game Habitat Impacts

The presence of federally-listed species does not appear to be a major issue for Site No. 2. Several sensitive wildlife and plant species occur in the area, and some of these species may be present on the reservoir site. As this reservoir is located on the Bighorn National Forest, surveys for sensitive species would likely be required. Impacts to sensitive species, if present, can likely be mitigated.

Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nest of such species as northern goshawk.

This site occurs in an area designated as crucial winter range for elk. The Wyoming Game and Fish Department may request mitigation if a reservoir is constructed on elk crucial winter range. Site 2 is within moose and mule deer winter-yearlong range, but not crucial winter range. Site 2 is within white-tailed deer and pronghorn yearlong range.

6.2.7 Summary

The inefficient dam site would require a large quantity of embankment per acre-foot of storage making this site economically not feasible. Additionally, a 4000-foot supply canal would need to be constructed. This site, due to inefficiency, is not recommended for further study if any alternatives are pursued.

6.3 Site No. 3 Preliminary Analysis

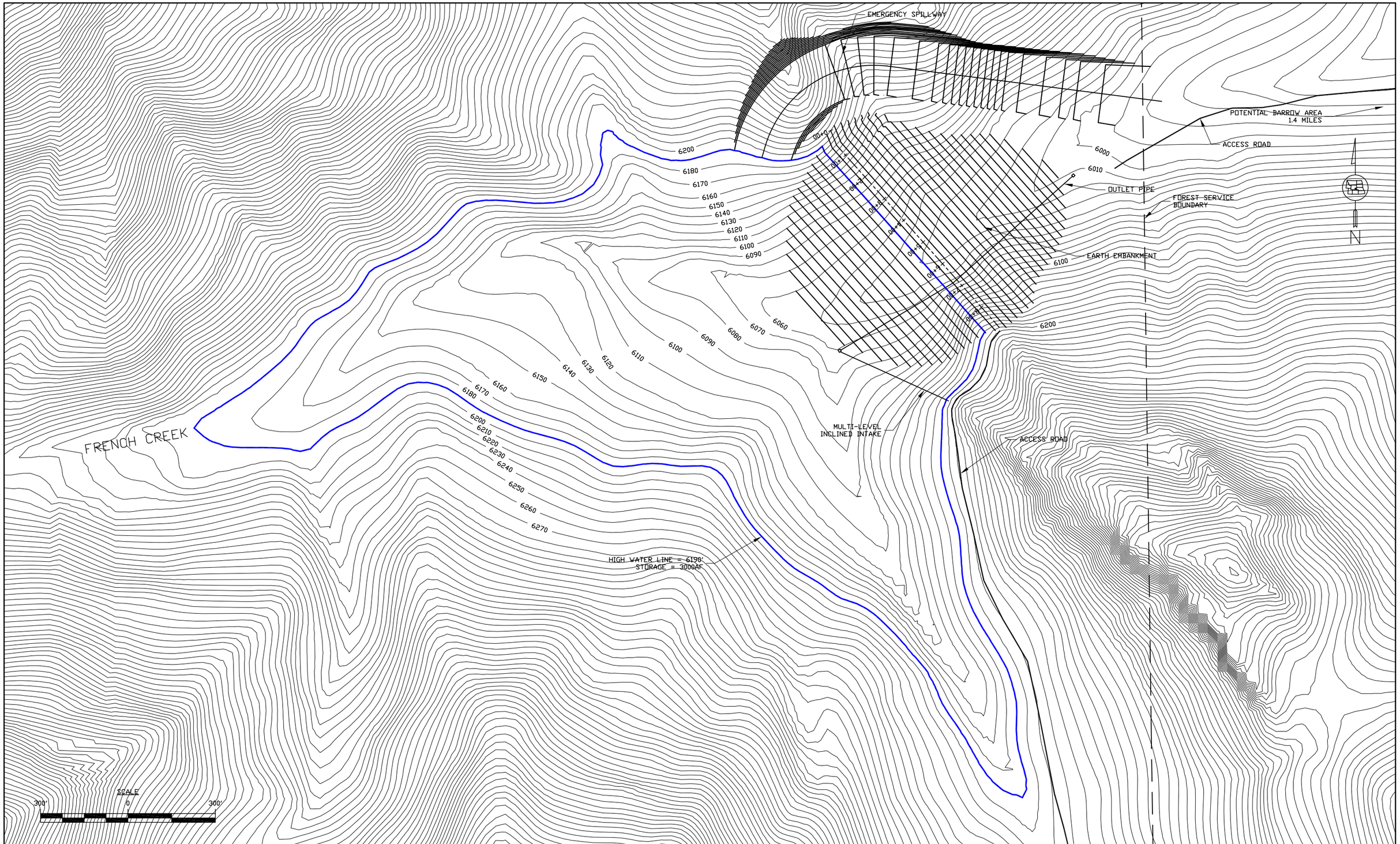
6.3.1 Introduction

Site No. 3 is located on French Creek on US Forest Service property approximately 700 feet above the boundary as shown on Figure 6.10, 6.11, 6.12 and 6.13. Site No. 3 is located in Section 32, Township 51 North, Range 83 West. The reservoir would be supplied by flows from the North Fork of Clear Creek and French Creek. 3000, 5500, 7500, and 10,000 ac-ft reservoirs were analyzed and preliminary designs and cost estimates were developed.

This site could be a multiple-use reservoir. The reservoir yield could be utilized in the French Creek, Johnson Creek, lower Rock Creek, and Clear Creek drainages for irrigation supplementary flows, municipal purposes, environmental uses, and recreation. Benefits to the Hopkins Producers ID and other downstream irrigators could be achieved with additional late season water. This water could be transferred to Clear Creek (see section 7) to be utilized for future municipal needs of the City of Buffalo and additional hydropower generation, supplemental irrigation water, and instream flows through Buffalo, and could delay regulation on the Clear Creek drainage. A minimum pool could be maintained in the reservoir to promote recreation and a fishery. Stream fishing improvements on French Creek could also be realized with the project. The analysis of the reservoir alternatives is discussed in detail in the following sections.

6.3.2 Reservoir Capacity

Elevation-area-capacity data was developed for this site. The capacity-elevation curve is shown on Figure 6.14. For this analysis, 3000AF, 5500AF, 7500AF, and 10000AF reservoirs were addressed. The reservoirs were assumed to incorporate a recreation pool of approximately 30% of the total storage. Consequently, the 3000AF reservoir would have 2100AF of active storage and the 5500AF, 7500AF, and 10000AF reservoirs would have 3850AF, 5250AF, and 7000AF of active storage respectively.



1	PRELIMINARY DESIGN	DWW	07/08
REV	DESCRIPTION OF REVISION	BY	DATE

FILE NAME: SITE 3
SCALE: 1"=300'
OPERATOR: DWW
DATE: 07/08
PROJECT NO: 522-WY
HSAK NO: 001-263
LOCATION: BUFFALO, WY
PROJECT: HOPKINS STORAGE
SEND TO: VICTOR E. ANDERSON
PHONE: (307) 634-7848

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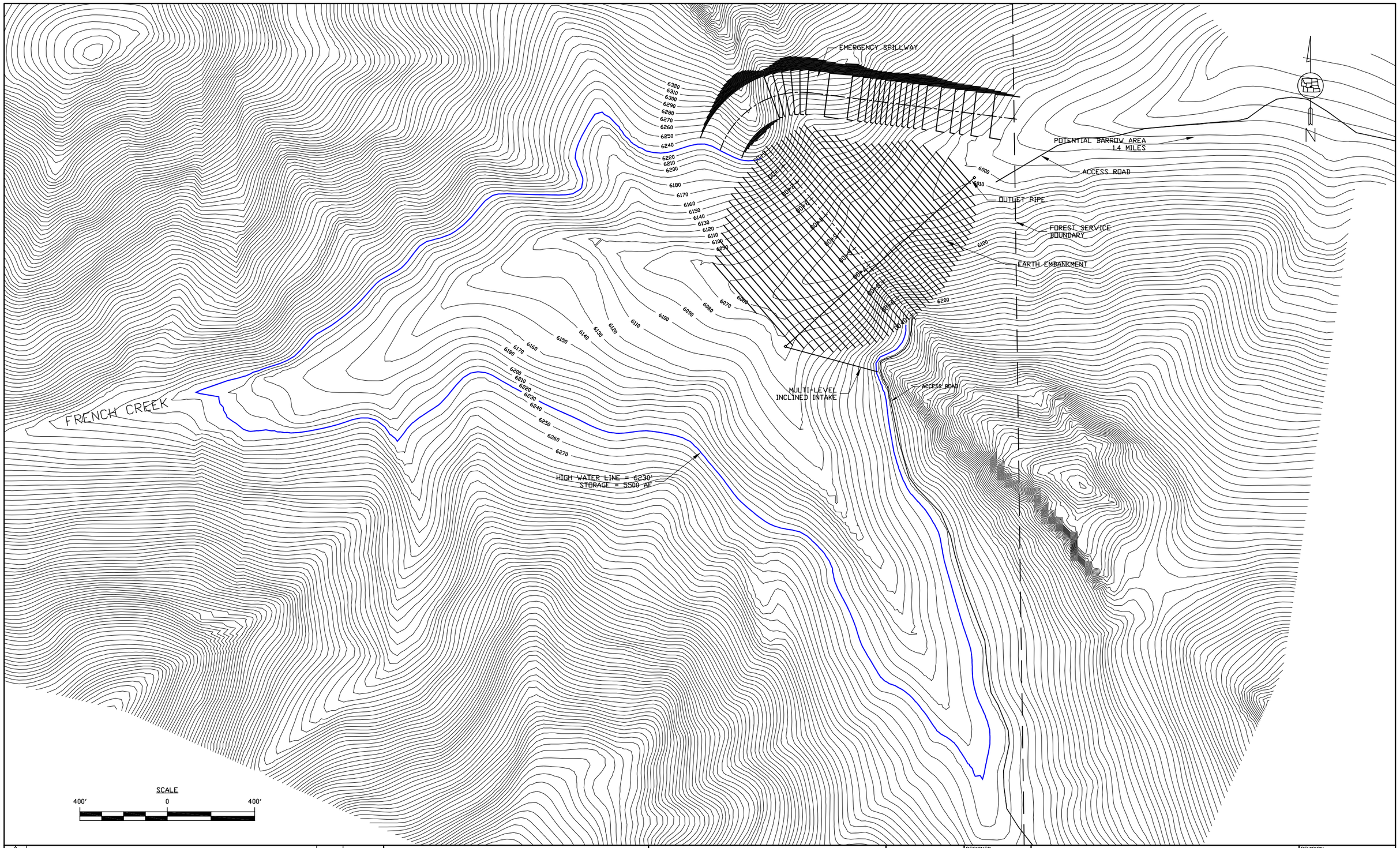
PEER REVIEWED	VEA
PROJECT MANAGER	VEA
DATE	07/08

HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 6.10
SITE 3 EARTH EMBANKMENT
SITE PLAN – 3000AF

REVISION 1
PROJECT 522-WY
DRAWING 6-22



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REV	DESCRIPTION OF REVISION	BY	DATE

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OPERATOR: DWW
DATE: 07/08
PROJECT NO: 522-WY
TASK NO: 001-283
LOCATION: BUFFALO, WY
PROJECT: HOPKINS STORAGE
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DATE	07/08

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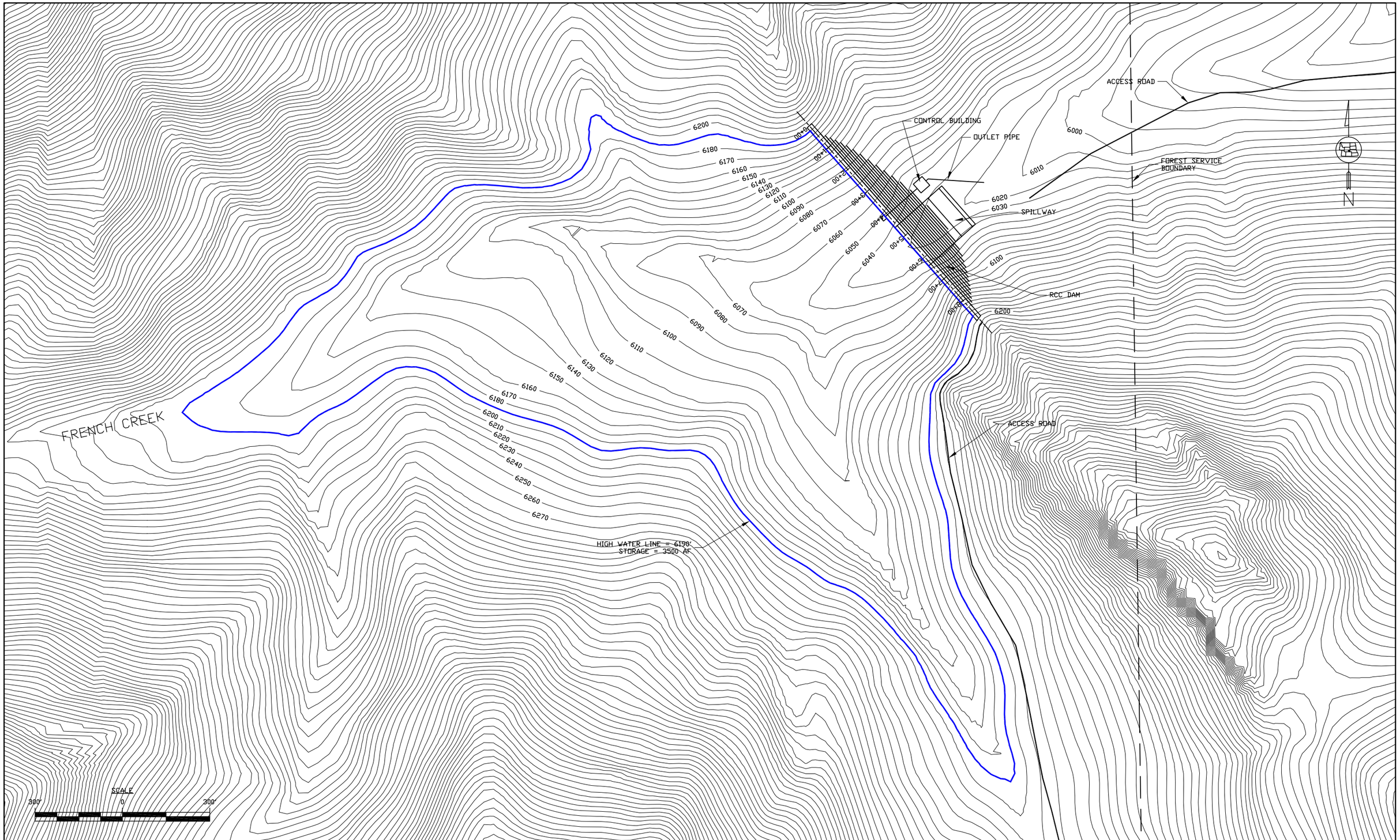
FIGURE 6.11
SITE 3 EARTH EMBANKMENT
SITE PLAN – 5500AF

REVISION 1
PROJECT 522-WY
DRAWING 6-23



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SCALE: 1" = 300'

OPERATOR: DWW
DATE: 07/08

PROJECT NO: 522-WY
HSK NO: 001-263

LOCATION: BUFFALO, WY
PROJECT: HOPKINS STORAGE

SEND TO: VICTOR E. ANDERSON
PHONE: (307) 634-7848

REV	DESCRIPTION OF REVISION	BY	DATE
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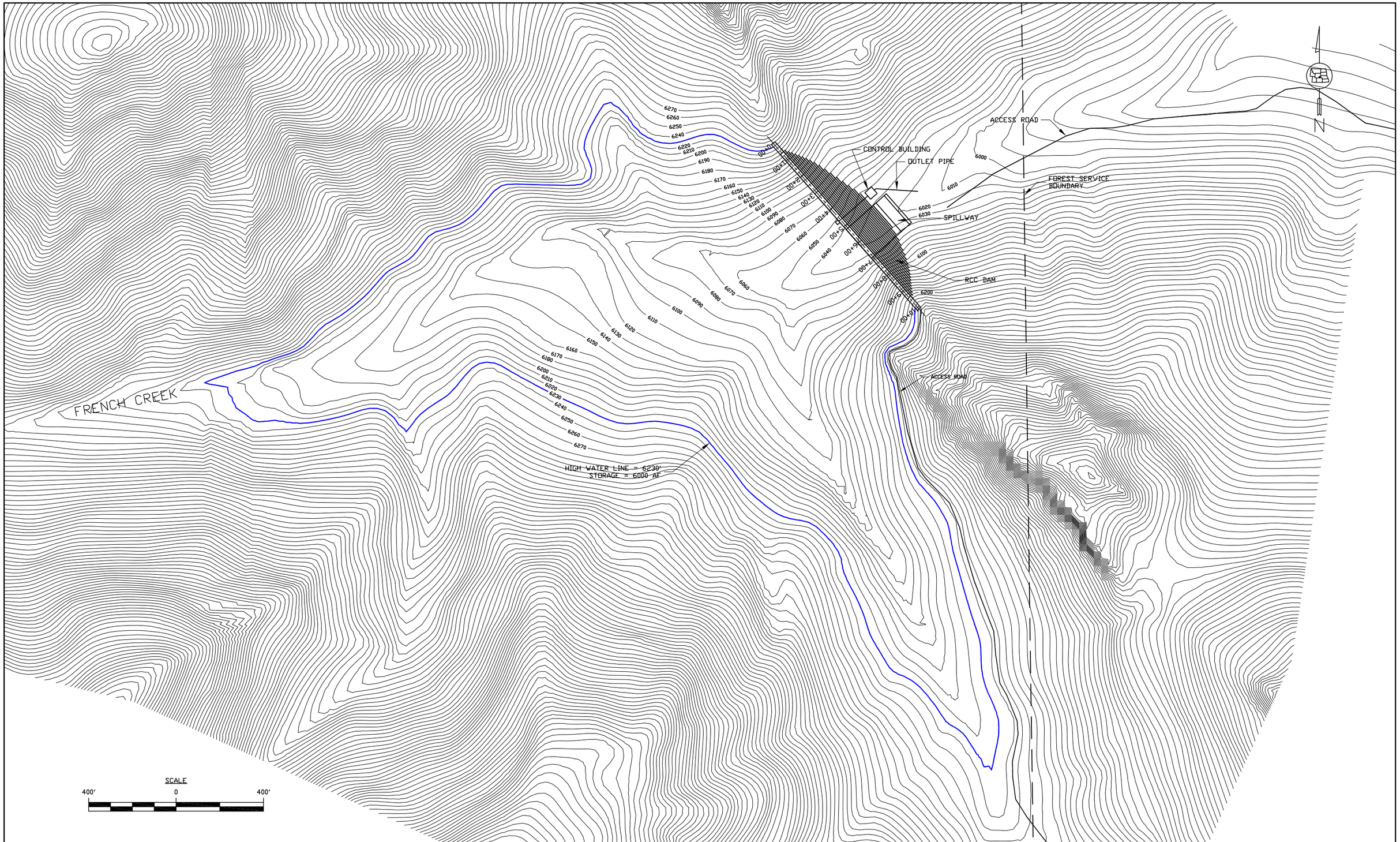
PROJECT MANAGER	VEA
DATE	07/08

HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 6.12
SITE 3 RCC SITE PLAN
3500AF

REVISION 1
PROJECT 522-WY
DRAWING 6-24



FILE NAME: SITE 3
SCALE: 1"=400'

OPERATOR: DWW
DATE: 07/08

PROJECT NO: 522-WY
TASK NO: 001-283

LOCATION: BUFFALO, WY
PROJECT: HOPKINS STORAGE

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PHONE: (307) 634-7848

REV	DESCRIPTION OF REVISION	BY	DATE
1	PRELIMINARY DESIGN	DWW	07/08

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FIGURE 6.13
SITE 3 RCC SITE PLAN
6000AF

REVISION 1
PROJECT 522-WY
DRAWING 6-25

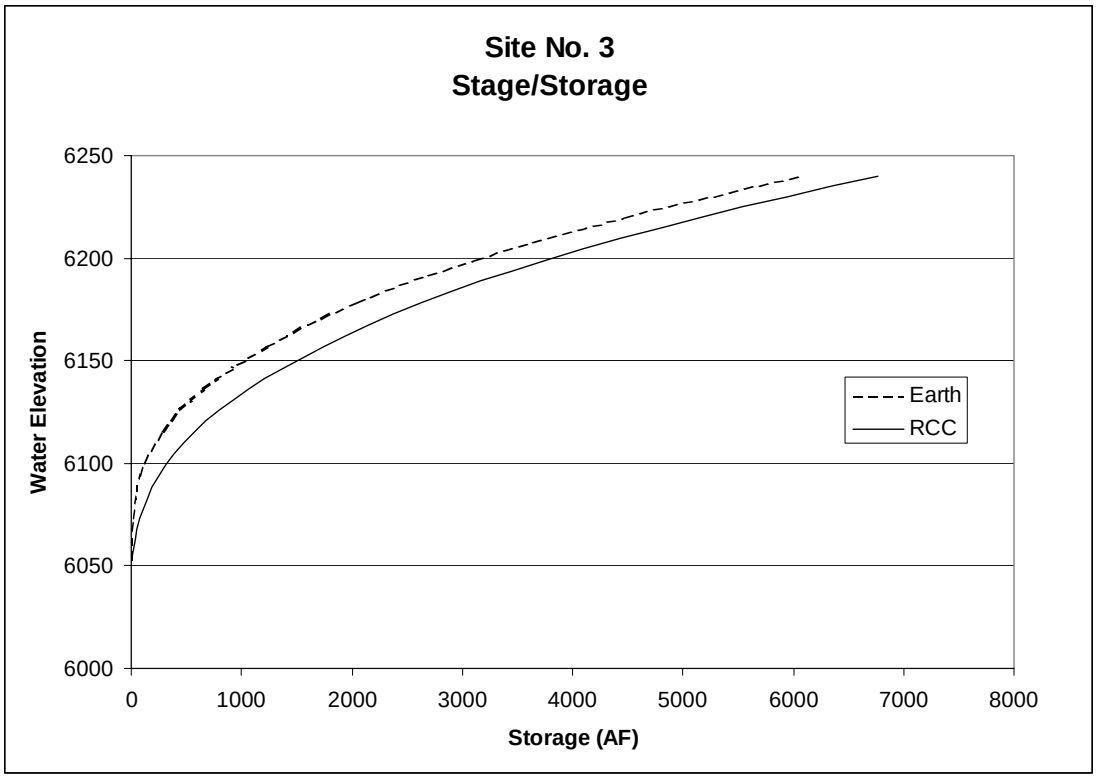


Figure 6.14 – Site No. 3 Capacity-Elevation Curve

6.3.3 Water Supply

The potential water supply for a reservoir at Site No. 3 would be from available flows on French Creek and available flows from the North Fork of Clear Creek. The North Fork of Clear Creek water supply analysis is discussed in detail in section 6. The hydrological analysis estimated the available storable flows for dry, average, and wet years as shown below:

	French Creek	North Fork Clear Creek	Total
Dry Years	200-400 AF	500-900 AF	700-1300 AF
Average Years	900-1200 AF	2800-3500 AF	3700-4700 AF
Wet Years	1100-1400 AF	3500-4300 AF	4600-5700 AF

6.3.4 Reservoir Yield

The potential yield of the reservoir alternative sizes were estimated in the hydrological analysis as shown on Figure 6.15. The estimated average annual yields of the 3000 AF reservoir with an active capacity of 2100AF would be approximately 1950AF. The estimated average annual yield with an active capacity of 3850AF would be approximately 3350AF. The estimated average annual yield with an active capacity of 5250AF and 7000AF would be approximately 4000AF.

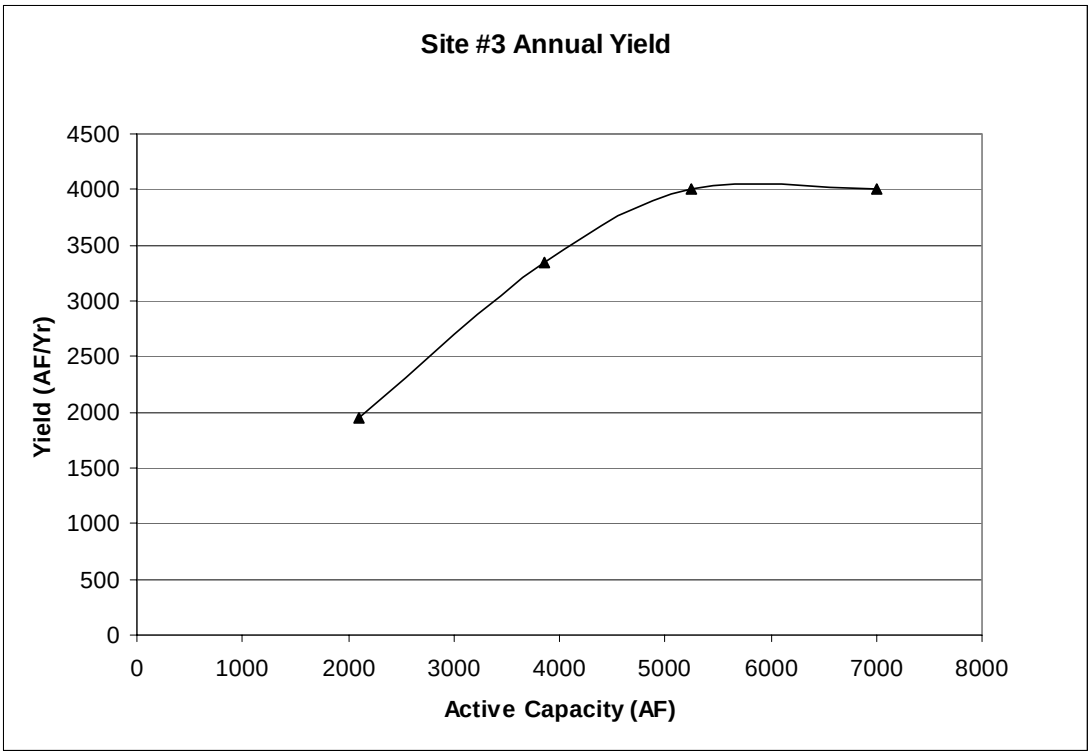


Figure 6.15 Annual yield vs. active capacity at Site No. 3

6.3.5 Geologic and Geotechnical Investigation

Site No. 3 is located in a U-shaped valley with French Creek flowing through. The bedrock is Precambrian granite. The only rock outcrops were high up on the abutments well above the reservoir high water line. Both abutments were mantled with silty sand and gravel and scattered boulders. Depth to bedrock is probably 30 feet or greater in the valley bottom and 5 feet to 15 feet on the abutments. There are several springs on the left side of the reservoir about at the reservoir high water line and above that may indicate a shallow depth of bedrock. The site has a good grass and tree cover.

A dam from 190 to 230 feet high was analyzed. At least three types of dams, homogeneous or zoned earth embankment, concrete faced rockfill, and roller compacted concrete, appear to be applicable to the site.

There would have to be a sufficient amount of fines, 10% or greater, in the granular soils in the reservoir area or downstream borrow areas to construct a homogeneous or zoned earth embankment dam. For an embankment dam, the crest width should be at least the height of the dam divided by 5 plus 10 feet. Therefore, the dam crest should be at least 46 feet wide. The exterior slopes should be 3H:1V or flatter on the upstream face and 2.5H:1V or flatter on the downstream face. If a core is used, the core should have upstream and downstream slopes of 1.5H:1V or flatter. Any of the granular soils may be used for the exterior shells and the granular soils with at least 10% fines should be used for the core. Down stream of the core, a 3-foot wide chimney drain and a 5-foot thick

blanket drain should be installed. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the abutments and 30 feet in the valley bottom. A 5-foot deep cutoff trench should be excavated below the dam centerline with a width of at least 10 feet and 1H:1V side slopes.

The site is suitable for the construction of a concrete faced rockfill dam similar in design to the Deer Creek Dam. The rock for the fill and the concrete face aggregate is available on site both as granular soils and quarried rock. The upstream and downstream slopes of the rockfill should be 1.3H:1V or flatter. The reinforced concrete facing should be at least 12 inches thick. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the abutments and 30 feet in the valley bottom.

The site is suitable for the construction of a roller compacted concrete (RCC) dam similar in design to the Tie Hack Dam. The rock for the concrete aggregate is available on site both as granular soils and quarried rock. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam at least 2 feet into the sound bedrock. The excavation depths are estimated to be 20 feet on the abutments and 40 feet in the valley bottom.

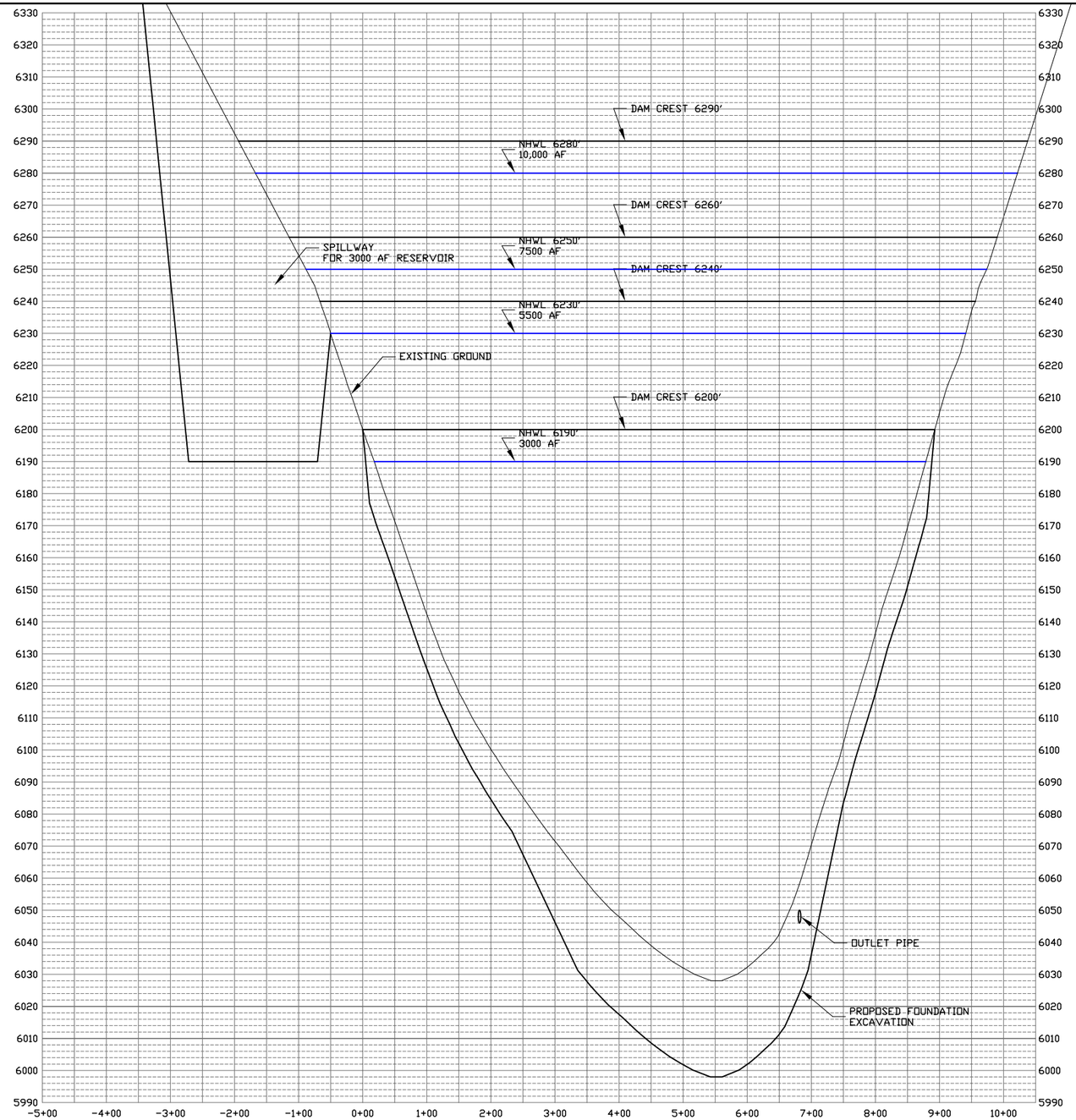
6.3.6 Dam and Reservoir Preliminary Design

Both the roller-compacted concrete (RCC) dam and earth embankment concepts were utilized for development of preliminary designs, as shown in Figures 6.16 and 6.17. The 3500AF and 6000AF sizes were analyzed for RCC and the 3000AF, 5500AF, 7500AF, and 10,000AF sizes were analyzed for earth embankment. The concrete faced rockfill dam was not analyzed due to the history of RCC dams being more economical.

The outlet works for the RCC dam would consist of a multi-level intake attached to the upstream face of the dam, a conduit through the RCC dam, and a control valve structure located at the downstream toe of the dam. The locations of these structures are shown on Figures 6.10 and 6.11. The outlet works for the earth embankment would consist of an inclined multilevel intake structure located on the right abutment of the embankment, a conduit through the embankment, a control building and an energy dissipation structure located at the toe of the embankment. These structures are shown on Figures 6.12 and 6.13.

Material for the earth embankment dam could be borrowed from private land downstream of the reservoir site and from the spillway and foundation excavations. Haul distance to the off site borrow area is estimated at 1.4 miles.

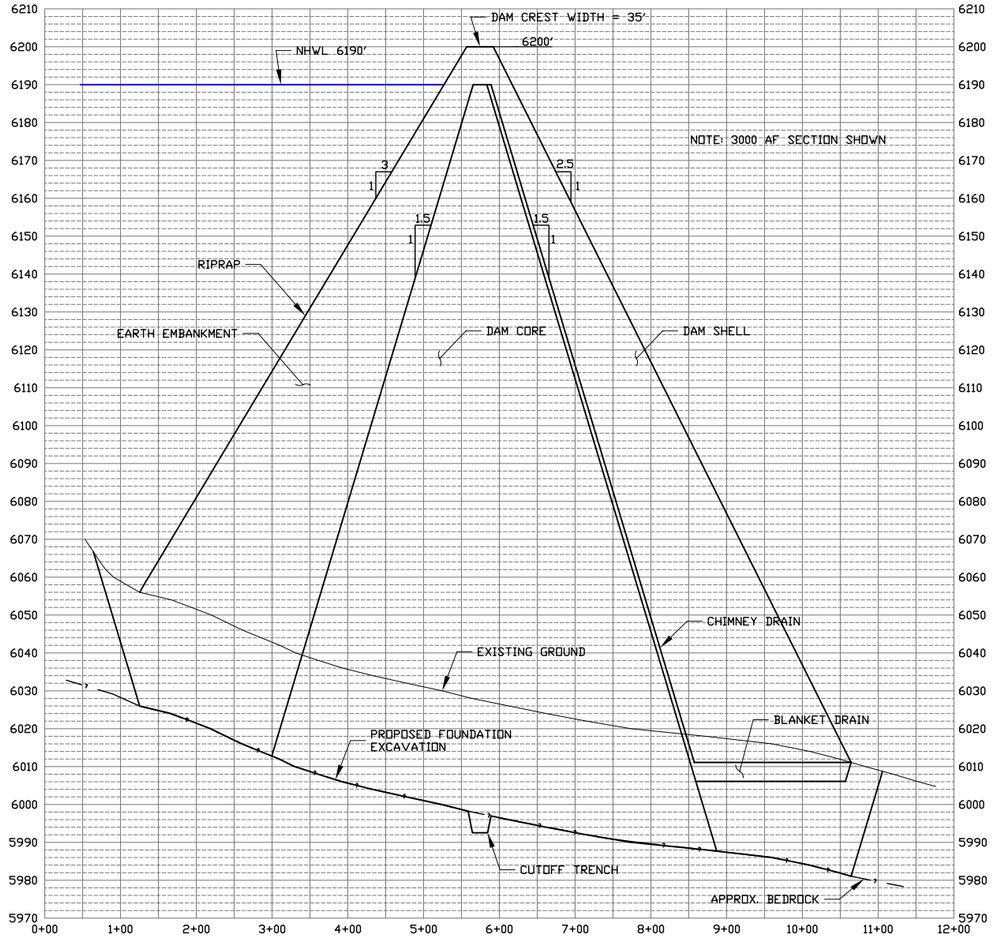
Access roads would have to be constructed to the reservoir site. An existing Jeep trail located on Forest Service and private property could be improved to serve this purpose. This route would require 1.5 miles of improvements. Access from downstream along French Creek across private land is also an option. Approximately 2.5 mile of



PROPOSED DAM CENTERLINE PROFILE
EARTH EMBANKMENT

HORIZ. SCALE
200' 0 200'

VERT. SCALE
40' 0 40'



PROPOSED DAM MAXIMUM SECTION
EARTH EMBANKMENT

REV	DESCRIPTION OF REVISION	BY	DATE
1	PRELIMINARY DESIGN	DWW	07/08

FILE NAME: SITE 3
SCALE: 1"=200'
OPERATOR: DWW
DATE: 07/08
PROJECT NO: 522-WY
TASK NO: 001-283
LOCATION: BUFFALO, WY
PROJECT: HOPKINS STORAGE
SEND TO: VICTOR E. ANDERSON
PHONE: (307) 634-7848

STATES WEST WATER
RESOURCES CORPORATION
1904 E. 15th STREET
CHEYENNE, WYOMING 82001
(307) 634-7848
FAX: (307) 634-7851

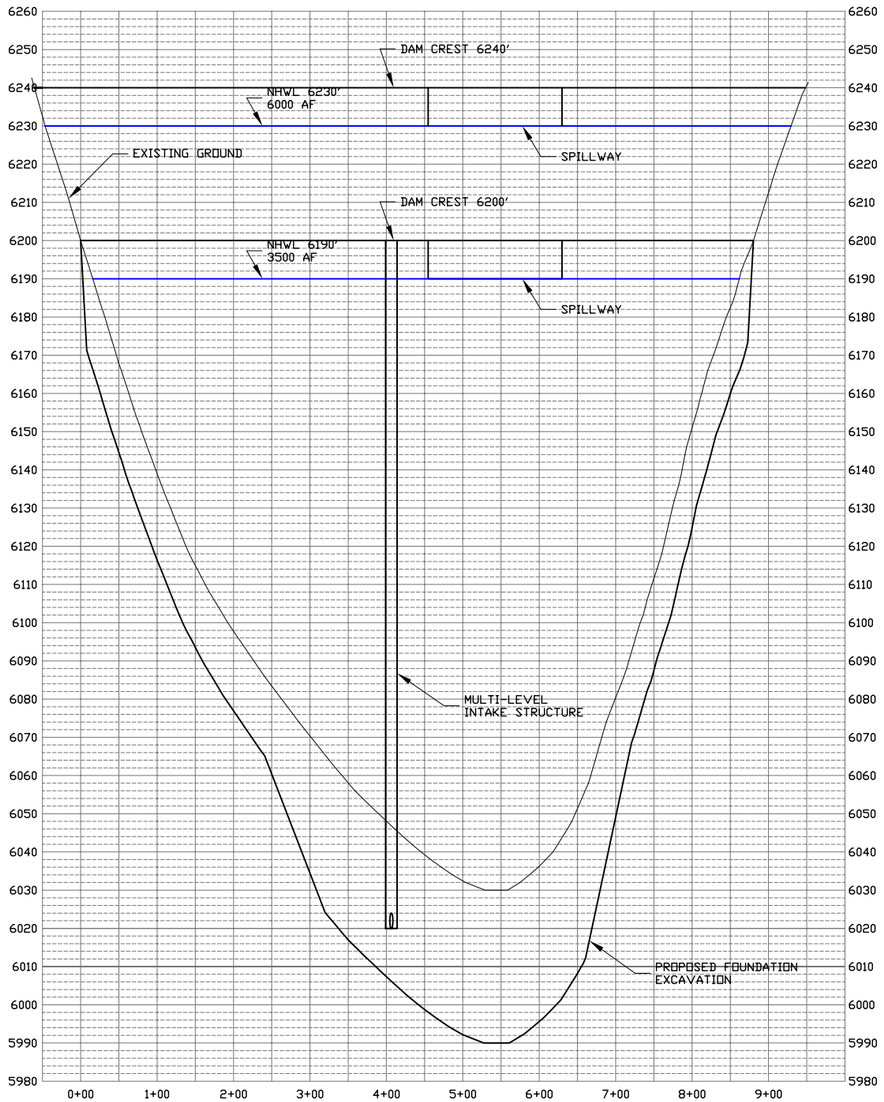
WARNING
IF THIS BAR DOES NOT MEASURE 1/2" THEN DRAWING IS NOT TO SCALE

DESIGNED	DWW
DRAWN	DWW
CHECKED	VEA
PEER REVIEWED	VEA
PROJECT MANAGER	VEA
DATE	07/08

HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 6.16
SITE 3 EARTH EMBANKMENT SECTIONS – 3000AF

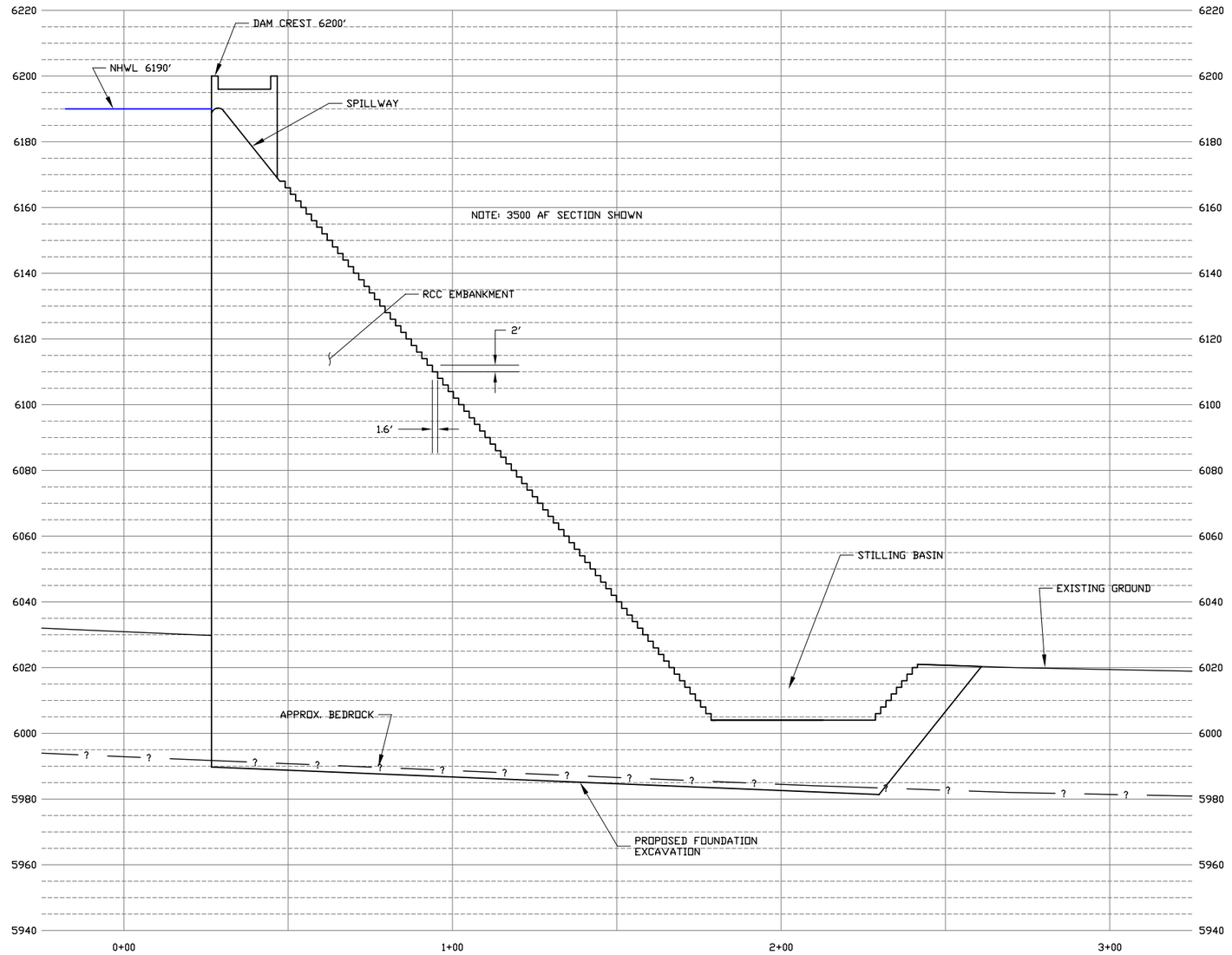
REVISION 1
PROJECT 522-WY
DRAWING 6-29



PROPOSED DAM CENTERLINE PROFILE
RCC EMBANKMENT - 3500AF

HORIZ. SCALE
200' 0 200'

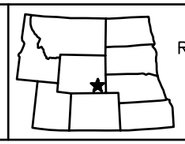
VERT. SCALE
40' 0 40'



PROPOSED DAM MAXIMUM SECTION
RCC EMBANKMENT - 3500AF

SCALE
40' 0 40'

1	PRELIMINARY DESIGN	DWW	07/08
REV	DESCRIPTION OF REVISION	BY	DATE



STATES WEST WATER
RESOURCES CORPORATION

1904 E. 15th STREET
CHEYENNE, WYOMING 82001
(307) 634-7848
FAX: (307) 634-7851

WARNING

IF THIS BAR DOES NOT MEASURE 1/2" THEN DRAWING IS NOT TO SCALE

DESIGNED	DWW
DRAWN	DWW
CHECKED	VEA
PEER REVIEWED	VEA
PROJECT MANAGER	VEA
DATE	07/08

HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 6.17
SITE 3 RCC
SECTIONS - 3500AF

REVISION	1
PROJECT	522-WY
DRAWING	6-30

FILE NAME:	SITE 3
SCALE:	1"=200'
OPERATOR:	DWW
DATE:	07/08
PROJECT NO:	522-WY
TASK NO:	001-283
LOCATION:	BUFFALO, WY
PROJECT:	HOPKINS STORAGE

SEND TO: VICTOR E. ANDERSON
PHONE: (307) 634-7848

improvements would be required for access from the east. Total road improvements would be approximately four miles.

With Site No. 3's close proximity to the Forest Service boundary, there is potential for a land swap with the Forest Service.

6.3.7 Emergency Spillway

Conceptual design for the emergency spillway was developed. Spillway capacity must be designed according to the inflow design flood requirements, in this case the Probable Maximum Flood. Generation of the PMF begins with the development of the Probable Maximum Precipitation (PMP) using Hydrometeorological Report No. 55A. The PMP was generated for the local storm. The local storm generated higher peak flows and is characteristic of this region's intense isolated storm events. The index 1 hr 1 mi^2 PMP estimate adjusted for mean drainage elevation was determined. Then the depth-duration curve for 1 mi^2 was generated using the 1 mi^2 factors for durations up to six hours. Next the areal reduction factors were applied. The result was the PMP depth-duration curve for the drainage basin above Site 3.

The Natural Resources Conservation Service classifies soils into four Hydrologic Soil Groups based on the soil's potential for runoff. The four Hydrologic Soil Groups are A, B, C, and D. HSG A soils generally have the least runoff potential and HSG D soils have the greatest. Details for these classifications can be found in 'Urban Hydrology for Small Watersheds', Soil Conservation Service Technical Release 55 (June 1986). The drainage basin above Site 3 consists of HSG B. The soils in the basin are deep and well drained with moderate infiltration rates when thoroughly wetted. Runoff is generally slow to moderate. The drainage basin is comprised of woods and forest and range lands. Land cover is good and generally consisting of grasses and forbs and conifer and deciduous trees. The resulting pre-development Soil Conservation Service Curve Number based on land cover type, Hydrologic condition, and Hydrologic Soil Group is 60.

Hydrologic modeling of the drainage basin above Site 3 was completed to determine the PMF. Stormwater runoff simulation was completed using U.S. Army Corps of Engineers developed HEC-HMS 2.2.2 hydrologic modeling system. The Soil Conservation Service (SCS) Unit Hydrograph method was used to generate the basin outflow hydrograph. The PMP depth-duration curve along with the drainage basin area, basin lag time, and drainage basin curve number were required input parameters. Basin lag time can be related to time of concentration for ungaged watersheds by:

$$t_{lag} = 0.6\ t_c \qquad (1)$$

Time of concentration is the time it takes for the most distant point in the watershed to contribute runoff at the design point. Runoff is assumed to travel as either sheet flow, shallow concentrated flow, and channel flow. Time of concentration is estimated as the sum of the travel times of these three types of flow. Flow velocities and basin geometry

determine the time of concentration for the basin. The basin lag time was calculated to be 50 minutes. The drainage area for the basin is 11.9 mi^2.

The local storm PMF is estimated to generate 3050 ac-ft of water with a peak flow of 14,132 cfs at this site. This flood would be passed over the RCC dam through a spillway section as shown on Figure 6.17. For the earth embankment dam, the flood would be passed around the embankment through a 200' wide emergency spillway. The emergency spillway would be excavated into the rock adjacent to the left abutment of the embankment and discharge into the drainage below the toe of the dam as shown on Figure 6.16. This spillway could also act as the principal spillway.

6.3.8 Permitting

Site 3 would require filing an application for a permit to appropriate surface water with the State Engineer (SEO). This site would require Form S.W. 3 reservoir permit. In addition, the Wyoming SEO would, prior to construction, need to review the plans and specifications for dam safety approval and to provide approval to construct the proposed facility.

In addition to the Wyoming SEO permits and approval, there are additional permits and approvals required for new dam construction. The Army Corp of Engineers regulates activities involving the waters of the United States. It is anticipated that an Individual Section 404 Permit would be required. This would require that an Environmental Impact Statement be prepared and submitted along with the Section 404 application. These include a Wyoming Department of Environmental Quality National Pollution Discharge Elimination System (NPDES) permit and Section 401 Certification. This permit controls the discharge of stormwater pollutants associated with construction activities. The Section 401 Certification is the State's approval to ensure that the proposed activities meet state water quality standards and do not degrade water quality. A Forest Service Special Use permit would be required to construct a reservoir on Forest Service property. U.S. Fish and Wildlife Service Endangered Species Act Compliance (Section 7) would be required. Coordination with the U.S. Department of Interior Advisory Council on Historic Preservation (Section 106), which protects cultural and historic resources, would be required. State of Wyoming Historic Preservation Office (SHPO) archaeological clearance which determines significance of cultural resources potentially affected by ground disturbing activities would be required.

6.3.9 Wetland Impacts

Site No. 3 has very minimal amounts of wetlands. Wetlands are limited to narrow fringes one to two feet wide in places along the stream. Most wetlands are wet meadows with little shrub cover. The presence of a cobble stream bottom and steep banks along the channel limit wetland formation in this area. Total wetland impacts at this site would likely be less than 0.5 acres. These impacts would have to be mitigated. They could possibly be mitigated downstream of the dam.

6.3.10 Sensitive Species, Migratory Birds, Riparian Areas, and Big Game Habitat Impacts

The presence of federally-listed species does not appear to be a major issue for Site No. 3. Several sensitive wildlife and plant species occur in the area, and some of these species may be present on the reservoir site. As this reservoir is located on the Bighorn National Forest, surveys for sensitive species would likely be required. Impacts to sensitive species, if present, can likely be mitigated.

No raptor nests were observed during the site visit, but this site is partially forested and nests would have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nest of such species as northern goshawk.

This site has some woody riparian areas along the stream within the inundation area. In general, these woody riparian areas are fairly narrow and there are no extensive areas of wood riparian vegetation. Common species include cottonwood, aspen, alder, and mountain maple. Mitigation for woody riparian areas may be required.

This site occurs in an area designated as crucial winter range for elk. The Wyoming Game and Fish Department may request mitigation if a reservoir is constructed on elk crucial winter range. Portions of Site 3 are within moose winter-yearlong range. Site 3 is within mule deer winter-yearlong range, but not crucial winter range.

6.3.11 Cultural Impacts

A class I cultural resource survey of the Site No. 3 Reservoir was performed by the Office of the Wyoming State Archaeologist. The purposes of the class I survey are to document all previously recorded sites and to provide an assessment of the potential for cultural resources in the reservoir area. A file search of the Wyoming State Historical Preservation Office (SHPO), Cultural Records Office database in Laramie, Wyoming, was conducted on September 13, 2007. Previously recorded historical sites at this reservoir site include 48JO1603, the Fort McKinney Wood Reservation Road which has been recommended as not eligible to the National Register of Historic Places (NRHP), and 48JO3777, a historic mining site which has also been recommended as not eligible to the National Register of Historic Places. These historical sites are shown on Figure 2. Given the results of the SHPO file search, the overall topographic setting, and evidence of prior ground disturbance, it is possible to predict with some confidence the density and kinds of cultural sites that may be found in the proposed development areas. Prehistoric sites are expected along the valley of French Creek and its major tributaries. The potential number of prehistoric sites is expected to be small, however. This is due to the small size of the reservoir sites, relatively narrow valleys cut by French Creek and its tributaries, and expected dense vegetation in the reservoir site. Surface artifact scatters are the type of prehistoric sites expected.

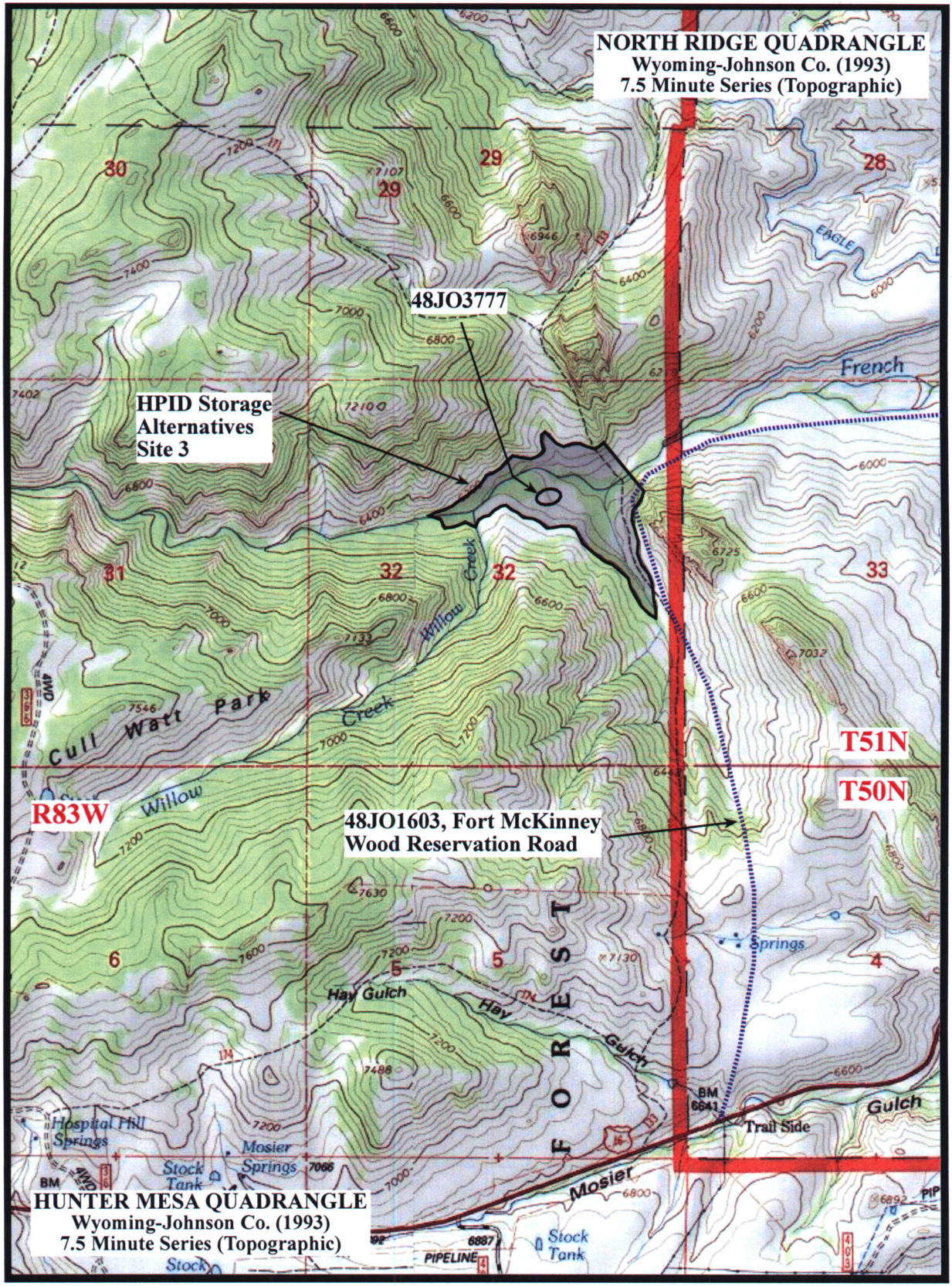


Figure 2. Map of project area and sites, HPID Storage Alternatives, Site 3.

6.3.12 Fishery Impacts

Construction of a reservoir at Site No. 3 would inundate approximately 0.7 miles of stream. In this reach, French Creek is classified as a Class 3 fishery, which is considered important trout waters and a fishery of regional importance. French Creek is a non-native fishery containing mostly brook and rainbow trout. Impacts to the stream would be required to be mitigated. As discussed in section 6, French Creek fishery habitats both above and below the dam site could be improved as mitigation.

6.3.13 Public Involvement

If further study of this project is pursued, all parties that could benefit or be affected should be involved. This includes the Hopkins Producers ID, other irrigators on French Creek, Clear Creek, Johnson Creek, and Rock Creek, the City of Buffalo, and the National Forest Service. A key component in the success of any project is keeping affected parties and stakeholders informed and involved on project activities. This project will need to have public support in order to come to fruition.

6.3.14 Preliminary Cost Estimates

Preliminary cost estimates were developed for the two alternative dam types and three alternative reservoir sizes at Reservoir Site No. 3. The cost estimates were developed utilizing the standard format to estimate the total project costs. The cost estimates are shown in Tables 6.9, 6.10, 6.11, 6.12, and 6.13. The information is presented in graphical form in Figure 6.18. This figure allows for cost estimates comparisons of other sizes of reservoirs.

Table 6.9 - Site Number 3 - Earth Embankment - 3000 ac-ft, Crest Elev: 6200', NHWL: 6190'

No.	Item	Units	Estimated Quantity	Unit Cost	Cost
1	Mobilization	L.S.	--	--	$1,600,000
2	Clearing	Ac.	50	$2,000.00	$100,000
3	Stream Diversion	L.S.	--	--	$200,000
4	Dewatering	L.S.	--	--	$250,000
5	Foundation Excavation, Earth	C.Y.	575,000	$4.00	$2,300,000
6	Foundation Excavation, Key Trench	C.Y.	5,000	$20.00	$100,000
8	Embankment	C.Y.	2,200,000	$7.50	$16,500,000
9	Outlet Works	L.S.	--	--	$3,000,000
10	Emergency Spillway	C.Y.	500,000	$10.00	$5,000,000
11	Access Road Construction	Mi.	4.0	$100,000.00	$400,000
12	Wetllands Mitigation	Ac.	1.00	$100,000.00	$100,000
13	Riparian Mitigation	Ac.	15	$50,000.00	$750,000
14	Fishery Mitigation	L.S.	--	--	$250,000
15	Revegetation	Ac.	60	$2,000.00	$120,000
16	N. Clear Creek Diversion and Pipeline	L.S.	--	--	$2,390,000
				Construction Cost Sub-Total:	**$33,060,000**
				10% Engineering:	$3,306,000
				Sub-Total:	**$36,366,000**
				15% Contingency:	$5,454,900
				CONSTRUCTION COST TOTAL:	**$41,820,900**
				Preparation of Final Designs and Specifications:	$1,600,000
				Permitting:	$500,000
				Legal Fees:	$100,000
				Acquisition of Access and Rights of Way:	$200,000
				TOTAL PROJECT COST:	**$44,220,900**
				USE:	**$43.3M**

Table 6.10 - Site Number 3 - RCC - 3500 ac-ft, Crest Elev: 6200', NHWL: 6190'

No.	Item	Units	Estimated Quantity	Unit Cost	Cost
1	Mobilization	L.S.	--	--	$1,900,000
2	Clearing	Ac.	50	$2,000.00	$100,000
3	Stream Diversion	L.S.	--	--	$200,000
4	Dewatering	L.S.	--	--	$250,000
5	Foundation Excavation, Earth	C.Y.	100,000	$4.00	$400,000
6	Foundation Excavation, Rock	C.Y.	7,500	$10.00	$75,000
7	Foundation Prep and Grouting	L.S.	--	--	$2,000,000
8	Dam RCC	C.Y.	300,000	$90.00	$27,000,000
9	Outlet Works	L.S.	--	--	$2,000,000
10	Spillway	L.S.	--	--	$850,000
11	Access Road Construction	Mi.	4.0	$100,000.00	$400,000
12	Wetllands Mitigation	Ac.	1.00	$100,000.00	$100,000
13	Riparian Mitigation	Ac.	15	$50,000.00	$750,000
14	Fishery Mitigation	L.S.	--	--	$250,000
15	Revegetation	Ac.	20	$2,000.00	$40,000
16	N. Clear Creek Diversion and Pipeline	L.S.	--	--	$2,390,000
				Construction Cost Sub-Total:	**$38,705,000**
				10% Engineering:	$3,870,500
				Sub-Total:	**$42,575,500**
				15% Contingency:	$6,386,325
				CONSTRUCTION COST TOTAL:	**$48,961,825**
				Preparation of Final Designs and Specifications:	$1,900,000
				Permitting:	$500,000
				Legal Fees:	$100,000
				Acquisition of Access and Rights of Way:	$200,000
				TOTAL PROJECT COST:	**$51,661,825**
				USE:	**$50.7M**

Table 6.11 - Site Number 3 - Earth Embankment - 5500 ac-ft, Crest Elev: 6240', NHWL: 6230'

No.	Item	Units	Estimated Quantity	Unit Cost	Cost
1	Mobilization	L.S.	--	--	$2,200,000
2	Clearing	Ac.	60	$2,000.00	$120,000
3	Stream Diversion	L.S.	--	--	$200,000
4	Dewatering	L.S.	--	--	$250,000
5	Foundation Excavation, Earth	C.Y.	800,000	$4.00	$3,200,000
6	Foundation Excavation, Key Trench	C.Y.	6,000	$20.00	$120,000
8	Embankment	C.Y.	3,500,000	$7.50	$26,250,000
9	Outlet Works	L.S.	--	--	$2,500,000
10	Emergency Spillway	C.Y.	550,000	$10.00	$5,500,000
11	Access Road Construction	Mi.	4.0	$100,000.00	$400,000
12	Wetllands Mitigation	Ac.	1.50	$100,000.00	$150,000
13	Riparian Mitigation	Ac.	20	$50,000.00	$1,000,000
14	Fishery Mitigation	L.S.	--	--	$250,000
15	Revegetation	Ac.	70	$2,000.00	$140,000
16	N. Clear Creek Diversion and Pipeline	L.S.	--	--	$2,390,000
				Construction Cost Sub-Total:	**$44,670,000**
				10% Engineering:	$4,467,000
				Sub-Total:	**$49,137,000**
				15% Contingency:	$7,370,550
				CONSTRUCTION COST TOTAL:	**$56,507,550**
				Preparation of Final Designs and Specifications:	$2,200,000
				Permitting:	$500,000
				Legal Fees:	$100,000
				Acquisition of Access and Rights of Way:	$200,000
				TOTAL PROJECT COST:	**$59,507,550**
				USE:	**$58.2M**

Table 6.12 - Site Number 3 - RCC - 6000 ac-ft, Crest Elev: 6240, NHWL: 6230'

No.	Item	Units	Estimated Quantity	Unit Cost	Cost
1	Mobilization	L.S.	--	--	$2,700,000
2	Clearing	Ac.	60	$2,000.00	$120,000
3	Stream Diversion	L.S.	--	--	$200,000
4	Dewatering	L.S.	--	--	$250,000
5	Foundation Excavation, Earth	C.Y.	130,000	$4.00	$520,000
6	Foundation Excavation, Rock	C.Y.	10,000	$10.00	$100,000
7	Foundation Prep and Grouting	L.S.	--	--	$2,000,000
8	Dam RCC	C.Y.	470,000	$80.00	$37,600,000
9	Outlet Works	L.S.	--	--	$2,500,000
10	Spillway	L.S.	--	--	$1,000,000
11	Access Road Construction	Mi.	4.0	$100,000.00	$400,000
12	Wetlands Mitigation	Ac.	1.50	$100,000.00	$150,000
13	Riparian Mitigation	Ac.	20	$50,000.00	$1,000,000
14	Fishery Mitigation	L.S.	--	--	$250,000
15	Revegetation	Ac.	25	$2,000.00	$50,000
16	N. Clear Creek Diversion and Pipeline	L.S.	--	--	$2,390,000
				Construction Cost Sub-Total:	**$51,230,000**
				10% Engineering:	$5,123,000
				Sub-Total:	**$56,353,000**
				15% Contingency:	$8,452,950
				CONSTRUCTION COST TOTAL:	**$64,805,950**
				Preparation of Final Designs and Specifications:	$2,700,000
				Permitting:	$500,000
				Legal Fees:	$100,000
				Acquisition of Access and Rights of Way:	$200,000
				TOTAL PROJECT COST:	**$68,305,950**
				USE:	**$72.9M**

Table 6.13 - Site Number 3 - Earth Embankment - 7500 ac-ft, Crest Elev: 6260', NHWL: 6250'

No.	Item	Units	Estimated Quantity	Unit Cost	Cost
1	Mobilization	L.S.	--	--	$2,500,000
2	Clearing	Ac.	70	$2,000.00	$140,000
3	Stream Diversion	L.S.	--	--	$200,000
4	Dewatering	L.S.	--	--	$250,000
5	Foundation Excavation, Earth	C.Y.	900,000	$4.00	$3,600,000
6	Foundation Excavation, Key Trench	C.Y.	7,000	$20.00	$140,000
8	Embankment	C.Y.	4,500,000	$7.50	$33,750,000
9	Outlet Works	L.S.	--	--	$2,750,000
10	Emergency Spillway	C.Y.	600,000	$10.00	$6,000,000
11	Access Road Construction	Mi.	4.0	$100,000.00	$400,000
12	Wetllands Mitigation	Ac.	2.00	$100,000.00	$200,000
13	Riparian Mitigation	Ac.	25	$50,000.00	$1,250,000
14	Fishery Mitigation	L.S.	--	--	$300,000
15	Revegetation	Ac.	80	$2,000.00	$160,000
16	N. Clear Creek Diversion and Pipeline	L.S.	--	--	$2,390,000
				Construction Cost Sub-Total:	**$54,030,000**
				10% Engineering:	$5,403,000
				Sub-Total:	**$59,433,000**
				15% Contingency:	$8,914,950
				CONSTRUCTION COST TOTAL:	**$68,347,950**
				Preparation of Final Designs and Specifications:	$2,500,000
				Permitting:	$500,000
				Legal Fees:	$100,000
				Acquisition of Access and Rights of Way:	$200,000
				TOTAL PROJECT COST:	**$71,647,950**
				USE:	**$71.6M**

6.3.15 Reservoir Alternative Size Comparison

The reservoir size alternatives analyzed for Site 3 are compared in Table 6.14. As indicated, the 10,000 AF earth reservoir has the lower unit cost per acre-foot of storage. The comparison of the unit cost per acre-foot of yield indicates that the 5500-7500 AF reservoir size range has the lowest unit cost as shown on Figure 6.19. This site would be most economically developed at the 5500-7500 AF size range alternative.

Table 6.14 - Site No. 3 Alternatives Comparison

Dam Type	Total Capacity	Est. Cost	Storage Unit Cost	Active Capacity	Est. Yield	Unit Cost Yield
	AF	$Mil	$/AF	AF	AF/Yr	$/AF Yield
RCC	3,500	$51.7	$14,761	2450	2230	$23,167
RCC	6,000	$68.3	$11,384	4200	3630	$18,817
Earth	3,000	$44.2	$14,740	2100	1950	$22,677
Earth	5,500	$59.5	$10,820	3850	3350	$17,763
Earth	7,500	$71.6	$9,553	5250	4000	$17,912
Earth	10,000	$86.9	$8,690	7000	4000	$21,725

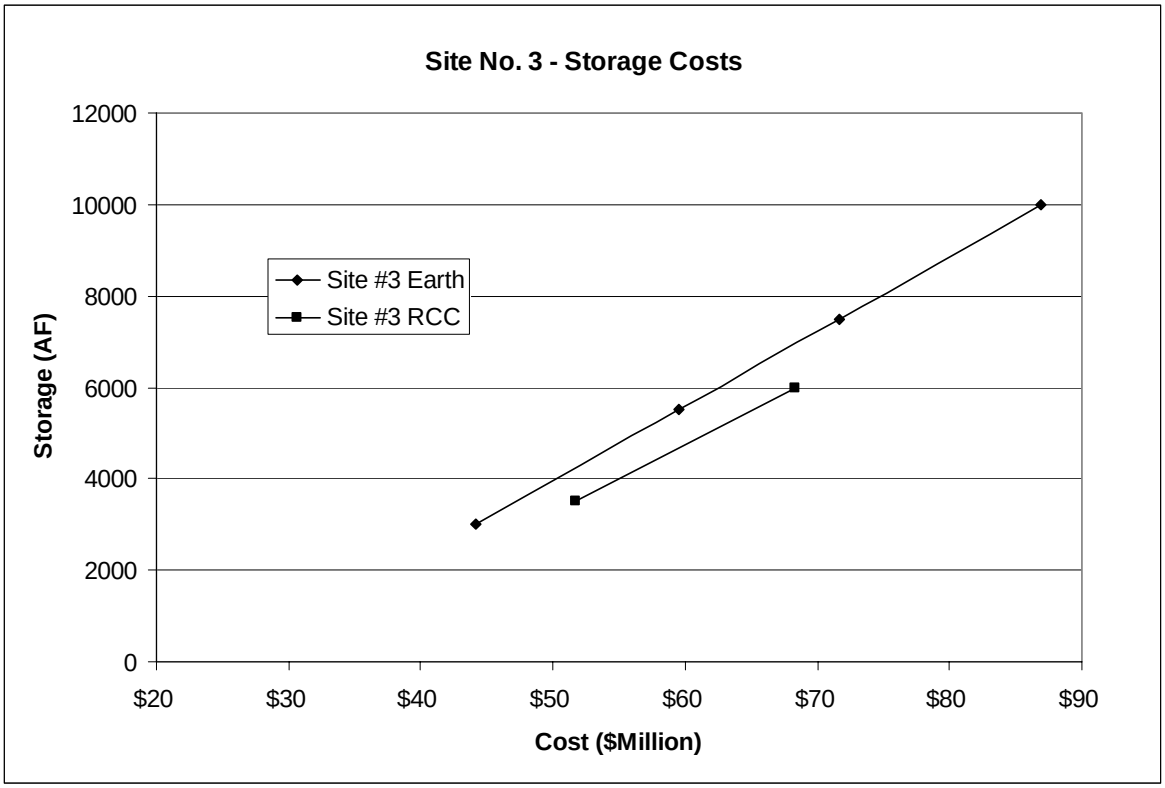


Figure 6.18 Site #3 Storage Costs

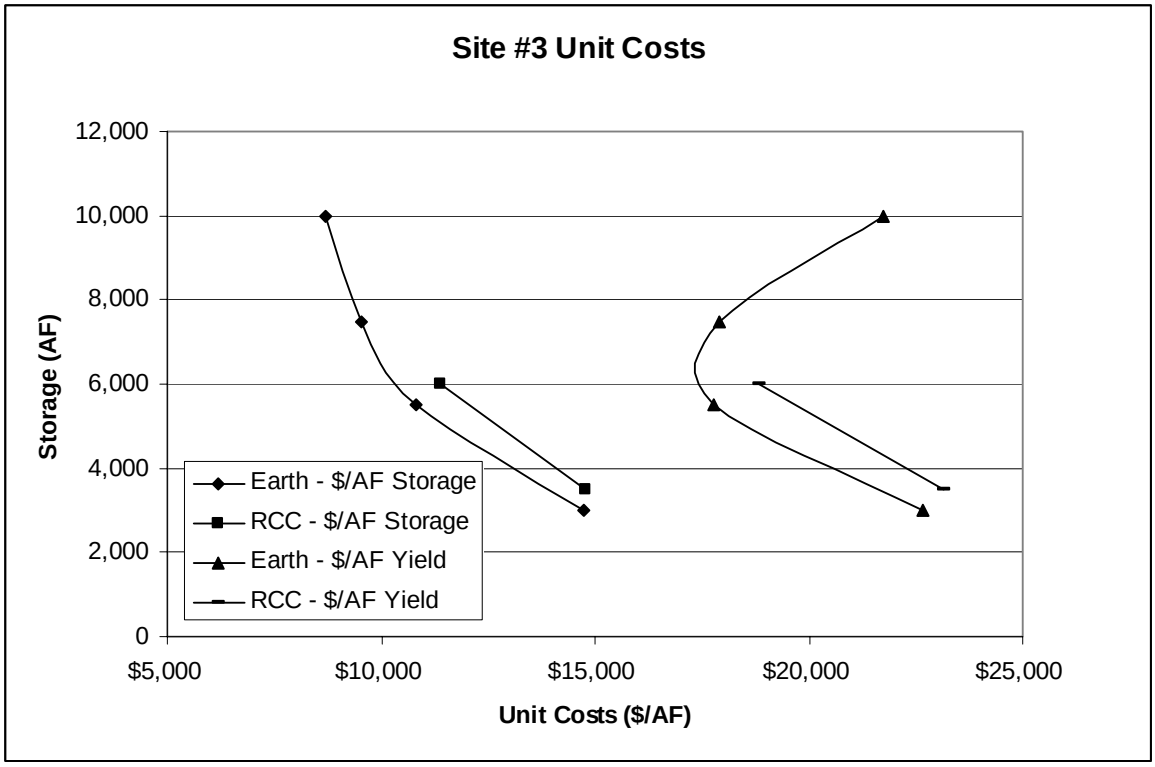


Figure 6.19 Site No. 3 Unit Costs

6.3.16 Project Financing

The current financing package offered by the Wyoming Water Development Commission is 67% grant, 33% loan at 4% for a case specific term not to exceed 50 years. The Commission has the ability in their criteria to grant up to 75%. The Commission has the authority with Wyoming Legislature approval to grant 100% of the total project costs. In order to achieve this level of financing the project would have to give significant benefit to the State of Wyoming. Additional funding sources may include the NRCS.

Assuming a 67% WWDC grant and 33% loan at 4% for 50 years, the annual repayment would be as follows:

Table 6.15 - Site No. 3 Annual Repayment

Dam Type	Total Capacity	Est. Cost	Annual Repayment
	AF	$Mil	$/Yr
RCC	3500	$51.7	$802,400
RCC	6000	$68.3	$1,060,913
Earth	3000	$44.2	$686,829
Earth	5500	$59.5	$924,258
Earth	7500	$71.6	$1,112,820
Earth	10000	$86.9	$1,349,712

6.3.17 Summary

Site No. 3 would be a multipurpose facility located on the Bighorn National Forest. Site No. 3 is most efficient based on the water availability and project cost in the 5500-7500 AF range. With the anticipated availability of fine grain material, an earth embankment at this location would be the most economical dam. The cultural resources in the vicinity are likely not fatal flaws but may require mitigation. Wetland impacts at this site are minimal but will likely require mitigation. Riparian impacts are present at this site and will likely require mitigation. This site is within crucial winter range for elk which will likely require mitigation. The design flood at this site is relatively large requiring a relatively substantial spillway. Access to the site requires improvement of an existing Forest Service road and improvement of a private road. The reservoir is sited on the Bighorn National Forest which will require a special use permit and will likely be more difficult to permit. This site is recommended for further study if any alternatives are pursued.

6.4 Site No. 4 Preliminary Analysis

6.4.1 Introduction

Site No. 4 is located on French Creek on US Forest Service property as shown on Figure 6.20. Site No. 4 is located in Section 36, Township 51 North, Range 84 West. The reservoir would be supplied by flows from the North Fork of Clear Creek and French Creek. Conceptual level designs were not developed for this site.

This site could be a multiple-use reservoir. The reservoir yield could be utilized in the French Creek, Johnson Creek, lower Rock Creek, and Clear Creek drainages for irrigation supplementary flows, municipal purposes, environmental uses, and recreation. Benefits to the Hopkins Producers ID and other downstream irrigators could be achieved with additional late season water. This water could be transferred to Clear Creek (see section 7) to be utilized for future municipal needs of the City of Buffalo and additional hydropower generation, supplemental irrigation water, and instream flows through Buffalo, and could delay regulation on the Clear Creek drainage. A minimum pool could be maintained in the reservoir to promote recreation and a fishery. Stream fishing improvements on French Creek could also be realized with the project.

6.4.2 Reservoir Capacity

Site No. 4 could store approximately 3200 AF. This reservoir was assumed to incorporate a recreation pool of approximately 30% of the total storage. Consequently, the 3200AF reservoir would have 2240AF of active storage.

6.4.3 Water Supply

The potential water supply for a reservoir at Site No. 4 would be from available flows on French Creek and available flows from the North Fork of Clear Creek. The North Fork of Clear Creek water supply analysis is discussed in detail in section 6. The hydrological analysis estimated the available storable flows for dry, average, and wet years as shown below:

	French Creek	North Fork Clear Creek	Total
Dry Years	100-250 AF	500-900 AF	600-1150 AF
Average Years	300-700 AF	2800-3500 AF	3100-4200 AF
Wet Years	400-800 AF	3500-4300 AF	3900-5100 AF

6.4.4 Reservoir Yield

The potential yield of the reservoir alternative sizes were estimated in the hydrological analysis. The estimated average annual yields of a 3200 AF reservoir with an active capacity of 2240 AF would be approximately 2020 AF.

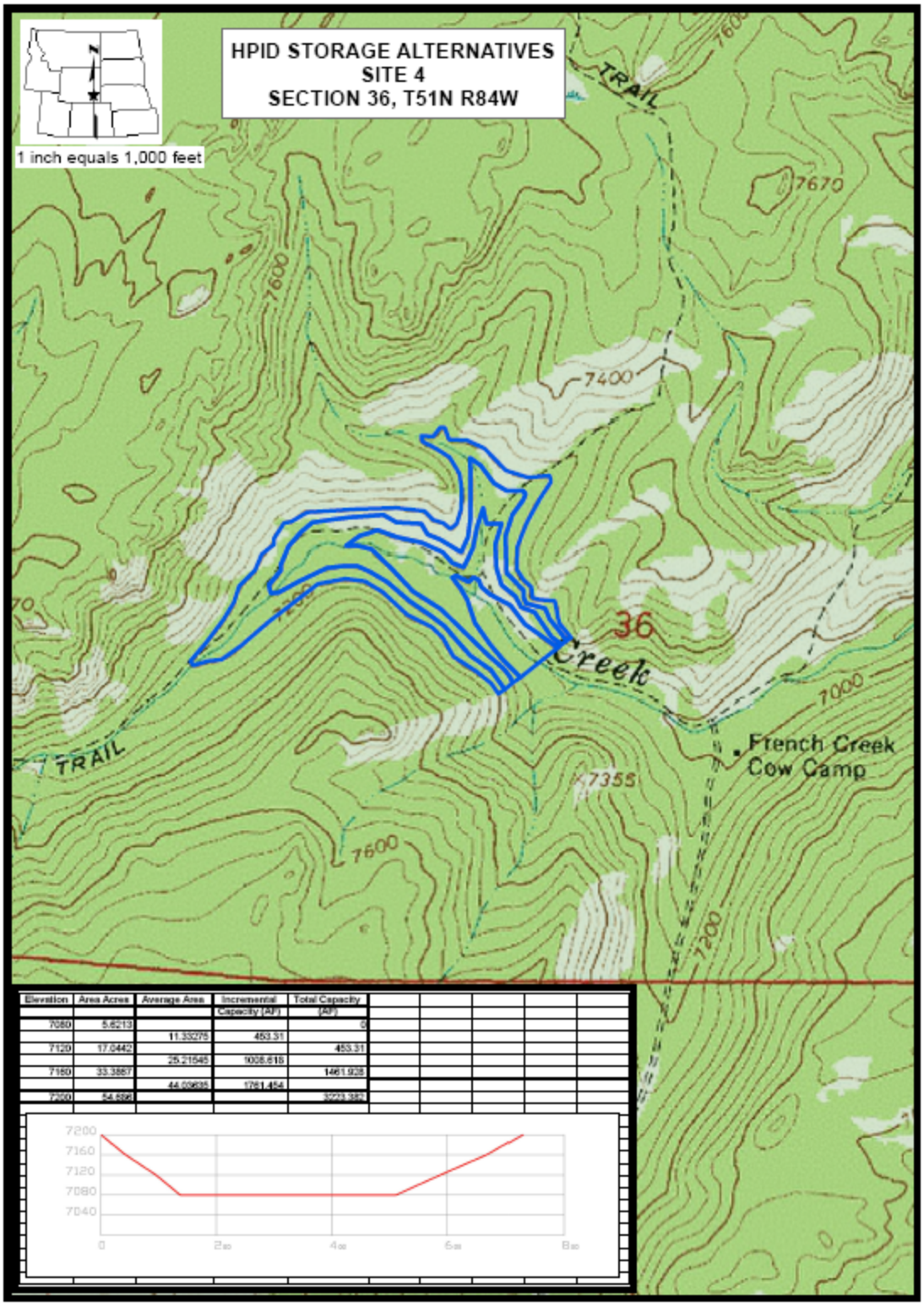


Figure 6.20 Site No. 2

6.4.5 Geologic and Geotechnical Investigation

Site No. 4 is located in a narrow, very steep V-shaped valley with French Creek flowing through. The bedrock is Precambrian granite. There were numerous rock outcrops on the left abutment. There were no rock outcrops on the right abutment. The valley bottom was filled with silty sand and gravel and numerous boulders. Depth to bedrock is probably 30 feet or greater in the valley bottom and 5 feet to 15 feet on the abutments. The site has a heavy tree cover.

A dam approximately 120 feet high was planned. At least three types of dams, homogeneous or zoned earth embankment, concrete faced rockfill, and roller compacted concrete, appear to be applicable to the site.

There would have to be a sufficient amount of fines, 10% or greater, in the granular soils in the reservoir area to construct a homogeneous or zoned earth embankment dam. For an embankment dam, the crest width should be at least the height of the dam divided by 5 plus 10 feet. Therefore, the dam crest should be at least 34 feet wide. The exterior slopes should be 3H:1V or flatter on the upstream face and 2.5H:1V or flatter on the downstream face. If a core is used, the core should have upstream and downstream slopes of 1.5H:1V or flatter. Any of the granular soils may be used for the exterior shells and the granular soils with at least 10% fines should be used for the core. Down stream of the core, a 3-foot wide chimney drain and a 5-foot thick blanket drain should be installed. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the abutments and 30 feet in the valley bottom. A 5-foot deep cutoff trench should be excavated below the dam centerline with a width of at least 10 feet and 1H:1V side slopes.

The site is suitable for the construction of a concrete faced rockfill dam similar in design to the Deer Creek Dam. The rock for the fill and the concrete face aggregate is available on site both as granular soils and quarried rock. The upstream and downstream slopes of the rockfill should be 1.3H:1V or flatter. The reinforced concrete facing should be at least 12 inches thick. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the abutments and 30 feet in the valley bottom.

The site is suitable for the construction of a roller compacted concrete (RCC) dam similar in design to the Tie Hack Dam. The rock for the concrete aggregate is available on site both as granular soils and quarried rock. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam at least 2 feet into the sound bedrock. The excavation depths are estimated to be 20 feet on the abutments and 40 feet in the valley bottom.

6.4.6 Wetland Impacts

Site No. 4 has narrow wetland fringes along the stream. No extensive areas of off-channel wetlands are present and wetland impacts would likely be less than 1.0 acre. These impacts would have to be mitigated. They could possibly be mitigated downstream of the dam.

6.4.7 Sensitive Species, Migratory Birds, Riparian Areas, and Big Game Habitat Impacts

The presence of federally-listed species does not appear to be a major issue for Site No. 4. Several sensitive wildlife and plant species occur in the area, and some of these species may be present on the reservoir site. As this reservoir is located on the Bighorn National Forest, surveys for sensitive species would likely be required. Impacts to sensitive species, if present, can likely be mitigated.

No raptor nests were observed during the site visit, but this site is partially forested and nests would have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nest of such species as northern goshawk.

This site has some woody riparian areas along the stream within the inundation area. In general, these woody riparian areas are fairly narrow and there are no extensive areas of wood riparian vegetation. Common species include cottonwood, aspen, alder, and mountain maple. Mitigation for woody riparian areas may be required.

This site occurs in an area designated as crucial winter range for elk. The Wyoming Game and Fish Department may request mitigation if a reservoir is constructed on elk crucial winter range. Site 4 is within moose and mule deer winter-yearlong range, but not crucial winter range.

6.4.8 Cultural Impacts

The French Creek Cow Camp is located downstream of Site 4. This site is a recorded historical site (48JO3778) and is suggested that the site be considered eligible for nomination to the National Register of Historic Places. This site would not be impacted by a reservoir at Site No. 4. It is predicted that prehistoric sites are expected along the valley of French Creek and its major tributaries. The potential number of prehistoric sites is expected to be small, however. This is due to the small size of the reservoir sites, relatively narrow valleys cut by French Creek and its tributaries, and expected dense vegetation in the reservoir site. Surface artifact scatters are the type of prehistoric sites expected.

6.4.9 Fishery Impacts

Construction of a reservoir at Site No. 4 would inundate approximately 0.7 mile of stream. In this reach, French Creek is classified as a Class 3 fishery, which is considered important trout waters and a fishery of regional importance. French Creek is a non-native

fishery containing mostly brook and rainbow trout. Impacts to the stream will be required to be mitigated. As discussed in section 6, French Creek fishery habitats both above and below the dam site could be improved as mitigation.

6.4.10 Summary

Site No. 4 would be a multipurpose facility located on the Bighorn National Forest. Site No. 4 would not impact the French Creek Cow Camp cultural site which would be inundated by Site No. 8. Wetland impacts at this site are minimal but will likely require mitigation. Riparian impacts are present at this site and may require mitigation. This site is within crucial winter range for elk which would likely require mitigation. The design flood at this site is relatively large requiring a relatively substantial spillway. Conceptual level designs were not developed for this site. Site No. 8 would be more efficient than Site No. 4; therefore Site No. 8 was analyzed instead. This site, due to inefficiency, is not recommended for further study if any alternatives are pursued.

6.5 Site No. 5 Preliminary Analysis

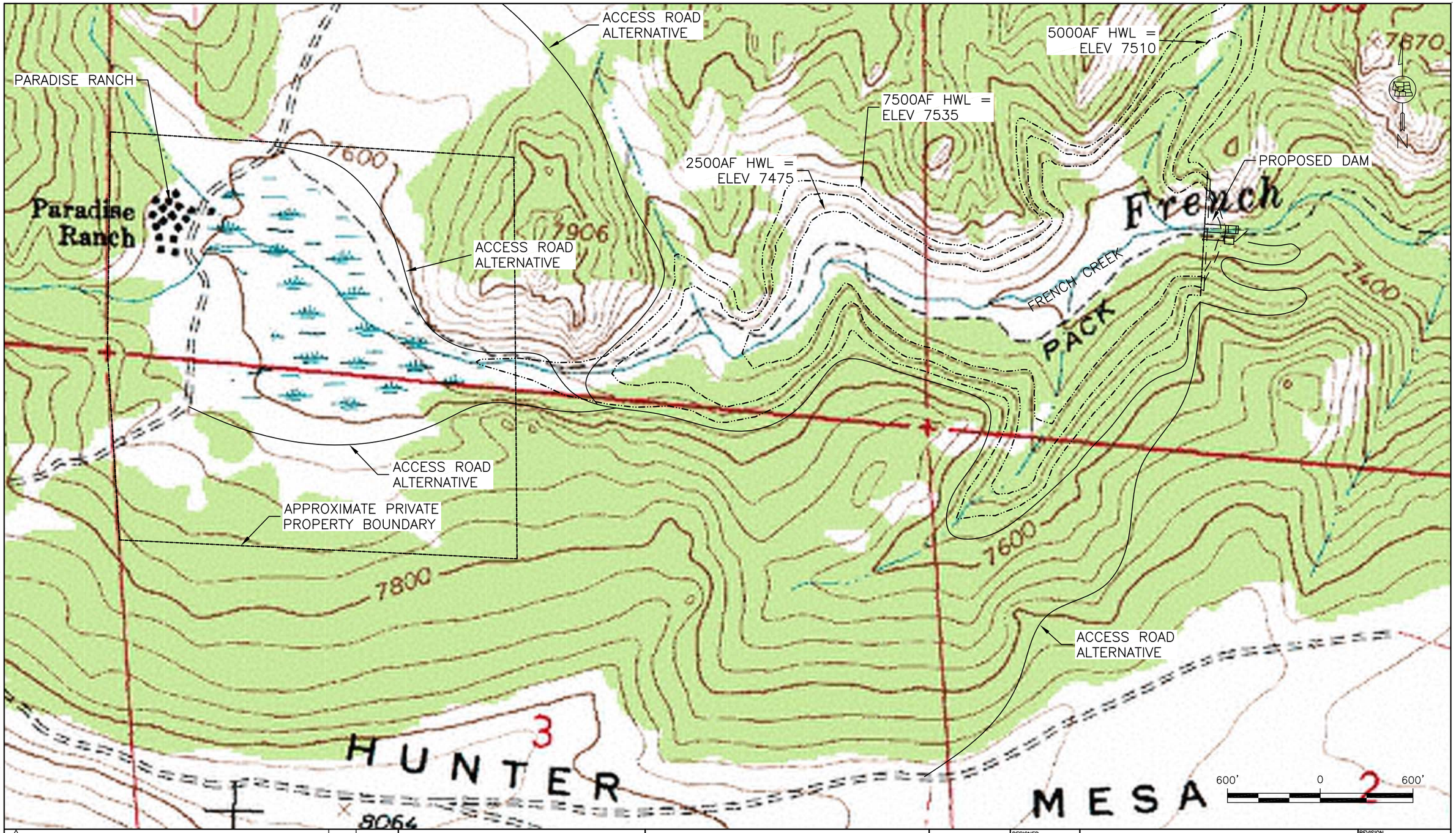
6.5.1 Introduction

Site No. 5 is located on French Creek on US Forest Service property approximately 3.5 miles above the boundary in the south half of Sections 34 and 35, Township 51 North, Range 84 West as shown on Figure 6.21. The reservoir would be supplied by flows from the North Fork of Clear Creek and French Creek. Alternative sized reservoirs were analyzed and preliminary designs and cost estimates were developed.

This site could be a multiple-use reservoir. The reservoir yield could be utilized in the French Creek, Johnson Creek, Rock Creek, and Clear Creek drainages for irrigation supplementary flows. Water could be utilized for City of Buffalo municipal purposes as discussed in section 7. The reservoir could be utilized for environmental uses by providing water for instream flows. The reservoir could be utilized for recreation purposes with incorporation of a recreation pool. Stream fishing improvements on French Creek could also be realized with the project. The analysis of the reservoir alternatives is discussed in detail in the following sections.

6.5.2 Reservoir Capacity

Elevation-area-capacity data were developed for this site. The summary of information is shown in Table 6.16 and the capacity-elevation curve is shown on Figure 6.22. The maximum storage capacity of the site is approximately 11,000AF. For this analysis, alternative sizes of 2500AF, 5000AF, and 7500 AF have been addressed. The reservoirs were assumed to incorporate a recreation pool of approximately 30% of the total storage. Consequently, the 2500AF reservoir would have 1750AF of active storage, the 5000AF reservoir would have 3500 AF of active storage, and the 7500 AF reservoir would have 5250 AF of active storage.



1	PRELIMINARY DESIGN	JMR	05/30/08
REV	DESCRIPTION OF REVISION	BY	DATE

FILE NAME SITE 5
PLOT SCALE 1" = 300'
OPER. JMR
DATE 2008MAY30
PROJ. # 522WY
TASK # CONCEP. DESIGN
LOC: BUFFALO, WY
PROJ. HOPKINS STUDY
SEND TO JENNIFER RUSSELL
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PROJECT MANAGER	VEA
DATE	MAY 2008

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FIGURE 6.21
SITE 5 RCC
SITE PLAN

REVISION 1
PROJECT 522-WY

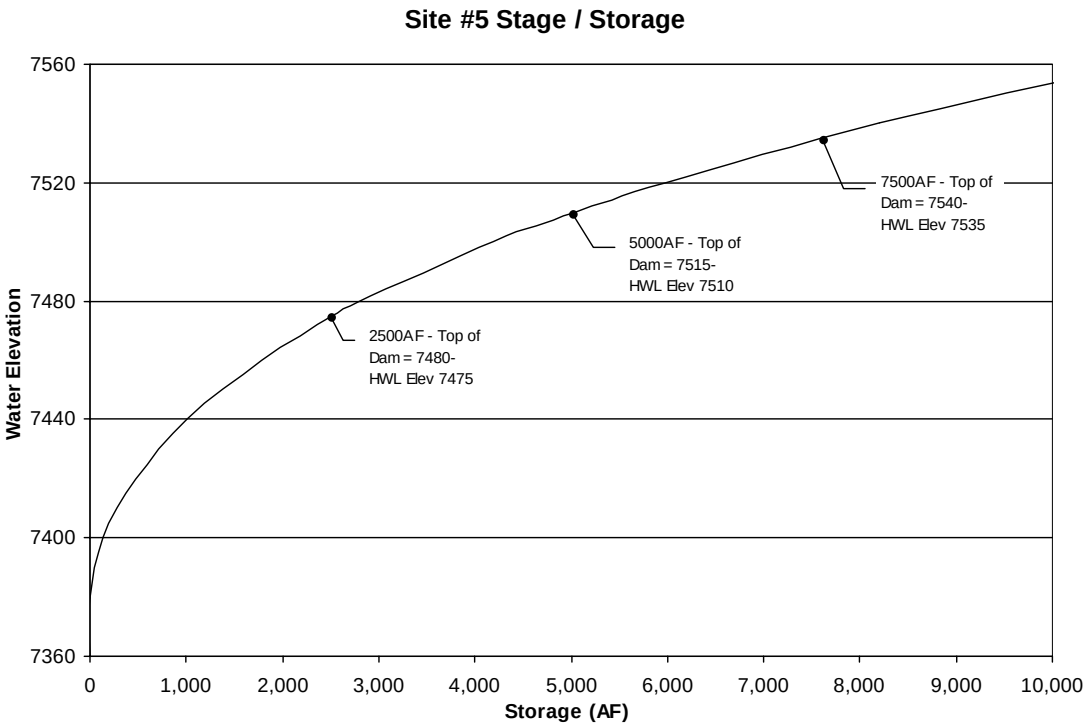


Figure 6.22 Site No. 5 stage / storage curve

Table 6.16 - Site #5 Elevation-Area-Capacity

Top of Dam Elevation	Water Elevation	Water Area (sq.ft.)	Water Area (Ac)	Incr. Volume (AF)	Total Volume (AF)
7365	7360	4,475	0.0		0
				6.9	
7385	7380	29,991	0.7		7
				132.3	
7405	7400	546,246	12.5		139
				332.2	
7425	7420	900,843	20.7		471
				539.3	
7445	7440	1,448,355	33.2		1,011
				766.9	
7465	7460	1,892,401	43.4		1,778
				735.8	
7480	7475	2,380,971	54.7		2,513
				291.1	
7485	7480	2,691,496	61.8		2,805
				1,396.5	
7505	7500	3,391,471	77.9		4,201
				832.4	
7515	7510	3,860,090	88.6		5,033
				948.5	
7525	7520	4,403,255	101.1		5,982
				2,234.9	
7545	7540	5,331,820	122.4		8,217
				2,717.5	
7565	7560	6,505,494	149.3		10,934

6.5.3 Water Supply

The potential water supply for a reservoir at Site No. 5 would be from available flows on French Creek and available flows from the North Fork of Clear Creek. The hydrological analysis estimated the storable flows for dry, average, and wet years as shown below:

	French Creek	North Fork Clear Creek	Total
Dry Years	100-200 AF	500-900 AF	600-1100 AF
Average Years	300-600 AF	2800-3500 AF	3100-4100 AF
Wet Years	400-700 AF	3500-4300 AF	3900-5000 AF

6.5.4 Reservoir Yield

The potential yield of the reservoir alternative sizes were estimated in the hydrological analysis as shown on Figure 6.23. The estimated average annual yield for the 2500Af reservoir with an active capacity of 1750AF would be approximately 1620 AF. The estimated average annual yield with an active capacity of 3500AF would be approximately 3020 AF. The estimated average annual yield with an active capacity of 5250AF would be approximately 3500 AF.

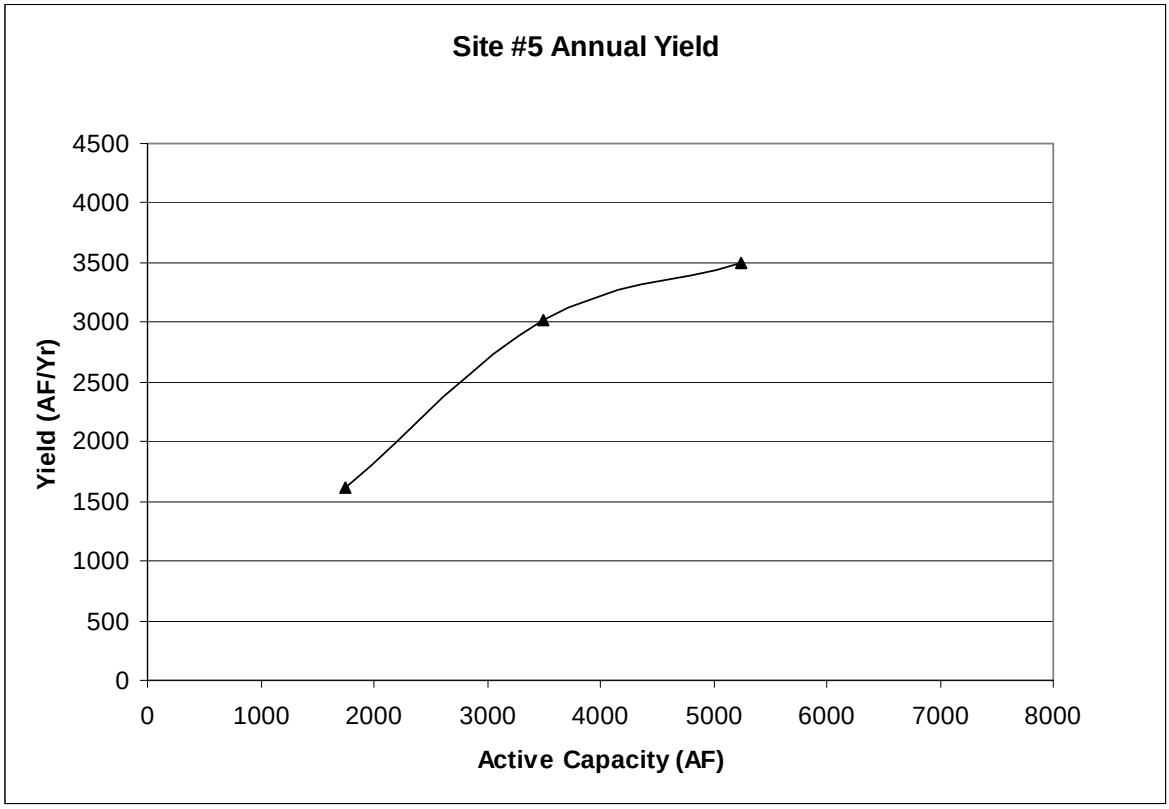


Figure 6.23 Annual yield vs. active capacity at Site No. 5

6.5.5 Geological and Geotechnical Investigation

Site No. 5 is located in a fairly wide, very steep V-shaped valley with French Creek running through it. The bedrock is Precambrian granite. There were numerous rock outcrops on the left abutment with the first being a near 60 feet vertical outcrop. Above that point, the abutment flattens to a slope of 2H:1V with numerous outcrops. That portion of the slope had up to 5 feet of silty sand soils. There were numerous rock outcrops on the right abutment, which was very steep. The lower portion of the right abutment was a talus slope. The valley bottom was filled with silty sand and gravel and numerous boulders. Depth to bedrock is probably 30 feet or greater in the valley bottom and 5 feet to 15 feet on the abutments. The site has a heavy tree cover.

A dam approximately 150 feet to 190 feet high is planned. At least three types of dams, homogeneous or zoned earth embankment, concrete faced rockfill, and roller compacted concrete, appear to be applicable to the site.

There would have to be a sufficient amount of fines, 10% or greater, in the granular soils in the reservoir area to construct a homogeneous or zoned earth embankment dam. For an embankment dam, the crest width should be at least the height of the dam divided by 5 plus 10 feet. Therefore, the dam crest should be at least 42 feet wide. The exterior slopes should be 3H:1V or flatter on the upstream face and 2.5H:1V or flatter on the downstream face. If a core is used, the core should have upstream and downstream slopes of 1.5H:1V or flatter. Any of the granular soils may be used for the exterior shells and the granular soils with at least 10% fines should be used for the core. Down stream of the core, a 3-foot wide chimney drain and a 5-foot thick blanket drain should be installed. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the abutments and 30 feet in the valley bottom. A 5-foot deep cutoff trench should be excavated below the dam centerline with a width of at least 10 feet and 1H:1V side slopes.

The site is suitable for the construction of a concrete faced rockfill dam similar in design to the Deer Creek Dam. The rock for the fill and the concrete face aggregate is available on site both as granular soils and quarried rock. The upstream and downstream slopes of the rockfill should be 1.3H:1V or flatter. The reinforced concrete facing should be at least 12 inches thick. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the abutments and 30 feet in the valley bottom.

The site is suitable for the construction of a roller compacted concrete (RCC) dam similar in design to the Tie Hack Dam. The rock for the concrete aggregate is available on site both as granular soils and quarried rock. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam at least 2 feet into the

sound bedrock. The excavation depths are estimated to be 20 feet on the abutments and 40 feet in the valley bottom.

6.5.6 Dam and Reservoir Preliminary Design

The roller-compacted concrete (RCC) dam concept was utilized for development of preliminary designs, as shown in Figures 6.24 and 6.25. Alternative sizes of 2500AF, 5000 AF and 7500AF were analyzed. The earth embankment alternative dam type was not analyzed due to the concern that adequate fill material would not be available at the site. Costs for a concrete faced rockfill dam were analyzed for the 2500AF and 5000AF alternative sizes.

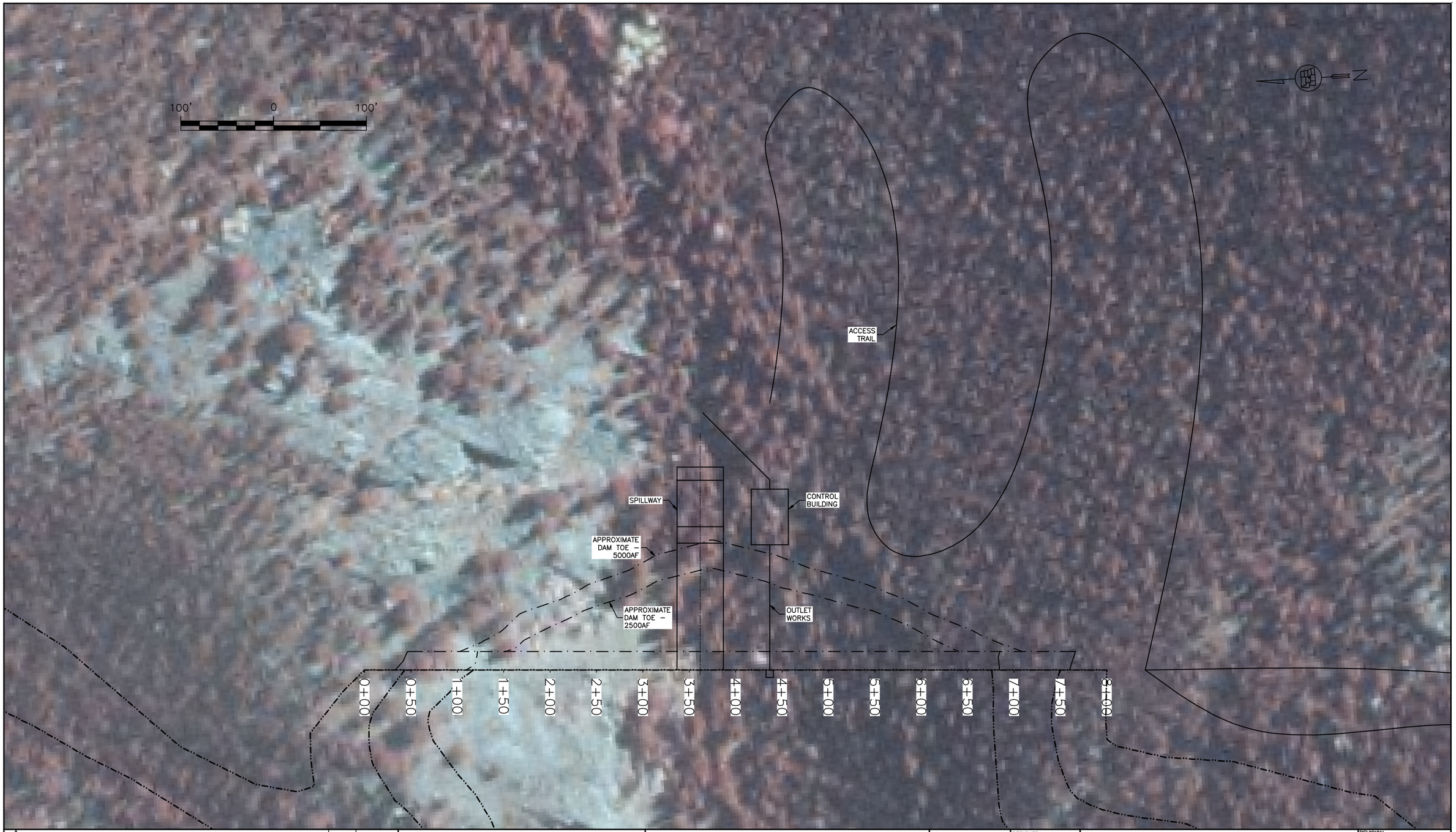
The outlet works would consist of a multi-level intake attached to the upstream face of the dam, a conduit through the RCC dam, and a control valve structure located at the downstream toe of the dam. The locations of these structures are shown on Figure 6.24.

An access road would have to be constructed to the reservoir site. Potential routes for this access are shown on Figure 6.21. These access roads, including the portion to the outlet control structure, vary in length from 1.3 miles to 2.5 miles.

6.5.7 Emergency Spillway

Conceptual design for the emergency spillway was developed. Spillway capacity must be designed according to the inflow design flood requirements, in this case the Probable Maximum Flood. Generation of the PMF begins with the development of the Probable Maximum Precipitation (PMP) using Hydrometeorological Report No. 55A. The PMP was generated for the local storm. The local storm generated higher peak flows and is characteristic of this region's intense isolated storm events. The index 1 hr 1 mi^2 PMP estimate adjusted for mean drainage elevation was determined. Then the depth-duration curve for 1 mi^2 was generated using the 1 mi^2 factors for durations up to six hours. Next the areal reduction factors were applied. The result was the PMP depth-duration curve for the drainage basin above Site 5.

The Natural Resources Conservation Service classifies soils into four Hydrologic Soil Groups based on the soil's potential for runoff. The four Hydrologic Soil Groups are A, B, C, and D. HSG A soils generally have the least runoff potential and HSG D soils have the greatest. Details for these classifications can be found in 'Urban Hydrology for Small Watersheds', Soil Conservation Service Technical Release 55 (June 1986). The drainage basin above Site 5 consists of HSG B. The soils in the basin are deep and well drained with moderate infiltration rates when thoroughly wetted. Runoff is generally slow to moderate. The drainage basin is comprised of woods and forest and range lands. Land cover is good and generally consisting of grasses and forbs and conifer and deciduous trees. The resulting pre-development Soil Conservation Service Curve Number based on land cover type, Hydrologic condition, and Hydrologic Soil Group is 60.



FILE NAME	OPER.	LOC.	SEND TO
PLOT SCALE 1:1	DATE 2008MAY30	PROJ. # 522WY TASK # CONCEP. DESIGN	PROJ. HOPKINS STUDY BUFFALO, WY	PHONE (307) 634-7848

REV	DESCRIPTION OF REVISION	BY	DATE
1	PRELIMINARY DESIGN	JMR	05/30/08

STATES WEST WATER RESOURCES CORPORATION

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PROJECT MANAGER	VEA
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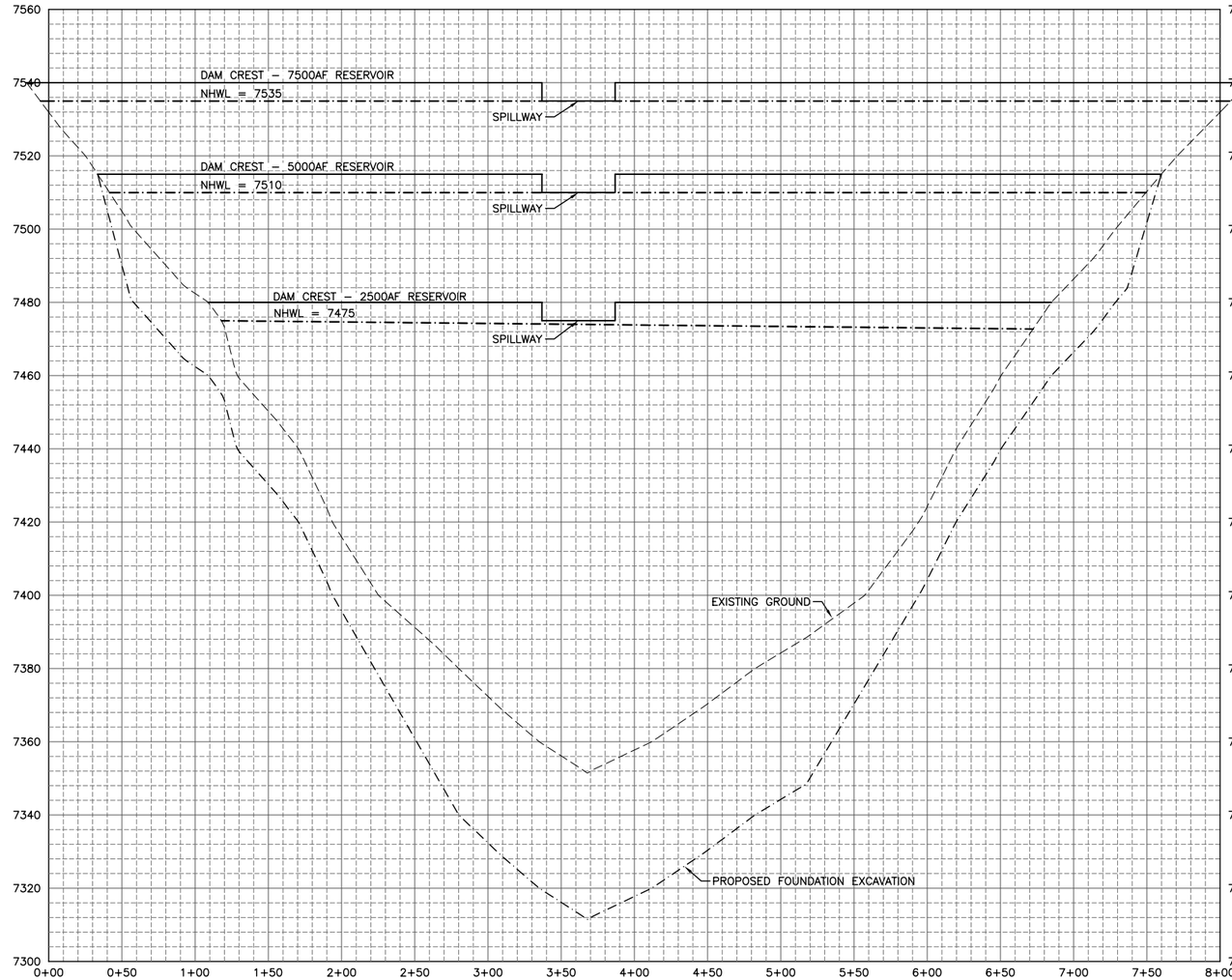
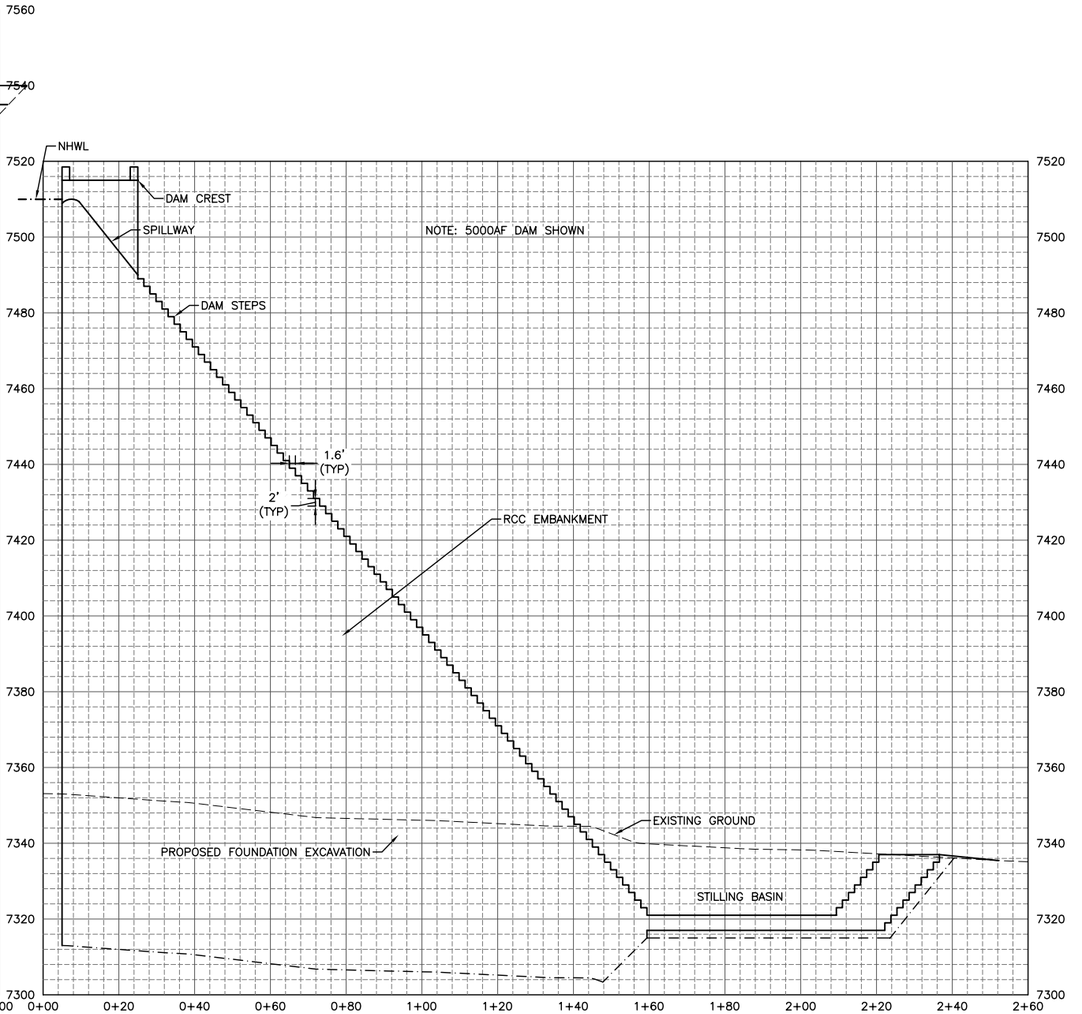
FIGURE 6.24
SITE 5
DAM PLAN VIEW

REVISION 1

PROJECT 522-WY



PROPOSED DAM UPSTREAM FACE PROFILE



PROPOSED DAM SPILLWAY PROFILE

VERT. SCALE
40' 0 40'

HORIZ. SCALE
100' 0 100'

SCALE
40' 0 40'

REV	DESCRIPTION OF REVISION	BY	DATE
1	PRELIMINARY DESIGN	JMR	05/30/08

FILE NAME: notes
PLOT SCALE: 1:1
OPER: JMR
DATE: 2008MAY30
PROJ. # TASK #: 522WY CONCEP. DESIGN
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FIGURE 6.25
SITE 5
DAM AND SPILLWAY PROFILES

REVISION 1
PROJECT 522-WY

Hydrologic modeling of the drainage basin above Site 5 was completed to determine the PMF. Stormwater runoff simulation was completed using U.S. Army Corps of Engineers developed HEC-HMS 2.2.2 hydrologic modeling system. The Soil Conservation Service (SCS) Unit Hydrograph method was used to generate the basin outflow hydrograph. The PMP depth-duration curve along with the drainage basin area, basin lag time, and drainage basin curve number were required input parameters. Basin lag time can be related to time of concentration for ungaged watersheds by:

$$t_{lag} = 0.6\ t_c \qquad (1)$$

Time of concentration is the time it takes for the most distant point in the watershed to contribute runoff at the design point. Runoff is assumed to travel as either sheet flow, shallow concentrated flow, and channel flow. Time of concentration is estimated as the sum of the travel times of these three types of flow. Flow velocities and basin geometry determine the time of concentration for the basin. The basin lag time was calculated to be 36 minutes. The drainage area for the basin is 5.0 mi^2.

The local storm PMF is estimated to generate 1340 ac-ft of water with a peak flow of 8,060 cfs at this site. This flood would be passed over the RCC dam through a spillway section as shown on Figure 6.25.

6.5.8 Permitting

Site 3 would require filing an application for a permit to appropriate surface water with the State Engineer (SEO). This site would require Form S.W. 3 reservoir permit. In addition, the Wyoming SEO would, prior to construction, need to review the plans and specifications for dam safety approval and to provide approval to construct the proposed facility.

In addition to the Wyoming SEO permits and approval, there are additional permits and approvals required for new dam construction. The Army Corp of Engineers regulates activities involving the waters of the United States. It is anticipated that an Individual Section 404 Permit would be required. This would require that an Environmental Impact Statement be prepared and submitted along with the Section 404 application. These include a Wyoming Department of Environmental Quality National Pollution Discharge Elimination System (NPDES) permit and Section 401 Certification. This permit controls the discharge of stormwater pollutants associated with construction activities. The Section 401 Certification is the State's approval to ensure that the proposed activities meet state water quality standards and do not degrade water quality. A Forest Service Special Use permit would be required to construct a reservoir on Forest Service property. U.S. Fish and Wildlife Service Endangered Species Act Compliance (Section 7) would be required. Coordination with the U.S. Department of Interior Advisory Council on Historic Preservation (Section 106), which protects cultural and historic resources, would be required. State of Wyoming Historic Preservation Office (SHPO) archaeological clearance which determines significance of cultural resources potentially affected by ground disturbing activities would be required.

6.5.9 Wetland Impacts

Site No. 5 has fringe wetlands along the stream as well as several off-channel wetlands. Two wetlands, as shown in Figure 6.26, on this site are classified as fens based on the presence of histic epipedon (organic soils). These wetlands were surveyed using a survey-grade GPS unit and were found to be approximately 1.03 acres in size. Total wetland impact at this site would likely be over two acres. Wetlands at this site are approximately half wet meadow and half scrub shrub wetlands.

The primary issue affecting feasibility of this site is the presence of fen wetlands. Fens take decades to develop and there is no easy way to mitigate impacts to fens. As a result, it will be difficult to obtain a 404 permit from the Corps of Engineers if there are any feasible alternative sites that do not have fens. For the analysis of Site 5, it was assumed that the fens could be mitigated at a ratio of 14:1. This ratio has been suggested for mitigation for other projects.

6.5.10 Sensitive Species, Riparian Areas, and Big Game Habitat Impacts

The presence of federally-listed species does not appear to be a major issue for Site No. 5. Several sensitive wildlife and plant species occur in the area, and some of these species may be present on the reservoir site. As this reservoir is located on the Bighorn National Forest, surveys for sensitive species would likely be required. Impacts to sensitive species, if present, can likely be mitigated.

No raptor nests were observed during the site visit, but this site is partially forested and nests would have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nest of such species as northern goshawk.

This site has some woody riparian areas along the stream within the inundation area. In general, these woody riparian areas are fairly narrow and there are no extensive areas of wood riparian vegetation. Common species include cottonwood, aspen, alder, and mountain maple. Mitigation for woody riparian areas may be required.

This site occurs in an area designated as crucial winter range for elk. The Wyoming Game and Fish Department may request mitigation if a reservoir is constructed on elk crucial winter range. Site 5 is within mule deer winter-yearlong range, but not crucial winter range.

6.5.11 Cultural Impacts

A class I cultural resource survey of the Site No. 5 Reservoir was performed. The purposes of the class I survey are to document all previously recorded sites and to provide an assessment of the potential for cultural resources in the reservoir area. A file search of the Wyoming State Historical Preservation Office (SHPO), Cultural Records

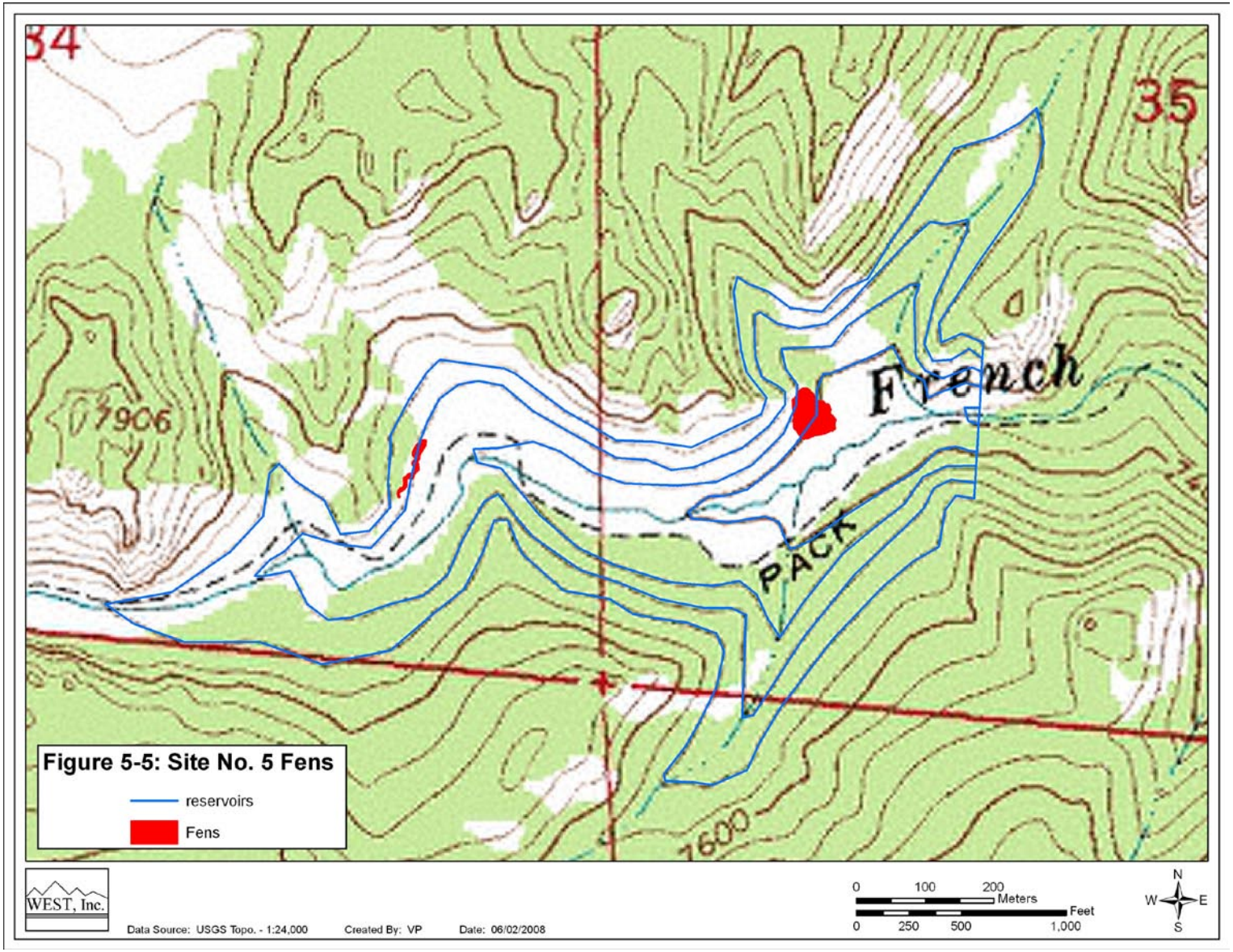


Figure 6.26. Location of fens within the inundation area of Reservoir Site 5

Office database in Laramie, Wyoming, was conducted on September 13, 2007. Previously recorded historical sites at this reservoir site include 48JO808, which is the Paradise Ranch. This site is just west of the reservoir and has not been evaluated to the National Register of Historic Places.

6.5.12 Fishery Impacts

Construction of a reservoir at Site No. 5 would inundate approximately 0.7 miles of stream for the 2500AF size and 0.9 miles of stream for the 5000AF size. In this reach, French Creek is classified as a Class 3 fishery, which is considered important trout waters and a fishery of regional importance. Impacts to the stream would be required to be mitigated. As discussed in section 6, French Creek fishery habitats both above and below the dam site within the National Forest could be improved as mitigation.

6.5.13 Public Involvement

If further study of this project is pursued, all parties that could benefit or be affected should be involved. This includes the Hopkins Producers ID, other irrigators on French Creek, Clear Creek, Johnson Creek and Rock Creek, the City of Buffalo, and the National Forest Service. A key component in the success of any project is keeping affected parties and stakeholders informed and involved on project activities. This project will need to have public support in order to come to fruition.

6.5.14 Preliminary Cost Estimates

Preliminary cost estimates for Reservoir Site No. 5 were developed for the two dam types and three alternative sizes of 2500 AF, 5000 AF, and 7500 AF. The cost estimates were developed utilizing the standard WWDC format to estimate the total project costs. The cost estimates are shown in Tables 6.17, 6.18, 6.19, 6.20, and 6.21. The information is presented in graphical form in Figure 6.27. This figure allows for cost estimates of other sizes of reservoirs.

Table 6.17 - Site Number 5 - RCC - 2500 ac-ft, Crest Elev: 7480, NHWL: 7475

No.	Item	Unit	Quantity	Unit Cost	Cost
1	Mobilization	LS	--	--	$1,200,000
2	Clearing	Ac	75	$2,000.00	$150,000
3	Stream Diversion	LS	--	--	$200,000
4	Dewatering	LS	--	--	$250,000
5	Foundation Excavation, Earth	CY	48,500	$5.00	$242,500
6	Foundation Excavation, Rock	CY	6,750	$10.00	$67,500
7	Foundation Preparation and Grouting	LS	--	--	$1,500,000
8	Dam RCC	CY	140,000	$90.00	$12,600,000
9	Outlet Works	LS	--	--	$1,500,000
10	Spillway	LS	--	--	$1,000,000
11	Access Road Construction	Mi	3.0	$250,000.00	$750,000
12	Wetland Mitigation	Ac	20.0	$100,000.00	$2,000,000
13	Riparian Mitigation	Ac	10.0	$50,000.00	$500,000
14	Fishery Mitigation	LS	--	--	$250,000
	Revegetation	Ac	20.0	$2,000.00	$40,000
15	N. Clear Diversion and Pipeline	LS	--	--	$2,400,000
				Construction Cost Sub-Total:	**$24,650,000**
				10% Engineering:	$2,465,000
				Sub-Total:	**$27,115,000**
				15% Contingency:	$4,067,250
				CONSTRUCTION COST TOTAL:	**$31,182,250**
				Preparation of Final Designs and Specifications:	$1,500,000
				Permitting:	$500,000
				Legal Fees:	$100,000
				Acquisition of Access and Rights of Way:	$200,000
				TOTAL PROJECT COST:	**$33,482,250**
				USE:	**$33.5M**

Table 6.18 - Site Number 5 - RCC - 5000 ac-ft, Crest Elev: 7515, NHWL: 7510

No.	Item	Unit	Quantity	Unit Cost	Cost
1	Mobilization	LS	--	--	$1,750,000
2	Clearing	Ac	110	$2,000.00	$220,000
3	Stream Diversion	LS	--	--	$200,000
4	Dewatering	LS	--	--	$250,000
5	Foundation Excavation, Earth	CY	73,000	$5.00	$365,000
6	Foundation Excavation, Rock	CY	10,100	$10.00	$101,000
7	Foundation Preparation and Grouting	LS	--	--	$2,000,000
8	Dam RCC	CY	250,000	$90.00	$22,500,000
9	Outlet Works	LS	--	--	$2,000,000
10	Spillway	LS	--	--	$1,250,000
11	Access Road Construction	Mi	3.0	$250,000.00	$750,000
12	Wetland Mitigation	Ac	20.0	$100,000.00	$2,000,000
13	Riparian Mitigation	Ac	10.0	$50,000.00	$500,000
14	Fishery Mitigation	LS	--	--	$250,000
	Revegetation	Ac	25.0	$2,000.00	$50,000
15	N. Clear Diversion and Pipeline	LS	--	--	$2,400,000
				Construction Cost Sub-Total:	**$36,586,000**
				10% Engineering:	$3,658,600
				Sub-Total:	**$40,244,600**
				15% Contingency:	$6,036,690
				CONSTRUCTION COST TOTAL:	**$46,281,290**
				Preparation of Final Designs and Specifications:	$2,500,000
				Permitting:	$500,000
				Legal Fees:	$100,000
				Acquisition of Access and Rights of Way:	$200,000
				TOTAL PROJECT COST:	**$49,581,290**
				USE:	**$49.6M**

Table 6.19 - Site Number 5 - RCC - 7500 ac-ft, Crest Elev: 7540, NHWL: 7535

No.	Item	Unit	Estimated Quantity	Unit Cost	Cost
1	Mobilization	LS	--	--	$2,000,000
2	Clearing	Ac	125	$2,000.00	$250,000
3	Stream Diversion	LS	--	--	$200,000
4	Dewatering	LS	--	--	$250,000
5	Foundation Excavation, Earth	CY	75,000	$5.00	$375,000
6	Foundation Excavation, Rock	CY	11,000	$10.00	$110,000
7	Foundation Preparation and Grouting	LS	--	--	$2,250,000
8	Dam RCC	CY	350,000	$80.00	$28,000,000
9	Outlet Works	LS	--	--	$2,250,000
10	Spillway	LS	--	--	$1,500,000
11	Access Road Construction	Mi	3.0	$250,000.00	$750,000
12	Wetland Mitigation	Ac	20.0	$100,000.00	$2,000,000
13	Riparian Mitigation	Ac	10.0	$50,000.00	$500,000
14	Fishery Mitigation	LS	--	--	$300,000
	Revegetation	Ac	30.0	$2,000.00	$60,000
15	N. Clear Diversion and Pipeline	LS	--	--	$2,400,000
				Construction Cost Sub-Total:	**$43,195,000**
				10% Engineering:	$4,319,500
				Sub-Total:	**$47,514,500**
				15% Contingency:	$7,127,175
				CONSTRUCTION COST TOTAL:	**$54,641,675**
				Preparation of Final Designs and Specifications:	$2,750,000
				Permitting:	$500,000
				Legal Fees:	$100,000
				Acquisition of Access and Rights of Way:	$200,000
				TOTAL PROJECT COST:	**$58,191,675**
				USE:	**$58.2M**

Table 6.20 - Site Number 5 Rockfill - 2500 ac-ft, Crest Elev: 7480, NHWL: 7475

No.	Item	Unit	Estimated Quantity	Unit Cost	Cost
1	Mobilization	LS	--	--	$1,000,000
2	Clearing	Ac	75	$2,000.00	$150,000
3	Stream Diversion	LS	--	--	$200,000
4	Dewatering	LS	--	--	$250,000
5	Foundation Excavation, Earth	CY	50,000	$5.00	$250,000
6	Foundation Excavation, Rock	CY	6,750	$10.00	$67,500
7	Foundation Preparation and Grouting	LS	--	--	$750,000
8	Dam Rockfill	CY	450,000	$25.00	$11,250,000
9	Concrete Facing	CY	7,500	$400.00	$3,000,000
10	Plinth	LF	600	$2,000.00	$1,200,000
11	Outlet Works	LS	--	--	$2,000,000
12	Spillway	LS	--	--	$250,000
13	Access Road Construction	Mi	3.0	$250,000.00	$750,000
14	Wetland Mitigation	Ac	20.0	$100,000.00	$2,000,000
15	Riparian Mitigation	Ac	10.0	$50,000.00	$500,000
16	Fishery Mitigation	LS	--	--	$250,000
17	Revegetation	Ac	20.0	$2,000.00	$40,000
18	N. Clear Diversion and Pipeline	LS	--	--	$2,400,000
				Construction Cost Sub-Total:	**$26,307,500**
				10% Engineering:	$2,630,750
				Sub-Total:	**$28,938,250**
				15% Contingency:	$4,340,738
				CONSTRUCTION COST TOTAL:	**$33,278,988**
				Preparation of Final Designs and Specifications:	$1,500,000
				Permitting:	$500,000
				Legal Fees:	$100,000
				Acquisition of Access and Rights of Way:	$200,000
				TOTAL PROJECT COST:	**$35,578,988**
				USE:	**$35.6M**

Table 6.21 - Site Number 5 Rockfill - 5000 ac-ft, Crest Elev: 7515, NHWL: 7510

No.	Item	Unit	Estimated Quantity	Unit Cost	Cost
1	Mobilization	LS	--	--	$1,500,000
2	Clearing	Ac	110	$2,000.00	$220,000
3	Stream Diversion	LS	--	--	$200,000
4	Dewatering	LS	--	--	$250,000
5	Foundation Excavation, Earth	CY	75,000	$5.00	$375,000
6	Foundation Excavation, Rock	CY	10,100	$10.00	$101,000
7	Foundation Preparation and Grouting	LS	--	--	$1,000,000
8	Dam Rockfill	CY	750,000	$20.00	$15,000,000
9	Concrete Facing	CY	9,000	$400.00	$3,600,000
10	Plinth	LF	700	$2,000.00	$1,400,000
11	Outlet Works	LS	--	--	$2,500,000
12	Spillway	LS	--	--	$250,000
13	Access Road Construction	Mi	3.0	$250,000.00	$750,000
14	Wetland Mitigation	Ac	20.0	$100,000.00	$2,000,000
15	Riparian Mitigation	Ac	10.0	$50,000.00	$500,000
16	Fishery Mitigation	LS	--	--	$250,000
17	Revegetation	Ac	25.0	$2,000.00	$50,000
18	N. Clear Diversion and Pipeline	LS	--	--	$2,400,000
				Construction Cost Sub-Total:	**$32,346,000**
				10% Engineering:	$3,234,600
				Sub-Total:	**$35,580,600**
				15% Contingency:	$5,337,090
				CONSTRUCTION COST TOTAL:	**$40,917,690**
				Preparation of Final Designs and Specifications:	$2,000,000
				Permitting:	$500,000
				Legal Fees:	$100,000
				Acquisition of Access and Rights of Way:	$200,000
				TOTAL PROJECT COST:	**$43,717,690**
				USE:	**$43.7M**

6.5.15 Reservoir Alternative Size Comparison

The two alternative size reservoirs analyzed for Site 5 are compared in Table 6.22. As indicated, the 7500 AF reservoir has the lower unit cost per acre-foot of storage. The comparison of the unit cost per acre-foot of yield indicates that the 5000 - 7500 AF reservoir size range has the lowest unit cost as shown on Figure 6.28. This site would be most economically developed at the 5000-7500 AF size range alternative.

Table 6.22 - Site No. 5 Alternatives Comparison

Dam Type	Total Capacity	Est. Cost	Storage Unit Cost	Active Capacity	Est. Yield	Unit Cost Yield
	AF	$Mil	$/AF	AF	AF/Yr	$/AF Yield
RCC	2500	$33.5	$13,400	1750	1620	$20,679
RCC	5000	$49.6	$9,920	3500	3020	$16,424
RCC	7500	$58.2	$7,760	5250	3500	$16,629
Rock Fill	2500	$35.6	$14,240	1750	1620	$21,975
Rock Fill	5000	$43.7	$8,740	3500	3020	$14,470

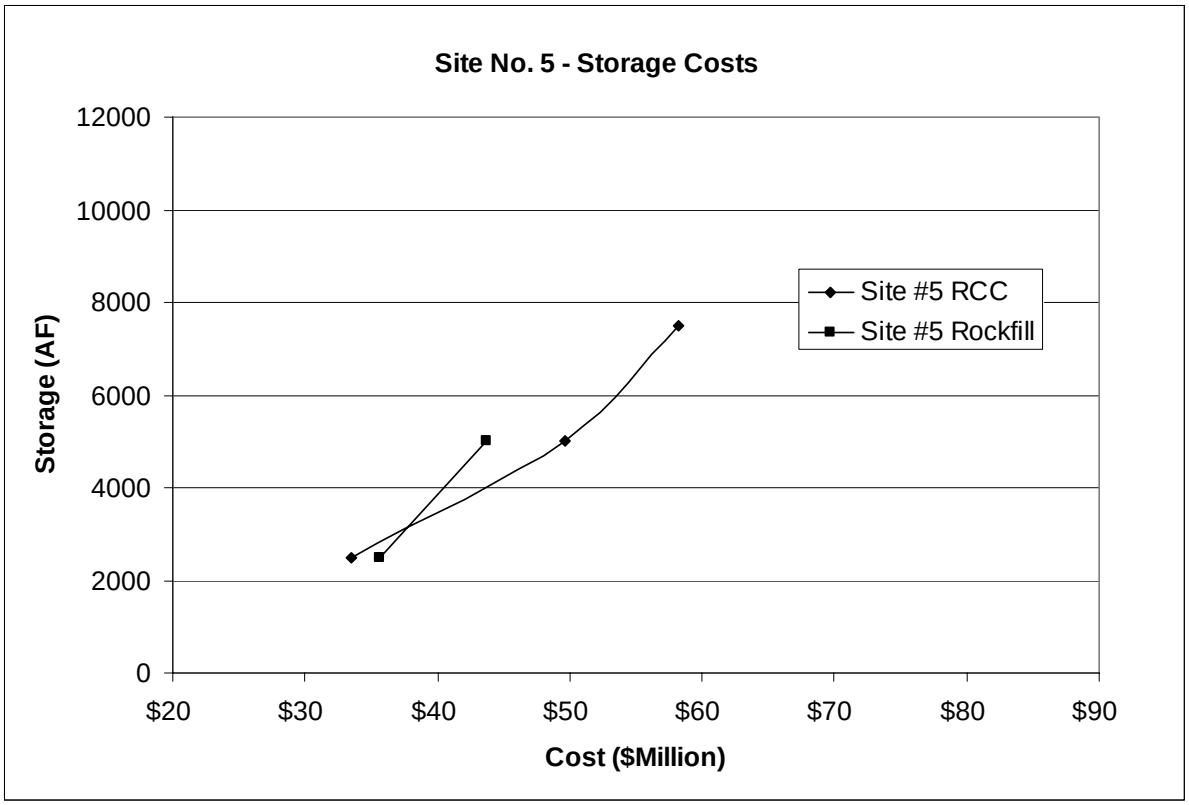


Figure 6.27 Site No. 5 Storage Costs

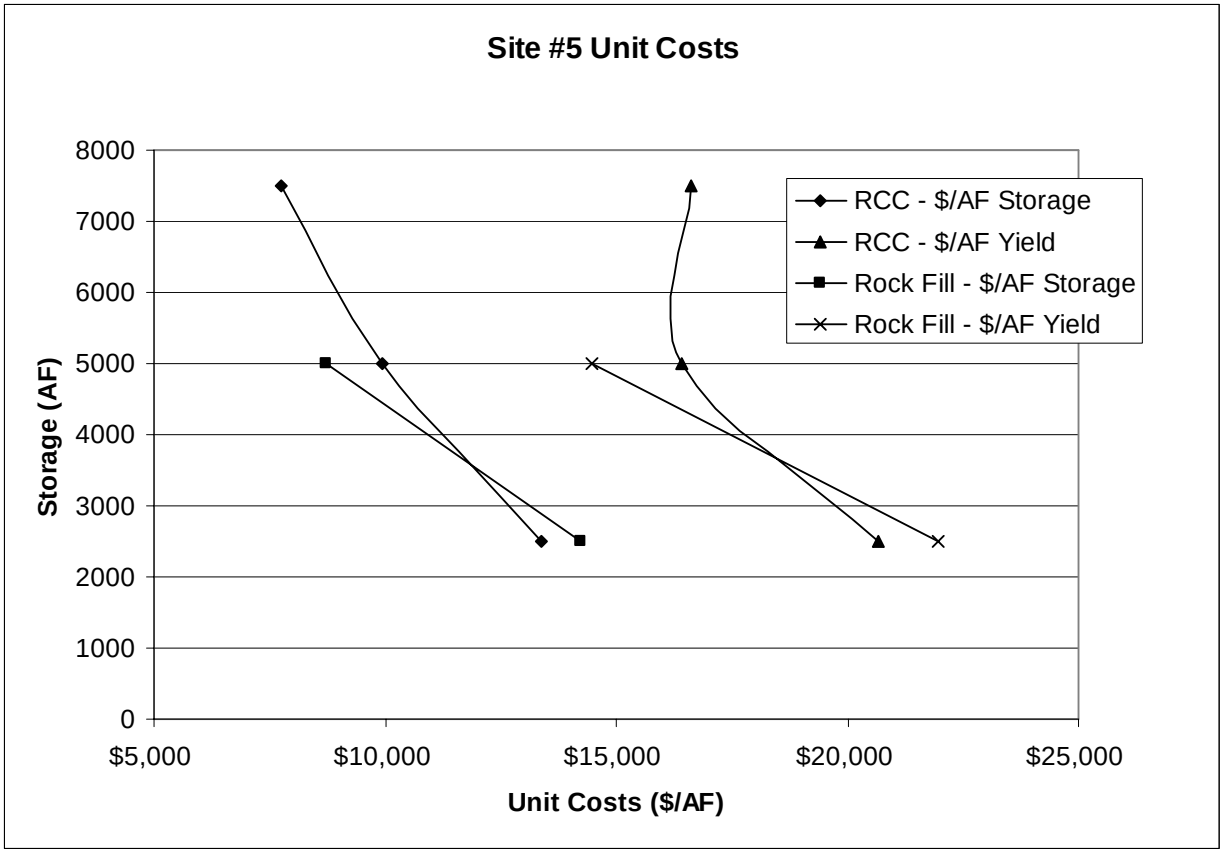


Figure 6.28 Site No. 5 Unit Costs

6.5.16 Project Financing

The current financing package offered by the Wyoming Water Development Commission is 67% grant, 33% loan at 4% for a case specific term not to exceed 50 years. The Commission has the ability in their criteria to grant up to 75%. The Commission has the authority with Wyoming Legislature approval to grant 100% of the total project costs. In order to achieve this level of financing the project would have to give significant benefit to the State of Wyoming. Additional funding sources may include the NRCS.

Assuming a 67% WWDC grant and 33% loan at 4% for 50 years, the annual repayment would be as follows:

Table 6.23 - Site No. 5 Annual Repayment

Dam Type	Total Capacity	Est. Cost	Annual Repayment
	AF	$Mil	$/Yr
RCC	2500	$33.5	$520,315
RCC	5000	$49.6	$770,376
RCC	7500	$58.2	$903,950
Rock Fill	2500	$35.6	$552,931
Rock Fill	5000	$43.7	$678,739

6.5.17 Summary

Site No. 5 would be a multipurpose facility located on the Bighorn National Forest. Site No. 5 is most efficient based on the water availability and project cost in the 5000-7500 AF range. With the anticipated lack of fine grain material availability, a RCC or rockfill embankment at this location would be the most economical dam. The cultural resources in the vicinity are likely minimal. Wetland impacts at this site are substantial and mitigation would likely not be feasible due to the presence of fens. Riparian impacts are present at this site and will likely require mitigation. This site is within crucial winter range for elk which will likely require mitigation. The design flood at this site is relatively large requiring a moderate spillway. Access to the site requires road construction on Forest Service property. The reservoir is sited on the Bighorn National Forest which will require a special use permit and will likely be more difficult to permit. This site, due to the wetland impacts, is not recommended for further study if any alternatives are pursued.

6.6 South Rock Creek Water Supply (Site No. 6)

6.6.1 Introduction

A reservoir site was previously identified at Triangle Park on South Rock Creek as shown on Figure 6.29. This site is located on US Forest Service property in a proposed wilderness area. This site (Site No. 6) was evaluated in this study as a potential additional water source for French Creek. Storage developed at this site could be utilized by irrigators on French Creek, Johnson Creek, and Rock Creek. Based on the following results of evaluation, this site was dropped from consideration as a storage reservoir facility. A water transfer concept was analyzed at this site.

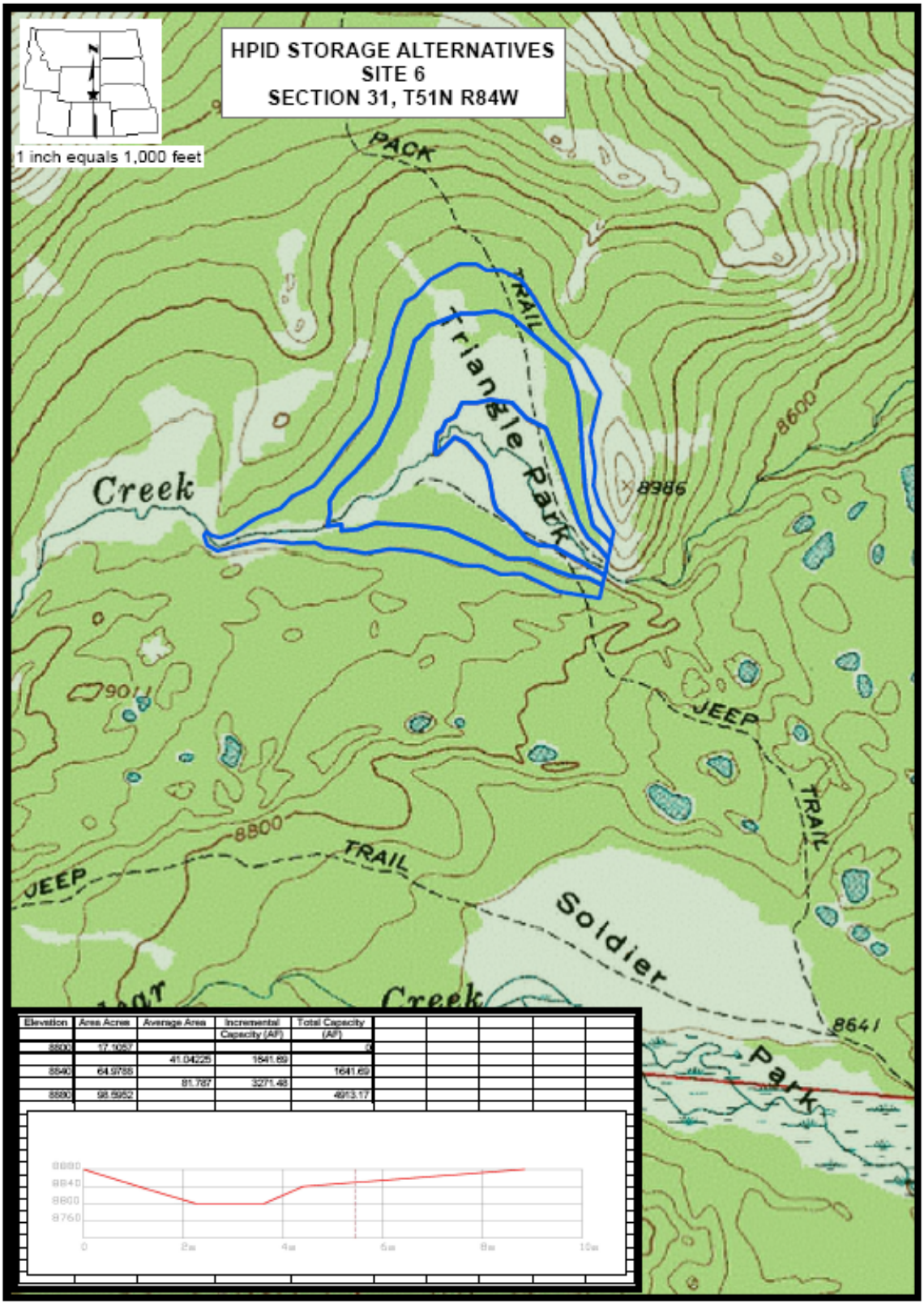


Figure 6.29 Site No. 6

6.6.2 Geologic and Geotechnical Investigation

Site No. 6 is located in a U-shaped valley on upper South Rock Creek. The bedrock is Precambrian granite. The left abutment was mainly broken pieces of granite that had been re-arrange erratically by frost action with a silty sand soil cover on the lower slope. The lower slope of the left abutment had a heavy tree cover. The right abutment was a heavily wooded lateral moraine composed of silty sand and gravel with cobble boulders. At the planned dam centerline, the valley bottom was filled with silty sand and gravel and numerous boulders. Upstream of the planned dam centerline, the reservoir area opens up into a broad meadow covered with grass and small brush. The exposed soils were silty sands with scatterrd boulders throughout. Immediately downstream of the planned dam centerline, the stream drops steeply. Approximately 100 downstream of the dam centerline, bedrock outcrops in the stream channel and on both sides of the stream channel at an elevation of approximately 20 feet below the stream level at the planned dam centerline. Depth to bedrock is probably 30 feet in the valley bottom and 15 go 30 feet on the left abutment. The depth to bedrock on the right abutment cannot be estimated with any reasonable degree of accuracy. At this time, the depth to bedrock on the right abutment should be assumed to be 30 feet at the stream channel and at least 100 feet up the slope.

A dam approximately 80 feet high was planned. At this time, only a homogeneous or zoned earth embankment dam appears to be applicable to the site. That evaluation is contingent on there being sufficient fines, 10% of greater, in the soils of the right abutment to hold the reservoir waters without excessive seepage losses.

There would have to be a sufficient amount of fines, 10% or greater, in the granular soils in the reservoir to construct a homogeneous or zoned earth embankment dam. For an embankment dam, the crest width should be at least the height of the dam divided by 5 plus 10 feet. Therefore, the dam crest should be at least 26 feet wide. The exterior slopes should be 3H:1V or flatter on the upstream face and 2.5H:1V or flatter on the downstream face. If a core is used, the core should have upstream and downstream slopes of 1.5H:1V or flatter. Any of the granular soils may be used for the exterior shells and the granular soils with at least 10% fines should be used for the core. Down stream of the core, a 3-foot wide chimney drain and a 5-foot thick blanket drain should be installed. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam for a depth of 15 feet. A 5-foot deep cutoff trench should be excavated below the dam centerline with a width of at least 10 feet and 1H:1V side slopes.

The site may or may not be suitable for the construction of a concrete faced rockfill dam or a roller compacted concrete dam depending on the depth to sound bedrock beneath the dam. If further consideration is given to this site, the foundation exploration may find that sound bedrock is within economical excavation depth for the construction of a concrete faced rockfill dam or a roller compacted concrete dam. The rock for fill and concrete aggregate is available on site both as granular soils and quarried rock.

6.6.3 Wetland Impacts

Site No. 6 has extensive wetlands within the inundation area, many of which are dominated by willow and would be considered scrub-shrub wetlands. Many of these wetlands appear to be fens based on the presence of organic soil. The total area of wetland impact could be up to 98 acres, depending on size of the reservoir. Fens take decades to develop and there is no easy way to mitigate impacts to fens. As a result, it will be difficult to obtain a 404 permit from the Corps of Engineers if there are any feasible alternative sites that do not have fens.

6.6.4 Sensitive Species, Migratory Birds, Riparian Areas, and Big Game Habitat Impacts

The presence of federally-listed species does not appear to be a major issue for Site No. 6. Several sensitive wildlife and plant species occur in the area, and some of these species may be present on the reservoir site. As this reservoir is located on the Bighorn National Forest, surveys for sensitive species would likely be required. Impacts to sensitive species, if present, can likely be mitigated.

No raptor nests were observed during the site visit, but this site is partially forested and nests would have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nest of such species as northern goshawk.

This site has some woody riparian areas along the stream within the inundation area. In general, these woody riparian areas are fairly narrow and there are no extensive areas of wood riparian vegetation. Common species include cottonwood, aspen, alder, and mountain maple. Mitigation for woody riparian areas may be required.

This site occurs in spring-summer-fall range for elk, moose, and mule deer.

6.6.5 Cultural Impacts

A class I cultural resource survey of the Site No. 6 Reservoir was performed by the Office of the Wyoming State Archaeologist. The purposes of the class I survey are to document all previously recorded sites and to provide an assessment of the potential for cultural resources in the reservoir area. A file search of the Wyoming State Historical Preservation Office (SHPO), Cultural Records Office database in Laramie, Wyoming, was conducted on September 13, 2007. There were no previously recorded historical sites in or near this reservoir site. Given the results of the SHPO file search, the overall topographic setting, and evidence of prior ground disturbance, it is possible to predict with some confidence the density and kinds of cultural sites that may be found in the proposed development areas. Prehistoric sites are expected along the valley of French Creek and its major tributaries. The potential number of prehistoric sites is expected to be small, however. This is due to the small size of the reservoir sites, relatively narrow valleys cut by South Rock Creek and its tributaries, and expected dense vegetation in the reservoir site. Surface artifact scatters are the type of prehistoric sites expected.

6.6.6 Water Supply

Preliminary hydrology has indicated the availability of water from South Rock Creek. This water could be transferred to the North Fork of Clear Creek and then transferred to French Creek and stored in a reservoir facility on French Creek. The hydrological analysis estimated the available divertable flows in South Rock Creek at Triangle Park for dry, average, and wet years as shown below:

	South Rock Creek
Dry Years	300-550 AF
Average Years	1000-1600 AF
Wet Years	1100-1850 AF

Anecdotally, the Board of Control, Water Division II indicated there was not much water available in South Rock Creek. Transferring water out of a water short basin is likely not a popular concept.

6.6.7 Preliminary Design

This system, to capture additional water, would require construction of a transfer mechanism South Rock Creek to the North Fork of Clear Creek and modification of the existing facilities on the North Fork of Clear Creek to transfer water to French Creek. Preliminary design and cost estimates of these modifications have been developed. A concrete diversion structure, headgate, wasteway, tunnel, pipeline, and flow measurement device could be constructed. A tunnel and pipeline from the diversion to North Clear Creek is proposed as shown on Figures 6.30 and 6.31. The diversion would discharge to a 24" pipeline to convey approximately 40 cfs 5200 feet to the North Fork of Clear Creek drainage. See section 5 for details of the North Fork of Clear Creek to French Creek transfer.

6.6.8 Cost Estimates

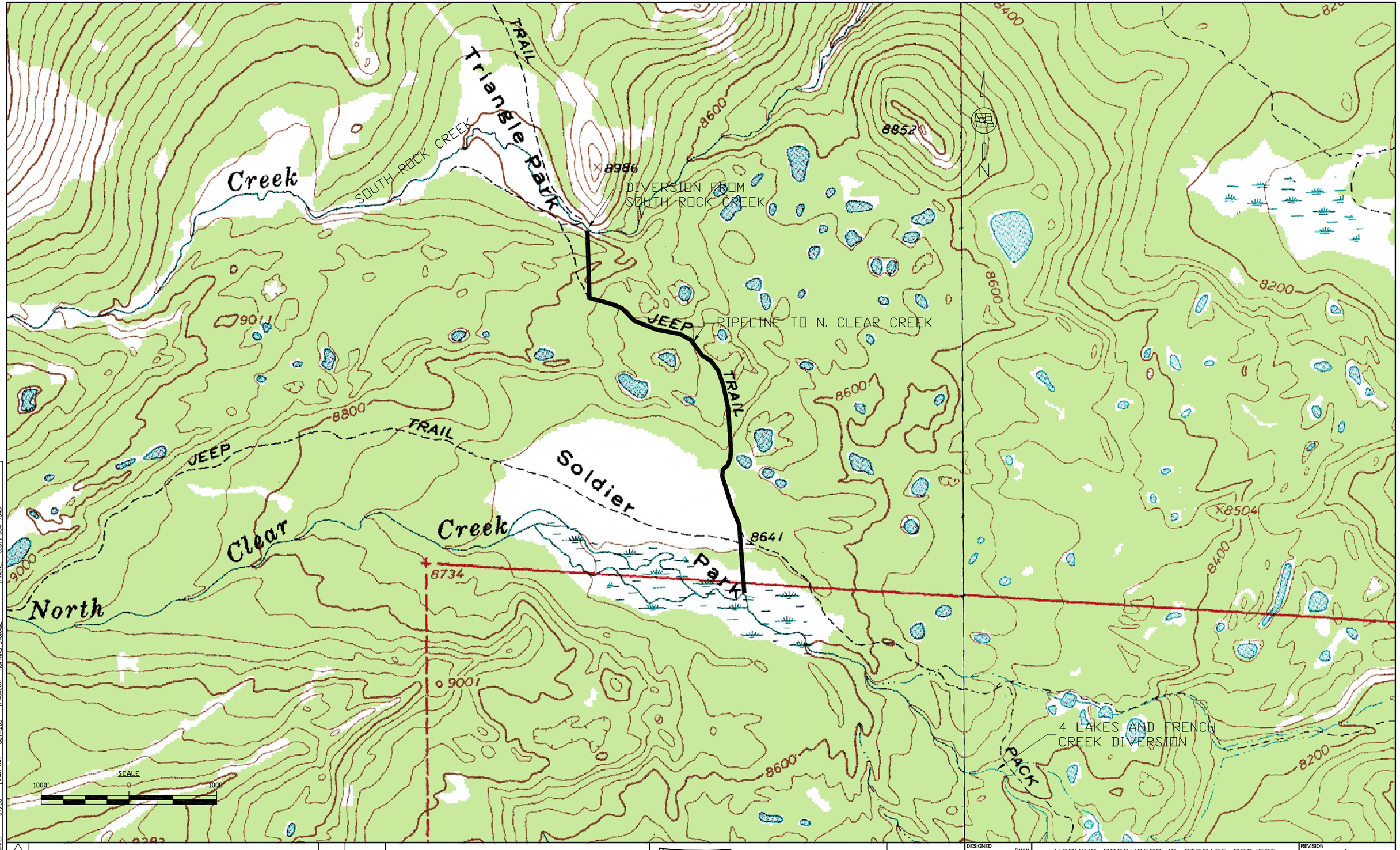
A preliminary construction cost estimate was developed for the South Rock Creek water supply to the North Fork of Clear Creek. The cost estimate was developed utilizing the standard format and is shown on Table 6.24. The estimated construction cost for the system is approximately $1.6 million.

Table 6.24 - South Rock Creek to N. Clear Creek Pipeline and Diversion

No.	Item	Units	Estimated Quantity	Unit Cost	Cost
1	Mobilization	L.S.	--	--	$60,000
2	Diversion Structure	L.S.	--	--	$300,000
3	Flow Meter	L.S.	--	--	$50,000
4	24" Tunnel	L.F.	770	$600.00	$462,000
5	24" Pipeline	L.F.	4,370	$150.00	$655,500
6	Energy Disipation Structure	L.S.	--	--	$50,000
7	Revegetation	Ac.	1	$2,000.00	$2,000
				Construction Cost:	**$1,579,500**

6.6.9 Summary

A reservoir at this site is likely not feasible due to the wetland and fen impacts and the location being within a proposed wilderness area. South Rock Creek as a water supply to French Creek is a possible concept, however, it is likely not a popular concept. Streamflow data collection and further analysis of water availability would be required to determine feasibility.



FILE NAME: SITE 3
SCALE: 1"=300'
OPERATOR: DWW
DATE: 07/08
PROJECT NO.: 522-WY
TASK NO.: 001-263
LOCATION: BUFFALO, WY
PROJECT: HOPKINS STORAGE
SEND TO: VICTOR E. ANDERSON
PHONE: (307) 634-7848

REV	DESCRIPTION OF REVISION	BY	DATE
1	PRELIMINARY DESIGN	DWW	07/08

STATES WEST WATER RESOURCES CORPORATION
1904 E. 15th STREET
CHEYENNE, WYOMING 82001
(307) 634-7848
FAX: (307) 634-7851

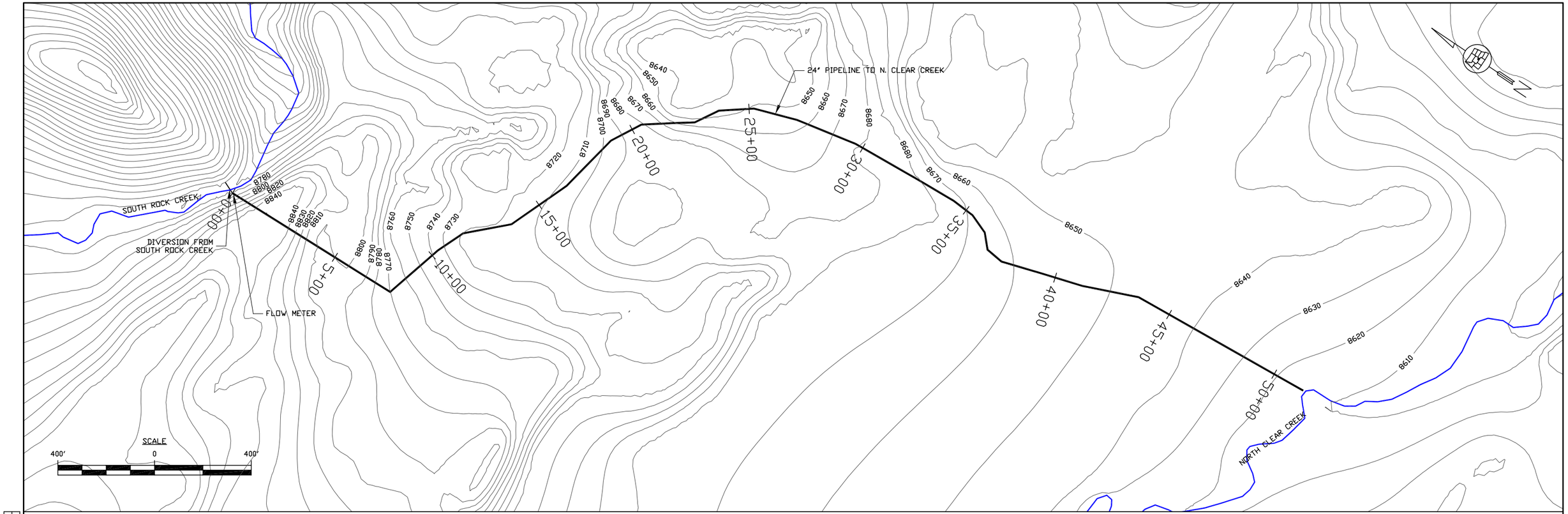
WARNING
IF THIS BAR DOES NOT MEASURE 1/2" THEN DRAWING IS NOT TO SCALE

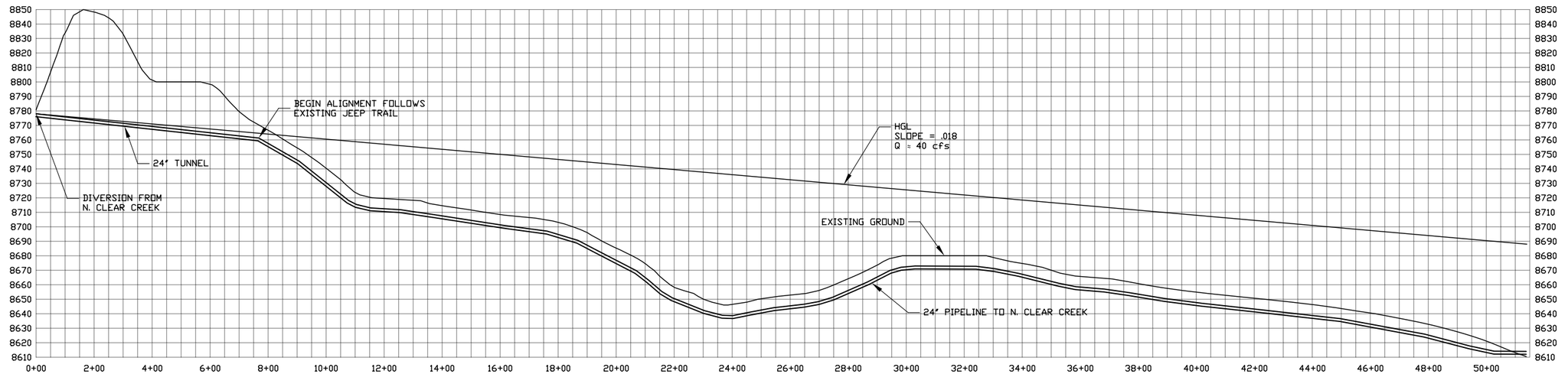
DESIGNED	DWW
DRAWN	DWW
CHECKED	VEA
PEER REVIEWED	VEA
PROJECT MANAGER	VEA
DATE	07/08

HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 6.30
ROCK CREEK DIVERSION AND PIPELINE

REVISION 1
PROJECT 522-WY
DRAWING 6-74





VERT. SCALE
80' 0 80'

HORIZ. SCALE
400' 0 400'

DIVERSION AND PIPELINE FROM ROCK CREEK TO NORTH CLEAR CREEK

FILE NAME: SITE 3
SCALE: 1"=300'
OPERATOR: DWW
DATE: 07/08
PROJECT NO: 522-WY
TASK NO: 001-263
LOCATION: BUFFALO, WY
PROJECT: HOPKINS STORAGE
SEND TO: VICTOR E. ANDERSON
PHONE: (307) 634-7848

REV	DESCRIPTION OF REVISION	BY	DATE
1	PRELIMINARY DESIGN	DWW	07/08

STATES WEST WATER RESOURCES CORPORATION
1904 E. 15th STREET
CHEYENNE, WYOMING 82001
(307) 634-7848
FAX: (307) 634-7851

WARNING
IF THIS BAR DOES NOT MEASURE 1/2" THEN DRAWING IS NOT TO SCALE

DESIGNED	DWW
DRAWN	DWW
CHECKED	VEA
PEER REVIEWED	VEA
PROJECT MANAGER	VEA
DATE	07/08

HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 6.31
ROCK CREEK
DIVERSION AND PIPELINE

REVISION 1
PROJECT 522-WY
DRAWING 6-75

6.7 Site No. 7

6.7.1 Introduction

Site No. 7 is an off channel site located on Forest Service land as shown on Figure 6.32. Site No. 7 is located in the South half of Section 32, Township 51 North, Range 84 West and the North half of Section 5, Township 50 North, Range 84 West. The reservoir would be supplied through a canal by flows from the North Fork of Clear Creek. This site could also be supplied by a tunnel and pipeline from South Rock Creek.

This site could be a multiple-use reservoir. The reservoir yield could be utilized in the French Creek, Clear Creek, Johnson Creek, and Rock Creek drainages for irrigation supplementary flows, municipal purposes, environmental uses, and recreation. Benefits to the Hopkins Producers ID and other downstream irrigators could be achieved with additional late season water. This water could be transferred to Clear Creek (see section 7) to be utilized for future municipal needs of the City of Buffalo and additional hydropower generation, supplemental irrigation water, instream flows through Buffalo, and could delay regulation on the Clear Creek drainage. A minimum pool could be maintained in the reservoir to promote recreation.

6.7.2 Reservoir Capacity

This reservoir site could potentially store approximately 10,000AF. The reservoir was assumed to incorporate a recreation pool of approximately 30% of the total storage. Consequently, the 10,000AF reservoir would have 7000AF of active storage.

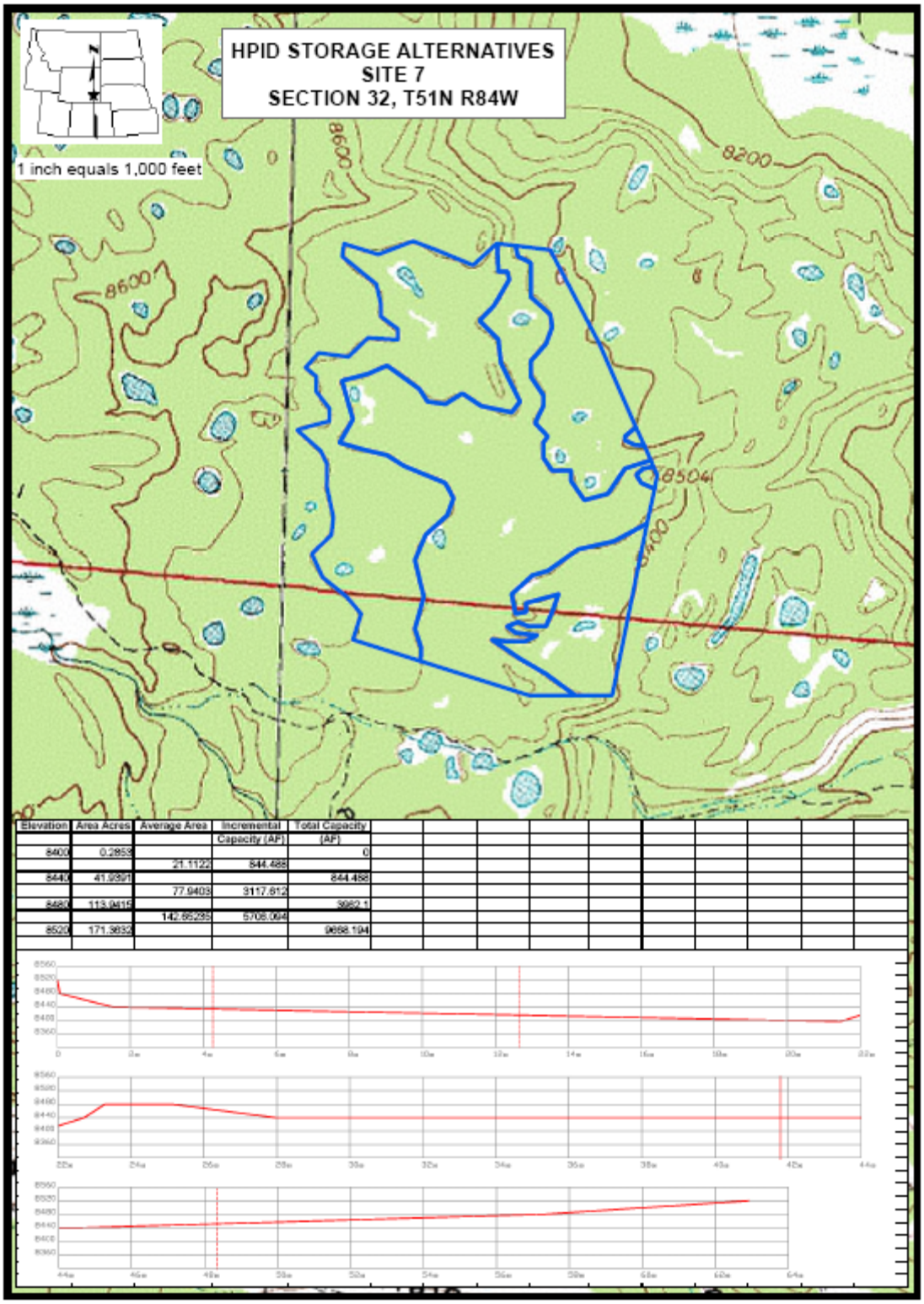
6.7.3 Water Supply

The potential water supply for a reservoir at Site No. 7 would be from available flows from the North Fork of Clear Creek and possibly South Rock Creek. The North Fork of Clear Creek water supply analysis is discussed in detail in section 6. The hydrological analysis estimated the available storable flows for dry, average, and wet years as shown below:

	South Rock Creek	North Fork Clear Creek	Total
Dry Years	300-550 AF	500-900 AF	800-1450 AF
Average Years	1000-1600 AF	2800-3500 AF	3800-5100 AF
Wet Years	1100-1850 AF	3500-4300 AF	4600-6150 AF

6.7.4 Reservoir Yield

The potential yield of the reservoir was estimated in the hydrological analysis. The estimated average annual yield of a 10,000 AF reservoir with an active capacity of 7,000AF would be approximately 4370AF.



Elevation	Area Acres	Average Area	Incremental Capacity (AF)	Total Capacity (AF)
8400	0.2853			0
		21.1122	844.488	
8440	41.9391			844.488
		77.9403	3117.612	
8480	113.9415			3962.1
		142.85295	5708.064	
8520	171.3835			9668.194

Figure 6.32 Site No. 7

6.7.5 Geologic and Geotechnical Investigation

The terrain was rather irregular with numerous “moose wallows”. For those wetlands to exist, an impervious layer, either bedrock or cohesive soils, must be present at a shallow depth below the exposed silty sand soils. The area was heavily wooded. There should be sufficient soils present for construction of an earth embankment dam.

6.7.6 Wetland Impacts

Site No. 7 has rather wide wetland fringes (up to 15 feet) along the Four Lakes and French Creek ditch as well as several off-channel wetland depressions. Most of these wetlands are wet meadows. Some of the off-channel wetlands appeared to be fens. Fens take decades to develop and there is no easy way to mitigate impacts to fens. As a result, it will be difficult to obtain a 404 permit from the Corps of Engineers if there are any feasible alternative sites that do not have fens.

6.7.7 Sensitive Species, Migratory Birds, and Big Game Habitat Impacts

The presence of federally-listed species does not appear to be a major issue for Site No. 7. Several sensitive wildlife and plant species occur in the area, and some of these species may be present on the reservoir site. As this reservoir is located on the Bighorn National Forest, surveys for sensitive species would likely be required. Impacts to sensitive species, if present, can likely be mitigated.

No raptor nests were observed during the site visit, but this site is partially forested and nests would have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nest of such species as northern goshawk.

This site has some woody riparian areas along the stream within the inundation area. In general, these woody riparian areas are fairly narrow and there are no extensive areas of wood riparian vegetation. Common species include cottonwood, aspen, alder, and mountain maple. Mitigation for woody riparian areas may be required.

This site is within winter-yearlong range for elk. This site is in moose and mule deer spring-summer-fall range.

6.7.8 Summary

The inefficient dam site would require a large quantity of embankment making this site economically not feasible. Additionally, wetland impacts and possible fens make this site not feasible. This site, due to inefficiency and wetland impacts, is not recommended for further study if any alternatives are pursued.

6.8 Site No. 8 Preliminary Analysis

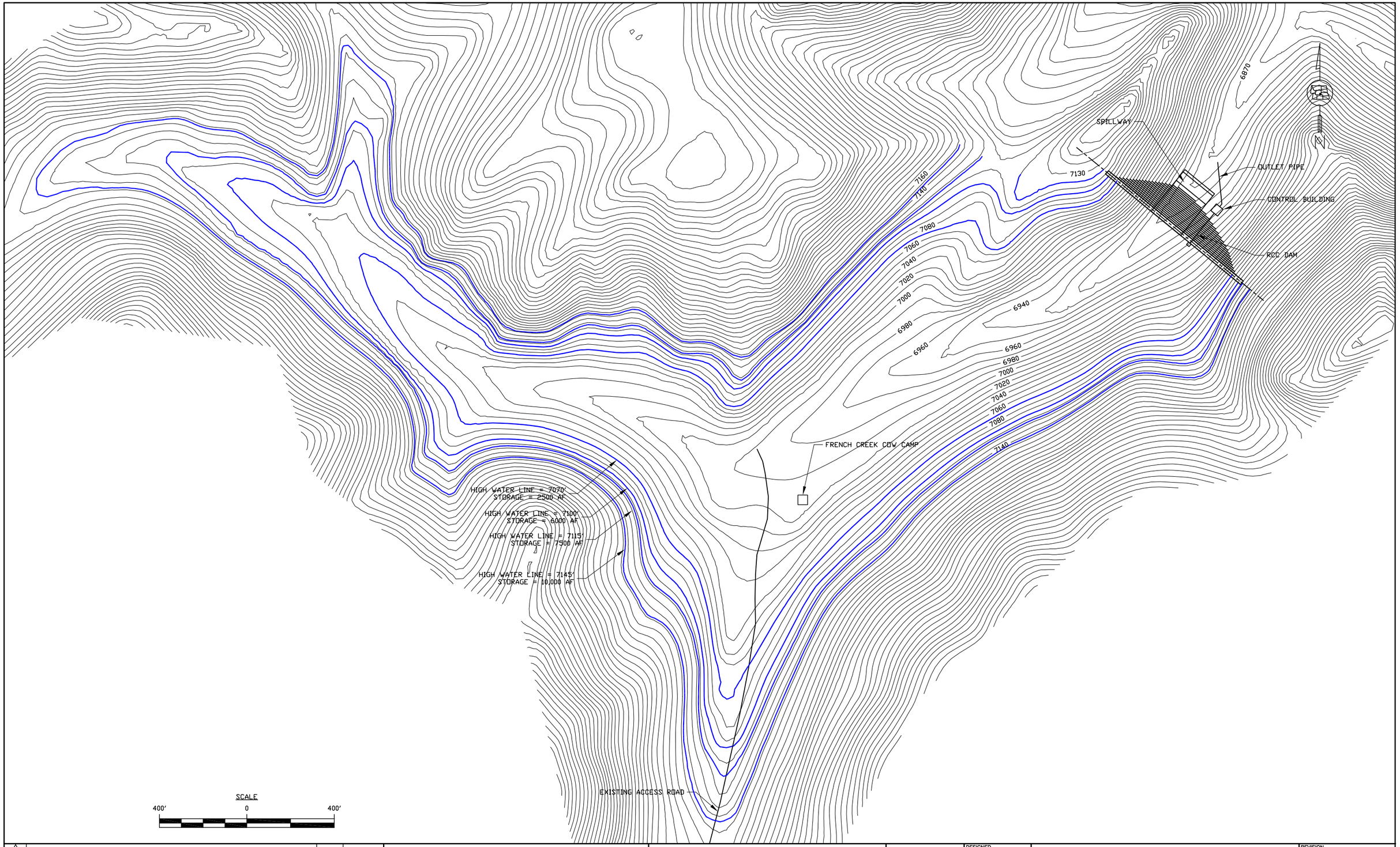
6.8.1 Introduction

Site No. 8 is located on French Creek on US Forest Service property as shown on Figure 6.33 and 6.34. Site No. 8 is located in Section 36, Township 51 North, Range 84 West. The reservoir would be supplied by flows from the North Fork of Clear Creek and French Creek. 2500, 5500, 7500 and 10,000 ac-ft reservoirs were analyzed and preliminary designs and cost estimates were developed.

This site could be a multiple-use reservoir. The reservoir yield could be utilized in the French Creek, Johnson Creek, lower Rock Creek, and Clear Creek drainages for irrigation supplementary flows, municipal purposes, environmental uses, and recreation. Benefits to the Hopkins Producers ID and other downstream irrigators could be achieved with additional late season water. This water could be transferred to Clear Creek (see section 7) to be utilized for future municipal needs of the City of Buffalo and additional hydropower generation, supplemental irrigation water, and instream flows through Buffalo, and could delay regulation on the Clear Creek drainage. A minimum pool could be maintained in the reservoir to promote recreation and a fishery. Stream fishing improvements on French Creek could also be realized with the project. The analysis of the reservoir alternatives is discussed in detail in the following sections.

6.8.2 Reservoir Capacity

Elevation-area-capacity data was developed for this site. The capacity-elevation curve is shown on Figure 6.35. For this analysis, 2500AF, 5500AF, 7500AF, and 10000AF reservoirs were addressed. The reservoirs were assumed to incorporate a recreation pool of approximately 30% of the total storage. Consequently, the 2500AF reservoir would have 1750AF of active storage and the 5500AF, 7500AF, and 10000AF reservoirs would have 3850AF, 5250AF, and 7000AF of active storage respectively.



FILE NAME: SITE_3	OPERATOR: DWW	PROJECT NO: 522-WY	LOCATION: BUFFALO, WY	SEND TO: VICTOR E. ANDERSON
SCALE: 1"=300'	DATE: 07/08	TASK NO: 001-283	PROJECT: HOPKINS STORAGE	PHONE: (307) 634-7848

REV	DESCRIPTION OF REVISION	BY	DATE
1	PRELIMINARY DESIGN	DWW	07/08

STATES WEST WATER RESOURCES CORPORATION
1904 E. 15th STREET
CHEYENNE, WYOMING 82001
(307) 634-7848
FAX: (307) 634-7851

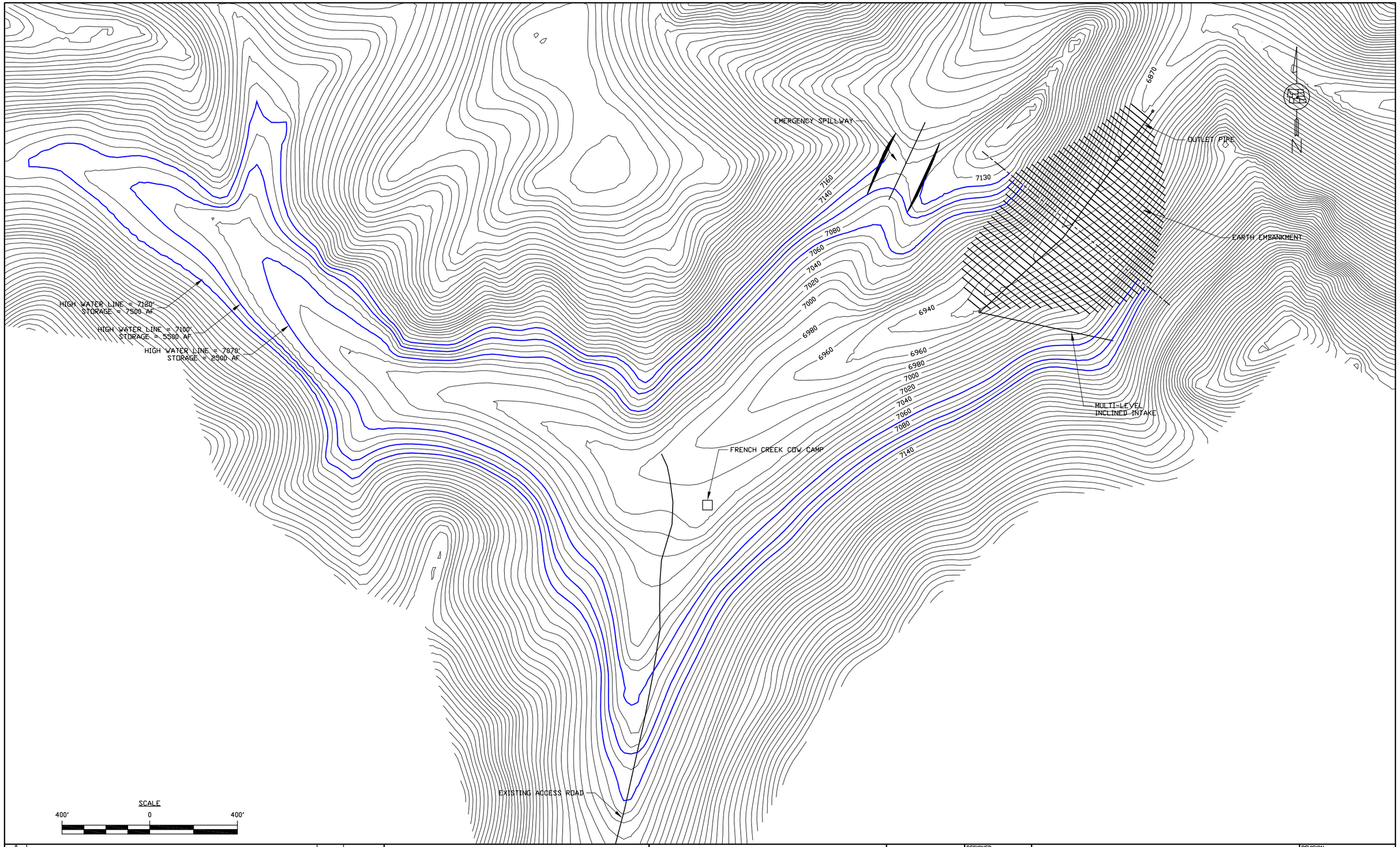
WARNING
IF THIS BAR DOES NOT MEASURE 1/2" THEN DRAWING IS NOT TO SCALE

DESIGNED	DWW
DRAWN	DWW
CHECKED	VEA
PEER REVIEWED	VEA
PROJECT MANAGER	VEA
DATE	07/08

HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 6.33
SITE 8 RCC
SITE PLAN – 6000AF

REVISION 1
PROJECT 522-WY
DRAWING 6-80



1	PRELIMINARY DESIGN	DWW	07/08
REV	DESCRIPTION OF REVISION	BY	DATE

FILE NAME: SITE_3
SCALE: 1"=200'
OPERATOR: DWW
DATE: 07/08
PROJECT NO: 522-WY
TASK NO: 001-263
LOCATION: BUFFALO, WY
PROJECT: HOPKINS STORAGE
SEND TO: VICTOR E. ANDERSON
PHONE: (307) 634-7848

STATES WEST WATER
RESOURCES CORPORATION

1904 E. 15th STREET
CHEYENNE, WYOMING 82001
(307) 634-7848
FAX: (307) 634-7851

WARNING

IF THIS BAR DOES NOT MEASURE 1/2" THEN DRAWING IS NOT TO SCALE

DESIGNED	DWW
DRAWN	DWW
CHECKED	VEA
PEER REVIEWED	VEA
PROJECT MANAGER	VEA
DATE	07/08

HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 6.34
SITE 8 EARTH EMBANKMENT
SITE PLAN – 5500AF

REVISION 1
PROJECT 522-WY
DRAWING 6-81

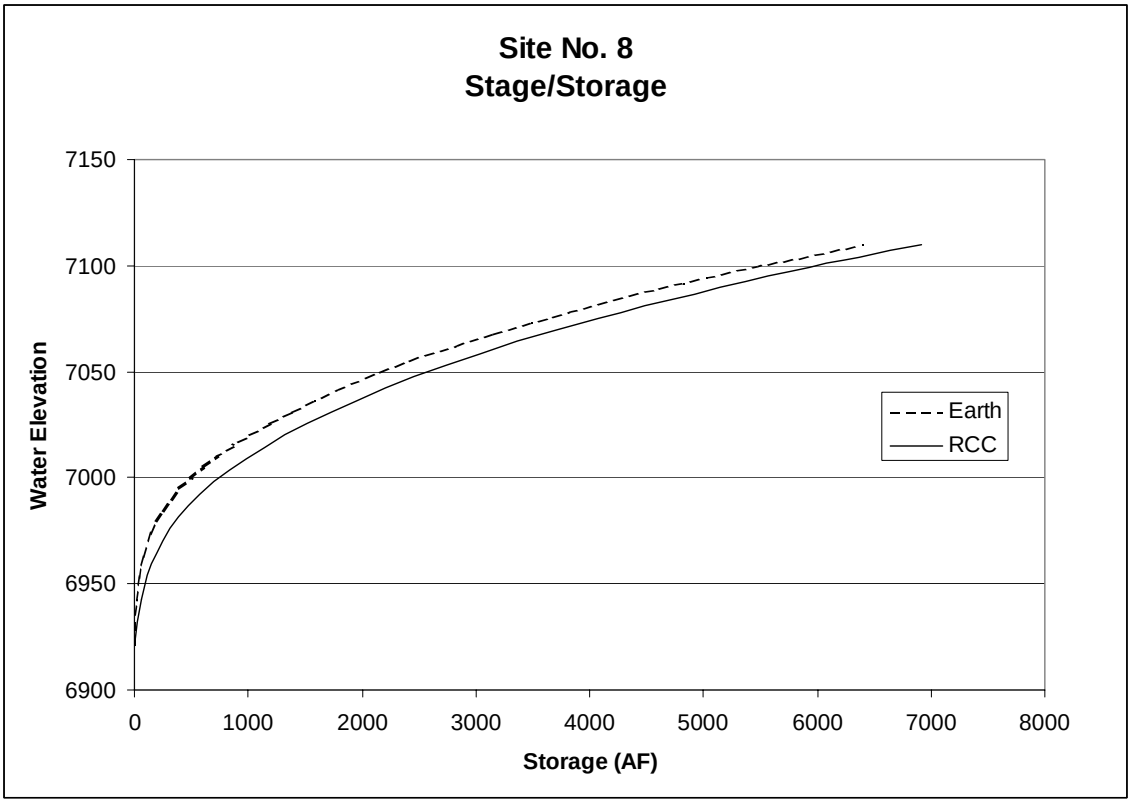


Figure 6.35 – Site No. 8 Capacity-Elevation Curve

6.8.3 Water Supply

The potential water supply for a reservoir at Site No. 8 would be from available flows on French Creek and available flows from the North Fork of Clear Creek. The North Fork of Clear Creek water supply analysis is discussed in detail in section 6. The hydrological analysis estimated the available storable flows for dry, average, and wet years as shown below:

	French Creek	North Fork Clear Creek	Total
Dry Years	100-250 AF	500-900 AF	600-1150 AF
Average Years	300-700 AF	2800-3500 AF	3100-4200 AF
Wet Years	400-800 AF	3500-4300 AF	3900-5100 AF

6.8.4 Reservoir Yield

The potential yield of the reservoir alternative sizes were estimated in the hydrological analysis as shown on Figure 6.36. The estimated average annual yields of the 2500 AF reservoir with an active capacity of 1750AF would be approximately 1630AF. The estimated average annual yield with an active capacity of 3850AF would be approximately 3310AF. The estimated average annual yield with an active capacity of 5250AF and 7000AF would be approximately 3590AF.

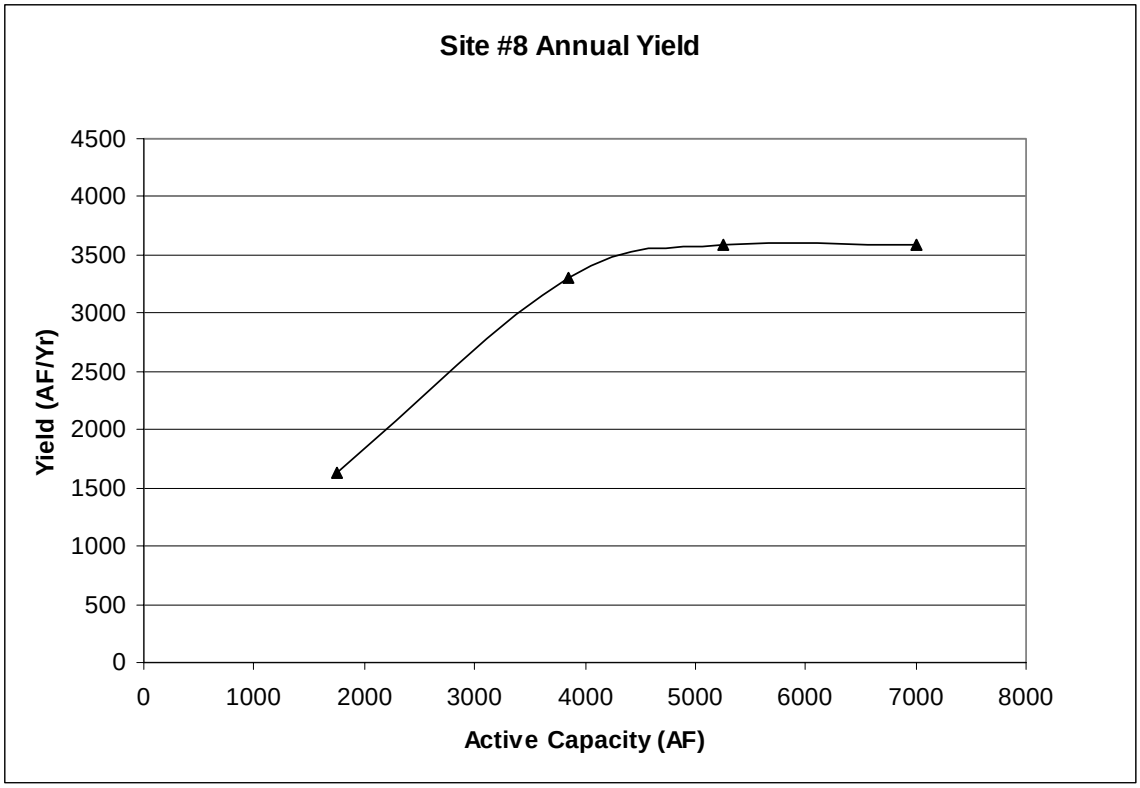


Figure 6.36 Annual yield vs. active capacity at Site No. 8

6.8.5 Geologic and Geotechnical Investigation

Site No. 8 is located in a narrow, very steep V-shaped valley with French Creek flowing through. The bedrock is Precambrian granite. The valley bottom was filled with silty sand and gravel and numerous boulders. Depth to bedrock is probably 30 feet or greater in the valley bottom and 5 feet to 15 feet on the abutments. The site has a heavy tree cover.

A dam from 190 to 230 feet high was analyzed. At least three types of dams, homogeneous or zoned earth embankment, concrete faced rockfill, and roller compacted concrete, appear to be applicable to the site.

There would have to be a sufficient amount of fines, 10% or greater, in the granular soils in the reservoir area to construct a homogeneous or zoned earth embankment dam. For an embankment dam, the crest width should be at least the height of the dam divided by 5 plus 10 feet. Therefore, the dam crest should be at least 56 feet wide. The exterior slopes should be 3H:1V or flatter on the upstream face and 2.5H:1V or flatter on the downstream face. If a core is used, the core should have upstream and downstream slopes of 1.5H:1V or flatter. Any of the granular soils may be used for the exterior shells and the granular soils with at least 10% fines should be used for the core. Down stream of the core, a 3-foot wide chimney drain and a 5-foot thick blanket drain should be installed. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the abutments and 30 feet in the valley bottom. A 5-foot deep cutoff

trench should be excavated below the dam centerline with a width of at least 10 feet and 1H:1V side slopes.

The site is suitable for the construction of a concrete faced rockfill dam similar in design to the Deer Creek Dam. The rock for the fill and the concrete face aggregate is available on site both as granular soils and quarried rock. The upstream and downstream slopes of the rockfill should be 1.3H:1V or flatter. The reinforced concrete facing should be at least 12 inches thick. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the abutments and 30 feet in the valley bottom.

The site is suitable for the construction of a roller compacted concrete (RCC) dam similar in design to the Tie Hack Dam. The rock for the concrete aggregate is available on site both as granular soils and quarried rock. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam at least 2 feet into the sound bedrock. The excavation depths are estimated to be 20 feet on the abutments and 40 feet in the valley bottom.

6.8.6 Dam and Reservoir Preliminary Design

Both the roller-compacted concrete (RCC) dam and earth embankment concepts were utilized for development of preliminary designs, as shown in Figures 6.33 and 6.34. The 2500AF, 5500AF, 7500AF, and 10,000AF sizes were analyzed for RCC, and the 2500AF, 5500AF, and 7500AF sizes were analyzed for earth embankment. It is unknown if adequate fill material is available at the site for the earth embankment concept. The concrete faced rockfill dam was not analyzed due to the history of RCC dams being more economical.

The outlet works for the RCC dam would consist of a multi-level intake attached to the upstream face of the dam, a conduit through the RCC dam, and a control valve structure located at the downstream toe of the dam. The locations of these structures are shown on Figure 6.33. The outlet works for the earth embankment would consist of an inclined multilevel intake structure, a conduit through the embankment, a control building and an energy dissipation structure located at the toe of the embankment. These structures are shown on Figure 6.34.

Access to the reservoir site could be via an existing road located on Forest Service property. The route would require approximately 2 miles of improvements.

6.8.7 Emergency Spillway

Conceptual design for the emergency spillway was developed. Spillway capacity must be designed according to the inflow design flood requirements, in this case the Probable Maximum Flood. Generation of the PMF begins with the development of the Probable Maximum Precipitation (PMP) using Hydrometeorological Report No. 55A. The PMP was generated for the local storm. The local storm generated higher peak flows and is

characteristic of this region's intense isolated storm events. The index 1 hr 1 mi^2 PMP estimate adjusted for mean drainage elevation was determined. Then the depth-duration curve for 1 mi^2 was generated using the 1 mi^2 factors for durations up to six hours. Next the areal reduction factors were applied. The result was the PMP depth-duration curve for the drainage basin above Site 8.

The Natural Resources Conservation Service classifies soils into four Hydrologic Soil Groups based on the soil's potential for runoff. The four Hydrologic Soil Groups are A, B, C, and D. HSG A soils generally have the least runoff potential and HSG D soils have the greatest. Details for these classifications can be found in 'Urban Hydrology for Small Watersheds', Soil Conservation Service Technical Release 55 (June 1986). The drainage basin above Site 8 consists of HSG B. The soils in the basin are deep and well drained with moderate infiltration rates when thoroughly wetted. Runoff is generally slow to moderate. The drainage basin is comprised of woods and forest and range lands. Land cover is good and generally consisting of grasses and forbs and conifer and deciduous trees. The resulting pre-development Soil Conservation Service Curve Number based on land cover type, Hydrologic condition, and Hydrologic Soil Group is 60.

Hydrologic modeling of the drainage basin above Site 8 was completed to determine the PMF. Stormwater runoff simulation was completed using U.S. Army Corps of Engineers developed HEC-HMS 2.2.2 hydrologic modeling system. The Soil Conservation Service (SCS) Unit Hydrograph method was used to generate the basin outflow hydrograph. The PMP depth-duration curve along with the drainage basin area, basin lag time, and drainage basin curve number were required input parameters. Basin lag time can be related to time of concentration for ungaged watersheds by:

$$t_{lag} = 0.6\ t_c \qquad (1)$$

Time of concentration is the time it takes for the most distant point in the watershed to contribute runoff at the design point. Runoff is assumed to travel as either sheet flow, shallow concentrated flow, and channel flow. Time of concentration is estimated as the sum of the travel times of these three types of flow. Flow velocities and basin geometry determine the time of concentration for the basin. The basin lag time was calculated to be 40 minutes. The drainage area for the basin is 6.5 mi^2.

The local storm PMF is estimated to generate 1630 ac-ft of water with a peak flow of 9,100 cfs at this site. This flood would be passed over the RCC dam through a spillway section as shown on Figure 6.33. For the earth embankment dam, the flood would be passed around the embankment through a 200' wide emergency spillway. The emergency spillway would be excavated into the rock in a swale adjacent to the left abutment of the embankment and discharge into a drainage north of the embankment as shown on Figure 6.34.

6.8.8 Permitting

Site 3 would require filing an application for a permit to appropriate surface water with the State Engineer (SEO). This site would require Form S.W. 3 reservoir permit. In addition, the Wyoming SEO would, prior to construction, need to review the plans and specifications for dam safety approval and to provide approval to construct the proposed facility.

In addition to the Wyoming SEO permits and approval, there are additional permits and approvals required for new dam construction. The Army Corp of Engineers regulates activities involving the waters of the United States. It is anticipated that an Individual Section 404 Permit would be required. This would require that an Environmental Impact Statement be prepared and submitted along with the Section 404 application. These include a Wyoming Department of Environmental Quality National Pollution Discharge Elimination System (NPDES) permit and Section 401 Certification. This permit controls the discharge of stormwater pollutants associated with construction activities. The Section 401 Certification is the State's approval to ensure that the proposed activities meet state water quality standards and do not degrade water quality. A Forest Service Special Use permit would be required to construct a reservoir on Forest Service property. U.S. Fish and Wildlife Service Endangered Species Act Compliance (Section 7) would be required. Coordination with the U.S. Department of Interior Advisory Council on Historic Preservation (Section 106), which protects cultural and historic resources, would be required. State of Wyoming Historic Preservation Office (SHPO) archaeological clearance which determines significance of cultural resources potentially affected by ground disturbing activities would be required.

6.8.9 Wetland Impacts

Site No. 8 has narrow wetland fringes along the stream. No extensive areas of off-channel wetlands are present and wetland impacts would likely be less than 1.0 acre. These impacts would have to be mitigated. They could possibly be mitigated downstream of the dam.

6.8.10 Sensitive Species, Migratory Birds, Riparian Areas, and Big Game Habitat Impacts

The presence of federally-listed species does not appear to be a major issue for Site No. 8. Several sensitive wildlife and plant species occur in the area, and some of these species may be present on the reservoir site. As this reservoir is located on the Bighorn National Forest, surveys for sensitive species would likely be required. Impacts to sensitive species, if present, can likely be mitigated.

Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nest of such species as northern goshawk.

This site has some woody riparian areas along the stream within the inundation area. In general, these woody riparian areas are fairly narrow and there are no extensive areas of

wood riparian vegetation. Common species include cottonwood, aspen, alder, and mountain maple. Mitigation for woody riparian areas may be required.

This site occurs in an area designated as crucial winter range for elk. The Wyoming Game and Fish Department may request mitigation if a reservoir is constructed on elk crucial winter range. Site 8 is within moose and mule deer winter-yearlong range, but not crucial winter range.

6.8.11 Cultural Impacts

The French Creek Cow Camp is located within the inundation area of Site 8. This site is a recorded historical site (48JO3778) and is suggested that the site be considered eligible for nomination to the National Register of Historic Places. This cultural structure would likely require mitigation and is potentially a fatal flaw. This historical site is shown on Figure 6.33. Additional descriptions of this site are included in Appendix C. It is predicted that prehistoric sites are expected along the valley of French Creek and its major tributaries. The potential number of prehistoric sites is expected to be small, however. This is due to the small size of the reservoir sites, relatively narrow valleys cut by French Creek and its tributaries, and expected dense vegetation in the reservoir site. Surface artifact scatters are the type of prehistoric sites expected.

6.8.12 Fishery Impacts

Construction of a reservoir at Site No. 8 would inundate approximately 1.0 mile of stream. In this reach, French Creek is classified as a Class 3 fishery, which is considered important trout waters and a fishery of regional importance. French Creek is a non-native fishery containing mostly brook and rainbow trout. Impacts to the stream would be required to be mitigated. As discussed in section 6, French Creek fishery habitats both above and below the dam site could be improved as mitigation.

6.8.13 Public Involvement

If further study of this project is pursued, all parties that could benefit or be affected should be involved. This includes the Hopkins Producers ID, other irrigators on French Creek, Clear Creek, Johnson Creek and Rock Creek, the City of Buffalo, and the National Forest Service. A key component in the success of any project is keeping affected parties and stakeholders informed and involved on project activities. This project will need to have public support in order to come to fruition.

6.8.14 Preliminary Cost Estimates

Preliminary cost estimates were developed for the two alternative dam types and alternative reservoir sizes at Reservoir Site No. 8. The cost estimates were developed utilizing the standard format to estimate the total project costs. The cost estimates are shown in Tables 6.25 and 6.26. The information is presented in graphical form in Figure 6.35. This figure allows for cost estimates comparisons of other sizes of reservoirs.

Table 6.25 - Site Number 8 - RCC - 6000 ac-ft, Crest Elev: 7110, NHWL: 7100'

No.	Item	Units	Estimated Quantity	Unit Cost	Cost
1	Mobilization	L.S.	--	--	$2,200,000
2	Clearing	Ac.	100	$2,000.00	$200,000
3	Stream Diversion	L.S.	--	--	$200,000
4	Dewatering	L.S.	--	--	$250,000
5	Foundation Excavation, Earth	C.Y.	96,000	$4.00	$384,000
6	Foundation Excavation, Rock	C.Y.	7,100	$10.00	$71,000
7	Foundation Prep and Grouting	L.S.	--	--	$2,000,000
8	Dam RCC	C.Y.	350,000	$80.00	$28,000,000
9	Outlet Works	L.S.	--	--	$2,500,000
10	Spillway	L.S.	--	--	$1,000,000
11	Access Road Construction	Mi.	2.0	$100,000.00	$200,000
12	Wetllands Mitigation	Ac.	1.50	$100,000.00	$150,000
13	Riparian Mitigation	Ac.	20	$50,000.00	$1,000,000
14	Fishery Mitigation	L.S.	--	--	$250,000
15	Revegetation	Ac.	25	$2,000.00	$50,000
16	N. Clear Creek Diversion and Pipeline	L.S.	--	--	$2,390,000
				Construction Cost Sub-Total:	**$40,845,000**
				10% Engineering:	$4,084,500
				Sub-Total:	**$44,929,500**
				15% Contingency:	$6,739,425
				CONSTRUCTION COST TOTAL:	**$51,668,925**
				Preparation of Final Designs and Specifications:	$2,700,000
				Permitting:	$500,000
				Legal Fees:	$100,000
				Acquisition of Access and Rights of Way:	$200,000
				TOTAL PROJECT COST:	**$55,168,925**
				USE:	**$55.2M**

Table 6.26 - Site Number 8 - Earth Embankment - 5500 ac-ft, Crest Elev: 7110', NHWL: 7100'

No.	Item	Units	Estimated Quantity	Unit Cost	Cost
1	Mobilization	L.S.	--	--	$1,400,000
2	Clearing	Ac.	100	$2,000.00	$200,000
3	Stream Diversion	L.S.	--	--	$200,000
4	Dewatering	L.S.	--	--	$250,000
5	Foundation Excavation, Earth	C.Y.	550,000	$4.00	$2,200,000
6	Foundation Excavation, Key Trench	C.Y.	5,000	$20.00	$100,000
8	Embankment	C.Y.	2,400,000	$7.50	$18,000,000
9	Outlet Works	L.S.	--	--	$2,500,000
10	Emergency Spillway	C.Y.	20,000	$10.00	$200,000
11	Access Road Construction	Mi.	2.0	$100,000.00	$200,000
12	Wetllands Mitigation	Ac.	1.50	$100,000.00	$150,000
13	Riparian Mitigation	Ac.	20	$50,000.00	$1,000,000
14	Fishery Mitigation	L.S.	--	--	$250,000
15	Revegetation	Ac.	70	$2,000.00	$140,000
16	N. Clear Creek Diversion and Pipeline	L.S.	--	--	$2,390,000
				Construction Cost Sub-Total:	**$29,180,000**
				10% Engineering:	$2,918,000
				Sub-Total:	**$32,098,000**
				15% Contingency:	$4,814,700
				CONSTRUCTION COST TOTAL:	**$36,912,700**
				Preparation of Final Designs and Specifications:	$2,200,000
				Permitting:	$500,000
				Legal Fees:	$100,000
				Acquisition of Access and Rights of Way:	$200,000
				TOTAL PROJECT COST:	**$39,912,700**
				USE:	**$40.0M**

6.8.15 Reservoir Alternative Size Comparison

The reservoir size alternatives analyzed for Site 8 are compared in Table 6.27. As indicated, the 10,000 AF earth reservoir has the lower unit cost per acre-foot of storage. The comparison of the unit cost per acre-foot of yield indicates that the 5500-7500 AF reservoir size range has the lowest unit cost as shown on Figure 6.36. This site would be most economically developed at the 5500-7500 AF size range alternative.

Table 6.27 - Site No. 8 Alternatives Comparison

Dam Type	Total Capacity AF	Est. Cost $Mil	Storage Unit Cost $/AF	Active Capacity AF	Est. Yield AF/Yr	Unit Cost Yield $/AF Yield
RCC	2500	$32.1	$12,840	1750	1630	$19,693
RCC	6000	$55.2	$9,195	4200	3590	$15,367
RCC	7500	$65.4	$8,720	5250	3590	$18,217
RCC	10000	$82.0	$8,200	7000	3590	$22,841
Earth	2500	$21.9	$8,760	1750	1630	$13,436
Earth	5500	$39.9	$7,257	3850	3310	$12,058
Earth	7500	$52.4	$6,987	5250	3590	$14,596

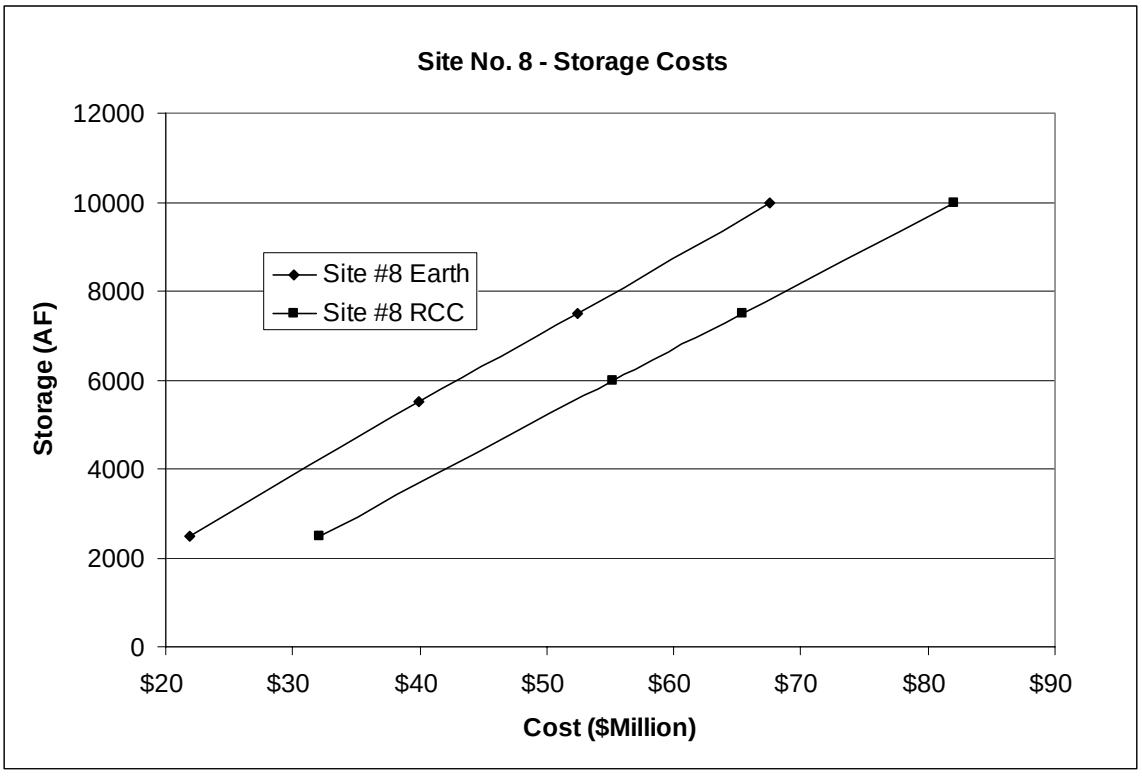


Figure 6.35 Site #8 Storage Costs

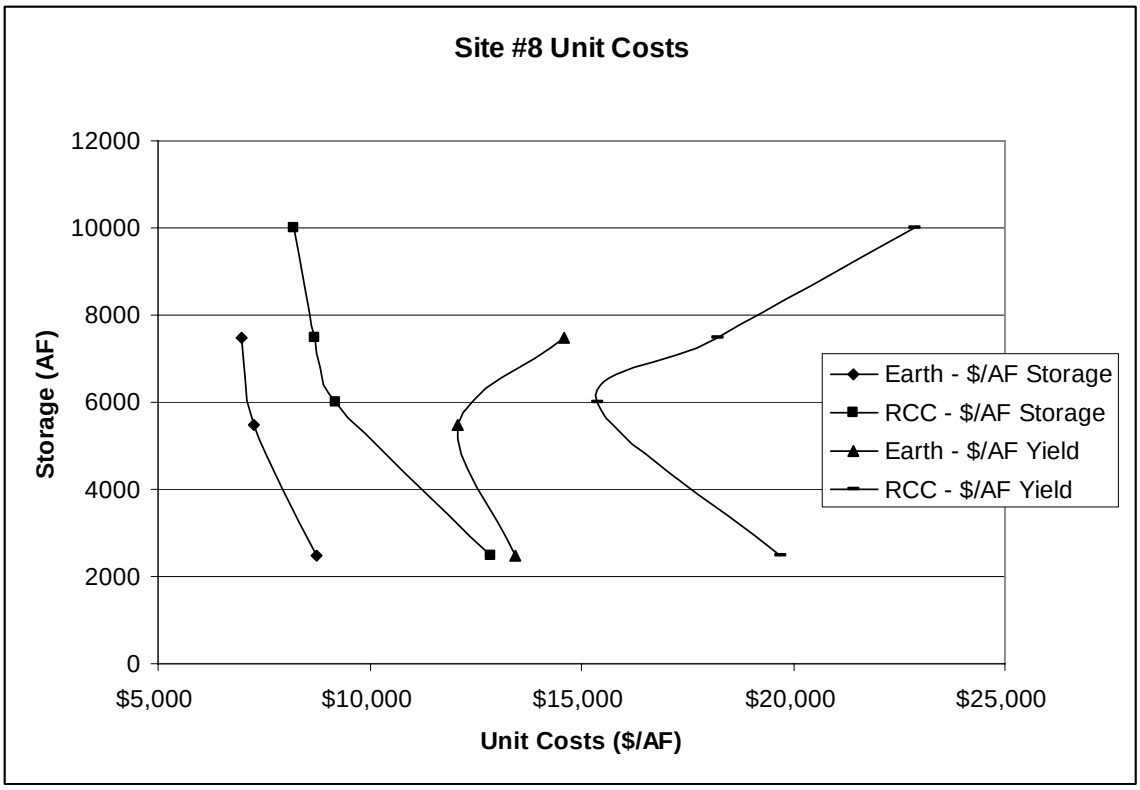


Figure 6.36 Site No. 8 Unit Costs

6.8.16 Project Financing

The current financing package offered by the Wyoming Water Development Commission is 67% grant, 33% loan at 4% for a case specific term not to exceed 50 years. The Commission has the ability in their criteria to grant up to 75%. The Commission has the authority with Wyoming Legislature approval to grant 100% of the total project costs. In order to achieve this level of financing the project would have to give significant benefit to the State of Wyoming. Additional funding sources may include the NRCS.

Assuming a 67% WWDC grant and 33% loan at 4% for 50 years, the annual repayment would be as follows:

Table 6.28 - Site No. 8 Annual Repayment

Dam Type	Total Capacity	Est. Cost	Annual Repayment
	AF	$Mil	$/Yr
RCC	2500	$32.1	$498,570
RCC	6000	$55.2	$856,872
RCC	7500	$65.4	$1,015,778
RCC	10000	$82.0	$1,273,606
Earth	2500	$21.9	$340,146
Earth	5500	$39.9	$619,915
Earth	7500	$52.4	$813,865

6.8.17 Summary

Site No. 8 would be a multipurpose facility located on the Bighorn National Forest. Site No. 8 is most efficient based on the water availability and project cost in the 5500-7500 AF range. Both RCC and earth embankment were analyzed. With the anticipated lack of fine grain material availability, an RCC embankment at this location is likely the most economical dam. The French Creek Cow Camp cultural resource is potentially a fatal flaw. Mitigation of this structure will likely be required. Wetland impacts at this site are minimal but will likely require mitigation. Riparian impacts are present at this site and will likely require mitigation. This site is within crucial winter range for elk which will likely require mitigation. The design flood at this site is relatively large requiring a relatively substantial spillway. Access to the site requires improvement of an existing Forest Service road. The reservoir is sited on the Bighorn National Forest which will require a special use permit and will likely be more difficult to permit. This site is recommended for further study if any alternatives are pursued.

7. French Creek to Clear Creek Pipeline

7.1 Introduction

Storage water from Sites No. 3, 4, 5, and 8 could be diverted from French Creek to Clear Creek as shown on Figures 7.1 and 7.2. A diversion structure could be constructed below the US Forest Service (USFS) boundary and water diverted by gravity to Clear Creek. This water could be utilized for future municipal needs of the City of Buffalo, supplemental irrigation water, and instream flows through Buffalo, and could delay regulation on the Clear Creek drainage. Senior water right demands below the City of Buffalo typically call for regulation of most other water rights in the basin. Storage water could be utilized to satisfy these rights and allow water usage throughout the basin for a longer time period for the more junior water rights.

7.2 Preliminary Design

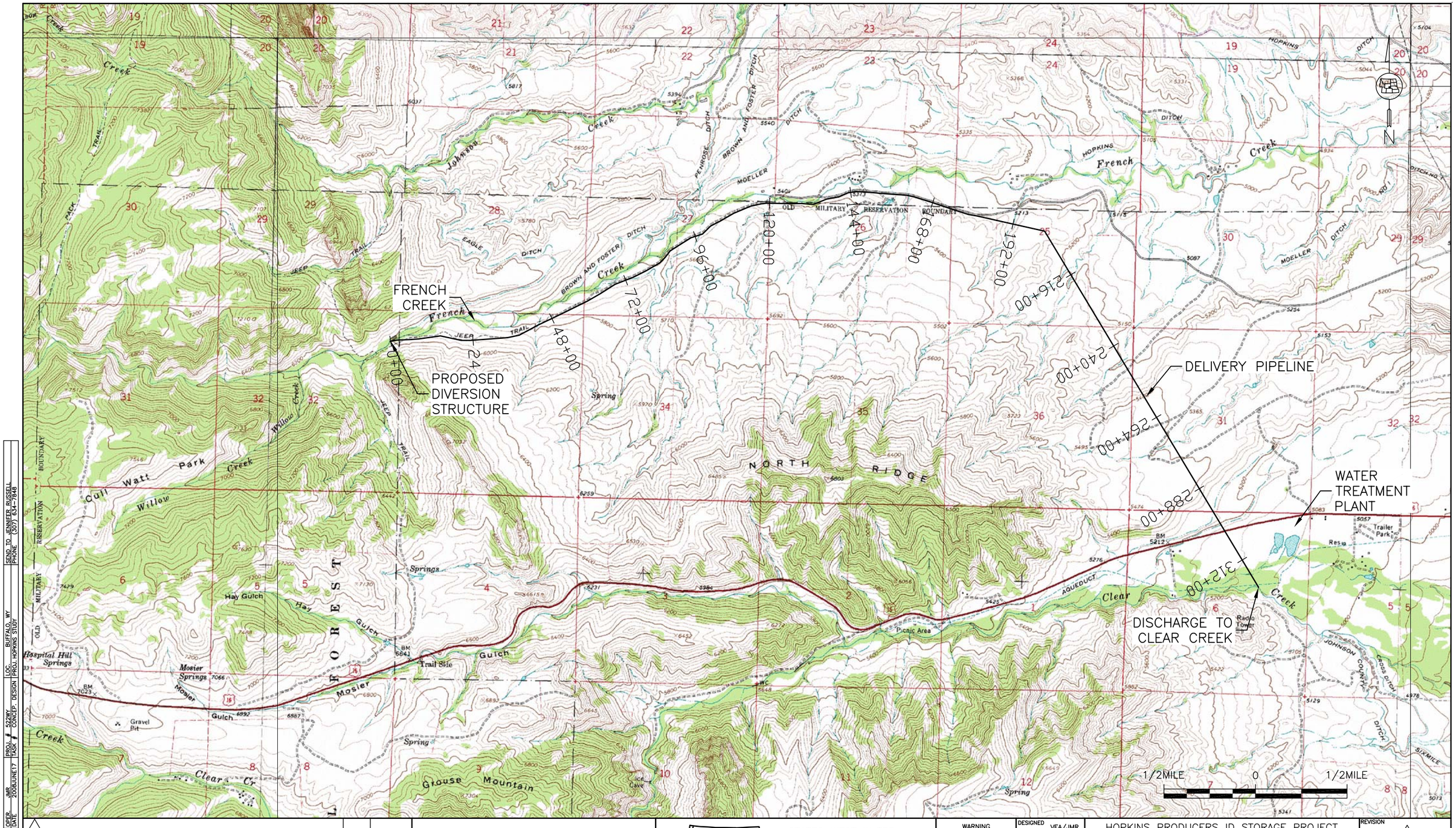
A diversion structure, headgate, and flow measurement device could be constructed below the USFS boundary as shown on Figure 7.3. This installation could discharge to a PVC pipeline approximately 32,250 feet in length that would discharge to Clear Creek. Water could also be delivered to the Buffalo Water Treatment Plant. There is potential for hydropower production with the head available and flow rate. A 24-inch pipeline could deliver approximately 40cfs.

7.3 Cost Estimates

A preliminary cost estimate was developed for the French Creek to Clear Creek Pipeline system. The cost estimate was developed utilizing the WWDC standard format and is shown on Table 7.1. The estimated cost for the 24-inch pipeline to deliver 40cfs is approximately $6.0 million.

Table 7.1 - French Ck to Clear Ck Pipeline

No.	Item	Units	Estimated Quantity	Unit Cost	Cost
1	Mobilization	L.S.	--	--	$200,000
2	Diversion Structure	L.S.	--	--	$200,000
3	Stream Gage	L.S.	--	--	$50,000
4	24" Pipeline	L.F.	32,250	$100.00	$3,225,000
5	Pipeline Appurtenances	L.S.	--	--	$250,000
6	Air-Vac Structures	Ea.	6	$20,000.00	$120,000
8	Blow-offs	Ea.	6	$5,000.00	$30,000
9	Highway Bore	L.F.	100	$1,000.00	$100,000
10	Drainage Crossings	Ea.	10	$10,000.00	$100,000
11	Energy Dissipation Structure	L.S.	--	--	$50,000
				Construction Cost Sub-Total:	**$4,325,000**
				10% Engineering:	$432,500
				Sub-Total:	**$4,757,500**
				15% Contingency:	$713,625
				CONSTRUCTION COST TOTAL:	**$5,471,125**
				Preparation of Final Designs and Specifications:	$300,000
				Permitting:	$50,000
				Legal Fees:	$25,000
				Acquisition of Access and Rights of Way:	$100,000
				TOTAL PROJECT COST:	**$5,946,125**
				USE:	**$6.0M**



1	CONCEPTUAL DESIGN	JMR	06/17/08
REV	DESCRIPTION OF REVISION	BY	DATE

FILE NAME: (none)
PLOT SCALE: 1:1
OPER: JMR
DATE: 2008\JUNE17
PROJ. # 522WY
TASK # CONCEP. DESIGN
LOC: BUFFALO, WY.
PROJ. HOPKINS STUDY
SEND TO: JENNIFER RUSSELL
PHONE: (307) 634-7848

STATES WEST WATER RESOURCES CORPORATION

1904 EAST 15th STREET
CHEYENNE, WYOMING 82001
(307) 634-7848
FAX: (307) 634-7851

WARNING

IF THIS BAR DOES NOT MEASURE 1.0" THEN DRAWING IS NOT TO SCALE

DESIGNED	VEA/JMR
DRAWN	JMR
CHECKED	
PEER REVIEWED	
PROJECT MANAGER	VEA
DATE	JUNE 2008

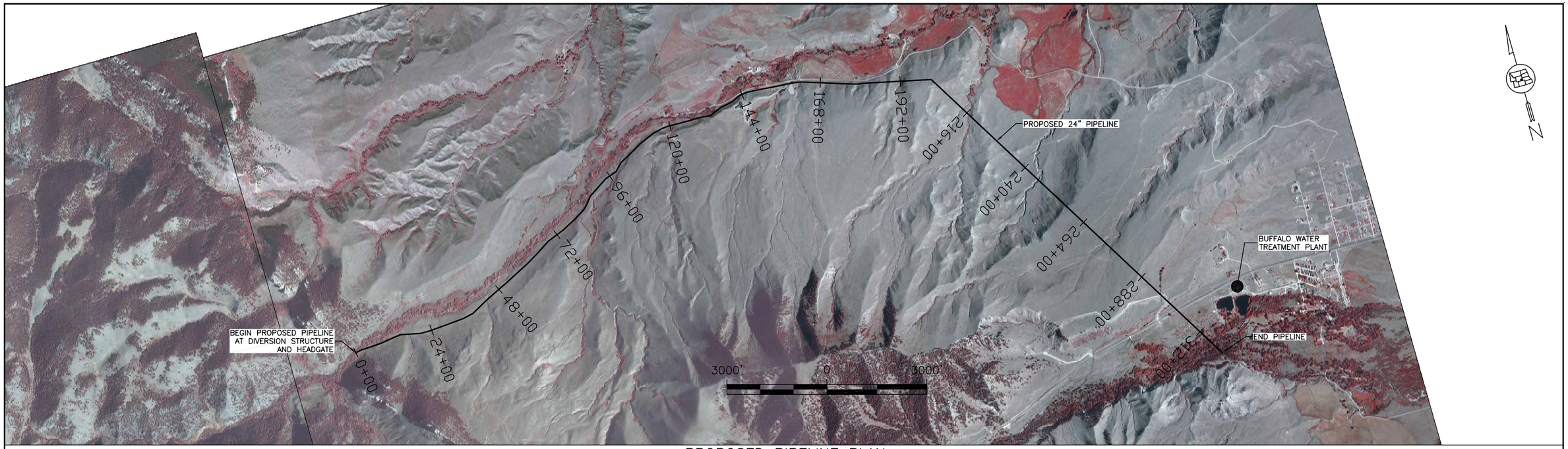
HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 7.1
FRENCH CREEK TO CLEAR CREEK PIPELINE – PLAN VIEW

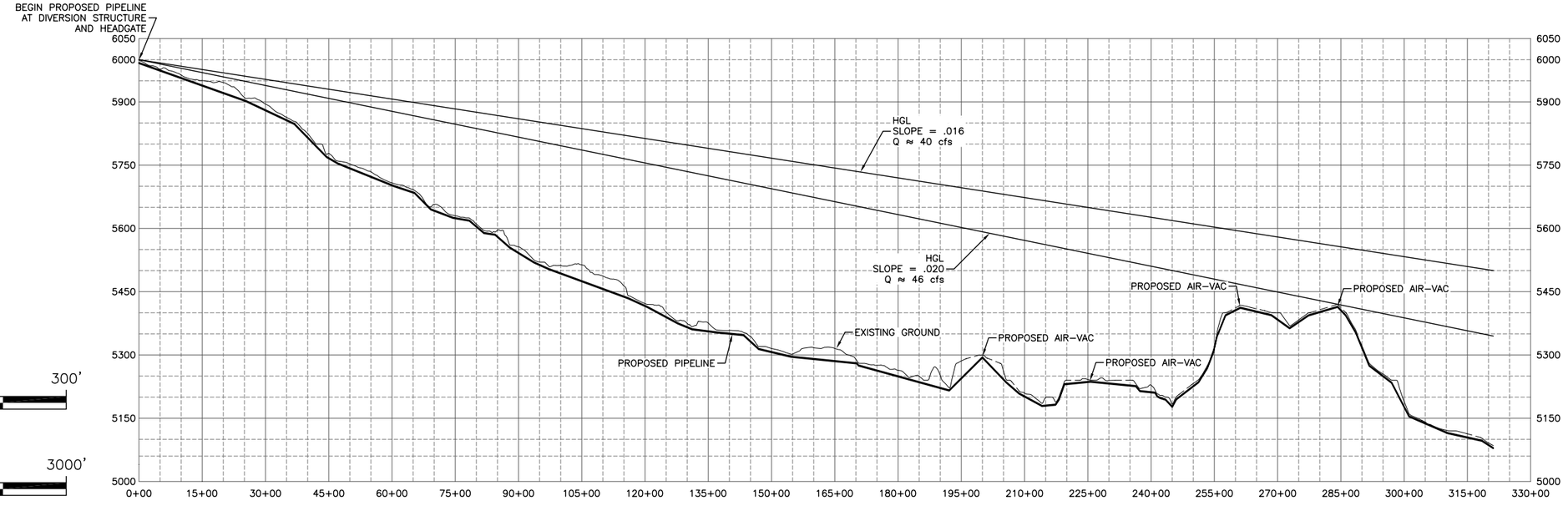
REVISION 1

PROJECT 522-WY

7-2



PROPOSED PIPELINE PLAN



PROPOSED PIPELINE PROFILE

VERT. SCALE

300' 0 300'

HORIZ. SCALE

3000' 0 3000'

REV	DESCRIPTION OF REVISION	BY	DATE
1	CONCEPTUAL DESIGN	JMR	06/17/08

STATES WEST WATER RESOURCES CORPORATION
1904 EAST 15th STREET
CHEYENNE, WYOMING 82001
(307) 634-7848
FAX: (307) 634-7851

WARNING

IF THIS BAR DOES NOT MEASURE 1.0" THEN DRAWING IS NOT TO SCALE

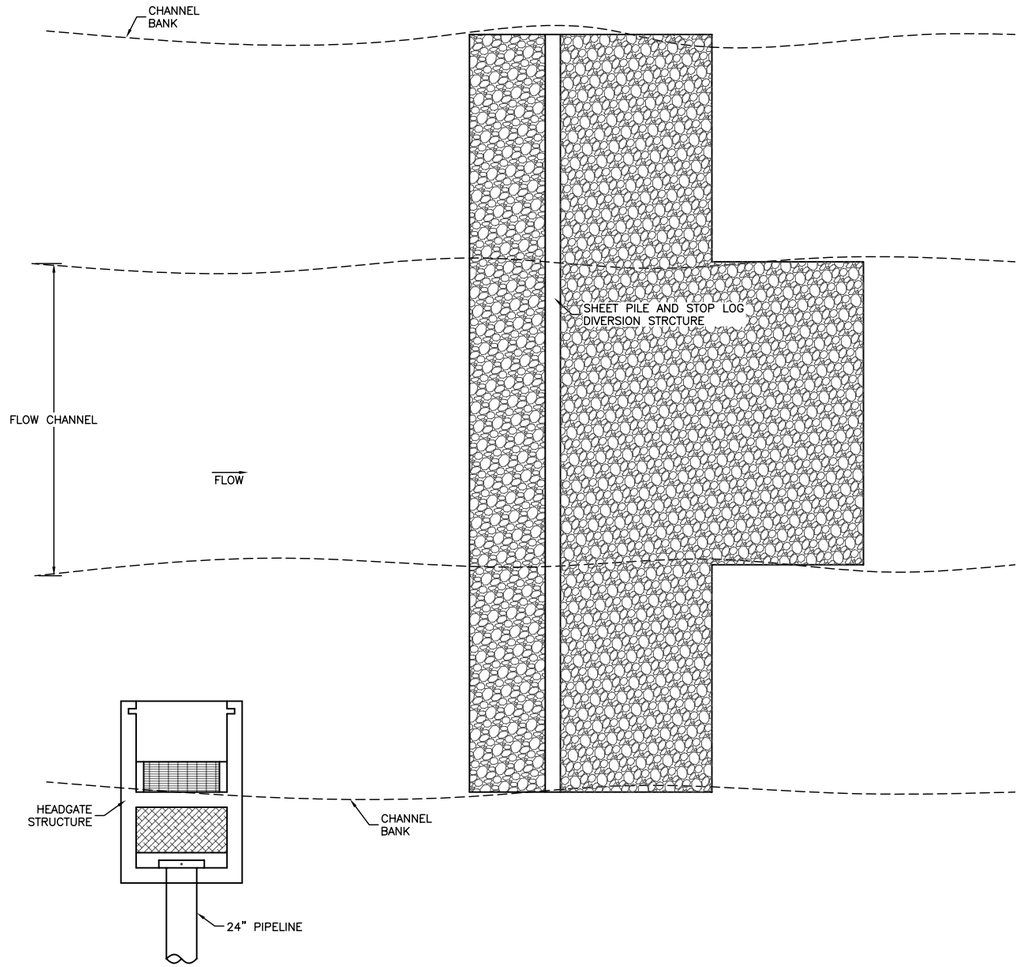
DESIGNED	VEA/JMR
DRAWN	JMR
CHECKED	
PEER REVIEWED	
PROJECT MANAGER	VEA
DATE	JUNE 2008

HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 7.2
FRENCH CK TO CLEAR CK
PIPELINE PLAN AND PROFILE

REVISION 1
PROJECT 522-WY

FILE NAME FIGURES
PLOT SCALE 1:1
OPER. JMR
DATE 2008JUNE17
PROJ. # 522WY
TASK CONCEP. DESIGN
LOC. BUFFALO, WY
PROJ. HOPKINS STUDY
SEND TO JENNIFER RUSSELL
PHONE (307) 634-7848



NOT TO SCALE

1	CONCEPTUAL DESIGN	JMR	06/17/08
REV	DESCRIPTION OF REVISION	BY	DATE

STATES WEST WATER
RESOURCES CORPORATION

1904 EAST 15th STREET
CHEYENNE, WYOMING 82001
(307) 634-7848
FAX: (307) 634-7851

WARNING

IF THIS BAR DOES NOT MEASURE 1.0" THEN DRAWING IS NOT TO SCALE

DESIGNED	VEA/JMR
DRAWN	JMR
CHECKED	
PEER REVIEWED	
PROJECT MANAGER	VEA
DATE	JUNE 2008

HOPKINS PRODUCERS ID STORAGE PROJECT

FIGURE 7.3
DIVERSION DAM PLAN

REVISION 1

PROJECT 522-WY

7-4

FILE NAME names
PLOT SCALE 1:1
OPER JMR
DATE 2008/JUNE17
PROJ. # 522WY
TASK # CONCEP. DESIGN
LOC. BUFFALO, WY
PROJ. HOPKINS STUDY
SEND TO JENNIFER RUSSELL
PHONE (307) 634-7848

8.1 Summary

This Level I Study conducted for the Hopkins Producers Irrigation District under the direction and funding of the Wyoming Water Development Commission develops reconnaissance level studies, designs and cost estimates of reservoir and rehabilitation projects in the French Creek and upper North Fork of Clear Creek watersheds.

Based on the preliminary hydrologic analysis of the watersheds, there appears to be some water available for storage in a potential reservoir facility. In order to further study reservoir feasibility, stream flow gauging data needs to be gathered and evaluated to better understand the basin hydrology and water availability. The water availability estimates made in this report are based on assumptions and correlations with gage data from other basins. Additionally, estimates of need should be further defined with additional stream flow gauging. With additional stream flow gauging, modeling can further the refinement of shortage estimates.

The cost estimates of potential reservoir facilities developed in this study were based on the reconnaissance level geotechnical information developed. Sub-surface exploration and laboratory testing is required to further assess the feasibility of a reservoir facility project and to better define cost estimates.

The following projects were presented in this study:

- North Fork of Clear Creek Diversion Rehabilitation
    - This project would rehabilitate the existing Four Lakes and French Creek diversion and expand the North Fork of Clear Creek as a water source to French Creek. The larger multipurpose reservoir projects on French Creek would require this project to supply water. Stream stability and erosion control structures would need to be constructed on some reaches of French Creek. $2.4 Million
    - Recommended for further study.
- Reservoir Site No. 1
    - Single purpose site to supply supplemental irrigation water to the Hopkins Producers ID
    - 985 AF maximum size
        - $6.8 Million
    - Off channel private land, existing supply canal
    - Minimal wetland impacts
    - Minimal cultural impacts
    - Minimal flood flow
    - Recommended for further study
- Reservoir Site No. 2
    - Single purpose site for supplemental supply to French Creek irrigators
    - 4000 AF
    - Off channel private land, requires 4000’ supply canal
    - Minimal wetland and riparian impacts
    - Crucial elk winter range
    - Moderate flood flow

    - Inefficient dam site
    - Not recommended for further study due to inefficiency
- Reservoir Site No. 3
    - Multipurpose site to supply French, Johnson, Rock, and Clear Creek irrigation, municipal, environmental and recreational uses.
    - 5500-7500 AF optimal range
        - $59.5M – $71.6M
    - On channel French Creek, Bighorn National Forest
    - Earth embankment would be most economical
    - Cultural resources may require mitigation
    - Minimal wetland impacts likely require mitigation
    - Riparian impacts likely require mitigation
    - Crucial elk winter range will likely require mitigation
    - Flood flow relatively large, relatively substantial spillway
    - Access requires improvement of Forest Service road and a private road
    - Recommended for further study
- Reservoir Site No. 4
    - Multipurpose site to supply French, Johnson, Rock, and Clear Creek irrigation, municipal, environmental and recreational uses.
    - 3200 AF
    - On channel French Creek, Bighorn National Forest
    - Minimal wetland and riparian impacts will likely require mitigation
    - Crucial elk winter range will likely require mitigation
    - Flood flow relatively large
    - Access requires improvement of an existing Forest Service road
    - Not recommended for further study due to inefficiency
- Reservoir Site No. 5
    - Multipurpose site to supply French, Johnson, Rock, and Clear Creek irrigation, municipal, environmental and recreational uses.
    - 5000-7500 AF optimal range
        - $49.6M RCC ($43.7M rockfill) – $58.2M RCC
    - On channel French Creek, Bighorn National Forest
    - RCC or rockfill would be most economical
    - Minimal cultural resources
    - Substantial wetland and fen impacts may not be feasibly mitigated
    - Riparian impacts likely require mitigation
    - Crucial elk winter range will likely require mitigation
    - Flood flow relatively large, moderate spillway
    - Access requires road construction on Forest Service property
    - Not recommended for further study due to wetland impacts
- South Rock Creek Water Supply (Reservoir Site No. 6)
    - On channel South Rock Creek, Bighorn National Forest
    - Located in proposed wilderness area
    - Minimal cultural impacts
    - Substantial wetland and fen impacts in reservoir pool area may not be feasibly mitigated

    - Riparian impacts in reservoir pool area likely require mitigation
    - Flood flow relatively large, moderate spillway
    - Access requires improvement of a Forest Service road
    - Reservoir alternative not recommended for further study due to wetland impacts
    - Water supply to French Creek is a possible concept, requires more study to determine feasibility
- Reservoir Site No. 7
    - Multipurpose site to supply French, Johnson, Rock, and Clear Creek irrigation, municipal, environmental and recreational uses.
    - Off channel, Bighorn National Forest
    - Substantial wetland and fen impacts may not be feasibly mitigated
    - Riparian impacts likely require mitigation
    - Inefficient dam site
    - Not recommended for further study due to wetland impacts and inefficiency
- Reservoir Site No. 8
    - Multipurpose site to supply French, Johnson, Rock, and Clear Creek irrigation, municipal, environmental and recreational uses.
    - 5500-7500 AF optimal range
        - $55.2M – $65.4M (RCC)
    - On channel French Creek, Bighorn National Forest
    - RCC dam would be most economical with anticipated lack of fine grain material for earth embankment construction
    - Cultural resources may potentially be a fatal flaw
    - Minimal wetland impacts likely require mitigation
    - Riparian impacts likely require mitigation
    - Crucial elk winter range will likely require mitigation
    - Flood flow relatively large, relatively substantial spillway
    - Access requires improvement of an existing Forest Service road
    - Recommended for further study
- French Creek to Clear Creek Pipeline
    - Transfers water stored on French Creek to Clear Creek above the Buffalo water treatment plant - $6.0 Million
    - Could serve municipal, supplemental irrigation, instream flows and environmental uses, could delay regulation on Clear Creek
    - Recommended for further study.

8.2 Recommendations

If further study is requested, the following projects and tasks are recommended for further study of technical and economic feasibility:

- Potential Reservoir Site 1
    - Technical Studies
        - Streamflow gauging and hydrologic modeling
        - Subsurface geotechnical investigation
        - Survey
        - Preliminary design

        - Permitting and environmental mitigation
    - Economic Analysis
        - Direct and indirect benefits to costs analysis
        - Ability to pay analysis
- Potential Reservoir Site 3
    - Technical Studies
        - Streamflow gauging on North Clear Creek at 4 Lakes diversion and French Creek at Forest Service Boundary and hydrologic modeling
        - Subsurface geotechnical investigation
        - Stream stability of French Creek with increased flows
        - Survey
        - Preliminary design
        - Permitting and environmental mitigation
    - Economic Analysis
        - Direct and indirect benefits to costs analysis
        - Ability to pay analysis
- Potential Reservoir Site 8
    - Technical Studies
        - Streamflow gauging on North Clear Creek at 4 Lakes diversion and French Creek at Forest Service Boundary and hydrologic modeling
        - Subsurface geotechnical investigation
        - Stream stability of French Creek with increased flows
        - Survey
        - Preliminary design
        - Cultural mitigation
        - Permitting and environmental mitigation
    - Economic Analysis
        - Direct and indirect benefits to costs analysis
        - Ability to pay analysis
- North Fork of Clear Creek Diversion Rehabilitation
    - Technical Studies
        - Streamflow gauging on North Clear Creek and hydrologic modeling
        - Subsurface geotechnical investigation associated with diversion and pipeline
        - Stream stability of French Creek with increased flows
        - Survey
        - Preliminary design
        - Permitting and environmental mitigation
- French Creek to Clear Creek Pipeline
    - Technical Studies
        - Subsurface geotechnical investigation associated with diversion and pipeline facilities
        - Evaluate hydropower potential
        - Survey
        - Preliminary design
        - Permitting and environmental mitigation

TABLE OF CONTENTS

APPENDIX A.

Geotechnical Report

Date: September 28, 2007

Subject: Results of Preliminary Geotechnical Engineering Investigations of Six Potential Irrigation Water Storage Sites for the Hopkins Producers Irrigation District Watershed/Water Storage Project, Level I Study, west of Buffalo, Wyoming

Job No.: 07-85

Mr. Dylan Wade, Project Engineer
States West Water Resources Corporation
1904 East 15th Street
Cheyenne, Wyoming 82001

Dear Mr. Wade:

As requested, Hollingsworth Associates, Inc. conducted a review of available geologic, geotechnical, and soils data pertinent to the watershed and a field reconnaissance of six potential water storage sites with your team on August 21 and 22, 2007. The geotechnical engineering services were provided for Tasks 3B and 6 of the Hopkins Producers Irrigation District Watershed/Water Storage Project Level I Study. The project location is the 38,000 acre watershed of French Creek and Upper Clear Creek west of Buffalo, Wyoming.

The purpose of this letter is to report the results of the field reconnaissance studies of each of the six sites. The following is a brief description of each of the sites and the type(s) of dams appropriate for the sites.

Site No. 1: Site No. 1 is located in a well defined V-shaped valley with a well defined drainage way which was dry at the time of the field reconnaissance. There is a low saddle on the left abutment through which an irrigation ditch has been routed. The bedrock is interbedded sandstones and claystones of the Wasatch Formation. The right abutment was mantled with sand

and gravel with cobble overlying the bedrock for a depth of at least 15 feet. Silty sands and sandy clays were exposed in the stream cut in the valley bottom. The left abutment had a similar mantle of granular soils as the right abutment except that there were exposures of an uncemented, fairly coarse grained white sandstone and medium hard grey and brown claystone. The ditch crossing the saddle on the left abutment had cut at least 20 feet in depth exposing claystone 3 feet to 5 feet thick and interbedded sandstone at least 15 feet thick. The site has a good grass cover with a few small trees in the valley bottom.

A dam approximately 80 feet high is planned. There is a sufficient amount of cohesive and granular soils in the reservoir area to construct a zoned earth embankment dam. The crest width should be at least the height of the dam divided by 5 plus 10 feet. Therefore, the dam crest should be at least 26 feet wide. The exterior slopes should be 3H:1V or flatter on the upstream face and 2.5H:1V or flatter on the downstream face. The core should have upstream and downstream slopes of 1H:1V or flatter. The granular soils should be used for the exterior shells and the cohesive materials should be used for the core. Down stream of the core, a 3-foot wide chimney drain and a 5-foot thick blanket drain should be installed. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the right abutment, 10 feet in the valley bottom, and 5 feet on the left abutment. A 5-foot deep cutoff trench should be excavated below the core with a width of at least 10 feet and 1H:1V side slopes.

Site No. 3: Site No. 3 is located in a U-shaped valley with French Creek flowing through which had a low flow at the time of the field reconnaissance. The bedrock is Precambrian granite. The only rock outcrops were high up on the abutments well above the reservoir high water line. Both abutments were mantled with silty sand and gravel and scattered boulders. Depth to bedrock is probably 30 feet or greater in the valley bottom and 5 feet to 15 feet on the abutments. There are several springs on the left side of the reservoir about at the reservoir high water line and above that may indicate a shallow depth of bedrock. The site has a good grass and tree cover.

A dam approximately 120 feet high is planned. At least three types of dams, homogeneous or

zoned earth embankment, concrete faced rockfill, and roller compacted concrete, appear to be applicable to the site.

There would have to be a sufficient amount of fines, 10% or greater, in the granular soils in the reservoir area to construct a homogeneous or zoned earth embankment dam. For an embankment dam, the crest width should be at least the height of the dam divided by 5 plus 10 feet. Therefore, the dam crest should be at least 34 feet wide. The exterior slopes should be 3H:1V or flatter on the upstream face and 2.5H:1V or flatter on the downstream face. If a core is used, the core should have upstream and downstream slopes of 1.5H:1V or flatter. Any of the granular soils may be used for the exterior shells and the granular soils with at least 10% fines should be used for the core. Down stream of the core, a 3-foot wide chimney drain and a 5-foot thick blanket drain should be installed. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the abutments and 30 feet in the valley bottom. A 5-foot deep cutoff trench should be excavated below the dam centerline with a width of at least 10 feet and 1H:1V side slopes.

The site is suitable for the construction of a concrete faced rockfill dam similar in design to the Deer Creek Dam. The rock for the fill and the concrete face aggregate is available on site both as granular soils and quarried rock. The upstream and downstream slopes of the rockfill should be 1.3H:1V or flatter. The reinforced concrete facing should be at least 12 inches thick. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the abutments and 30 feet in the valley bottom.

The site is suitable for the construction of a roller compacted concrete dam similar in design to the Tie Hack Dam. The rock for the concrete aggregate is available on site both as granular soils and quarried rock. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam at least 2 feet in to the sound bedrock. The excavation depths are estimated to be 20 feet on the abutments and 40 feet in the valley bottom.

Site No. 4: Site No. 4 is located in a narrow, very steep V-shaped valley with French Creek running through which had a fair flow at the time of the field reconnaissance. The bedrock is Precambrian granite. There were numerous rock outcrops on the left abutment. There were no rock outcrops on the right abutment. The valley bottom was filled with silty sand and gravel and numerous boulders. Depth to bedrock is probably 30 feet or greater in the valley bottom and 5 feet to 15 feet on the abutments. The site has a heavy tree cover.

A dam approximately 120 feet high is planned. At least three types of dams, homogeneous or zoned earth embankment, concrete faced rockfill, and roller compacted concrete, appear to be applicable to the site.

There would have to be a sufficient amount of fines, 10% or greater, in the granular soils in the reservoir area to construct a homogeneous or zoned earth embankment dam. For an embankment dam, the crest width should be at least the height of the dam divided by 5 plus 10 feet. Therefore, the dam crest should be at least 34 feet wide. The exterior slopes should be 3H:1V or flatter on the upstream face and 2.5H:1V or flatter on the downstream face. If a core is used, the core should have upstream and downstream slopes of 1.5H:1V or flatter. Any of the granular soils may be used for the exterior shells and the granular soils with at least 10% fines should be used for the core. Down stream of the core, a 3-foot wide chimney drain and a 5-foot thick blanket drain should be installed. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the abutments and 30 feet in the valley bottom. A 5-foot deep cutoff trench should be excavated below the dam centerline with a width of at least 10 feet and 1H:1V side slopes.

The site is suitable for the construction of a concrete faced rockfill dam similar in design to the Deer Creek Dam. The rock for the fill and the concrete face aggregate is available on site both as granular soils and quarried rock. The upstream and downstream slopes of the rockfill should be 1.3H:1V or flatter. The reinforced concrete facing should be at least 12 inches thick. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam

down to the bedrock. The excavation depths are estimated to be 15 feet on the abutments and 30 feet in the valley bottom.

The site is suitable for the construction of a roller compacted concrete dam similar in design to the Tie Hack Dam. The rock for the concrete aggregate is available on site both as granular soils and quarried rock. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam at least 2 feet into the sound bedrock. The excavation depths are estimated to be 20 feet on the abutments and 40 feet in the valley bottom.

Site No. 5: Site No. 5 is located in a fairly wide, very steep V-shaped valley with French Creek running through which had a fair flow at the time of the field reconnaissance. The bedrock is Precambrian granite. There were numerous rock outcrops on the left abutment with the first bring a near 60 feet vertical outcrop. Above that point, the abutment flattens to a slope of 2H:1V with numerous outcrops. That portion of the slope had up to 5 feet of silty sand soils. There were numerous rock outcrops on the right abutment which was very steep. The lower portion of the right abutment was a talus slope. The valley bottom was filled with silty sand and gravel and numerous boulders. Depth to bedrock is probably 30 feet or greater in the valley bottom and 5 feet to 15 feet on the abutments. The site has a heavy tree cover.

A dam approximately 160 feet high is planned. At least three types of dams, homogeneous or zoned earth embankment, concrete faced rockfill, and roller compacted concrete, appear to be applicable to the site.

There would have to be a sufficient amount of fines, 10% or greater, in the granular soils in the reservoir area to construct a homogeneous or zoned earth embankment dam. For an embankment dam, the crest width should be at least the height of the dam divided by 5 plus 10 feet. Therefore, the dam crest should be at least 42 feet wide. The exterior slopes should be 3H:1V or flatter on the upstream face and 2.5H:1V or flatter on the downstream face. If a core is used, the core should have upstream and downstream slopes of 1.5H:1V or flatter. Any of the granular soils may be used for the exterior shells and the granular soils with at least 10% fines should be used for the core. Down stream of the core, a 3-foot wide chimney drain and a 5-foot thick blanket

drain should be installed. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the abutments and 30 feet in the valley bottom. A 5-foot deep cutoff trench should be excavated below the dam centerline with a width of at least 10 feet and 1H:1V side slopes.

The site is suitable for the construction of a concrete faced rockfill dam similar in design to the Deer Creek Dam. The rock for the fill and the concrete face aggregate is available on site both as granular soils and quarried rock. The upstream and downstream slopes of the rockfill should be 1.3H:1V or flatter. The reinforced concrete facing should be at least 12 inches thick. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam down to the bedrock. The excavation depths are estimated to be 15 feet on the abutments and 30 feet in the valley bottom.

The site is suitable for the construction of a roller compacted concrete dam similar in design to the Tie Hack Dam. The rock for the concrete aggregate is available on site both as granular soils and quarried rock. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam at least 2 feet in to the sound bedrock. The excavation depths are estimated to be 20 feet on the abutments and 40 feet in the valley bottom.

Site No. 6: Site No. 6 is located in a U-shaped valley on Upper Rock Creek which had a fair flow at the time of the field reconnaissance. The bedrock is Precambrian granite. The left abutment was mainly broken pieces of granite that had been re-arranged erratically by frost action with a silty sand soil cover on the lower slope. The lower slope of the left abutment had a heavy tree cover. The right abutment was a heavily wooded lateral moraine composed of silty sand and gravel with cobble and boulders. At the planned dam centerline, the valley bottom was filled with silty sand and gravel and numerous boulders. Upstream of the planned dam centerline, the reservoir area opens up into broad meadow covered with grass and small brush. The exposed soils were silty sands with scattered boulders throughout. Immediately downstream of the planned dam centerline, the stream drops steeply. Approximately 100 feet downstream of the

dam centerline, bedrock outcrops in the stream channel and on both sides of the stream channel at an elevation of approximately 20 feet below the stream level at the planned dam centerline. Depth to bedrock is probably 30 feet in the valley bottom and 15 feet to 30 feet on the left abutment. The depth to bedrock on the right abutment cannot be estimated with any reasonable degree of accuracy. At this time, the depth to bedrock on the right abutment should be assumed to be 30 feet at the stream channel and at least 100 feet up the slope.

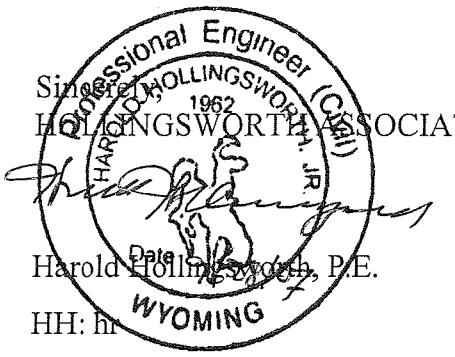
A dam approximately 80 feet high is planned. At this time, only a homogeneous or zoned earth embankment dam appears to be applicable to the site. That evaluation is contingent on there being sufficient fines, 10% or greater, in the soils of the right abutment to hold the reservoir waters without excessive seepage losses.

There would have to be a sufficient amount of fines, 10% or greater, in the granular soils in the reservoir area to construct a homogeneous or zoned earth embankment dam. For an embankment dam, the crest width should be at least the height of the dam divided by 5 plus 10 feet. Therefore, the dam crest should be at least 26 feet wide. The exterior slopes should be 3H:1V or flatter on the upstream face and 2.5H:1V or flatter on the downstream face. If a core is used, the core should have upstream and downstream slopes of 1.5H:1V or flatter. Any of the granular soils may be used for the exterior shells and the granular soils with at least 10% fines should be used for the core. Down stream of the core, a 3-foot wide chimney drain and a 5-foot thick blanket drain should be installed. Foundation preparation should consist of excavation of the soils from beneath the entire footprint of the dam for a depth of 15 feet. A 5-foot deep cutoff trench should be excavated below the dam centerline with a width of at least 10 feet and 1H:1V side slopes.

The site may or may not be suitable for the construction of a concrete faced rockfill dam or a roller compacted concrete dam depending on the depth to sound bedrock beneath the dam. If further consideration is given to this site, the foundation exploration may find that sound bedrock is within economical excavation depth for the construction of a concrete faced rockfill dam or a roller compacted concrete dam. The rock for fill and concrete aggregate is available on site both as granular soils and quarried rock.

Site No. 7: The general area of Site No. 7 was walked. The terrain was rather irregular with numerous "moose wallows". For those wetlands to exist, an impervious layer, either bedrock or cohesive soils, must be present at a shallow depth below the exposed silty sand soils. The area was heavily wooded. There should be sufficient soils present for construction of an earth embankment dam.

If we can provide further information at this time, please call.



Sincerely,
HOLLINGSWORTH ASSOCIATES, INC.

Harold Hollingsworth, P.E.
HH: hr
Reviewed By: TRH

APPENDIX B.

Environmental Report

WETLANDS, SENSITIVE SPECIES, RIPARIAN AREAS, AND BIG GAME HABITAT ASSOCIATED WITH POTENTIAL RESERVOIR SITES – HOPKINS PRODUCERS IRRIGATION DISTRICT

Prepared for:

States West Water Resources Corporation
Cheyenne, Wyoming

Prepared by:

Greg Johnson
W*estern* **E***co***S***ystems* ***T****echnology, Inc.*
2003 Central Avenue
Cheyenne, WY 82001

August 8, 2008

INTRODUCTION

The Wyoming Water Development Commission is considering construction of a reservoir to supply additional storage for the Hopkins Producers Irrigation District in Johnson County, Wyoming. Based on initial screening, the number of potential reservoir sites was reduced to eight (Figure 1). This report looks at biological criteria including wetlands; threatened, endangered and sensitive wildlife and plants; woody riparian areas, migratory birds; and big game habitats.

METHODS

U.S. Fish and Wildlife Service National Wetland Inventory (NWI) maps are available only for Site 6. The area of wetland within the dam footprint and inundation areas within this site was digitized off the NWI map. To assess potential wetland impacts at the other sites, each reservoir site (except Site 2) was visited on August 21 and 22, 2007 to determine the extent of wetlands potentially present on each site.

Previously documented occurrences of federally listed species and other species of concern within the project area (defined as all townships containing potential reservoir sites) were determined through searching the Wyoming Natural Diversity Database (WNDD) maintained by the University of Wyoming. The WNDD computer search included species of concern within their standard one township buffer around the township each site is in. To obtain information on big game habitats associated with each site, digital big game herd unit maps were obtained from the Wyoming Game and Fish Department (WGFD) and overlaid on maps of the reservoirs. In addition, potential habitat for sensitive species and raptor nesting habitat was assessed during the site visit.

RESULTS

Wetlands

Site 1. The proposed dam site for Site #1 is on a channel with wetland fringes, all of which were classified as wet meadow type wetlands. The total area of wetland impact at this site was estimated at approximately 0.7 acres.

Site 2. This site was dropped from consideration early in the screening process and was not visited during the site visit. Wetland impacts would likely be minimal as there are only narrow fringe wetlands along the drainage.

Site 3. There are very minimal amounts of wetlands at this site. Wetlands are limited to narrow fringes one to two feet wide in places along the stream. Most wetlands are wet meadows with little shrub cover. The presence of a cobbly stream bottom and steep banks along the channel limit wetland formation in this area**.** Total wetland impacts at this site would likely be less than 0.5 acres.

Site 4. This site has narrow wetland fringes along the stream. No extensive areas of off-channel wetlands are present and wetland impacts would likely be <1 acre.

Site 5. This site has fringe wetlands along the stream as well as several off-channel wetlands. Two wetlands on this site are classified as fens based on presence of a histic epipedon (organic soils). These wetlands were surveyed using a survey grade GPS and were found to be approximately 1.03 acres in size (Figure 2). Total wetland impact at this site would likely be over two acres. Wetlands at this site are approximately half wet meadows and half scrub shrub wetlands.

Site 6. Site 6 has extensive wetlands within the inundation area, many of which are dominated by willow and would be considered scrub-shrub wetlands. Many of these wetlands appear to be fens based on the presence of organic soil. The total area of wetland impact could be up to 98 acres, depending on size of the reservoir.

Site 7. This site has rather wide wetland fringes (up to 15 feet) along the stream as well as several off-channel wetlands in depressions. Most of these wetlands are wet meadows. Some of the off-channel wetlands appeared to be fens. Total wetland impact at this site would likely be on the order of 0.75 to 1.25 acres.

Site 8. This site has narrow wetland fringes along the stream. No extensive areas of off-channel wetlands are present and wetland impacts would likely be <1 acre.

Woody Riparian Areas

No woody riparian vegetation is present at Site 1. All of the other sites have some woody riparian areas along streams within the inundation areas. In general these woody riparian areas are fairly narrow and there are no extensive areas of woody riparian vegetation. Common species include cottonwood, aspen, alder and mountain maple. Mitigation for woody riparian areas may be required.

Listed or other Sensitive Species

The only federally listed species that may occur in the project area is Canada lynx. According to the WNDD, there is one record of Canada lynx approximately two miles northwest of Site 1 (Figure 3). All reservoirs are potentially located in Canada lynx habitat. However, the Bighorn Mountains are not considered highly suitable for Canada lynx and construction of a reservoir would not likely result in adverse impacts to this species.

Several species tracked by the WNDD as species of concern may occur in or near the reservoir sites. The entire area is considered grizzly bear habitat but these records are historical in nature. Sensitive mammals documented within a township buffer of the reservoir sites include American marten, Townsend's big-eared bat, Bear Lodge meadow jumping mouse, and white-footed mouse. None of these species have been documented within any of the reservoir sites. Thirty-two species of sensitive bird species have been documented within a township buffer of the project area (Figure 3). Many of these species occupy habitats that don't occur within the reservoir inundation areas, although some of these species may occur in habitats that would be affected by reservoir construction. Three sensitive species of reptiles and amphibians have also been documented in the project area (Figure

3). Northern leopard frogs have been documented within Site 7 and between Sites 5 and 6 and could occur at all of the sites. Ten species of sensitive plants have been documented in the project area (Figure 3). All six reservoirs are within the expected ranges of one or more of these species. Prior to constructing reservoirs in this area, surveys for sensitive wildlife and plant species would likely be required, especially for any sites on the Bighorn National Forest. If any sensitive species are found, mitigation measures would likely be required.

Migratory Birds

No raptor nests were observed during the site visit, but many of the sites are forested and nests would have been difficult to detect. Surveys would likely be required for raptor nests prior to construction activities. These surveys may include broadcasting taped calls to locate nests of such species as northern goshawk.

Big Game

Sites 2, 3, 4, 5 and 8 occur in areas designated as crucial winter range for elk. Site 1 is not considered to be elk habitat, Site 6 is in spring-summer-fall habitat for elk, and Site 7 is within winter-yearlong range for elk (Figure 4). The Wyoming Game and Fish Department may request mitigation if a reservoir is constructed on elk crucial winter range. Sites 1, 2, 3, 4, 5, and 8 are within moose and mule deer winter-yearlong range, but not crucial winter range. Sites 6 and 7 are in moose and mule deer spring-summer-fall range. Site 2 is within white-tailed deer yearlong range while none of the other sites are within areas designated as white-tailed deer habitat. Sites 1 and 2 are within pronghorn yearlong range; the other sites are not within pronghorn habitat (Figure 4).

CONCLUSIONS

The primary issue affecting feasibility of some of the sites is the presence of fen wetlands. Fens take decades to develop and there is no easy way to mitigate impacts to fens. As a result, it will be difficult to obtain a 404 permit from the Corps of Engineers if there are any feasible alternative sites that do not have fens. Sites 5, 6 and 7 all have fens, whereas none of the other sites appear to have fen wetlands. Woody riparian vegetation is present on most of the sites, and impacts to woody riparian areas may have to be mitigated. The presence of federally listed species does not appear to be a major issue for any of the sites. Several sensitive wildlife and plant species occur in the area, and some of these species may be present on the reservoir sites. Surveys for sensitive species would likely be required for all reservoir alternatives located on the Bighorn National Forest. Impacts to sensitive species, if present, can likely be mitigated. Sites 2, 3, 4, 5 and 8 occur within an area designated as crucial winter range for elk. The WGFD would likely require that impacts to crucial winter range be mitigated.

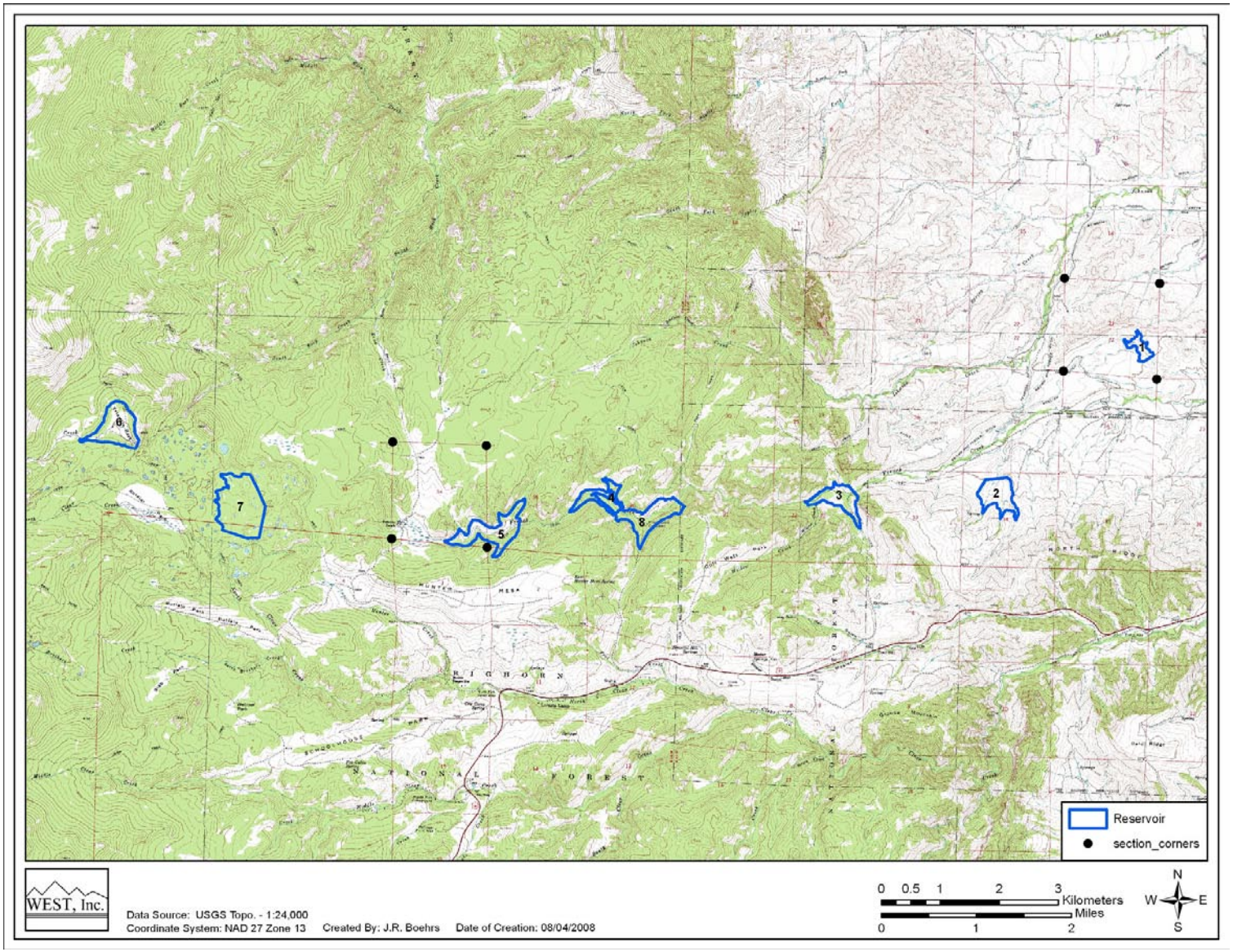


Figure 1. Location of the eight reservoirs being considered for the Hopkins Producers Irrigation District Project

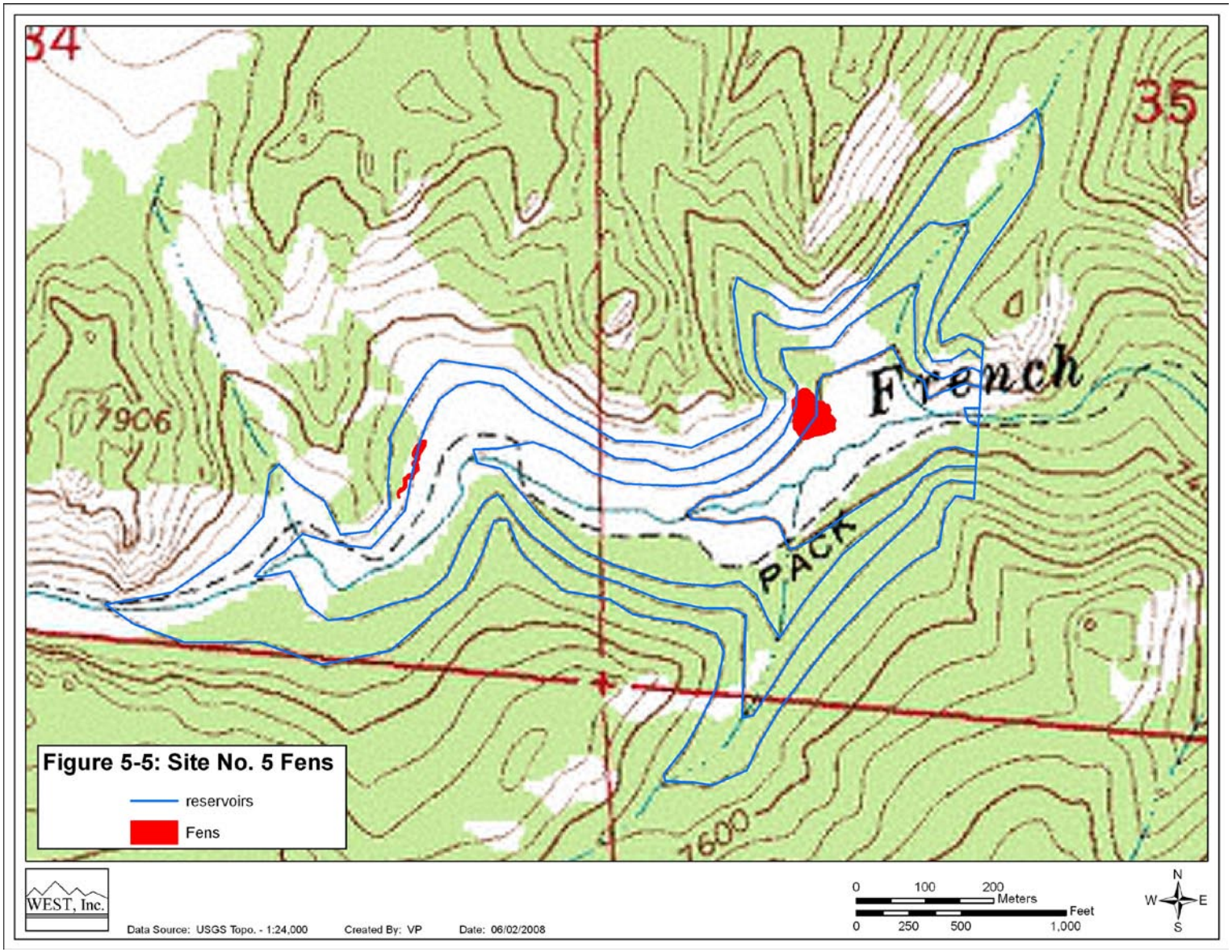


Figure 2. Location of fens within the inundation area of Reservoir Site 5

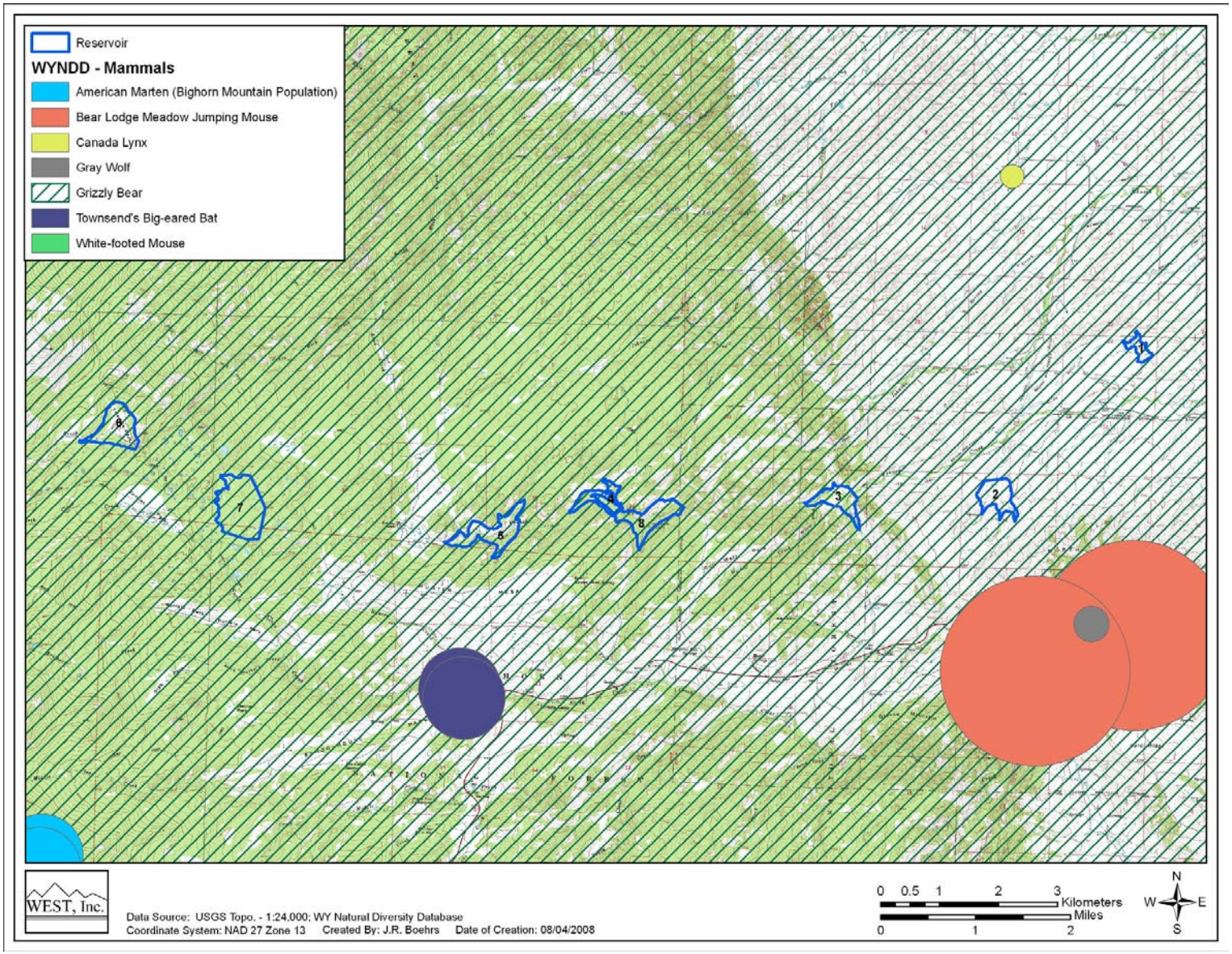


Figure 3. Observations of sensitive species within a township buffer of the Hopkins Producers reservoir sites

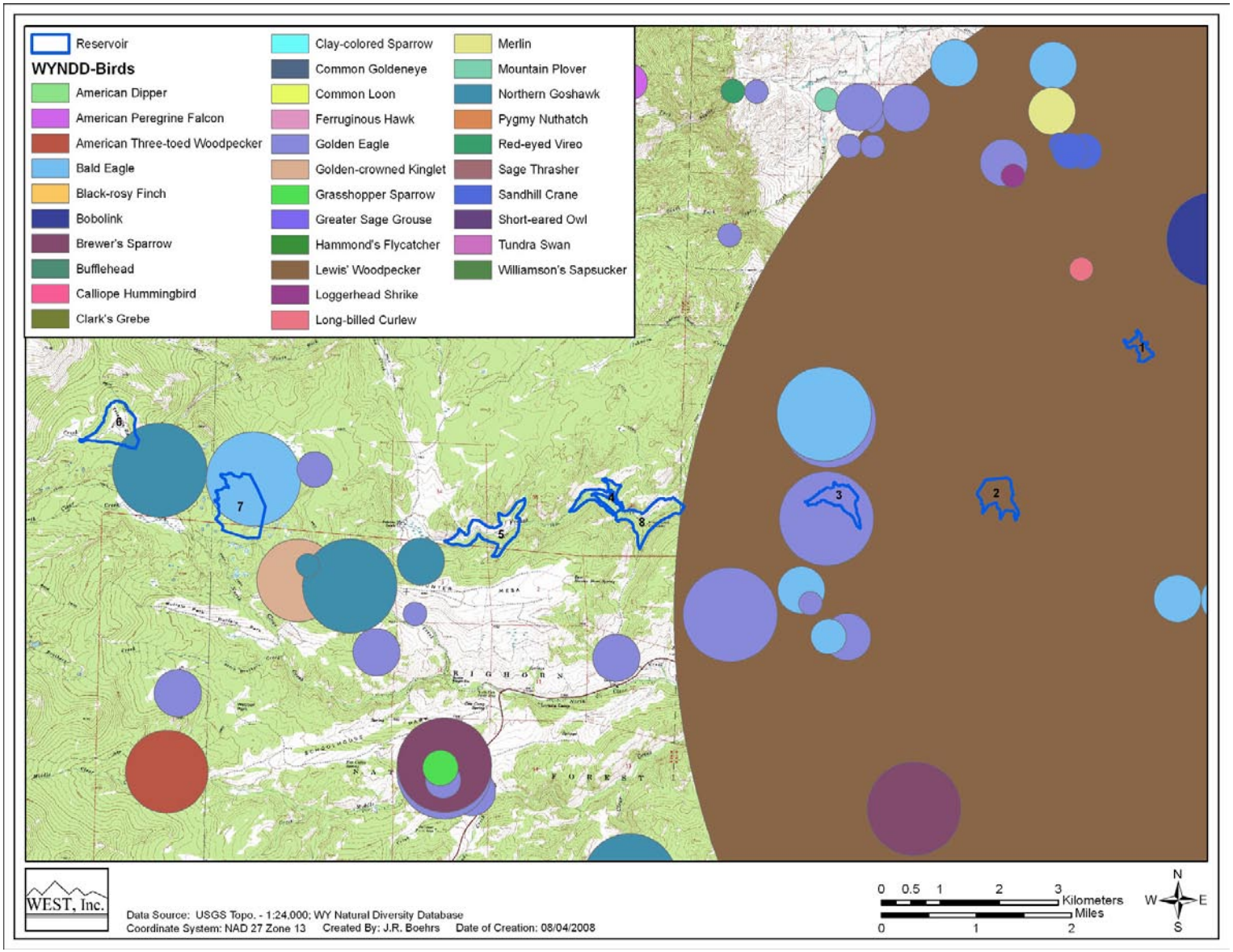


Figure 3 (continued). Observations of sensitive species within a township buffer of the Hopkins Producers reservoir sites

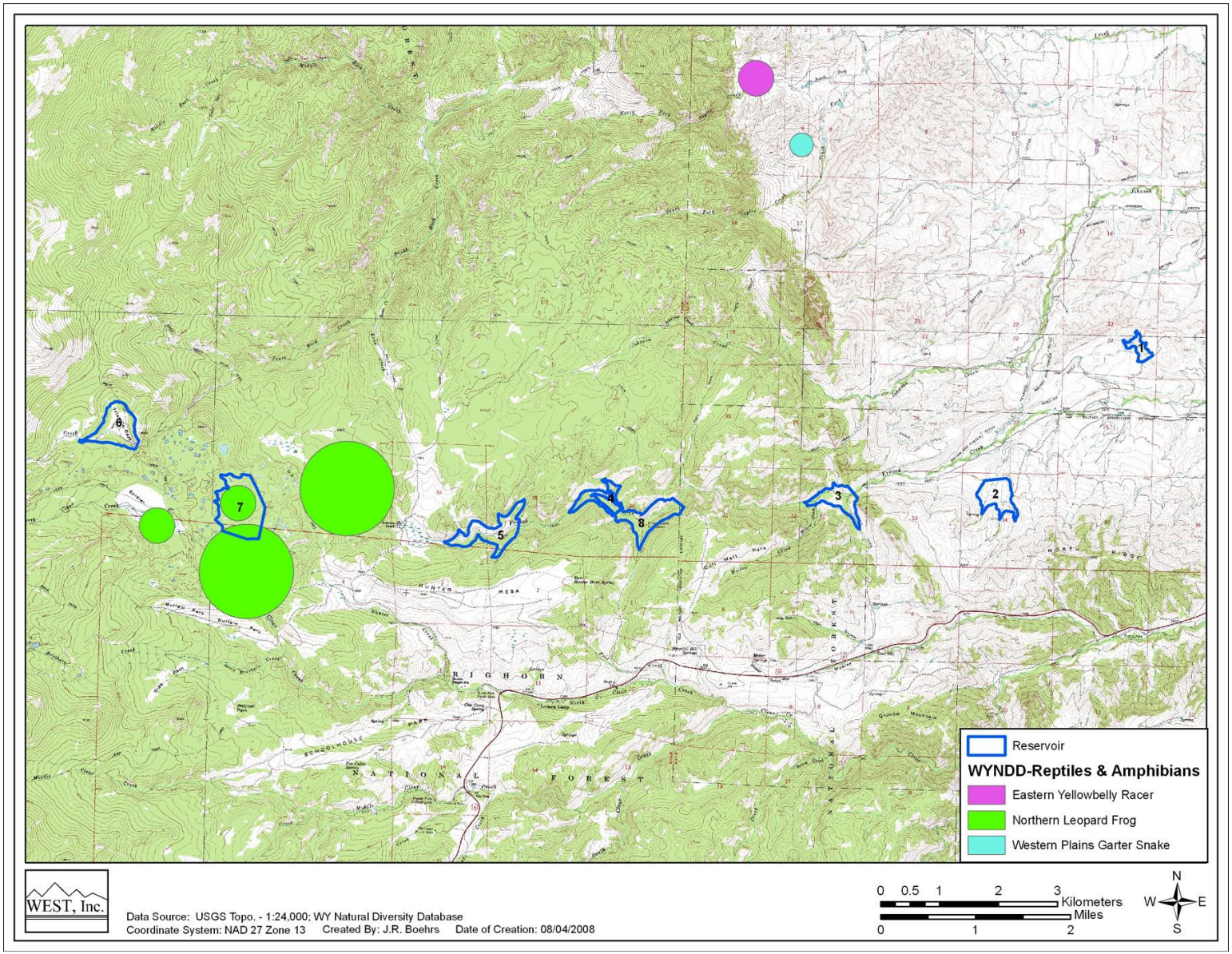


Figure 3 (continued). Observations of sensitive species within a township buffer of the Hopkins Producers reservoir sites

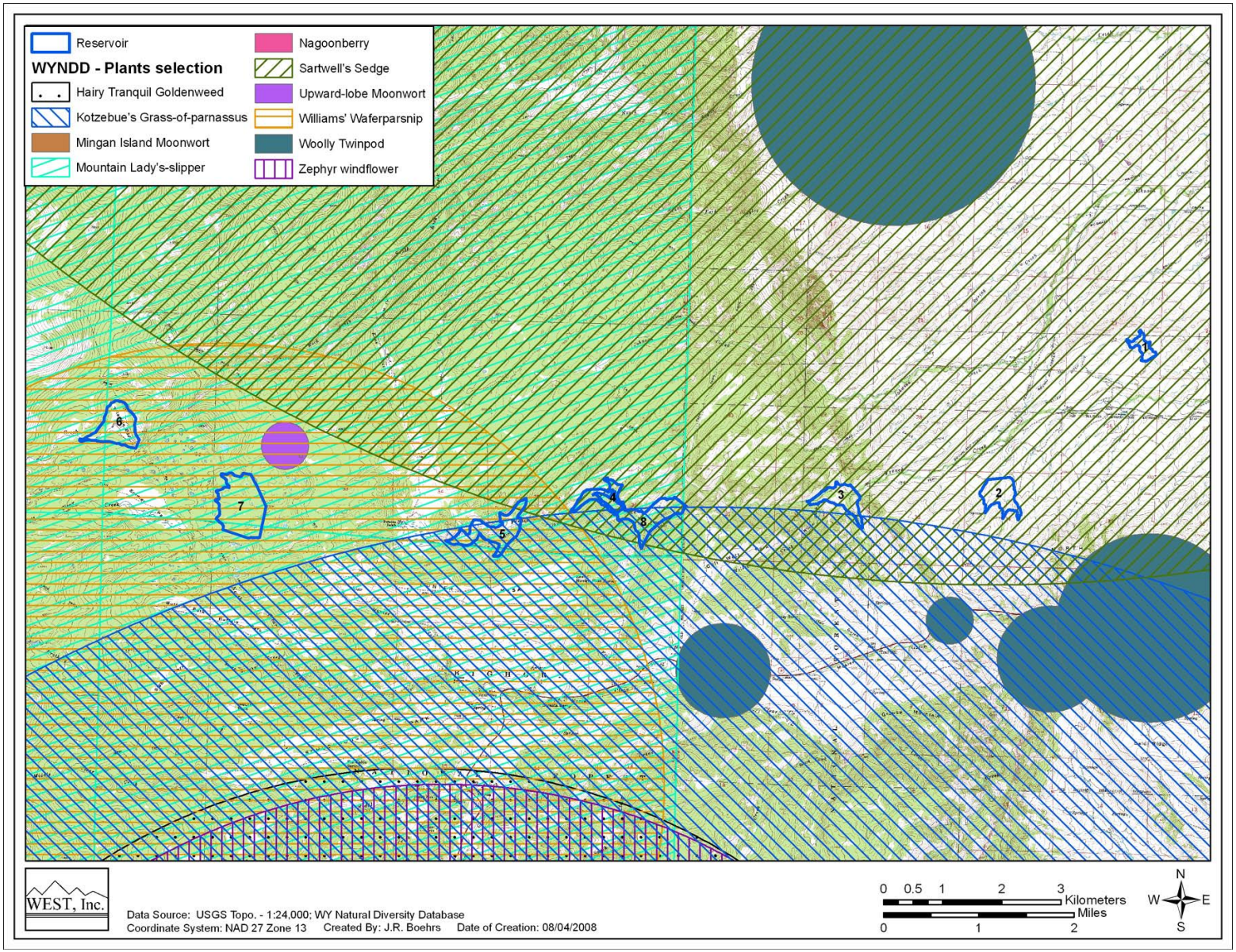


Figure 3 (continued). Observations of sensitive species within a township buffer of the Hopkins Producers reservoir sites

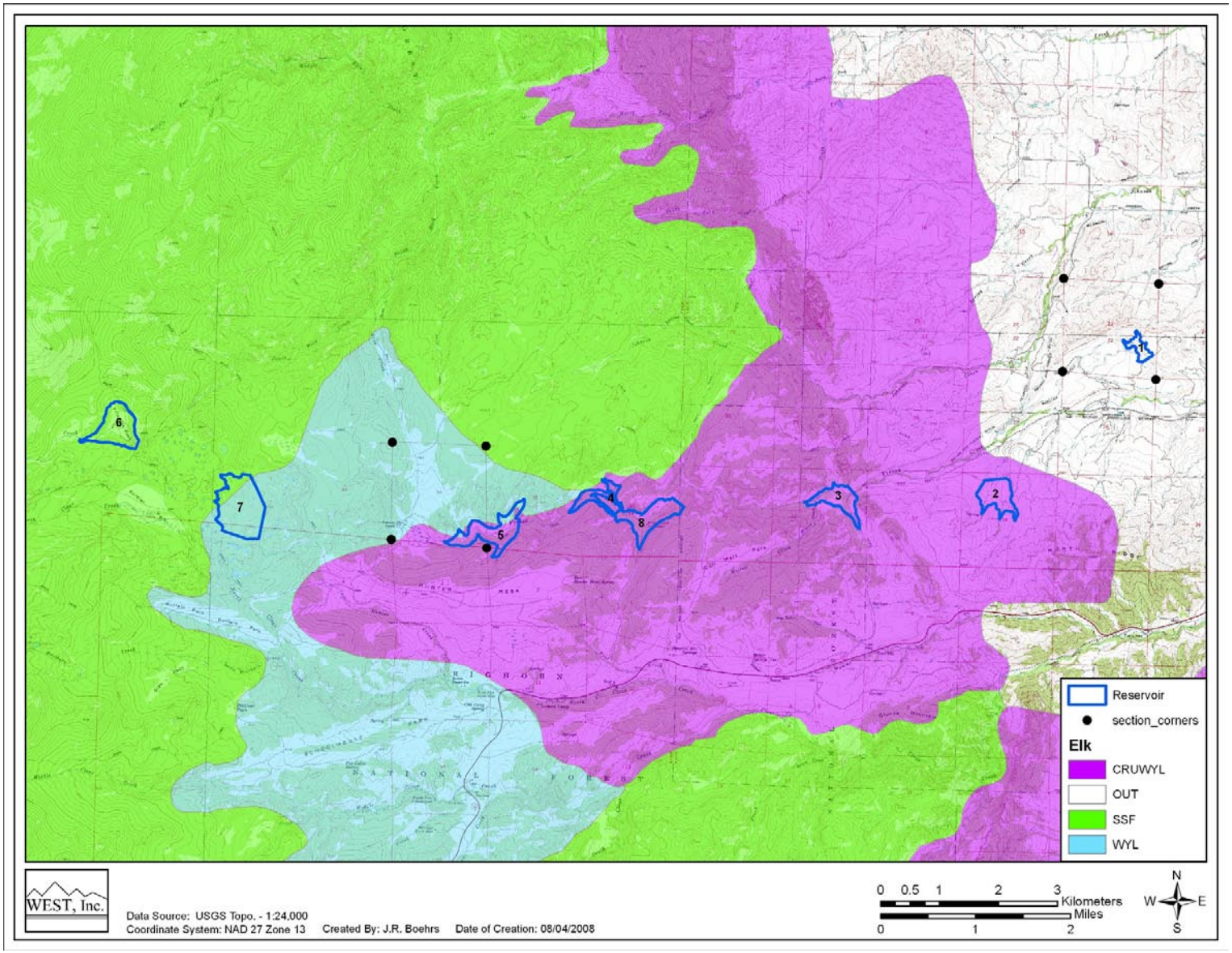


Figure 4. Big game habitat classifications at the Hopkins Producers reservoir sites

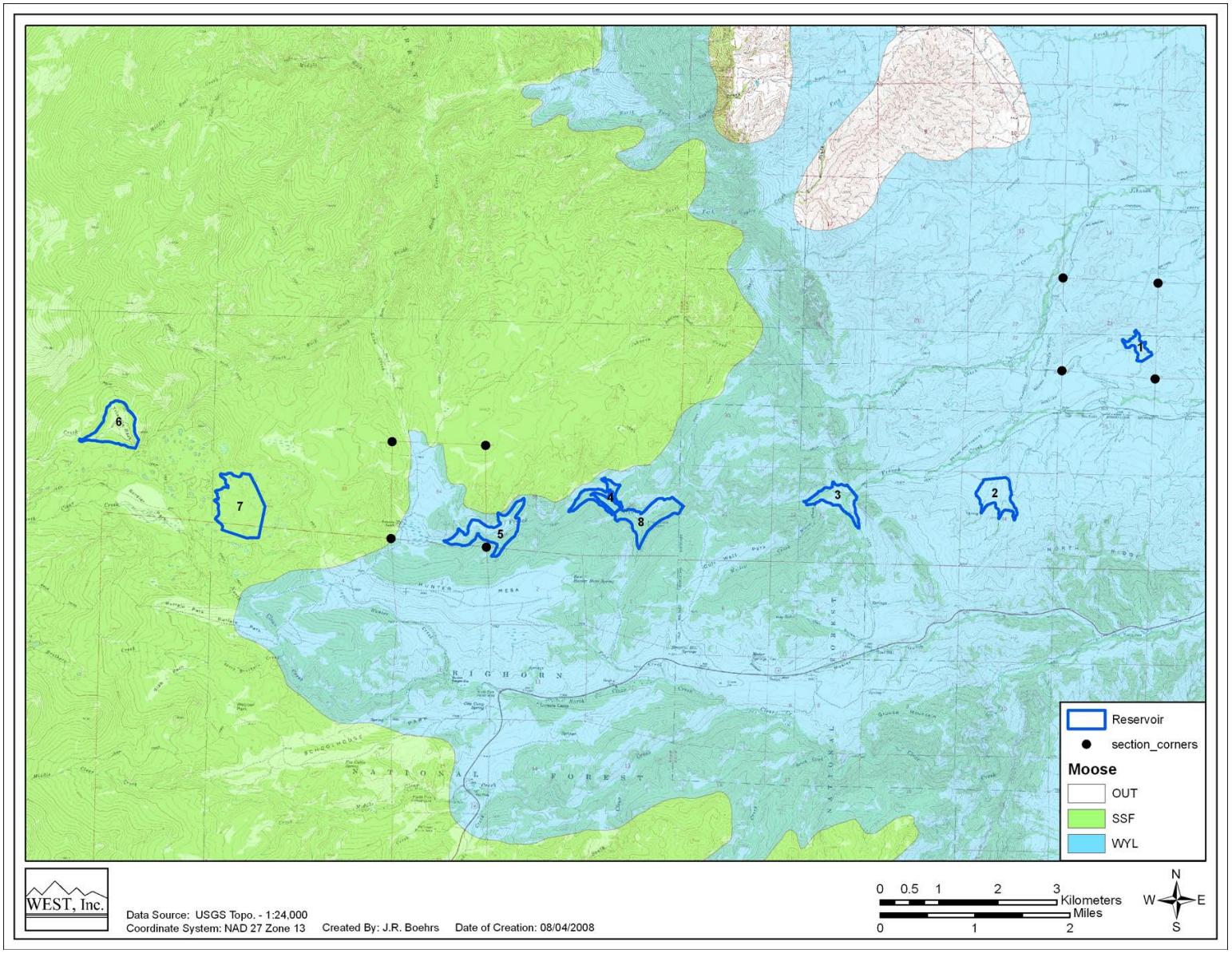


Figure 4 (continued). Big game habitat classifications at the Hopkins Producers reservoir sites

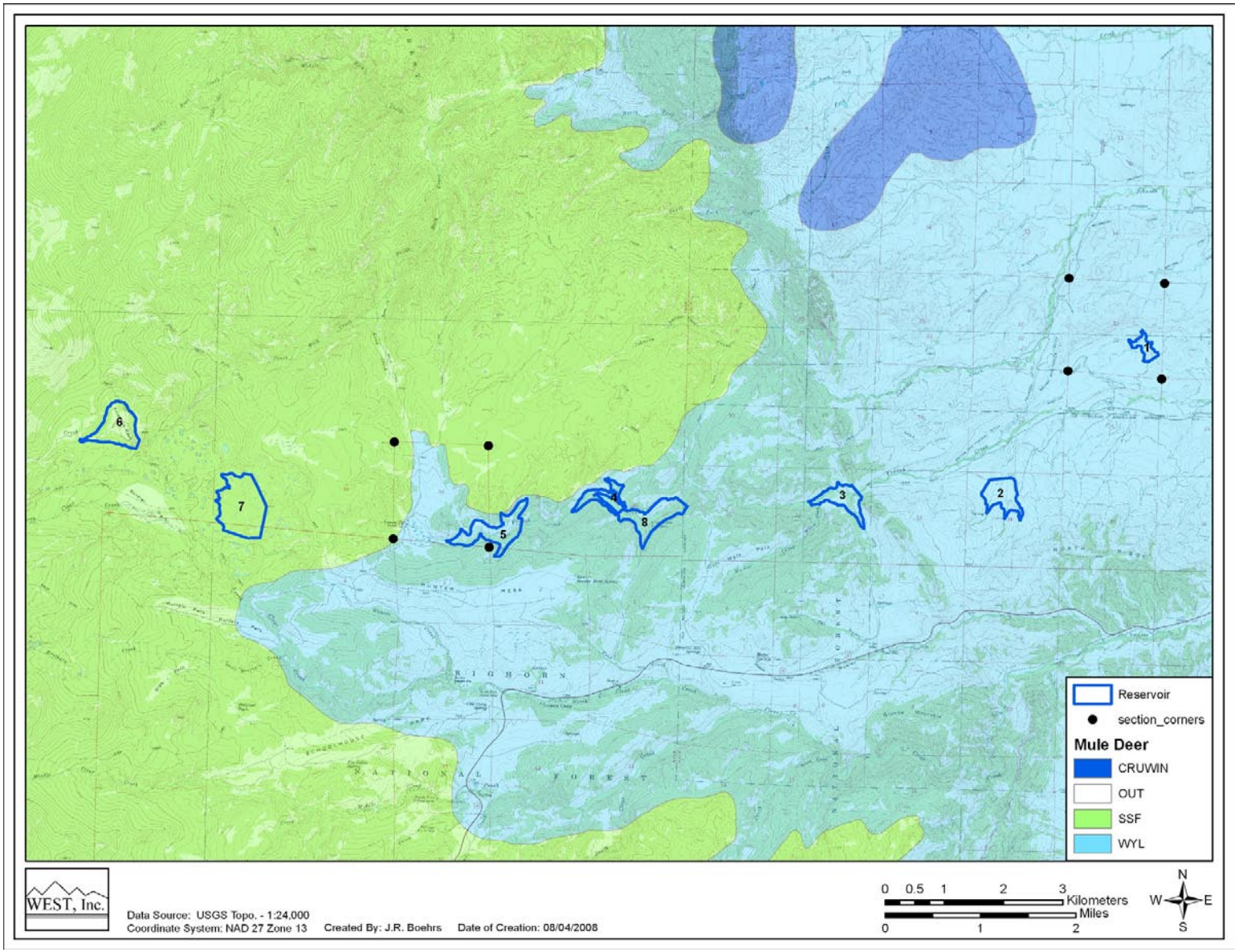


Figure 4 (continued). Big game habitat classifications at the Hopkins Producers reservoir sites

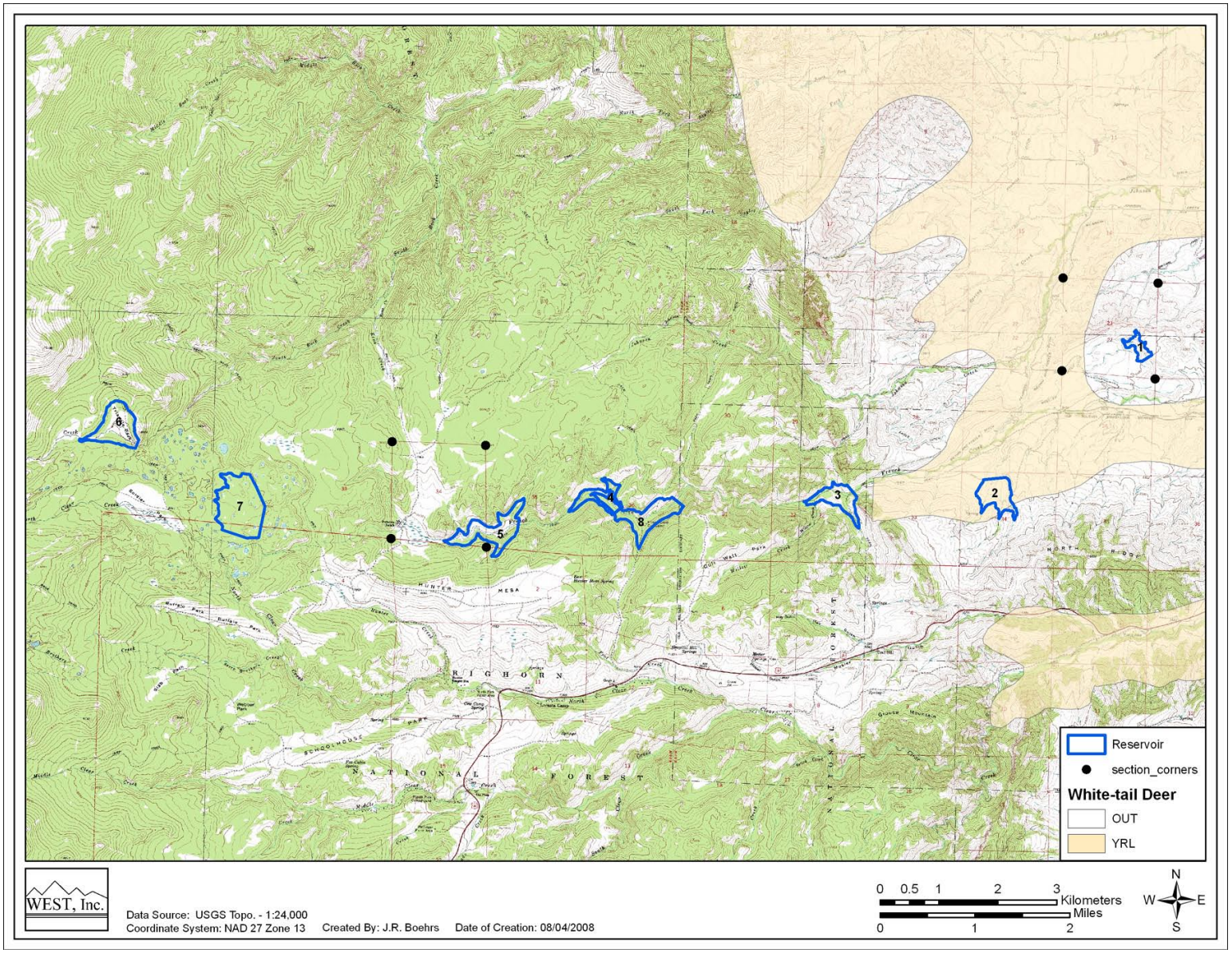


Figure 4 (continued). Big game habitat classifications at the Hopkins Producers reservoir sites

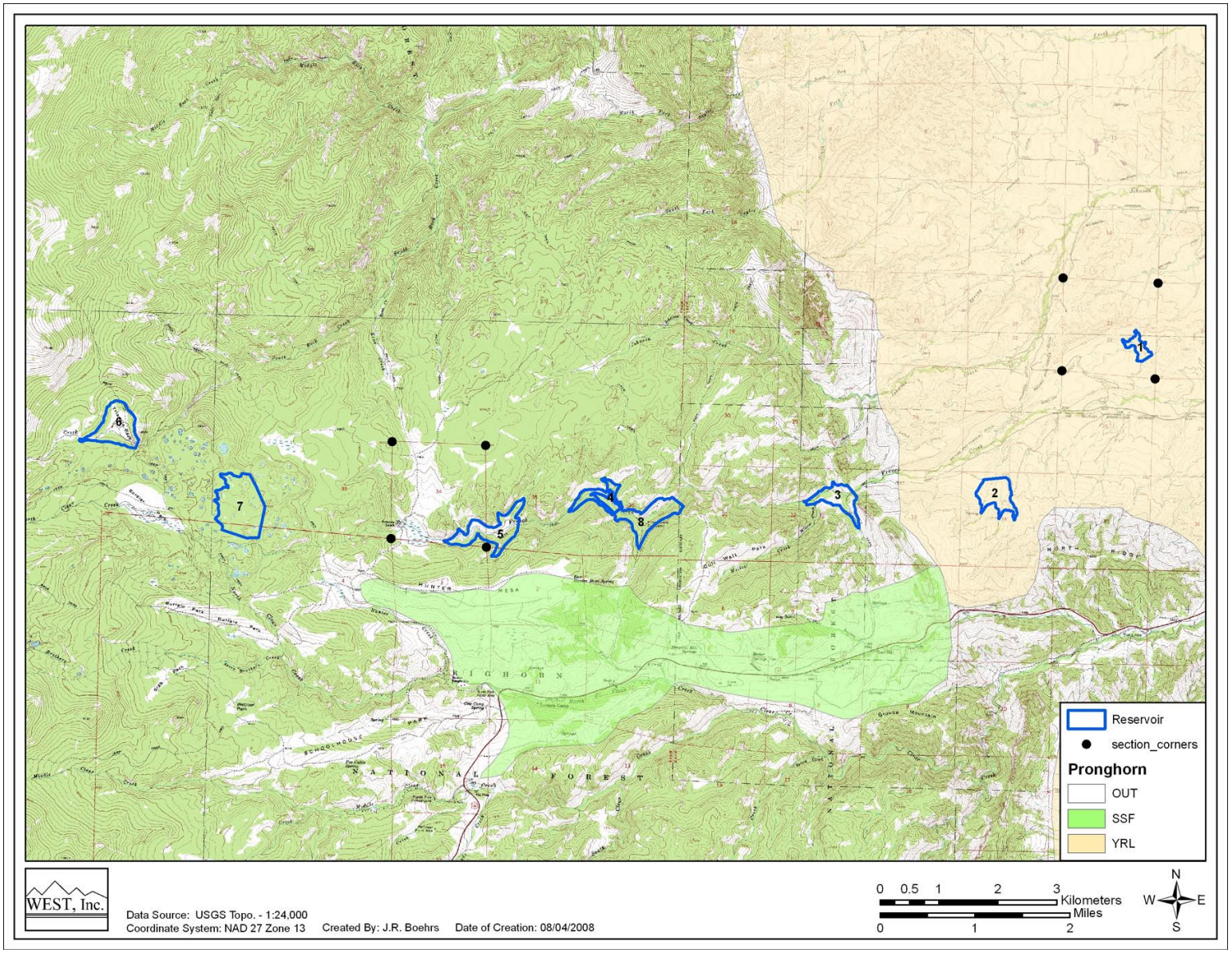


Figure 4 (continued). Big game habitat classifications at the Hopkins Producers reservoir sites

APPENDIX C.

Archaeological Report

A CLASS I CULTURAL RESOURCE SURVEY
FRENCH CREEK WATERSHED
HPID STORAGE ALTERNATIVES
JOHNSON COUNTY, WYOMING

By

David Eckles

Prepared for

States West Water Resources Corporation

Submitted by

Office of the Wyoming State Archaeologist
Wyoming Department of State Parks and Cultural Resources
P.O. Box 3431, University Station
Laramie, Wyoming 82070

Project Number WY-46-07

September 2006

ABSTRACT

A class I cultural resource survey of four reservoir sites in Johnson County, Wyoming, was performed by the Office of the Wyoming State Archaeologist. The reservoir sites are part of a study of the French Creek Watershed HPID Storage Alternatives project. The class I survey includes the results of a file search through the SHPO Cultural Records Office to identify previously recorded sites and previous class III surveys in the proposed project area. The file search indicated that only two surveys had been performed near the project areas. Three previously recorded cultural resource sites are known from in and near the reservoir alternatives. Given the small size of the reservoir alternatives, prehistoric and historic sites are expected in relatively low densities within each area.

INTRODUCTION

A class I cultural resource survey of the proposed French Creek Watershed, HPID Storage Alternatives in Johnson County, Wyoming was performed. The purposes of the class I survey are to document all previously recorded sites in these areas, and to provide an assessment of the potential for cultural resources in each of the proposed development areas.

The locations of the proposed project areas are shown in Figures 1-4. The legal locations (sections included in the SHPO Cultural Records Office file search) are as follows:

Site 1:

T51N R83W,
Section 23 (portions of S/NE/NW/SE. NE/SE/NW/SE, W/NE/SE, W/SE/NE/SE, NE/NW/SE/SE, NW/NE/SE/SE).

Site 3:

T51N R83W
Section 32 (portions of S/NW/NE, SW/NE/NE, NE/SE/NW, N/SW/NE, W/SE/NE, W/E/SE/NE, NE/NE/SE).

Site 5:

T51N R83W
Section 34 (portions SE/SE, SE/SW/SE, SE/SW/SW/SE)
Section 35 (portions SW/SW, E/SW/NW/SW, SE/NW/SW, W/NE/SW, W/NE/SE/SW).
T50N R84W
Section 2 (portions NW/NW/NW, NE/NE/NW/NW)
Section 3 (portions N/N/NW/NE, NW/NW/NE/NE).

Site 6:

T51N R84W
Section 30 (portions S/N/SW/SW, S/SW/SW, W/SW/SE/SW)
Section 31 (portions NW/NW, W/NE/NW, N/N/SW/NW, N/NW/SE/NW)
T51N R85W
Section 36 (portions E/NE/NE, S/SW/NE/NE, N/N/SE/NE).

In all, approximately 330 surface areas are involved. The reservoir alternative Sites 3, 5, and 6 are within the Bighorn National Forrest and Site 1 is on private land.

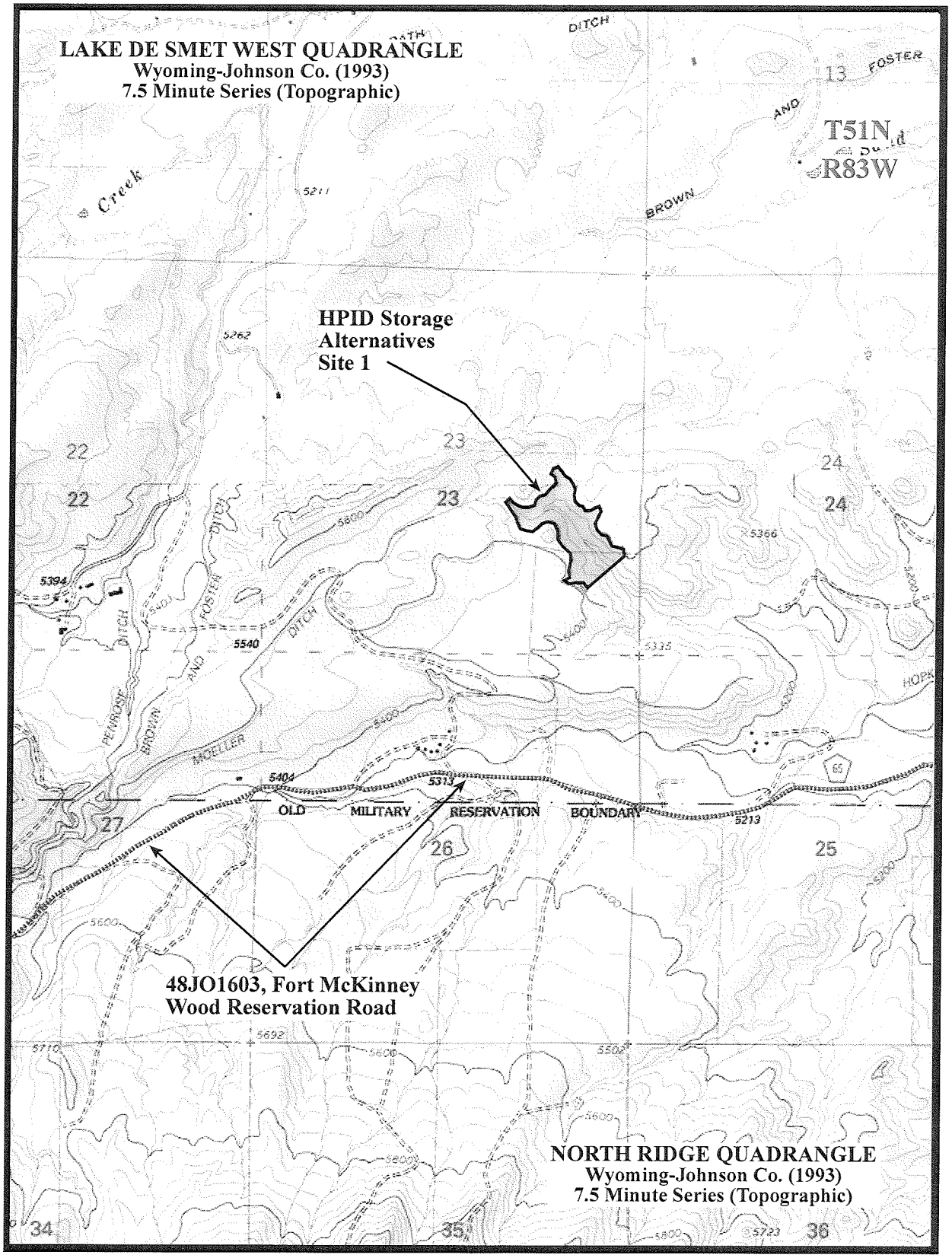


Figure 1. Map of project area and sites, HPID Storage Alternatives, Site 1.

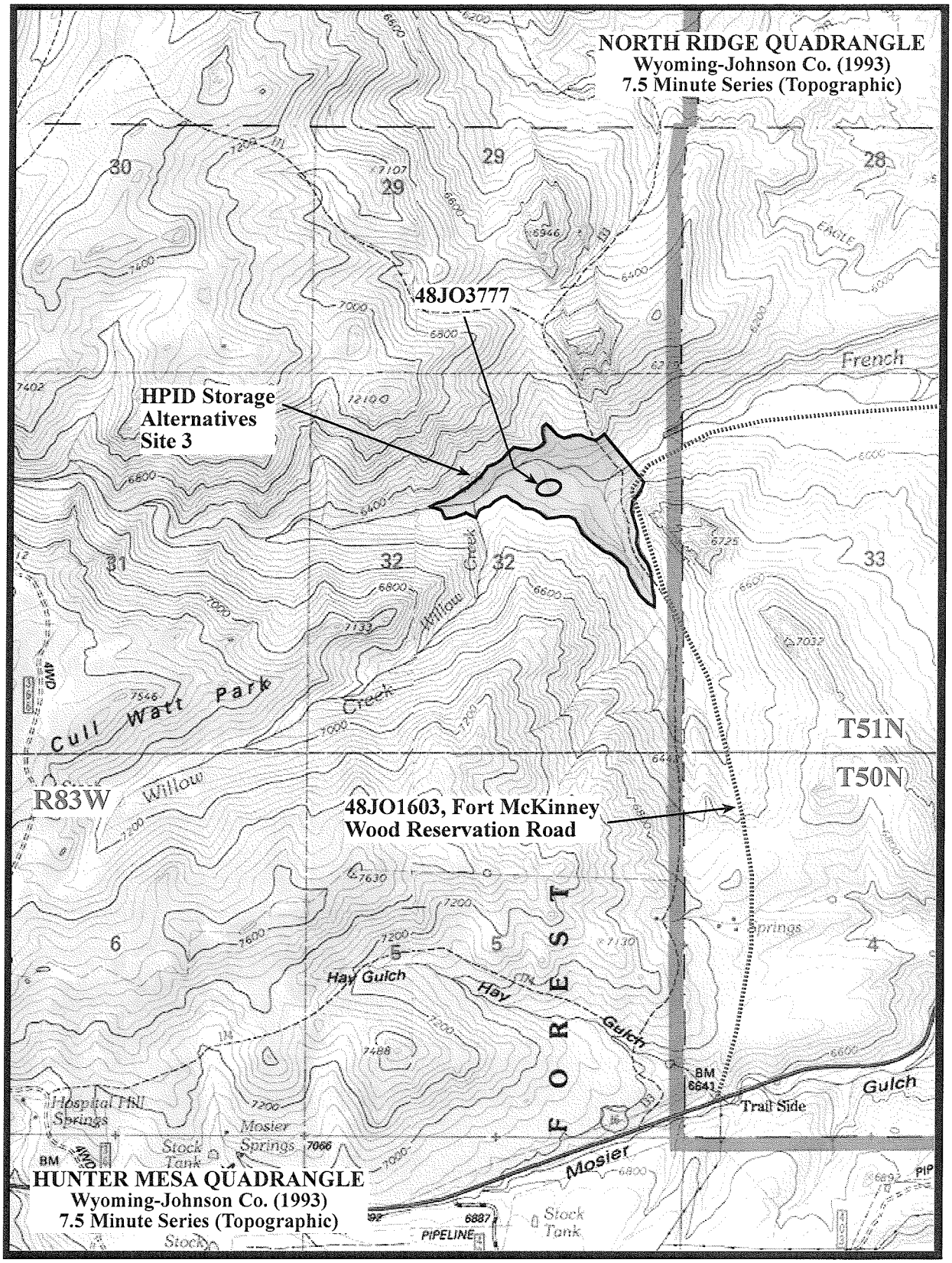


Figure 2. Map of project area and sites, HPID Storage Alternatives, Site 3.

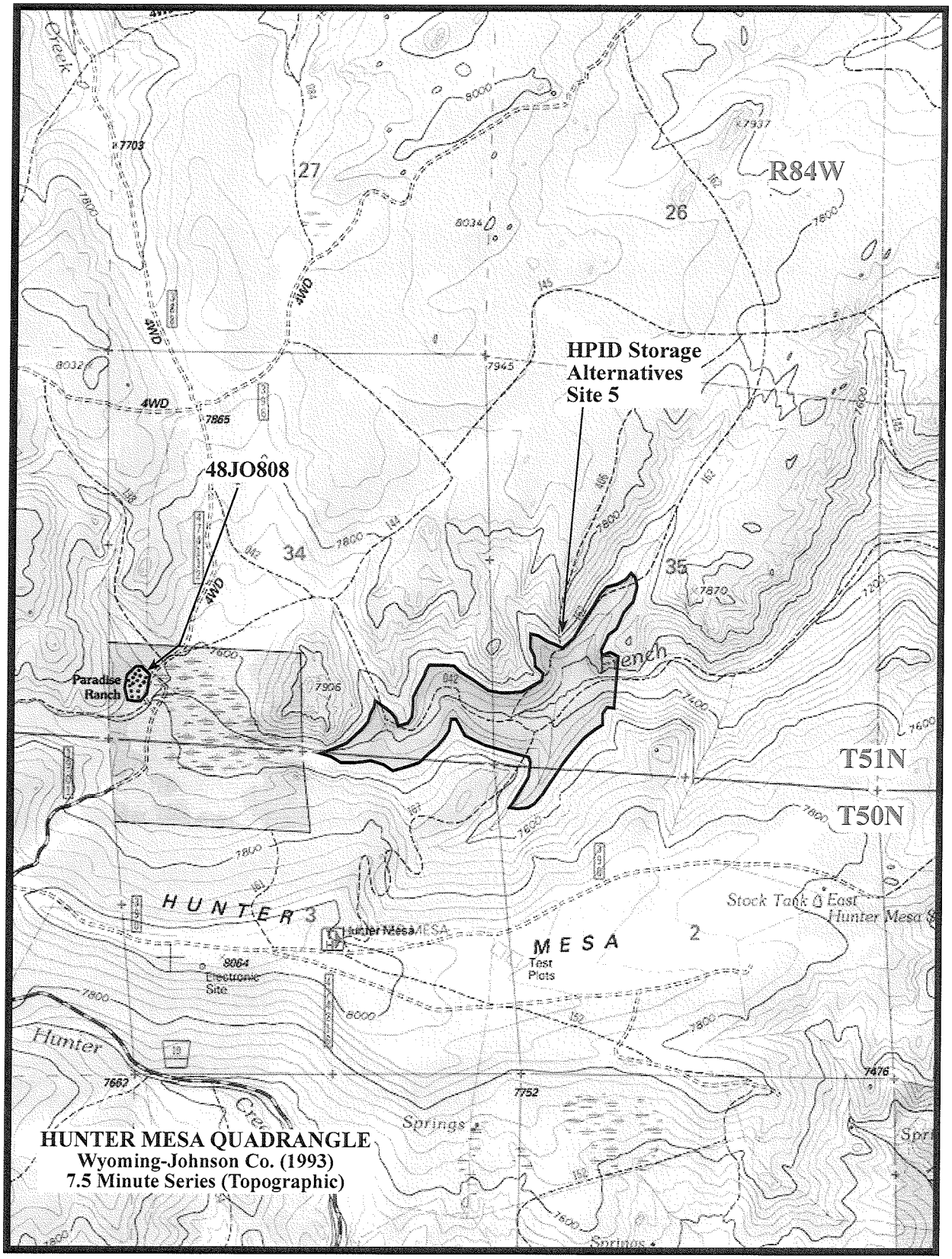


Figure 3. Map of project area and sites, HPID Storage Alternatives, Site 5.

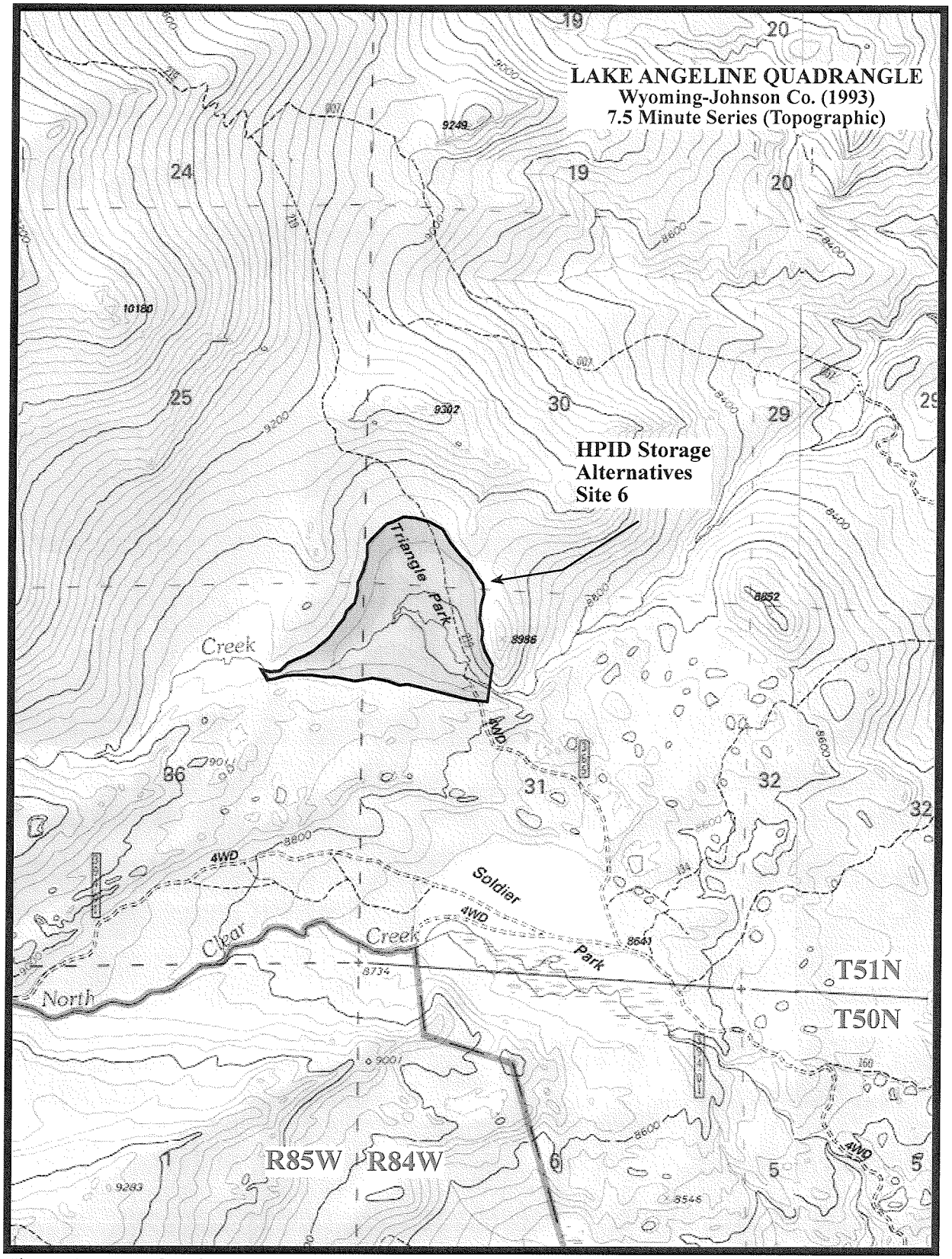


Figure 4. Map of project area and sites, HPID Storage Alternatives, Site 6.

PROJECT SETTING

The project areas are located on the eastern slopes of the Big Horn Mountains west of Buffalo, Wyoming. All of the reservoir alternatives are proposed along the generally east flowing French Creek drainage system. Bedrock geology consists of Early Archean age granitic gneiss and other metasedimentary rocks with Quaternary alluvial sands, silts, clays, and gravel along French Creek (Love and Christiansen 1985). The major drainage in the area is French Creek and several named and unnamed permanent and ephemeral tributaries drain into it from the north and south. The area consists of steep mountain slopes and rugged peaks deeply incised by French Creek and its ephemeral tributaries. Vegetation in the area consists of a riparian community along the permanent drainages with a dense mixed conifer forest on most mountain slopes and mixed sagebrush, grassland, and montane parkland communities in open areas. Elevation ranges from 5400 to 8940 ft (1646.3-2725.6 meters).

FILE SEARCH RESULTS

A file search of the Wyoming State Historic Preservation Office (SHPO), Cultural Records Office database, Laramie, Wyoming, was conducted on September 13, 2007. The file search indicates that two accessioned cultural resource surveys have been performed near the current project area and that three cultural sites had been previously recorded. The previous surveys were for a prescribed burn in Section 2, T50N R84W and Section 32, T51N R83W (Accession #051634) and a water pipeline in Section 2, T50N R84W (Accession #901343).

The previously recorded sites include 48JO1603, the Fort McKinney Wood Reservation Road which has been recommended as not eligible to the National Register of Historic Places (NRHP). It is south of HPID Site #1 and within HPID Site #3. 48JO3777 is a historic mining site located within HPID Site #3. It also has been recommended as not eligible to the National Register of Historic Places (NRHP). 48JO808 is the Paradise Ranch which is unevaluated to the NRHP. It is west of HPID Site #5. No sites are known in or near HPID Site #6.

EVALUATION OF THE POTENTIAL FOR CULTURAL SITES

Given the results of the SHPO file search, and the overall topographic setting, evidence of prior ground disturbance, it is possible to predict with some confidence the density and kinds of cultural sites that may be found in the proposed development areas. Prehistoric sites are expected along the valley of French Creek and its major tributaries. The potential number of prehistoric sites is expected to be small, however. This is due to the small size of the reservoir alternatives, relatively narrow valleys cut by French Creek and its tributaries, and expected dense vegetation in most if not all the alternatives. Surface artifact scatters are the type of prehistoric site expected. Historic mining sites may be found in any of the alternatives, but again in very low numbers, if at all. Historic roads may be found as well.

REFERENCES CITED

Love, J.D., and Ann Coe Christiansen
1985 *Geologic Map of Wyoming*. U.S. Geological Survey, Denver.

06016 28

WYOMING CULTURAL PROPERTIES FORM (rev. 3.0 10/19/2003) Page 1

Date: January 5, 2007

Smithsonian #48.JO.3778

RECORD TYPE: X First-recording, ___ Full Re-record, ___ Update, ___ Condition Report, ___ Site Lead

PROPERTY CATEGORY: ___Prehistoric Site, X Historic Site, X Building, X Structure, ___Object, ___District, ___Landscape, ___Lithic Landscape,

1. IDENTIFICATION/OWNERSHIP

Consultant Project Number: HJ2006-22 Agency Project Number(s): EZ-07-01(PWR) Cultural Records Office Project ID Number: 53837

Associated Project Name: Class III Cultural Resource Inventory of Bighorn National Forest's Rock Creek Range Allotment P.A., Johnson County, Wyoming.

Site Name: French Creek Cow Camp Temporary Field Number: HJ2006-22-3

Other Common names: Cow Camp Agency Site Number:

Landowner (at time of this reporting, specify agency/district, if private give name and address): ___ check here if site information is confidential
Federal, Bighorn National Forest with structures owned by Love Land and Cattle Co. of Sheridan, WY

2. LOCATION (repeat as needed on continuation sheets; ____ check here if additional locational information is on continuation sheet)

Street address _____ Town _____

Lot-Block: _____ Parcel _____ County: Johnson

USGS 7.5' Map Name, Date: Hunter Mesa, Wyoming 1993

Township 51N Range 84W Section 36 ¼'s N/SW/SE/NW/SE, NW/SE/NW/SE Template: Oriented to SE corner

Elevation (ft.): 7,000 UTM Coordinates (center point is required; bounding UTM(s) required for sites > 200m in any dimension)

UTM: Zone 13 347,848 m E and 4,911,756 m N Z13 in relation to NAD 1983.

UTM source: ___corrected GPS/rectified survey (<5m error), X uncorrected GPS (<8 m error), ___map template

Notes pertaining to access: Site lies adjacent to Forest Service Road 36802, a very rocky road requiring four-wheel drive. The resource occurs along a terrace south of perennial French Creek.

3. NATIONAL REGISTER STATUS (check all that apply in each category)

ENROLLED STATUS ___Landmark/Monument, ___Enrolled on NRHP X Not enrolled on NRHP

FACTORS AFFECTING INTEGRITY (check all that apply; indicate specific areas of disturbance and vandalism on a copy of the site map)

Disturbance/Vandalism : __none, __ erosion, __vandalism, __collection, __structural damage, __ manual excavation, __ mechanical excavation, __ vehicle traffic, X structural decay, __ grazing, __construction/development, __defacement, ___imminent destruction, X decay/collapse

Percent of property badly disturbed as of this recording date, to nearest 10%):

NATIONAL REGISTER OF HISTORIC PLACES SIGNIFICANCE

Period(s) of significance: Historic (not significant) - Pre-1956

NATIONAL REGISTER OF HISTORIC PLACES ELIGIBILTY RECOMMENDATIONS (check all applicable):

Recorder NRHP Evaluation: X Eligible under criteria X a, __ b, X c, __d ; ___Not Eligible, __Unevaluated

Contributing Components: ____Not applicable __Prehistoric, X Historic

Justification: (Include in justification a statement of significance; discussion of contributing components (indicate spatial extents on maps); and integrity (location, design, setting, materials, workmanship, feeling, association); discuss how significant periods and themes were determined)*: Please see the Site Narrative for a detailed discussion of NRHP evaluation factors and the seven aspects of integrity.

Agency Determination: ___ Eligible under criteria ___a, ___b, ___c, ___ d ; ___ Not Eligible, ___ Unevaluated Date/initials: _____

Justification:

SHPO Concurrence: ___ Eligible under criteria ___a, ___b, ___c, ___ d ; ___ Not Eligible, ___ Unevaluated Date/initials: _____

Justification:

4. INVESTIGATIVE HISTORY (Check all that apply, use property narrative for additional information as appropriate)

Recorded by: Patricia Carender Eggleston Organization: High Country Archaeology Field Dates: October 7, 2006

DISCOVERY METHOD (describe in site narrative description)

X Exposed on surface, ___ Exposed subsurface, __Construction discovery, ____ Documentary sources, __Informant

WORK PERFORMED (as part of this recording ONLY; describe numbers and dimensions of sampling/excavation units in narrative section)

X Surface recorded __ Shovel tested __Formal test unit(s) __ Trowel probes in features

MATERIALS COLLECTED AS PART OF THIS RECORDING? ___ yes, X no, ___ unknown

Repository: ___ U. W. Archaeological Repository (UWAR), ___Western Wyoming College, ___Other:_____

5. PROPERTY DESCRIPTION

PHYSICAL DIMENSIONS

Length 114 m Width: 18 m Area: 2,052 sq. m, (X estimated __ measurement method:_____)

Boundary estimates based on:

X feature/artifact distribution, ___ modern features or disturbance, ____ property boundaries, ___ topography, ___ other, ___ unknown.

Property datum? X yes, ___ no (describe if yes): Metal tag attached to spike.

RECORDS INVENTORY (check all appropriate attachments associated with this recording)

Required attachments*:

X (6) Prehistoric/Historic Archaeological Site Setting, Topography, Depositional Environment (*not required for urban and rural buildings, structures, objects, or historic districts)

X (7) Site Narrative Description

X (8) Prehistoric/Historic Site Matrix x site map w/scale,orientation.,key x location map (USGS 1:24,000 base) x photographs/images

Additional Attachments:

(One or more of the next 8 are required)

__(8A) artifacts associated with prehistoric component

___(8B) features associated with prehistoric component

X (8C) artifacts associated with historic component

___ (8D) features associated with historic component

__ (8E) historic and/or prehistoric rock art/inscription component

X (8F) historic architecture description

__ (8G) linear feature description

___ (8H) lithic landscape sample description

X (8I) historic structure/object description

Optional Attachments:

__ (8J)TCP description __ artifact illustrations __ stratigraphic profile __ field notes

__ artifact catalog __ electronic data __ other (describe):

6. PREHISTORIC/HISTORIC ARCHAEOLOGICAL SITE SETTING, TOPOGRAPHY, DEPOSITIONAL ENVIRONMENT*

Section 6 is not required for urban and rural buildings, structures, objects, or historic districts)

GENERAL TOPOGRAPHIC SETTING

___ Basin/Interior, ___Foothill/Basin Margin, ___Major River Terraces, X Mountain/Major Uplift, ___Unknown

Geographic Division (cf. "Wyoming Geologic Highway Map" published by Western Geographics with the cooperation of the Geological Survey of Wyoming Revised Edition 1991, R.D. Christiansen, Geologist Map compiled and adapted from Geologic Map of Wyoming. Divisions prepared by Richard W. Jones, 2002. See map in "Users Guide.")

___Absaroka Mtns. ___Bates Hole ___Beartooth Mtns. X Bighorn Mtns. ___Bridger Basin ___Bighorn Mtns.

___Black Hills Uplift ___Casper Arch ___Denver Basin ___Ferris Mtns. ___Fossil Basin ___Green River Basin

UNIQUE SITE SETTING (check as appropriate, describe site setting in general narrative):

___saddle/pass ___arroyo cutbank X ridge base X stream bank/terrace ___rockshelter ___cave ___spring

GENERAL TOPOGRAPHIC SETTING (few words): Site occurs in a timbered, narrow drainage valley.

VEGETATION ASSOCIATION (cf. Knight 1994:8, Mountains and Plains: The Ecology of Wyoming Landscapes; Yale Univ. Press)___Alpine

X Spruce/Fir ___Douglas-Fir X Lodgepole Pine ___Ponderosa Pine ___Aspen/Conifer ___Oak ___Juniper ___ Desert Shrub

__ Grassland ___ Sagebrush ___Sand Dunes ___Riparian ___Cultivated ___Unknown ___not applicable

OVERALL PERCENT BARE GROUND (discuss variation in ground visibility in general site narrative)

___0%, ___1-25%, ___26-50%, X 51-75%, ___ 76-99%, ___ 100%, ___ unknown, ___not applicable

GENERAL DEPOSITIONAL ENVIRONMENT (check all applicable, describe in general site narrative):

___unknown, ___ aeolian, X alluvial, X colluvial, __bare rock, __regolith, ___not applicable, ___other

AEOLIAN SETTINGS (Late Pleistocene and Holocene aeolian deposits)

Is site in/partly in an aeolian deposit?: __ yes, X no, ___unknown, ___ not applicable

If "yes", which type(s)? ___dune, __ sand shadow, ___sand sheet, ___ deflation area, ___don't know

SUBSURFACE POTENTIAL

Archaeological subsurface deposits: ___ yes, ___no, ___unknown/undetermined X not applicable

Maximum depth below surface of cultural deposits: ___meters, ___unknown, X not applicable (enter zero if no subsurface deposits are present)

Estimate based on: ___rough guess, ___shovel test(s), ___core/auger tests, ___excavation(s), ___road/arroyo cuts, X not applicable ____other information (describe in narrative):

7. SITE NARRATIVE DESCRIPTION

In addition to general description, the site narrative should address explicitly the kinds and amount of work done at a site, the site environment (setting, geomorphology, soils and sediments, vegetation), site condition and threats to the site. All other matters that demand more discussion than the other sections of the form allow should be discussed in a well-organized fashion here. Tables and other materials can be part of the site narrative, as appropriate. Dating and laboratory results should be cited here, with clear references to laboratory numbers and results.

Located in the eastern Bighorn Mountains, the site consists of the French Creek Cow Camp located amid a narrow drainage valley filled with abundant timber. The facility is positioned along the junction of the southerly French Creek terrace with a ridgeline's base. Gradients range from 3-30° with variable aspects. Vantages are obstructed by the adjacent ridgelines and dense trees.

Sediment consisted primarily of a semi-compact, 10YR 4/2-4/3, dark grayish brown to brown (Munsell Color 1994), sandy loam of probable colluvial and alluvial origins. Comprised largely of granites, gravels are typically moderate in density. Granite cobbles and small boulders range from moderate to dense in distribution. Vegetation consists largely of western wheatgrass and knickknack. The overstory is dominated by lodgepole pines accompanied by a lesser quantity of firs and aspens. Ground surface visibility averages 60%.

The cow camp encompasses one cabin, a log barn, and an outhouse. The site spans 114 m by 18 m and occupies about 2,052 square meters. Located in UTM Zone 13, the datum was placed south of the site at 347,848 m E and 4,911,756 m N in relation to NAD 83. According to the current owner, Ms. Christy Love of Love Land and Cattle Company (2007 interview), the camp has existed since at least 1936 and has always served as a cow camp. The site's overall condition is regarded as good. Recordation was performed during hunting season and the cabin and barn were locked shut. Several hunting camps were temporarily established with tents pitched adjacent to the site boundaries.

The rustic cabin is comprised of a two-pen or saddlebag structure spanning 24 feet by 13½ feet with the long axis oriented southwest-northeast. The peeled, lodgepole pine logs generally measure 6-9 inches in diameter. Divided by vertical flat on flat or half round logs, each pen spans 12 feet in length. A poured concrete foundation is

present which ranges from 4-30 inches in height. This reveals occasional granite inclusions amid the cracks.

The structure's sides are 9-11 logs tall. The constituent round logs are attached to vertical, corner posts via tenons or false notching. Ranging from 6½-9 feet in height, the corner posts typically span about 8-12 inches in diameter. The concrete chinking ranges from fair to good condition. The overall structure reaches about 15 feet in height along the apex of the medium pitched, gable roof covered with green rolled asphalt. Ascending for less than 2½ feet in height, a small brick chimney bearing a metal stove pipe is positioned on the roof just westward of the dividing pen.

Exhibiting a small porch, the front faces southwestward and displays an aged screen door cased by a flat wooden plank surround. Behind the screen door lies a wooden door exhibiting a glass pane above three recessed rectangular panels.

The porch's deck extends for about seven feet with the gable roof continuing above. It is accessed via two rectangular concrete steps; the upper one rises for nine inches. Covered with deteriorating plywood, the deck is comprised largely of 2 x 6 inch and 2 x 8 inch planks. Located along a slope, it occurs 1-3 feet above the ground. The roof's planks appear in very good condition when observed from the deck.

The cabin's southeasterly side displays two horizontally sliding, double sash windows. The southernmost one (nearer the door) displays 2/2 lites while the northerly reveals 3/3 panes. Spanning 54 inches wide by 25 inches tall, the windows are set adjacent to vertical log frames. It appears that the original window cutout was slightly reduced to accommodate narrower windows.

Fenestration along the structure's opposite face consists of two sliding double sash windows of the same size and elevation. Each sash contains 3/3 lites. The cabin's rear face lacks any windows or doors.

Overall, the structure is in good condition. There is a narrow crack running vertically through the foundation and some checking amid the logs. None of the logs appear to have rotted while the rafters appear in good shape. The roof does not show any signs of slumping.

Paralleling the ridgeline's contour, the small barn spans 17 feet northeast-southwest by 15 feet along the opposite axis. The structure was partially placed on a rudimentary foundation of granite cobbles reaching 4-7 inches in height. The stones typically measure 12-16 inches in maximum dimension. Located along an incline, the barn varies in height from about 3½-8 feet with walls from 5-10 logs tall. The structure appears to be tilting towards the adjacent ridge slope. The round logs measure 5-9 inches in diameter and are attached to vertical corner timbers (half-round and round) by probable false notching. Comprised of concrete, chinking remains in generally fair condition.

The front (southwest face) bears a door extending for 46 inches in width by 6 feet high. It is comprised of 1 x 6 and 1 x 12 inch planks. Locked up, the door apparently slides eastward to allow entry.

The northwest and northeast walls lack any evidence of windows or doors. The southeasterly wall adjacent to the ridgeline reveals a small rectangular opening measuring 42 inches long by 27 inches high. Extending from the ground (ridge slope) to nearly the roof, it is screened with 1¾ inch iron mesh. The opening is boxed with 1 x 4 inch boards revealing aging white paint.

The low pitched, gable roof is comprised of 1 x 6 and 1 x 12 inch planks covered with regular courses of brown, probable composition shingles. Many of the shingles are peeling and at least ten are missing. No rafters were visible. The planks' perimeters reveal slight to moderate degrees of water damage with fungus growth occurring in several spots. Roughly six feet of the northwestern wall's sill log is highly decayed and spalling into fragments.

A single seat outhouse spanning 4¼ x 4¼ feet by 6½ feet tall is present along the south-southwestern edge of the site. The edges are positioned on concrete blocks. The gray board and batten walls are comprised of 2 x 8 and 2 x 4 inch planks interspersed with narrow 2½ inch wide strips. Composed of 1 x 6 inch vertical planks, the wooden door measures 23 inches wide by 5 ½ feet tall. Modern looking, the shed roof is of corrugated sheet metal.

The cabin is in very good physical condition while the barn is in fair to good shape. The barn's roof needs recovering and the sill log will necessitate eventual replacement. The outhouse is in good condition. The Bighorn National Forest Supervisors Office did not contain any files on the French Creek cow camp which lies with the Rock Creek Allotment. This allotment was first depicted on Forest Land Use maps in 1911 (O'Dell 2005). Mr. Scott Gall, Range Specialist, was consulted at the Powder River Ranger District for grazing files information. Unfortunately, Forest Service Records only date back to the early 1970s on the permitted facility. The corral fences were replaced in 1970-1971 with some work done on the outhouse. According to Ms. Love (2007 interview), the cow camp was purchased from Clarence Tarbet by Love Land and Cattle in 1964. Tarbet owned the camp from 1936 until 1964. Apparently in place by 1936, the facility always functioned as a cow camp was never utilized as a recreational residence. The cow camp remains in use and is currently operated by Love Land and Cattle Company.

Cow camps were historically very necessary for maintaining herds in the remote mountains far from their associated ranches. The facilities remain essential today, particularly during episodes of inclement weather, roundups, brandings, etc. In regard to the *Wyoming Comprehensive Historic Preservation Plan* (State Historic Preservation Office 2002), the French Creek Cow Camp is clearly associated with the ranching context and the cattle camp sub-theme.

Tongue Watershed Grazing Allotment Renewals, Bighorn National Forest, Tongue Ranger District, Sheridan and Bighorn Counties (Peterson and Laurent 2001) is quite effective for analyses of this site type on Bighorn National Forest. The context is subdivided into three periods (O'Dell 2005, Peterson and Laurent 2001) with Phase I dating to ca. pre-1917. By roughly 1902, many of the small ranchers were organized and given preference for permits by the Forest Reserve. They began returning to the same areas each year. Three cow camp styles were identified in this early period. The first was comprised of the tent and wagon, roaming camp. The second consisted of "line shacks" which frequently utilized cabins that had been abandoned by miners or trappers. Sometimes these extant cabins were moved from other locations. They were often constructed after receiving verbal permission from the Forest Ranger. By around 1908, several more complex cow camp facilities were constructed on the Forest such as one constructed at the Pines in 1908 and the Watt Cow Camp built in 1911. These permanent cow camps were often issued an actual permit for a small annual fee of around $10-15. The permits contained brief stipulations on rustic style, camp cabins requiring the use of rock masonry for foundations and chimneys, etc.

Dating ca. 1917-1934, Phase II revealed a greater emphasis on the establishment of formal camps although the line shack style remained in use (O'Dell 2005, Peterson and Laurent 2001). By the mid 1920s, most of the larger ranches had a primary camp (non-line shack) and in some cases shared with other grazing association members. The structures were usually built of native logs by the permittee/hired hands or cabins were hauled in from other areas. Key cabin features comprise a sleeping area, a cook stove, and a tack room. Outside elements often encompassed a water source (spring or creek) and a barn with some storage space in conjunction with a corral. A trash dump typically occurred nearby.

Phase III occurred from ca. 1934 to present times (O'Dell 2005, Peterson and Laurent 2001). Line shacks were razed or if fairly sound, relocated to the permanent camps for use as storage buildings. Arising out of concerns for overgrazing and range misuse, the Taylor Grazing Act of 1934 allowed the Secretary of the Interior (and federal government) to establish grazing districts on federal lands as well as to formulate regulations on rangelands. This had a pronounced effect on the ranching industry with agency focus shifting from primary interaction with the grazing association to allotment management with individual permittees who were held responsible for meeting Forest Service stipulations for their respective allotments.

By the 1940s, most cow camps were constructed utilizing modern methods and materials although they retained a rustic flavor as required by the Forest Service (O'Dell 2005, Peterson and Laurent 2001). Native stone foundations were replaced by concrete, while walkways and chimneys were composed of concrete rather than native stones or bricks. Buildings were installed with propane heat, running water, etc. Some cow camps exhibited outbuildings or garages for motor vehicles.

According to the *Wyoming Comprehensive Historic Preservation Plan,* ranch associated structures (when present) eligible under Criterion C should retain sufficient integrity to make their function, methods and materials of construction, and dimensions readily important. Furthermore, the structures should remain in their original or historic use locations. It is recommended that the French Creek Cow Camp be considered be considered eligible for nomination to the NRHP in regard to Criterion C and possibly A. Positioned in their original and historic use locations, the structures clearly indicate their functions, methods/materials of construction, and dimensions (Criterion C). Spatial relationships among the structures are clearly delineated. According to Peterson and Laurent (2001, O'Dell 2005), cow camps regarded as eligible under Criterion A were generally established by 1934. The later camps did not contribute as significantly to the development of the regional or local economies. Although its exact construction date remains unknown, the French Creek Cow Camp was established by 1936.

According to the National Park Service (1991), a property to be listed on the NRHP must also retain integrity which is defined as the ability to convey its significance. This is particularly applicable to historic resources. Whenever an historic site is evaluated and significance is fully established, the following seven aspects of integrity require examination. The attribute of location is present to a very high degree; the cow camp design, materials, and workmanship are considered high. According to the Forest Service grazing files, the small corral fence was replaced in the early 1970s. The modern wood post and rail fence maintains a fairly rustic flavor and does not detract from the historic structures. Although some work was performed on the outhouse during the 1970s, the structure appears rustic and harmonious with the cabin and barn.

Quite scenic, the aspect of setting is high and quite pristine; the surroundings have not changed substantially since the camp's historic period of use. No modern structures are present to diminish this aspect. The only obviously modern element consists of the adjacent metal post fencelines. Generally at least partially shrouded by the

overstory, these low level intrusions are easily overlooked. No overhead power or phone lines enter the structures. Surrounded by timber, the camp is tucked away in a drainage bound by steep ridgelines. Visibility from the facility is generally restricted to less than 500 feet. With the exception of the metal pole fencelines, no modern intrusions occur in the viewshed with the exception of a few temporary tents inhabited by hunters. Vehicular traffic is quite light on rocky adjacent Forest Service Road 36802. This four-wheel drive road is filled with numerous rocks and small boulders; the observed hunters were typically using ATVs to access their tent locations. The French Creek Cow Camp highly retains the qualities of feeling and association. The facility's function is readily apparent. It is quite easy to imagine being transported back through time to the site's period of historic usage. It has been utilized as a cow camp for at least 70 years and continues serving as a cow camp today.

It is suggested that the French Creek Cow Camp be considered eligible for nomination to the NRHP. The historic resource is positioned within the APE. In order to avoid any adverse impacts, it is suggested that no future ground disturbing activities occur within 200 feet of the site with the exception of routine fenceline maintenance. The barn's decaying sill log will likely require replacement at some future date. It is recommended that the barn's roof be recovered with a suitable rustic looking material this summer to avoid damage. In order to not detract from the structure's historic essence, the roofing material should meet both general Forest Service guidelines and the approval of Mr. Rick Laurent, Bighorn National Forest East Side Archaeologist. A determination of no adverse effect is advanced for site 48.JO.3778.

References Cited:

Love, Christy
2007 Phone interview.

Munsell Color
1994 *Munsell Soil Color Charts.* Macbeth Division of Kollmorgan Instruments Corporation. New Windsor, New York.

National Parks Service
1991 *National Register Bulletin No. 15: How to Apply the National Register Criteria for Evaluation.*

O'Dell, Kevin
2005 Wyoming Cultural Properties Form for Site 48.JO.3065. On file, Wyoming State Historic Preservation Office, Cultural Records Office, Laramie, Wyoming.

Peterson, Michael and Rick Laurent
2001 *The Archaeological Resource Inventory Report, Tongue Watershed Grazing Allotment Renewals, Bighorn National Forest, Tongue Ranger District, Sheridan and Bighorn Counties.* On file, Bighorn National Forest Supervisor's Office, Sheridan, Wyoming

Wyoming State Historic Preservation Office
2002 *Wyoming Comprehensive Historic Preservation Plan.* On file, Wyoming State Historic Preservation Office, Cheyenne, Wyoming.

8. Prehistoric/Historic Site Matrix (attach (8A) "Artifacts Associated with Prehistoric Component", (8B) "Features Associated with Prehistoric Component", (8C) "Artifacts Associated with Historic Component", (8D) "Features Associated with Historic Component" as appropriate). Check boxes for "yes" as appropriate.

	OCCURRENCE		CONTENTS			
COMPONENT	Surface	Subsurface	Artifacts	Features	Rock Art	Building(s)/ Structure(s)
HISTORIC						
1936-1956	X	___	___		___	3

8F. HISTORIC ARCHITECTURE COMPONENT DESCRIPTION - Cabin

Instructions: Complete this form for each primary standing building/structure as appropriate. If a site contains more than one building or structure, e.g. a ranch house and barn – complete an attachment for each structure. When using this form, structures should retain identifiable architectural elements. Generally, historic archeological sites should not be recorded on this form. Secondary structures such as corrals, fences, lean-to's, and outbuildings without architectural interest, may be documented on attachment 8D. Attach a sketch map showing the building, associated features and other buildings and the building setting as appropriate (with a scale and north arrow). Attach color photographs or images sufficient to illustrate the general building form and condition. Attach photographs, images, or measured drawings of unique architectural elements. Additional records (e.g., blueprints) can be attached as appropriate. References for this section include: Architecture in the Cowboy State; Eileen F. Starr, 1992; "National Register Bulletin 15", USDI/ NPS, 1991; A Field Guide to American Houses, Virginia & Lee McAlester, 1984.

Common name: Cabin

Historic name: _____

Type of building: Log cabin with two pens Number of associated resources: 2

Historic District Smithsonian Number (if applicable) _____

OWNERSHIP – Property owner and address: Bighorn National Forest, structures owned by Love Land and Cattle Company

NATIONAL REGISTER OF HISTORIC PLACES SIGNIFICANCE (discuss as appropriate in narrative and in core form; the following applies to the individual building)
Period of significance: Pre-1956 Theme: Ranching with the sub-theme of cow camps
Periods – Protohistoric (1720-1800) Early Historic (1801-1842) Pre-territorial (1843-1867) Territorial (1868-1889); Expansion (1890-1919); Depression (1920-1939) ; WWII-era (1940 to 1946); Post-WWII (1947 to 1955); Modern (1956-present); use exact dates if known.

NATIONAL REGISTER OF HISTORIC PLACES ELIGIBILITY RECOMMENDATION (discuss as appropriate in narrative and in core form):

If eligible, is this building X contributing or ___ non-contributing

Justification: (Include in justification a statement of significance for building; integrity (location, design, setting, materials, workmanship, feeling, association); discuss how significant periods and themes were determined): Please see Site Narrative for lengthy discussion.

CONSTRUCTION HISTORY (use "unknown" as appropriate)

Dates of construction/major modification (use more lines as appropriate)

Date	Circa y/n	Date source
Unknown	1936	Informant interview

Architect(s):

Builder(s): Undetermined, possibly Clarence Tarbet

Building moved? (yes/no/unknown) No Date(s) moved: _____, Moved from: _____
Current use(s): Cow Camp , Historic use(s): Cow camp

DESCRIPTION (see handbook for guidelines)

Style/Type: Rustic log cabin

Number of stories: X 1, __1-1/2, __2, __2-1/2, __multiple, __don't know, __other (describe):

Foundation (describe, i.e., stone, concrete, post and sill, etc.): Concrete

Roof (describe materials, i.e., asphalt, wood): Medium-pitch gable roof covered with rolled asphalt

Structural system (i.e., wood frame, masonry): Log frame

Cladding (i.e., wood siding, asphalt): None other than mortar chinking between logs

Windows (describe number and types, i.e., double hung, casement, fixed etc.): Three horizontally sliding, double sash windows with 3/3 lites, one window with two horizontally sliding sashes bearing 2/2 lites.

Porches: One front porch with wooden deck

Chimneys: One interior brick chimney.

Basement: None

Modifications/Additions: None visible.

Distinctive landscaping elements:

ARCHITECTURE KEYWORDS: Logs, gable roof, chinking, false notching.

ADDITIONAL NARRATIVE (e.g., relationship of building to complex and/or district; other notes; interior description): Please see the site narrative for a detailed description of the cabin and associated barn and outhouse.

8F. HISTORIC ARCHITECTURE COMPONENT DESCRIPTION - Barn

Common name: Log barn

Historic name: _____

Type of building: Log cabin Number of associated resources: 2

Historic District Smithsonian Number (if applicable) _____

OWNERSHIP – Property owner and address: Bighorn National Forest, structures owned by Love Land and Cattle Company

NATIONAL REGISTER OF HISTORIC PLACES SIGNIFICANCE (discuss as appropriate in narrative and in core form; the following applies to the individual building)
Period of significance: Pre-1956 Theme: Ranching with the sub-theme of cow camps
Periods – Protohistoric (1720-1800) Early Historic (1801-1842) Pre-territorial (1843-1867) Territorial (1868-1889); Expansion (1890-1919); Depression (1920-1939) ; WWII-era (1940 to 1946); Post-WWII (1947 to 1955); Modern (1956-present); use exact dates if known.

NATIONAL REGISTER OF HISTORIC PLACES ELIGIBILITY RECOMMENDATION (discuss as appropriate in narrative and in core form):

If eligible, is this building X contributing or ___ non-contributing

Justification: (Include in justification a statement of significance for building; integrity (location, design, setting, materials, workmanship, feeling, association); discuss how significant periods and themes were determined): Please see Site Narrative for lengthy discussion.

CONSTRUCTION HISTORY (use "unknown" as appropriate)

Dates of construction/major modification (use more lines as appropriate)

Date	Circa y/n	Date source
Unknown	1936	Informant interview

Architect(s):

Builder(s): Undetermined, possibly Clarence Tarbet

Building moved? (yes/no/unknown) No Date(s) moved: _____, Moved from: _____
Current use(s): Cow Camp , Historic use(s): Barn for cow camp

DESCRIPTION (see handbook for guidelines)

Style/Type: Rustic log barn

Number of stories: X 1, __1-1/2, __2, __2-1/2, __ multiple, __ don't know, __ other (describe):

Foundation (describe, i.e., stone, concrete, post and sill, etc.): Partial stone foundation

Roof (describe materials, i.e., asphalt, wood): Low-pitch gable roof covered with peeling composition shingles

Structural system (i.e., wood frame, masonry): Log frame

Cladding (i.e., wood siding, asphalt): None other than mortar chinking between logs

Windows (describe number and types, i.e., double hung, casement, fixed etc.): The wall adjacent to the ridgeline reveals a small rectangular opening measuring 42 inches long by 27 inches high. Extending from the ground (ridge slope) to nearly the roof, it is screened with 1¾ inch iron mesh.

Porches: None

Chimneys: None.

Basement: None

Modifications/Additions: None visible.

Distinctive landscaping elements:

ARCHITECTURE KEYWORDS: Logs, gable roof, chinking, false notching.

ADDITIONAL NARRATIVE (e.g., relationship of building to complex and/or district; other notes; interior description): Please see the site narrative for a detailed description of the barn and associated structures.

8I. HISTORIC STRUCTURE/OBJECT DESCRIPTION (must be accompanied by a core form) - Outhouse

Common name: Outhouse for (French Creek Cow Camp)

Historic name: _____

Type of structure/object: Associated resources: Log cabin and barn

Historic District Smithsonian Number (if applicable) _____

OWNERSHIP – Property owner and address: Bighorn National Forest, structure owned by Love Land and Cattle Company

Date: January 5, 2007 Smithsonian #48.JO.3778

NATIONAL REGISTER OF HISTORIC PLACES SIGNIFICANCE (discuss as appropriate in narrative and in core form; the following applies to the individual structure/object)
Period of significance: Pre-1956 Theme: Ranching with Cow Camp sub-theme
*Periods – Protohistoric (1720-1800) Early Historic (1801-1842) Pre-territorial (1843-1867) Territorial (1868-1889); Expansion (1890-1919); Depression (1920-1939) ; WWII-era (1940 to 1946); Post-WWII (1947 to 1955); Modern (1956-present); use exact dates if known.

NATIONAL REGISTER OF HISTORIC PLACES ELIGIBILITY RECOMMENDATION (discuss as appropriate in narrative and in core form):

If eligible, this structure/object is: X contributing or ___ non-contributing ___not applicable

Justification: (Include in justification a statement of significance for building; integrity (location, design, setting, materials, workmanship, feeling, association); discuss how significant periods and themes were determined): Please see Site Narrative for detailed discussion.

CONSTRUCTION HISTORY (use "unknown" as appropriate)

Dates of construction/major modification (use more lines as appropriate)

Date	Circa y/n	Date source
Unknown	1936	Informant

Architect(s): Unknown

Builder(s): Possibly Clarence Tarbet

Structure/Object moved? (yes/no/unknown): No, Date(s) moved: _____, Moved from: _____

Current use(s): Outhouse for Cow Camp, Historic use(s): Outhouse for Cow Camp

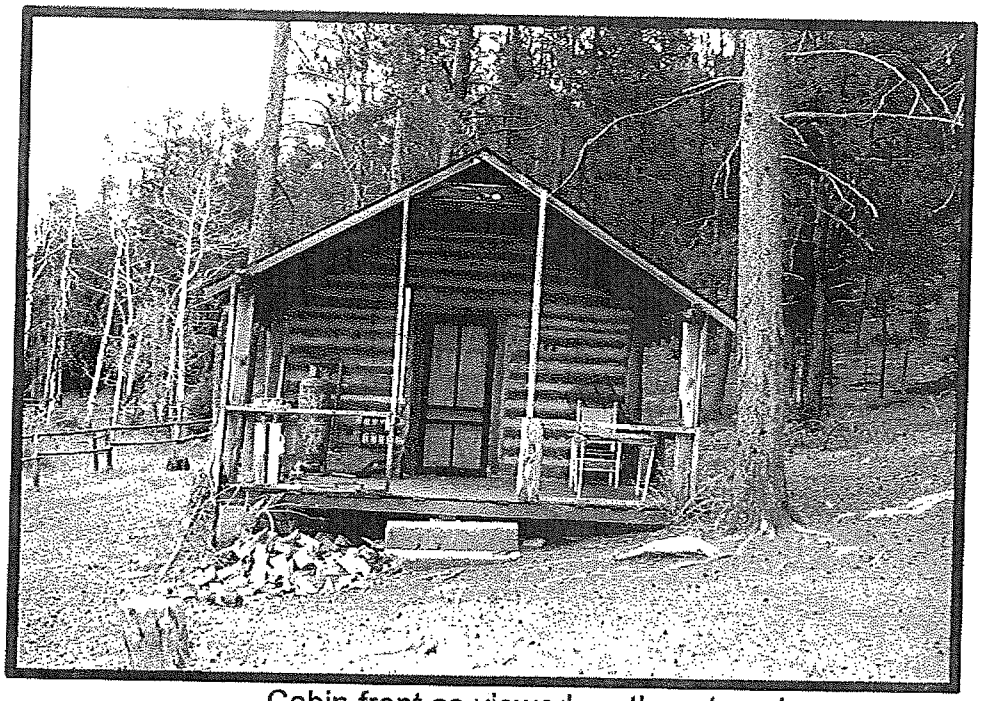
DESCRIPTION: A single seat outhouse spanning 4¼ x 4¼ feet by 6½ feet tall is present along the south-southwestern edge of the site. The edges are positioned on concrete blocks. The gray board and batten walls are comprised of 2 x 8 and 2 x 4 inch planks interspersed with narrow 2½ inch wide strips. Composed of 1 x 6 inch vertical planks, the wooden door measures 23 inches wide by 5 ½ feet tall. Modern looking, the shed roof is of corrugated sheet metal.

Construction Materials: Planks

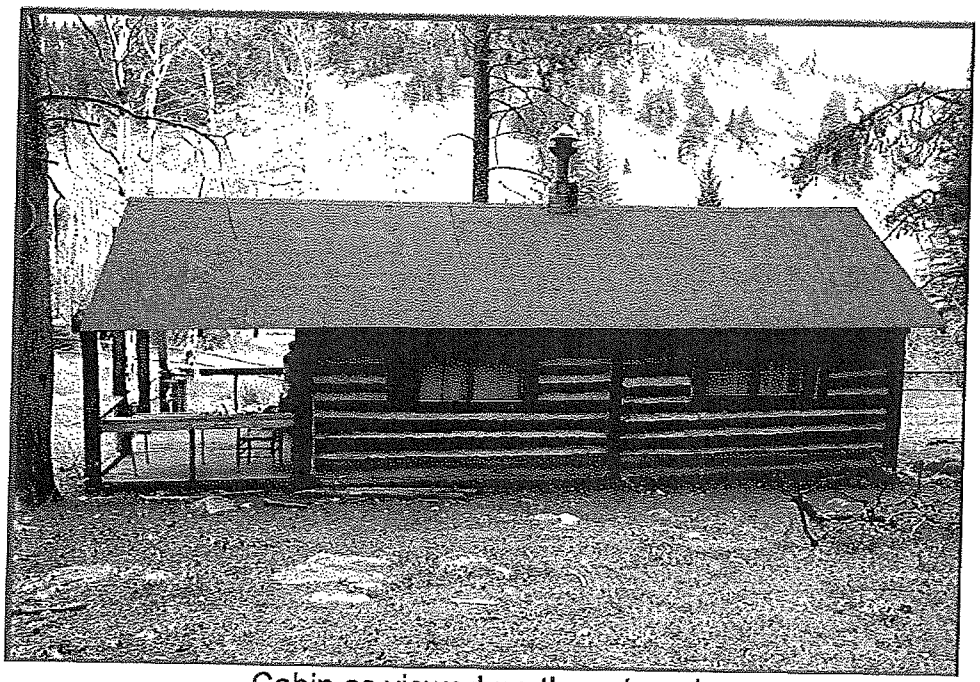
Style/Type: Board and batten.

STRUCTURE/OBJECT KEYWORDS: Board and batten, shed roof, outhouse

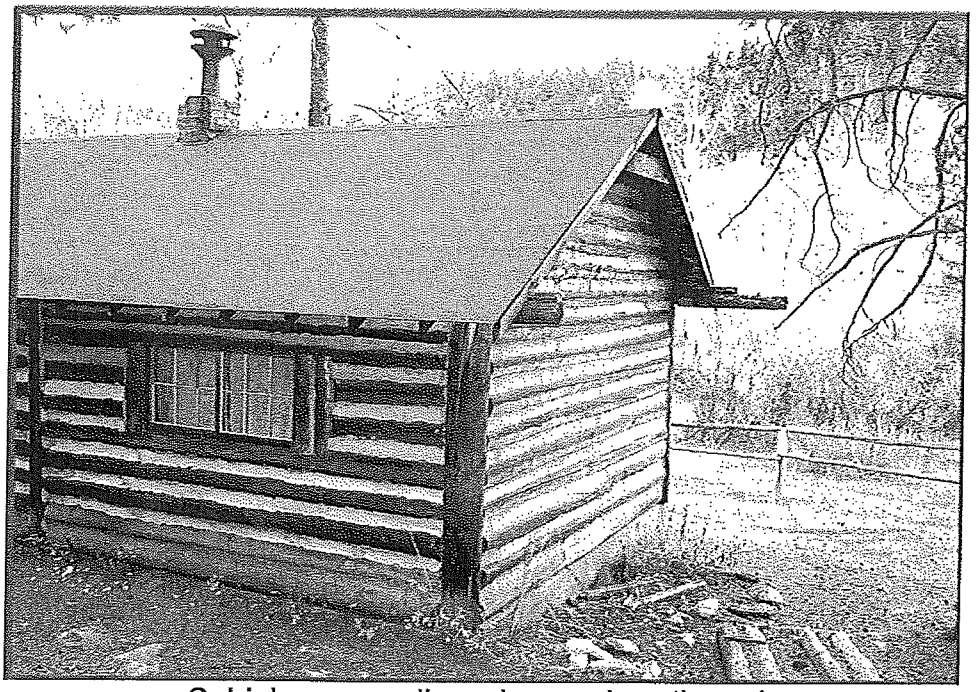
ADDITIONAL NARRATIVE (e.g., relationship of structure/object to complex and/or district; other notes): Please read Site Narrative for additional discussion.



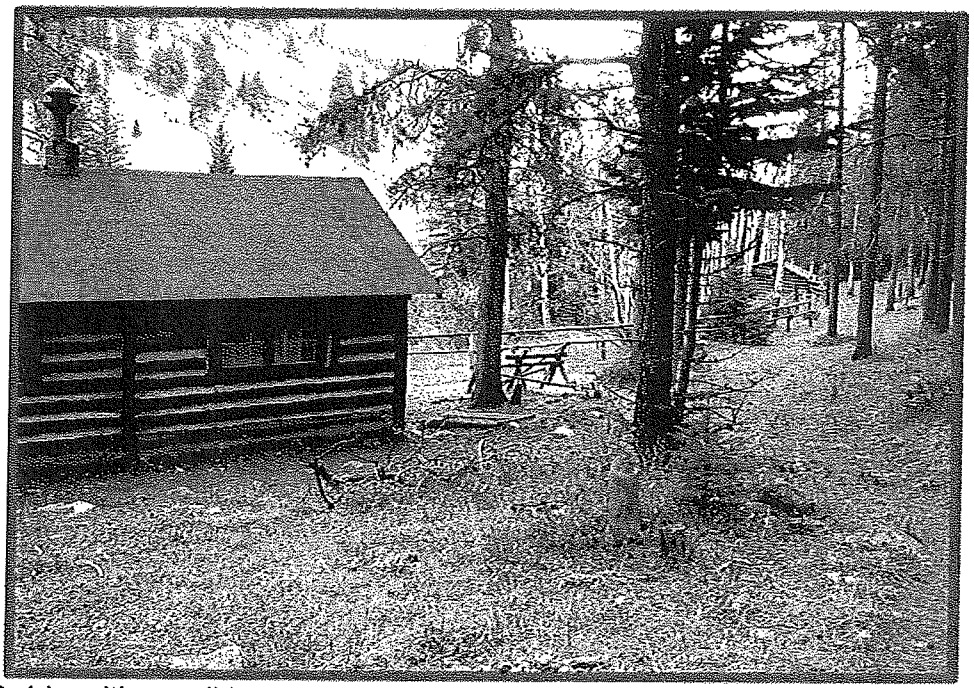
Cabin front as viewed northeastward.



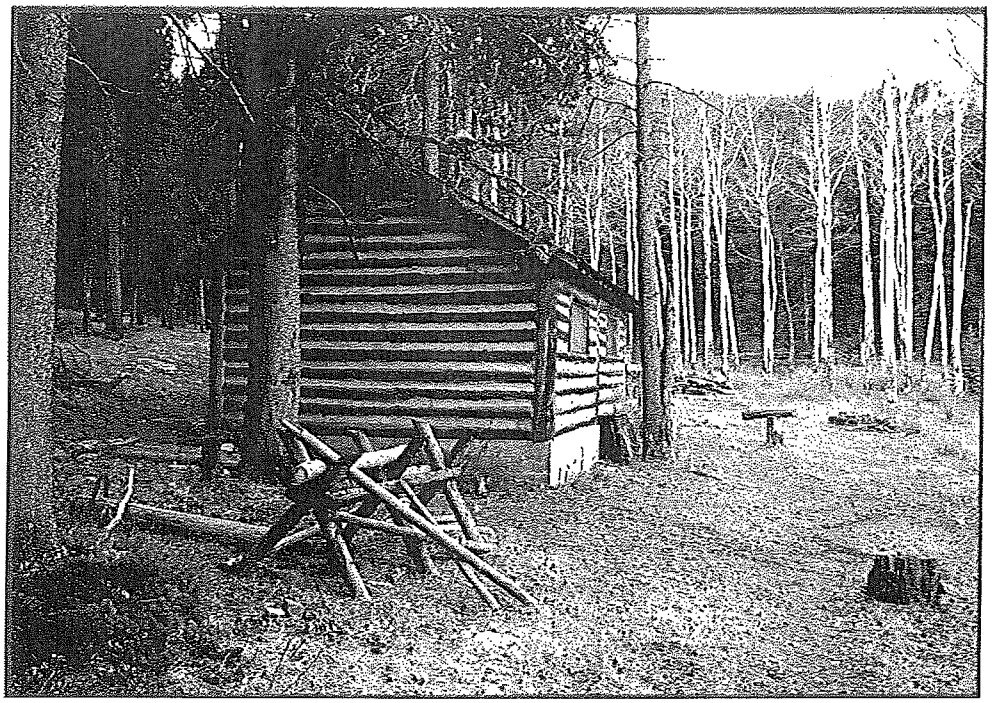
Cabin as viewed northwestward.



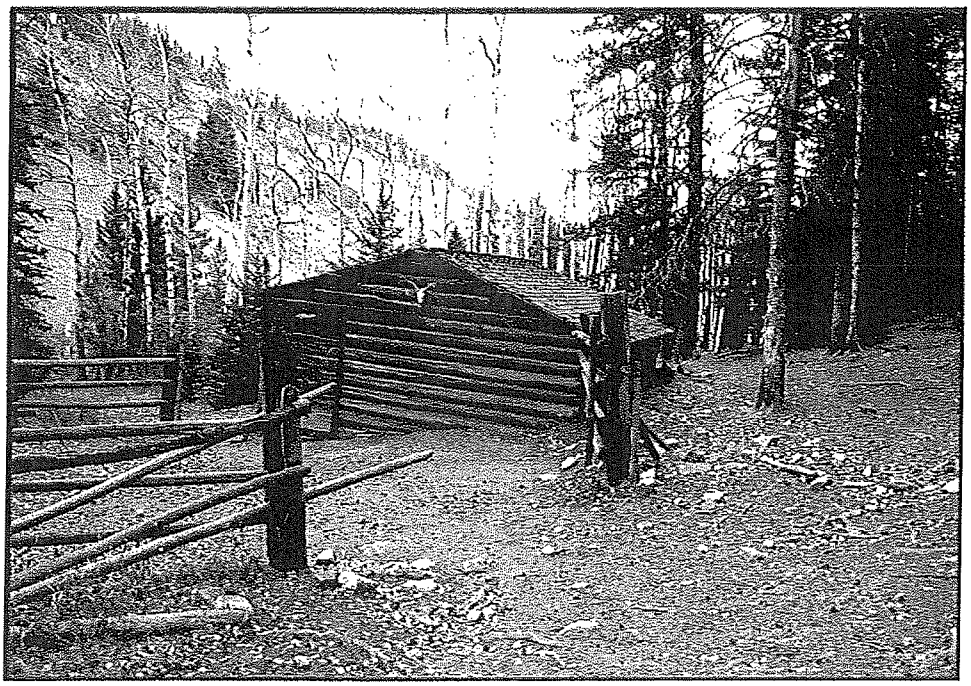
Cabin's rear wall as observed northward.



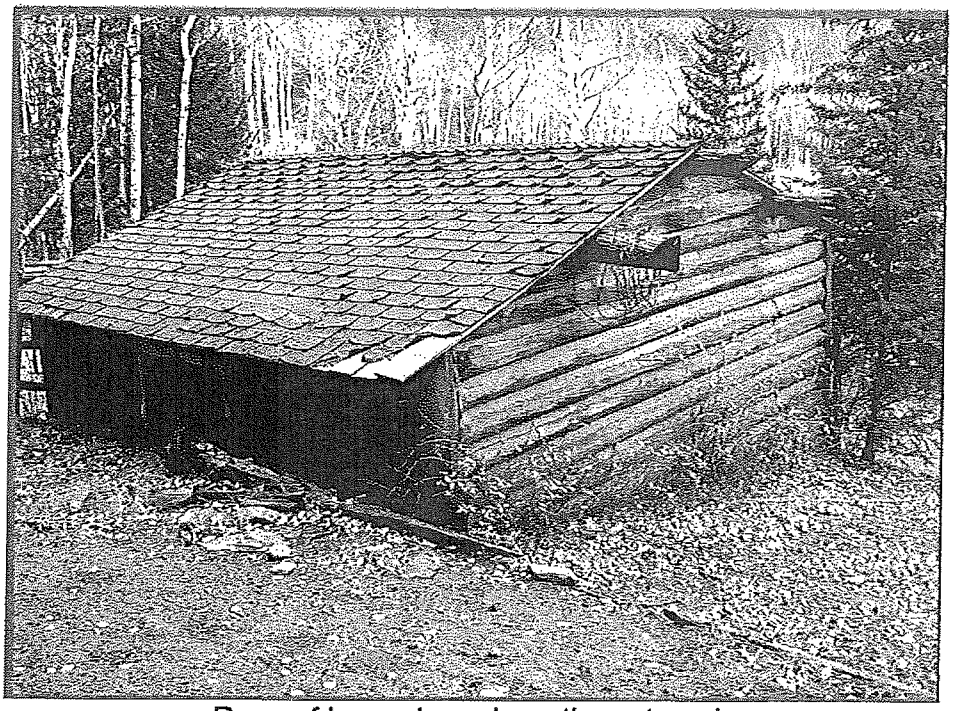
Cabin with small barn in left background as observed north-northeast.



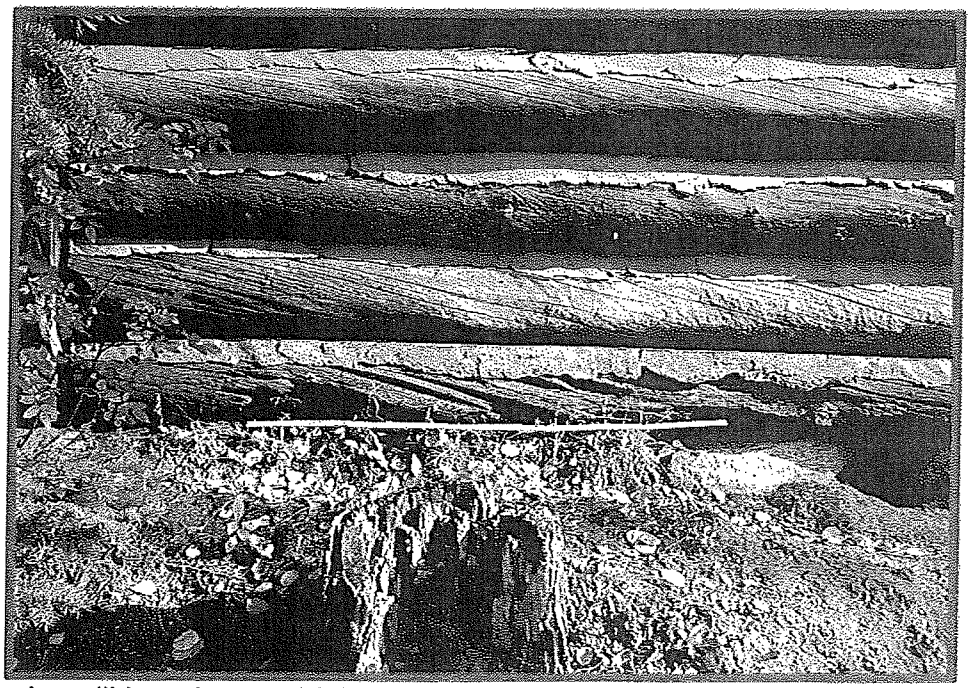
Rear of cabin viewed westward.



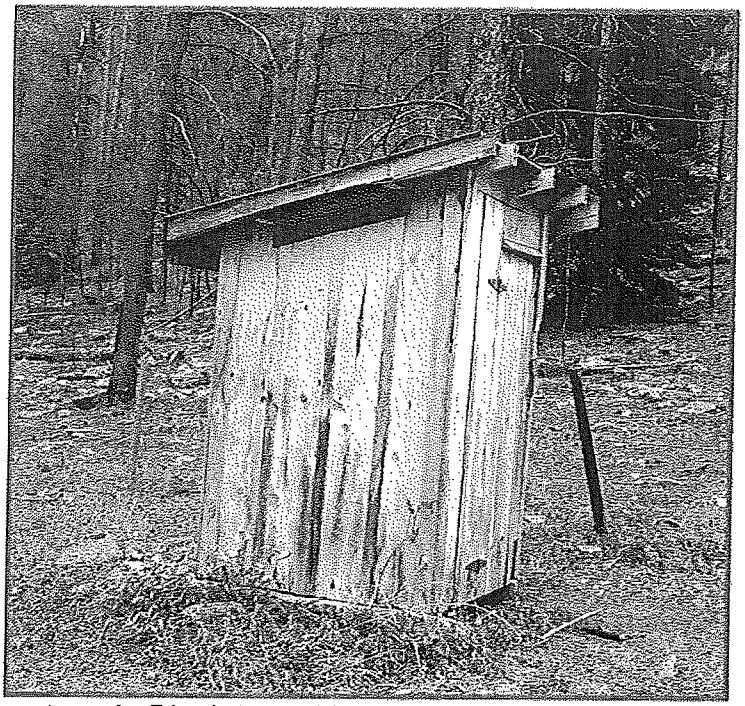
Small barn viewed northward.



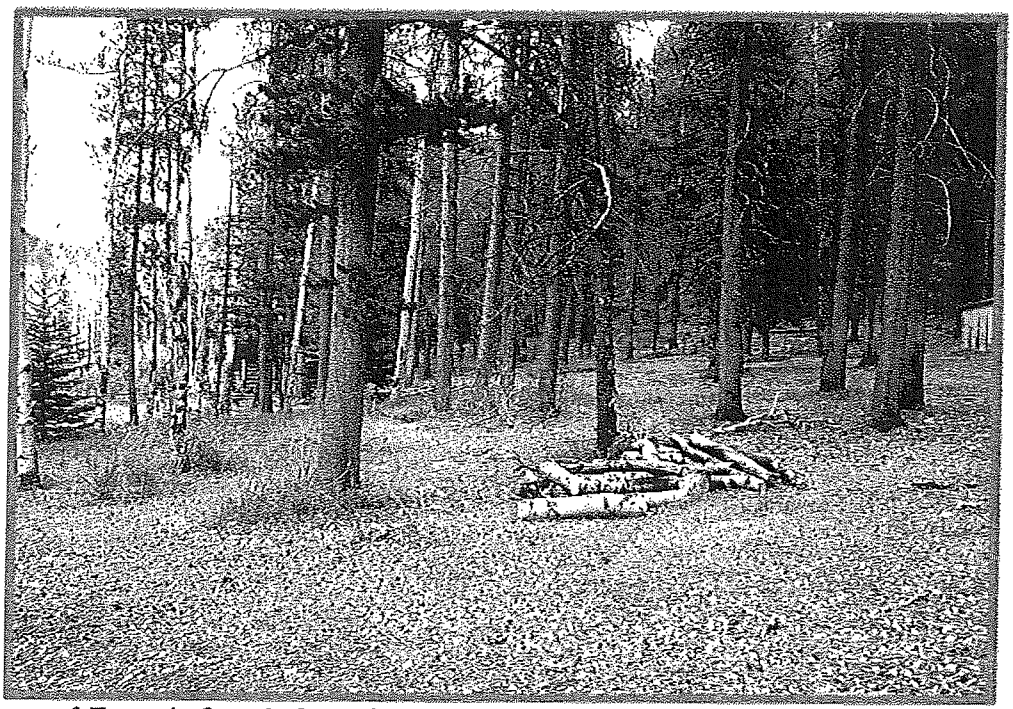
Rear of barn viewed southwestward.



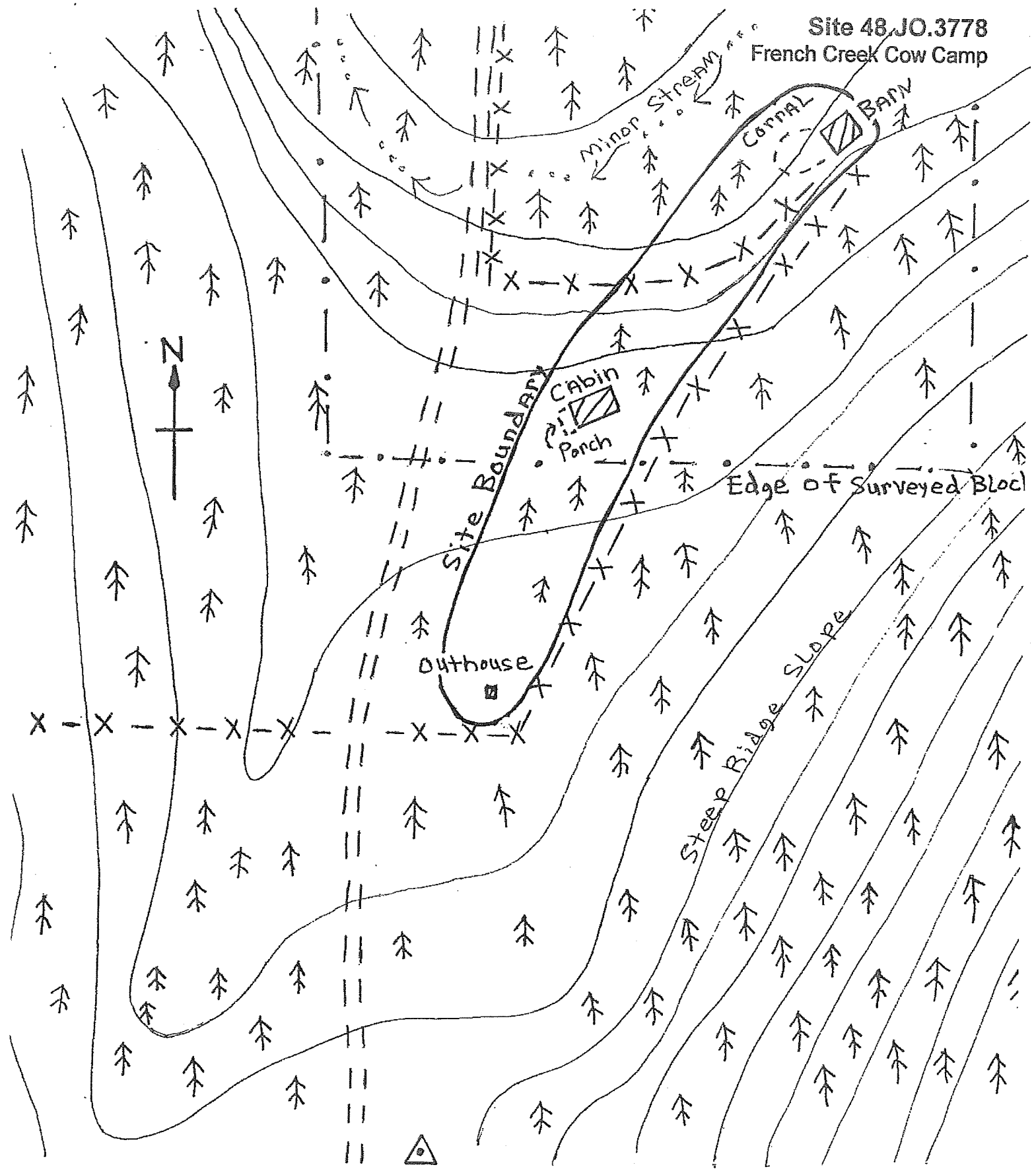
Decaying sill log along cabin's northwest wall. Yellow ruler is 39 inches long.



Outhouse as seen eastward. Black trowel is pointing north. Yellow ruler is 39 inches long.



General area of French Creek Cow Camp as seen northward. The photo was difficult to take due to tree cover, nearby hunters' tents, etc.



Scale: 1 inch represents 20 meters

Contour is approximately 3.5 meters

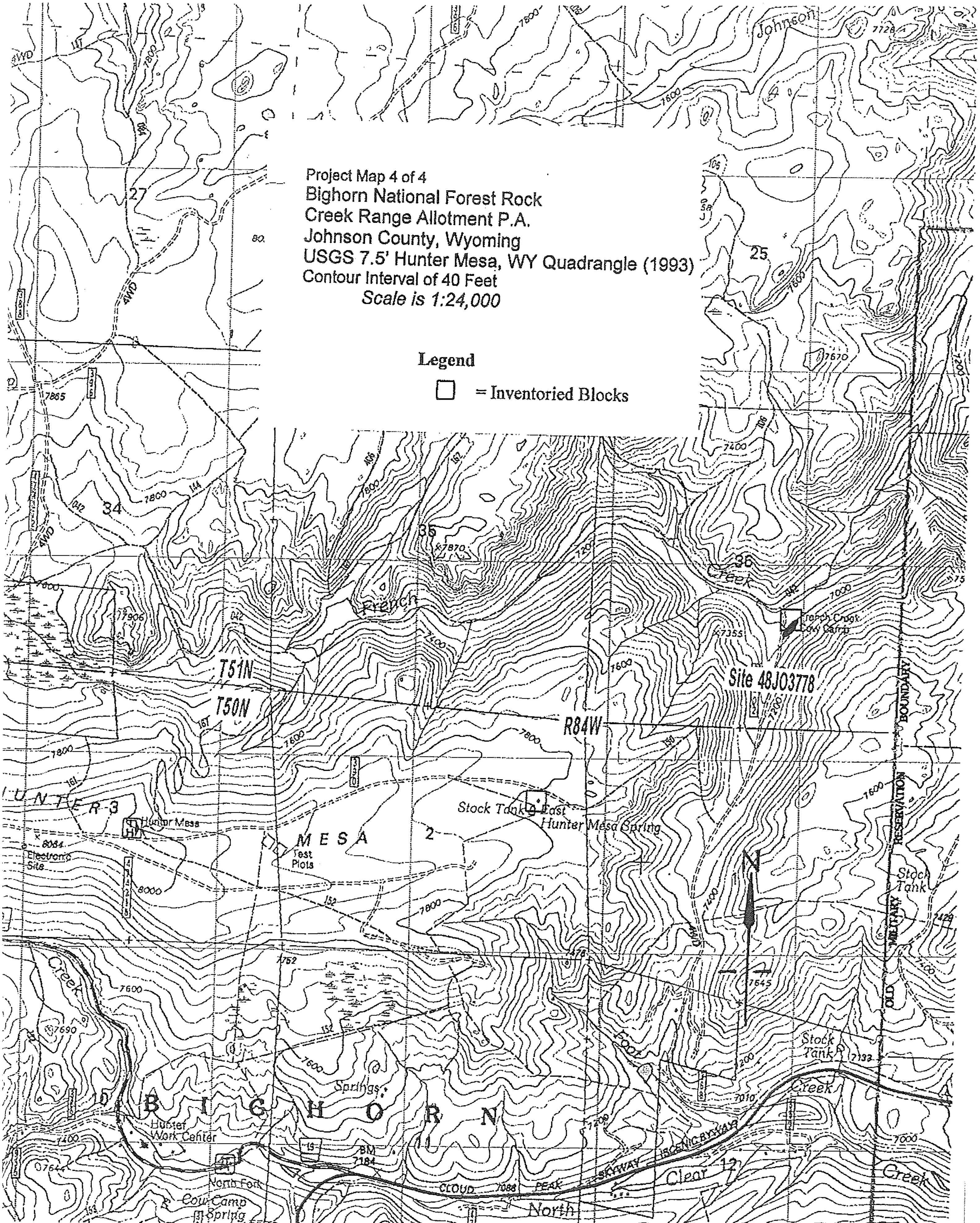
Legend

△ = Datum

= = = = Rocky two-track road

– X – X– = Fence

= Tree


Project Map 4 of 4
Bighorn National Forest Rock
Creek Range Allotment P.A.
Johnson County, Wyoming
USGS 7.5' Hunter Mesa, WY Quadrangle (1993)
Contour Interval of 40 Feet
Scale is 1:24,000
Legend
= Inventoried Blocks
Site 48JO3778
French Creek Cow Camp
T51N
T50N
R84W
Stock Tank
East Hunter Mesa Spring
MESA
Test Plots
Hunter Mesa
Electronic Site
Springs
B I G H O R N
Hunter Work Center
North Fork Cow Camp Spring
CLOUD PEAK SKYWAY SCENIC BYWAY
Clear Creek
North
Stock Tank
OLD MILITARY RESERVATION BOUNDARY
Johnson
French
Creek

APPENDIX D.

Correspondence

STATES WEST
WATER RESOURCES CORPORATION

1904 East 15th Street
Cheyenne, Wyoming 82001
(307) 634-7848

E-mail: stateswest@aol.com

P. O. Box 2029
Cheyenne, Wyoming 82003
Fax: (307) 634-7851

MEMORANDUM

DATE: June 28, 2007

TO: Steve Muth, WWDC,
Hopkins Producers ID

FROM: Dylan Wade, SWWRC

SUBJECT: Hopkins Producers ID Watershed/Water Storage Project, Level I Study – Scoping Meeting Minutes

A scoping meeting for the above referenced project was held in Buffalo June 27th, 2007, 7:00PM at the Johnson County Public Library. Those attending are as shown on the attached sheet.

Proceedings:

- Meeting called to order and introductions were made at 7:00PM by Steve Muth, WWDC.
- Presentation given by Dylan Wade, Project Engineer and Victor Anderson, Project Manager, both with States West Water, outlining the scope of the project and the tasks to be completed. In brief the project consists of a watershed study component and a water storage study component. The consultant approach to the watershed study in effort to make efficient use of funds will be to gather existing information where available and supplement with limited field reconnaissance. Emphasis will be placed on the water storage evaluation component of the study. The work products will be completed to the Level I reconnaissance level effort. Presentation slides are attached.
- Discussion on project scope followed the presentation.
    - John Jenkins, HPID noted the HPID was interested in the study producing one larger multiuse reservoir facility and one smaller project suited to supplying supplemental irrigation water to the irrigators in the district. John also noted that HPID was interested in various water swaps. John noted that any historical learning curve with Tie Hack Dam and Reservoir should be incorporated into this project. John asked how this project can be integrated into the regional water supply which is currently being studied by HKM and States West in the Buffalo/Sheridan Area Water Supply/Lake DeSmet Master Plan.
    - Discussion on whether to extend the area of study to include the Rock Creek drainage was held. Since no one representing that area was present at the meeting to give input and since the late season irrigation water shortages were less as indicated in the Powder/Tongue River Basin Plan the focus of study was determined to remain on the French and Upper Clear Creek basins at this time.

    - Discussion on reservoir storage volume was held. The Powder/Tongue River Basin Plan indicates a dry year irrigation shortage of 1,600 ac-ft on French Creek. Initial estimate of storage volume is approximately 5,000 ac-ft for a multiuse reservoir project.
    - Les Hook, City of Buffalo, Public Works Dept. indicated the City of Buffalo would potentially be interested in buying storage in a potential reservoir in these basins to satisfy downstream senior water rights.
- Other Business
    - Field work is planned to begin mid July. A second meeting is planned for mid to late August to present initial findings and work progress.
    - It was noted that the National Forest Service, Powder River District office was contacted and a representative was unable to attend tonight's meeting.
- Meeting adjourned 8:00 p.m.
- Minutes submitted by Dylan Wade.

HOPKINS PRODUCERS I.D. WATERSHED/STORAGE PROJECT

States West Water Resources Corporation 6/27/07

Project _____ No. _____ Date _____ Page _____

By _____ Of _____

NAME	Representing
STEVE MUTH	WY WATER DEV. OFFICE
George Mather	Hopkins Producers Irrigation District.
John Jenkins	HPID
Carl Jenkins	HPID
Brook Stromer	States West
Helen Heather	HPID
Dane Hall	HPID
Les Hook	City of Buffalo
CURT DOWNING	SWWRC
DYLAN WADE	SWWRC

STATES WEST
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MEMORANDUM

DATE: March 19, 2008

TO: Steve Muth, WWDC,
Hopkins Producers ID

FROM: Dylan Wade, SWWRC

SUBJECT: Hopkins Producers ID Watershed/Water Storage Project, Level I Study – Project Meeting #1 Minutes

A project meeting for the above referenced project was held in Buffalo March 18th, 2008 at 9:00 a.m. at the Johnson County Public Library. Those attending are as shown on the attached sheet.

Proceedings:

- Meeting called to order and Steve Muth, WWDC, made introductions at 9:00 a.m. Project budget and schedule both look good.
- Presentation given by Dylan Wade, Project Engineer and Victor Anderson, Project Manager, both with States West Water, outlining the work completed on the project to date and the tasks yet to be completed. Victor discussed the seven sites that were identified as potential supplemental water storage sites.
    - Site #1 could potentially be a viable single purpose site that could potentially supply supplemental water to the HPID.
    - Site #2 could potentially be an inefficient single purpose site that could potentially supply supplemental water to the HPID. Difficulties in delivering water to this site and large quantities of embankment to storage created dropped this site from further consideration.
    - Site #3 is located just inside the Forest Service boundary and could potentially be a multipurpose site that could potentially supply supplemental water to the HPID, the City of Buffalo through a pipeline to Clear Creek, and other downstream irrigators on Clear Creek alleviating shortages and regulation of the system. Availability of fine material is unknown for construction of embankment and could potentially be mined and imported off Forest Service property. This site could have additional benefits of a minimum pool for fisheries and recreation and hydropower generation. Access to this site could be on private land from downstream along French Creek.
    - Site #4 could potentially be a multipurpose site similar to Site #3. It was dropped from further consideration because the embankment required to storage created efficiency was less than that of Site #3.

- Site #5 could potentially be a multipurpose site similar to Site #3. It was dropped from further consideration because of the presence of valuable wetlands and fen in the reservoir pool area and difficult access to the site.
- Site #6 could potentially be a source of supplemental water on South Rock Creek. The reservoir would inundate valuable wetlands and fen and is in the proposed wilderness area. A reservoir at this site was dropped from further consideration.
- Site #7 could potentially supply supplemental water to the HPID, however, this site is inefficient and was dropped from further consideration.
- Basin yields determined through gage data analysis are shown in the handout. Based on a meeting with Mike Whitaker, Water Superintendent Division II, the analytical yields developed on Rock Creek at Site #6 (3000 ac-ft) and the yields in the French Creek drainage (1300 ac-ft) may be high. Neither drainage is gaged and yields are difficult to estimate with reasonable accuracy, however the yields will be reexamined based on the anecdotal information from Mr. Whitaker.
- There appears to be water available in N. French Creek (1000 to 2000 ac-ft) that could potentially be diverted into the French Creek drainage and stored in a facility at Site #3. Modification of the Four Lakes diversion and canal could be required to facilitate diversions prior to the irrigation season and spring thaw.
- Water could also potentially be diverted out of South Rock Creek at Site #6 and piped to N. Clear Creek and diverted into French Creek for storage in a facility at Site #3.
- Conceptual designs and cost estimates will be developed for Site #1 and Site #3. A range of sizes and their associated costs will be developed based on water availability and needs. Supplemental water sources will be developed first in French Creek, then N. Clear Creek and third from South Rock Creek as need requires.

- Discussion of the project
  - ? If a site like Site #3 goes to Level III who would be the sponsor? SWWRC reply: The HPID could be a participant among a group of sponsors or entities, a new entity or coalition comprised of various participants could be formed, or it could be a State owned project.
  - Steve Muth, WWDC: With enough benefit to the State, the Wyoming Legislature could grant additional funding beyond the criteria of the WWDC.
  - Discussion with the Forest Service representatives Mark Booth and Dan Scaife on potential for land swaps and other potential flaws and issues. They indicated land swaps or a special use permit could be possible and wildlife winter range and grazing leases are types of things that would need addressed but they did not foresee any major flaws with Site #3.
  - Mark Booth, Forest Service, indicated that French Creek is a non-native fishery mainly consisting of brook and rainbow trout.
  - ? What is the current funding package available from the WWDC? SWWRC reply: 1/3 loan at 4%, 2/3 grant with the WWDC having the ability to go to 1/4 loan at 4%, 3/4 grant. Loan term varies.
- Other Business

    - Conceptual level designs and cost estimates will be developed, the watershed management plan will be developed, identification of required permits and clearances will be completed, and project funding sources will be identified.
    - A draft copy of the report will be made available in June.
- Meeting adjourned 10:00 a.m.
- Minutes submitted by Dylan Wade.

States West Water Resources Corporation

Project _____ No. _____ Date _____ Page _____

By _____ Of _____

PROJECT MEETING #1

MARCH 18TH 2008

HPID WATERSHED / WATER STORAGE LEVEL I STUDY

NAME	WITH	PHONE	EMAIL
DYLAN WADE	STATESWEST	307-634-7848	dwade@stateswest
STEVE MUTH	WWDO	307 777 5447	smuth@state.wy.us .com
Victor Anderson	State West	307-634-7848	statewest@aol.com
Helen Mathes	HPID	307-684-8828	hmathes@collinscom.net
Dan Scalfe	USFS	307-674-2646	dscalfe@fs.fed.us
MARK Booth	USFS - Buffalo	307-684-7806	mbooth@fs.fed.us
JERRY GLADSON	HPID (Sand Ck Ranch)	307-684-7138	jdgladson@bresnan.net
Greg Goddard	HPID	684-9595	gwu@wyoming.com
DAVE HALL	HPID	684-2311	dhall@collinscom.net

States West Water Resources Corporation

Project _____ No. _____ Date _____ Page _____

_____ By _____ Of _____

HOPKINS PRODUCERS ID WATERSHED/WATER STORAGE PROJECT, LEVEL I STUDY. – RESULTS MTG.
9-18-08

NAME		#	EMAIL
DYLAN WADE	SWWRC	634-7848	dwade@stateswest.com
VICTOR ANDERSON	SWWRC	634-7848	
Brook Stromer	SWWRC	684-7953	bstromer@stateswest.com
Chuck Keffer	———	684-2255	csklazy2@hotmail.com
Helen Mathes	HPID	684-8828	hmathes@ccsd.k12.wy.us
George Mathes	HPID	684-8828	gmathes@collinscom.net
DAVE HALL	HPID	684-2311	dhall@collinscom.net
Steve Smith	WCWDO	777 5417	ssmith@state.wy.us

APPENDIX E.

Sample Hydrologic and Design Flood Calculations

US Geological Survey, Water Resources Data
retrieved: 2008-01-02 16:57:43 EST
#
This file contains USGS Surface-Water Monthly Statistics
#
#Note:The statistics generated from this site are based on approved daily-mean data and may not match those published by the USGS in official publications.
#The user is responsible for assessment and use of statistics from this site.
#For more details on why the statistics may not match, visit http://waterdata.usgs.gov/wy/nwis/?dv_statistics_disclaimer.
#
#** No Incomplete Data is used for Statistical Calculation
#
This file includes the following columns:
#
#
agency_cd agency code
site_no USGS site number
parameter_cd
dd_nu
year_nu Water year for value
month_nu Month for value
mean_va monthly-mean value.
if there is not complete record
for a month this field is blank
#
#
Sites in this file include:
USGS 06320500 SOUTH PINEY CREEK AT WILLOW PARK, WY
#
Explanation of Parameter Code and dd_nu used in the Statistics Data
parameter_cd Parameter Name dd_nu Location Name
00060 Discharge, cubic feet per second 1
#
Gage Elevation 8540 ft

Drainage Basin		Drainage Area			Avg Elev (ft)	Loham Regression Equ. Elev. Term	Avg. Streamflow Reduction Factor based on Elev.
06320500 Gaged Drainage Area	33.6 mi^2	87877507 m^2	21504	acres	10155	793	
Site 2 Drainage Area	1.180 mi^2	3056722 m^2	755	acres	6172	189	0.238
Site 3 Drainage Area	11.872 mi^2	30748298 m^2	7598	acres	7571	340	0.429
Site 4 Drainage Area	6.246 mi^2	16175877 m^2	3997	acres	7901	385	0.485
Site 5 Drainage Area	5.030 mi^2	13027180 m^2	3219	acres	7982	396	0.500
Site 6 Drainage Area	7.072 mi^2	18315390 m^2	4526	acres	10066	773	0.975
Upper N Clear Creek Drainage Area	15.091 mi^2	39085678 m^2	9658	acres	10396	848	1.070
French Ck above Penrose Ditch (ungaged)	13.057 mi^2	33817190 m^2	8356	acres	7438	323	0.408

agency_cd	site_no	parameter_cd	dd_nu	year_nu	month_nu	mean_va

5s	15s	5s	3n	Year	Month	12n	cfs/acre	Site 2 Mean Monthly Flow (cfs)	Site 3 Mean Monthly Flow (cfs)	Site 4 Mean Monthly Flow (cfs)	Site 5 Mean Monthly Flow (cfs)	Site 6 Mean Monthly Flow (cfs)	Upper N Clear Creek Mean Monthly Flow (cfs)	French Ck above Penrose Ditch Mean Monthly Flow (cfs)
USGS		6320500	60	1947	7	135.9	0.00632	1.14	20.61	12.26	10.17	27.89	65.30	21.54
USGS		6320500	60	1947	8	80.5	0.00374	0.67	12.21	7.26	6.02	16.52	38.68	12.76
USGS		6320500	60	1947	9	29.6	0.00138	0.25	4.49	2.67	2.21	6.07	14.22	4.69
USGS		6320500	60	1947	10	21.7	0.00101	0.18	3.29	1.96	1.62	4.45	10.43	3.44
USGS		6320500	60	1947	11	14	0.00065	0.12	2.12	1.26	1.05	2.87	6.73	2.22
USGS		6320500	60	1947	12	13	0.00060	0.11	1.97	1.17	0.97	2.67	6.25	2.06
USGS		6320500	60	1948	1	12	0.00056	0.10	1.82	1.08	0.90	2.46	5.77	1.90
USGS		6320500	60	1948	2	11	0.00051	0.09	1.67	0.99	0.82	2.26	5.29	1.74
USGS		6320500	60	1948	3	10	0.00047	0.08	1.52	0.90	0.75	2.05	4.81	1.59
USGS		6320500	60	1948	4	22	0.00102	0.18	3.34	1.98	1.65	4.51	10.57	3.49
USGS		6320500	60	1948	5	153.4	0.00713	1.28	23.27	13.84	11.48	31.48	73.71	24.32
USGS		6320500	60	1948	6	133.2	0.00619	1.12	20.20	12.02	9.97	27.33	64.01	21.11

Site 3 - Probable Maximum Precipitation Sample Calculation

5000' PMP=	9.69	in
Elev Adj=	0.86	
index PMP =	8.33	in

PMP estimates for basin

Duration (hours)	0.25	0.5	0.75	1	2	3	4	5	6
PMP (inches)	5.7	7.2	7.8	8.3	9.7	10.2	10.7	11.0	11.2

Site 3 Drainage Area= 11.87 mi^2

Areal Reduction Factors

Duration (hours)	0.25	0.5	0.75	1	2	3	4	5	6
Reduction Factor	0.72	0.77	0.79	0.81	0.84	0.85	0.86	0.87	0.88
PMP (inches)	4.1	5.5	6.2	6.7	8.1	8.7	9.2	9.6	9.8

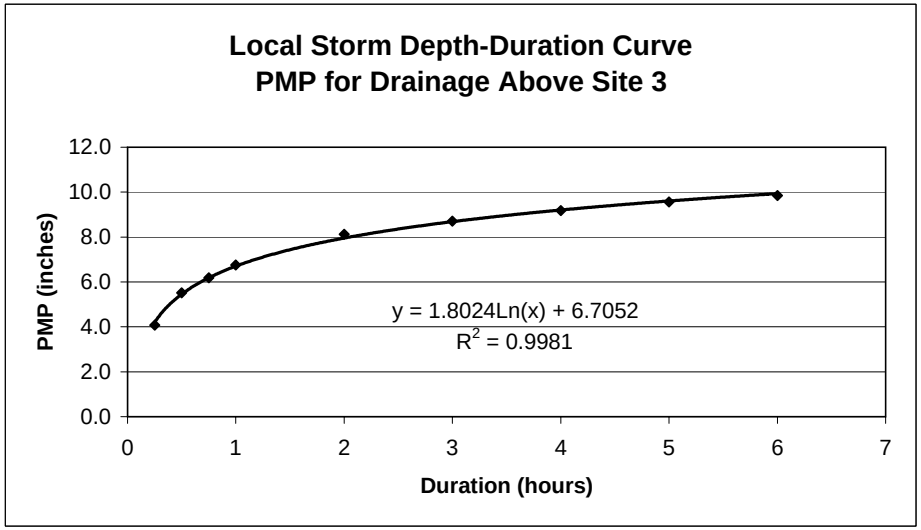
Incremental PMP estimates

Duration (hours)	0.25	0.5	0.75	1	2	3	4	5	6
PMP (inches)	4.1	1.4	0.7	0.6	1.4	0.6	0.5	0.4	0.3

PMP intermediate estimates

Duration (hours)	0.25	0.5	0.75	1	1.25	1.5	1.75	2	2.25	2.5
PMP (inches)	4.1	5.5	6.2	6.7	7.1	7.4	7.7	8.1	8.2	8.4

Drainage Area =	11.87	mi^2
Curve Number =	60	Cover type: Woods, Hydrologic condition: Fair, Hydrologic soil group: B
100yr, 24hr Rainfall Amount =		in.
Basin Lag Time =	0.832	hrs



APPENDIX F.

Sample Hydraulic Calculations

Sample Hydraulic Calculations

quantity	value	units
e=	0.00015	
ν=	1.21E-05	ft^2/s
g=	32.2	ft/s^2
γ=	62.4	lb/ft^3

$$\frac{p_1}{\gamma}+\frac{V_1^2}{2g}+z_1+h_P=\frac{p_2}{\gamma}+\frac{V_2^2}{2g}+z_2+h_L$$

$$h_L=\frac{V^2}{2g}\left(f\frac{L}{D}+\sum K_L\right)$$

$$\mathrm{Re}=\frac{VD}{\nu}$$

N. Clear Diversion Pipeline

quantity	value	units	quantity	value	units
D=	3.000	ft	V=	19.81	ft/s
Q=	140	ft^3/s	Re=	4910566	
f=	0.012		h_L=	141.317	ft
L=	4800	ft	$h_{T\ or\ P}$=	0.000	ft
K_L=	4		$\Delta z_{(free\ discharge)}$=	147.408	ft
$hp_{+T\ or\ -P}$=	0				
η=	0.7		$h_{L,TOTAL}$=		ft
hp_{shaft}=	0		$\Delta z_{available}$=		ft

French Creek to Clear Creek Pipeline

quantity	value	units	quantity	value	units
D=	2.000	ft	V=	12.73	ft/s
Q=	40	ft^3/s	Re=	2104528	
f=	0.012		h_L=	495.142	ft
L=	32116	ft	$h_{T\ or\ P}$=	0.000	ft
K_L=	4		$\Delta z_{(free\ discharge)}$=	497.659	ft
$hp_{+T\ or\ -P}$=	0				
η=	0.7		$h_{L,TOTAL}$=		ft
hp_{shaft}=	0		$\Delta z_{available}$=		ft

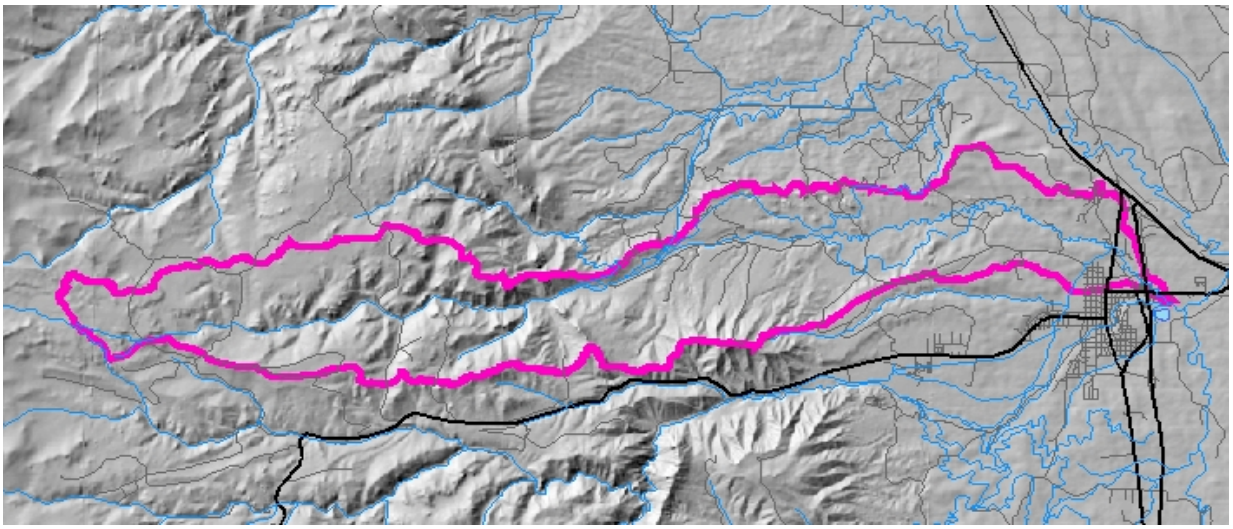
Rock Creek Diversion Pipeline

quantity	value	units	quantity	value	units
D=	2.000	ft	V=	12.73	ft/s
Q=	40	ft^3/s	Re=	2104528	
f=	0.012		h_L=	87.703	ft
L=	5140	ft	$h_{T\ or\ P}$=	0.000	ft
K_L=	4		$\Delta z_{(free\ discharge)}$=	90.220	ft
$hp_{+T\ or\ -P}$=	0				
η=	0.7		$h_{L,TOTAL}$=		ft
hp_{shaft}=	0		$\Delta z_{available}$=		ft

APPENDIX G.

French Creek Watershed Plan prepared by Lake DeSmet Conservation District

French Creek 205-J Watershed Plan



Submitted by: Lake DeSmet Conservation District
760 West Fetterman
Buffalo, WY 82834

Submission Date: February 2004

TABLE OF CONTENTS

Appendix

INTRODUCTION

The Lake DeSmet Conservation District (LDCD) is charged with the conservation of soil and water resources. Landowners, within the French Creek watershed, have taken a proactive approach in requesting technical assistance in assessing the French Creek watershed to identify resource and water quality concerns.

The LDCD, in 1998, completed a resource inventory by watershed in Northern Johnson County to provide direction for District water quality activities. Upon review of the inventory document, the District found French Creek ranking fourth on the watershed priority sheet.

The French Creek watershed is situated within the Powder River Basin, and is a tributary to the Clear Creek Sub-basin. Please refer to the Appendix Map 1, "Project Area Location". French Creek consists of 9635 acres. It is a perennial stream running approximately 12 miles. It is situated at the foothills of the Bighorn Mountains, with an elevation of 4550 to 6725 feet and a precipitation zone of 13 to 18 inches. Please refer to the Appendix Map 2, "Project Area". It has been classified by the Department of Environmental Quality (DEQ) as a Class 2AB stream, cold water fishery. Class 2AB waters are those known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where a game fishery and drinking water use is otherwise attainable. Unless it is shown otherwise, these waters are presumed to have sufficient water quality and quantity to support drinking water supplies and are protected for that use. Class 2AB waters are also protected for nongame fisheries, fish consumption, aquatic life other than fish, primary contact recreation, wildlife, industry, agriculture and scenic value uses. The French Creek watershed is classified by the Wyoming Game & Fish, as a Class 3 stream. It is identified as a rainbow and brown trout fishery.

Landownership, excluding the Big Horn National Forest, primarily consists of deeded (80.4%), state (6.2%) and other (13.4%) including urban and public roads. Please refer to the Appendix Map 3, "General Land Ownership". Land use within the watershed is predominantly rangeland (70%), with hay and pastureland (15%), woodland (3%) and urban/residential (12%). The ***French Creek 205-J Watershed Plan Project*** area addresses the upper/middle section of the watershed consisting mainly of agricultural units. The project area was enhanced to include Paradise Guest Ranch, which is located in the Bighorn Mountains, and the urban area.

Soils within the watershed vary from shallow to deep, moderately fine textured soils on old terraces and terrace margins and deep, moderately fine textured soils on hill slopes and in valleys to shallow and moderately deep, stony and moderately fine textured soils with rock outcrop on moderate to steep slopes to deep, coarse to moderately fine textured soils on flood plains along major drainages. Please refer to Appendix Map 4, "Soils".

RESOURCE INVENTORY – General (1998)

- Range sites vary from deep lowlands to very shallow. The watershed is predominantly deep uplands and shallow.

- There are extensive irrigated lands along the entire watershed. Lands are serviced by the Brown & Foster, Moeller #1, Hopkins and Penrose ditches, which carry imported water outside the watershed. Water is diverted into and out of this drainage, to & from adjoining watersheds. Stream damage has occurred due to excess water being introduced into the waterway. Fields are primarily flood irrigated with an overall estimated efficiency of 20%. Potential for erosion is high when fields are being farmed.

- Riparian area management is needed for protection of wildlife, water quality, fisheries, flood control and agriculture.

- The watershed hosts a small acreage of Pine occurring in the upper watershed, on private lands below the forest. These areas are steep and inaccessible. The timbered areas provide valuable wildlife habitat.

- The watershed is operated by fulltime and part-time agriculture, rural residence, urban development and subdivisions. It is a narrow, steep drainage and potential from flooding occurs from spring snow melt and intensive rain storms. Flooding potential is high. Damage to roads, residences, irrigation systems, and businesses may occur. Growth potential, within the watershed is high, due to an increase in urban and subdivision development.

- Less than 20% of Best Management Practices (BMP's) have been installed within the watershed to address soil & water conservation concerns.

The ***French Creek 205-j Watershed Plan Project*** provided the necessary financial assistance to develop a watershed plan for the participating landowners. This plan provides a watershed inventory, land use mapping, identification of riparian area concerns, and identification of BMP's for a future water quality initiative.

PROJECT ACTIVITIES

The Lake DeSmet Conservation District, in 2002, solicited for funding from Wyoming Department of Environmental Quality (DEQ) to develop a watershed plan for landowners within the French Creek drainage. The purpose of the project was to develop a watershed plan that would provide landowners and resource managers the necessary tool to assist in watershed management.

The District met with landowners within the drainage and formed a steering committee to assist the District in meeting the goals and objectives of the project. Everyone was in agreement for the assessment of the watershed. It was agreed that the project would focus on private landowners and agricultural units.

It was the general consensus of the committee that the basin transfer of water is a major contributor to resource concerns. The watershed is running more water than it can hydrologically handle, which produces potential streambank and riparian concerns within the mid zones and lower watershed. The assessment project will identify areas of concern and will provide alternatives to address these concerns.

The French Creek resource inventory, on agricultural units, was completed during the 2002 field season. Data was gathered and entered into the District's Geographical Information System (GIS). Approximately 9500 acres were mapped within the watershed. Soils information was also collected and areas lacking information were identified. The Lake DeSmet Conservation District requested assistance from NRCS Soil Scientists to map areas within the watershed that were lacking soils information. The data gaps were mapped and completed by NRCS.

A query was made to the landowners for input on expansion of the project area. It was agreed to include the Paradise Guest Ranch, located in the Bighorn Mountains at the top of the French Creek drainage, and to include the urban area as one inventory unit. These acres were inventoried and mapped in the fall of 2002.

The Lake DeSmet Conservation District had the opportunity to partner with NRCS in providing a GIS Specialist to the District staff. Our GIS specialist joined the District in November and has provided assistance in the restructuring and file management of this project.

Upon completion of the resource inventory and data input, the District compiled all the data and prepared the watershed plan as the final report for the ***French Creek 205-j Watershed Plan*** project. Copies, of the draft report, were disseminated to the landowners for review and comment. The final product was revised and submitted to DEQ.

DEQ MONITORING

In 1998, DEQ conducted a Beneficial Use Reconnaissance Program (BURP) Bioassessment within the French Creek watershed. Four monitoring sites were identified and ranged from the top of the watershed, a recreational and agricultural unit, to the lower watershed, which is primarily urban area. Please refer to the Appendix Map 5, "DEQ Monitoring Sites".

While the report has not been finalized, the expected conclusion is that French Creek fully supports its uses. Localized areas of habitat degradation were identified; however the overall stream appears to be in good condition. Although the stream is not as good as it could be, the water quality is good and the biotic community does not seem to be significantly altered.

PRESENT RESOURCE INVENTORY (2002 – 2003)

The following section describes the watershed by reach (upper, upper-mid zone, lower-mid zone, and lower) as it pertains to the rangeland inventory.

Rangelands

Upper Watershed

The upper watershed is located within a 20 inch plus precipitation zone. Precipitation is fairly evenly distributed throughout the year. Snows are heavy and remain in place throughout the winter. The average annual temperature is 37 degrees Fahrenheit. Plant growth begins in June but could be as late as July, depending on aspect, elevation and slope. Daily temperatures have a wide range between summer, winter and daily maximums and minimums. Freezing temperatures can occur any month during the years.

Wind will vary considerably for different parts of the area because of varied topography. The wind is usually much lighter at lower elevations and valleys compared to higher terrain.

Sunshine is abundant in the latter part of summer being quite sunny. Sunshine averages 70-75 percent during the summer and 40 percent during the winter.

This site provides potential habitat for these species, elk, moose, mule deer, black bear, snow show rabbit, coyote, mountain lion, badger, bobcat, beaver, blue and ruff grouse, hawks, owls and eagles and many songbirds.

Potential plant complex is composed of 70 percent grass and grass like plants, 15 percent forbs and 15 percent woody plants. There is a stand of Lodge Pole Pine on the forested lands surrounding the unit.

Soils on this site vary from shallow to deep and are well drained. They are rapidly to slow permeable, and can be any texture. These soils contain coarse fragments and increase with depth. Parent materials are derived from sandstone, limestone, siltstone and granite.

Major land use, within the upper watershed, is a recreational ranch located on private lands within the Bighorn Mountains, and surrounded by the Big Horn National Forest. It is on this property that water transfers, into French Creek, occur. The upper watershed is steep and graded. The stream bank is well armored with big rock. There is very little evidence of erosion.

The privately owned land in the upper watershed consists of approximately 156 acres. Please refer to Appendix Map 6, "Upper Watershed". Land use consists of 128 acres of rangeland, with 28 acres designated as headquarters. Rangeland is the primary source of forage for domestic livestock and wildlife. It provides water and habitat. The range condition is in good to fair shape.

The major class of livestock, on private lands, in the upper watershed, is horses. They are kept confined in the summer months, and are pastured off property for winter months.

Upper-Mid Zone

This portion of the watershed falls within a 15-19 inch precipitation zone, with June being the wettest month. July through September is somewhat less with daily amounts of precipitation rarely exceeding one inch.

The average annual temperature is 39 degrees Fahrenheit. Temperatures show a wide range during summer and winter between daily maximums and minimums. Temperatures show a wide range primarily due to both warm and cold masses and rapid incoming and outgoing radiation. Freezing temperatures can occur any month during the year. Summer nights are cool and temperatures drop into the mid-teens at most places before sunshine.

Snow can be heavy, and depths of one to two feet are common. Snow can remain in place throughout the year.

Soils in this portion of the watershed can be deep, poorly drained to stony and/or bouldery and well-drained.

This area of the watershed has potential habitat for numerous wildlife species. They include; elk, deer, jack and cottontail rabbit, beaver, small rodents, coyote, mountain lion, badger, song birds, eagles, hawks, owls, weasel, bobcats, sage grouse & marmots.

The plant community is characterized by a variety of plants which can grow on very cobbley, unstable, and somewhat droughty soils to plants that can benefit from a high water table.

The upper-mid zone of the watershed is steep and graded. The stream is quite swift and well armored.

Major land uses are by wildlife, livestock grazing, recreation and natural beauty. The major class of livestock consists of horses, with some cattle.

The upper-mid zone of the watershed consists of approximately 4509 acres. Land use, within this section, consists of approximately 4166 acres of rangeland, 313 acres of pastureland, and 30 acres being utilized as headquarters. Agricultural units number four, along with two ranchette home sites located within this portion of the watershed. Please refer to Appendix Map 7, “Upper Mid-Zone Agricultural Units”.

Land uses have not affected range health. There are minimal resource concerns on the rangelands. Recent years have seen a deferment in grazing, on some of the units. The range condition is good to fair. Runoff occurs in the uplands.

As you proceed down the watershed, in this section, grooming occurs along the riparian zone. This does not interfere with the health of the stream.

Lower-Mid Zone

The precipitation is fairly evenly distributed through the year and averages 12 inches, in this portion of the watershed. The wettest part of the year is April to mid June, with the driest being in July.

This area is subjected to a wide range of temperature from season to season, and somewhat from day to night due to the air mass coming from the north, along with the up and down slope air movement. This air movement can allow freezing to occur any month of the year.

Winds are common at times during the spring, fall, and winter months. Sunshine is quite abundant, with few days passing without some sunshine.

Soils on this site vary in texture from cobbley and/or stony to finer portions of silty clays. Loam to sandy loams and clay loams. Soils occur along stream courses which receive periodic overflow from adjacent slopes. Erosion can occur and is evident along the stream banks. Runoff potential is high.

Plant growth begins about April and continues through July. Fall re-growth will occur if moisture is available. Plant species is a mixture of 70 percent grasses and grass-like plants, 10 percent forbs and 20 percent woody plants.

Wildlife species that occur in this portion of the watershed are deer, antelope, jack and cotton tail rabbit, small rodents, coyote, badger, songbirds, magpies, eagles, hawks, owls, bobcats, sage grouse. The area is also used as a migratory route for many species, seasonally.

In this portion of the watershed, we start to see the area grading out. There appears to a lot of incising due to the water transfers. The stream banks are highly erodible. There is little protection, as the big rock armor is no longer present.

The lower-mid zone of the watershed consists of 6 agricultural units and one rural residence. Total approximate acreage is 4842 acres. Land uses, of this site include grazing, recreational and natural beauty. The land use consists of 3534 acres of rangeland, 853 acres of pastureland, 372 acres of hayland, 47 acres of wildlife habitat, 2 acres of natural area and approximately 34 acres utilized by headquarters. Please refer to Appendix Map 8, “Lower-Mid Zone Agricultural Units”.

Major class of animal use consists primarily of cattle, with a few horses, sheep and wildlife.

Throughout this portion of the watershed, the agricultural unit landowners have been proactive in addressing resource concerns independently and voluntarily. Some of the working facilities have been evaluated, with practices being implemented to reduce and remove landowner risk. These projects were partnered with private landowners and USDA cost share dollars.

There is a CRP buffer project within this portion of the watershed. Please refer to Appendix Photo 1, "CRP Project". Approximately 47 acres were enrolled in the program, with over 100 acres being fenced. Regeneration along the stream has been phenomenal.

Landowners in the watershed were very proactive and initiated the ***French Creek 205-j Watershed Plan*** project. Voluntarily, resource concerns are being addressed. Various conservation practices have been implemented that will enhance the riparian area throughout the watershed.

Lower Watershed

The lower portion of the watershed has annual precipitation that varies from 10-14 inches. The normal precipitation pattern shows lightest precipitation during December, January and February with the peak precipitation occurring from May to the first part of June. Precipitation will decrease from the latter part of June through August with some increase in September. Normally, 35 to 40 percent of the precipitation will fall between 32 degrees and 18 degrees Fahrenheit.

Sunshine is abundant with 65 percent possible sunshine on an annual basis ranging from 55 percent in the winter to 75 percent in late summer.

Wind is estimated to average 8 miles per hour annually, with occasional storms bringing in high winds with gusts bettering 75 miles per hour.

Temperatures show a wide range between summer and winter, and between daily maximums and minimums. This range is primarily due to the incoming and outgoing radiation and rapid passage of both warm and cold air masses. It is averaged that the last spring freezes occur at the end of May, with fall freezes beginning as early as September.

The growth of native cool season plants begins in April to July, with warm season plant growth from the middle of May through August.

The soils for this site are deep to moderately deep, well-drained & moderately to slow permeable. Top soil is 2 to 5 inches deep. Soils can become extremely hard when dry and very sticky when wet.

This site provides habitat for deer, antelope, jack rabbits, cotton tail rabbits, skunk, fox, raccoon and other small animals. Birds include; song birds, magpie, eagles, hawks and owls.

Major uses of this site are urban buildup, grazing and industrial activities. This site is vulnerable to human activities. Land use consists of urban, industrial and business. Please refer to Appendix Map 9, "Lower Watershed"

The riparian area is incised, and shows evidence of erosion. Vegetation manipulation has occurred on some of the stream banks. The stream bank, through the lower watershed, no longer is armored with natural rock. French Creek meanders through subdivision areas, industrial and business sites until the confluence of Clear Creek.

PRESENT RESOURCE INVENTORY (2002-2003)

The following section describes the watershed as it pertains to the irrigated land inventory.

Irrigated Lands

Irrigation occurs in the mid-zone of the watershed. Lands are irrigated for supplemental feeding for livestock and irrigated pastures. Very few acres are irrigated with sprinklers, with the majority of the irrigated lands being flood irrigation. Slopes are steep to moderately steep. Risk of erosion from irrigation water is high.

Water is transferred from French Creek to other basins. French Creek functions as a perennial stream due to the transfer of water in and out of the watershed.

Irrigated lands are being managed for high production to low production potential. There is potential for conversion to gravity sprinkler within the drainage.

GENERAL WATERSHED DISCUSSION

This section will discuss the results of the resource inventory in a general manner, and will encompass water, rangelands and irrigated lands.

Water

French Creek flows easterly with head waters beginning in the Bighorn Mountains. Irrigation water is transferred into the basin at the upper end of the watershed. As the water flows off the mountains, the stream is steep graded and well armored. As the stream flows further east, water is transferred to irrigated fields and out of the French Creek watershed. Once it reaches the lower-mid zones of the watershed, the stream becomes incised and has highly erosive banks. The lower reaches of the creek have been rearranged by urban and industrial buildup.

Rangelands

The upper watershed lands are managed as a recreational unit. Horse and wildlife use occurs throughout the season.

The upper-mid zone serves as a transitional zone of wildlife movements and season long use by wildlife. Livestock grazing occurs as weather permits. There are areas that serve as home sites that are only being grazed by wildlife.

The lower-mid zone is being grazed by wildlife and livestock. Historical use of this area, as well as the upper-mid zone, consisted of migration routes for wildlife herds and as horse pastures for the fort. This area shows signs of high use, along with riparian zones, due to the access to water and erosive soils.

The lower portion is almost non-existence of native rangelands because of urban and industrial build up. The riparian area shows high impact to the channel, as well as heavy use.

Irrigated Lands

Irrigated lands are steep and have a high potential for irrigation water erosion. Irrigation water delivery systems are on steep grades and some are in need of maintenance. Some irrigated lands may need to be farmed in order to improve production. Livestock management along irrigated fields and the riparian area have had an impact to the riparian habitat. Heavy use is occurring on smaller pastures within the watershed.

PRESENT BEST MANAGEMENT PRACTICES

Acres, within the watershed, have been fenced to protect the stream from stream bank erosion, as well as livestock. Working facilities have been reconstructed to reduce landowner risk and risk of livestock impact to the stream.

RECOMMENDED BEST MANAGEMENT PRACTICES

Upon completion of the resource inventory and assessment of the French Creek drainage, the following list describes a number of alternatives to address potential resource concerns, for the watershed as a whole.

- Irrigation water delivery system improvement to enhance irrigation efficiencies.

- To provide assistance in riparian management. Plans would include, but not be limited to, riparian management, riparian fencing, and off-site water development.

- To provide assistance in rangeland management Plans would include, but not be limited to, grazing management plans, fencing, and water development systems.

- General cleanup, within the urban area, fencing, off-site water development and a review of the stream manipulation.

The landowners will determine, from the results of the assessment, whether they will voluntarily move forward into a water quality initiative.

The District would like to thank the Wyoming Department of Environmental Quality, the landowners and the Natural Resources Conservation Service for partnering in a proactive, voluntary approach to address natural resource concerns.

FRENCH CREEK CRP PROJECT PHOTOS

BEFORE

AFTER

BEFORE

AFTER

BEFORE

AFTER

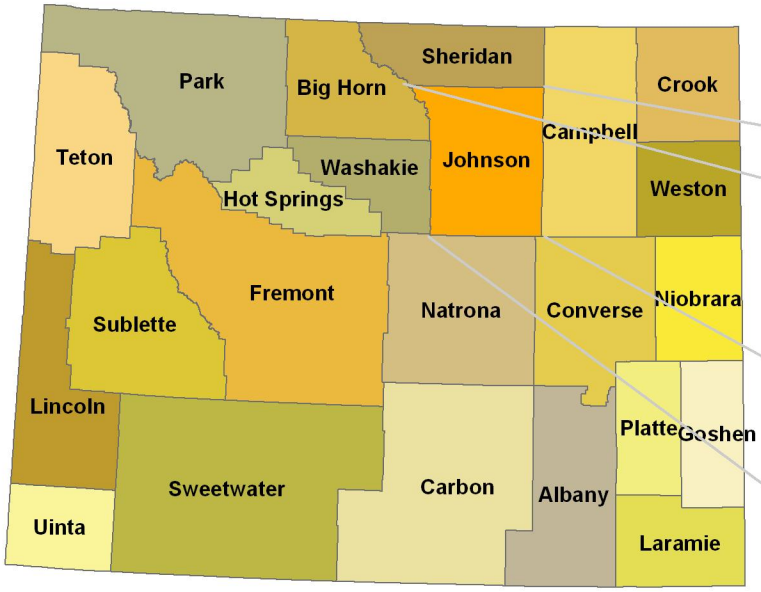
French Creek Watershed - Project Area Location

Project Location

French_Creek_watershed

pls_wy019

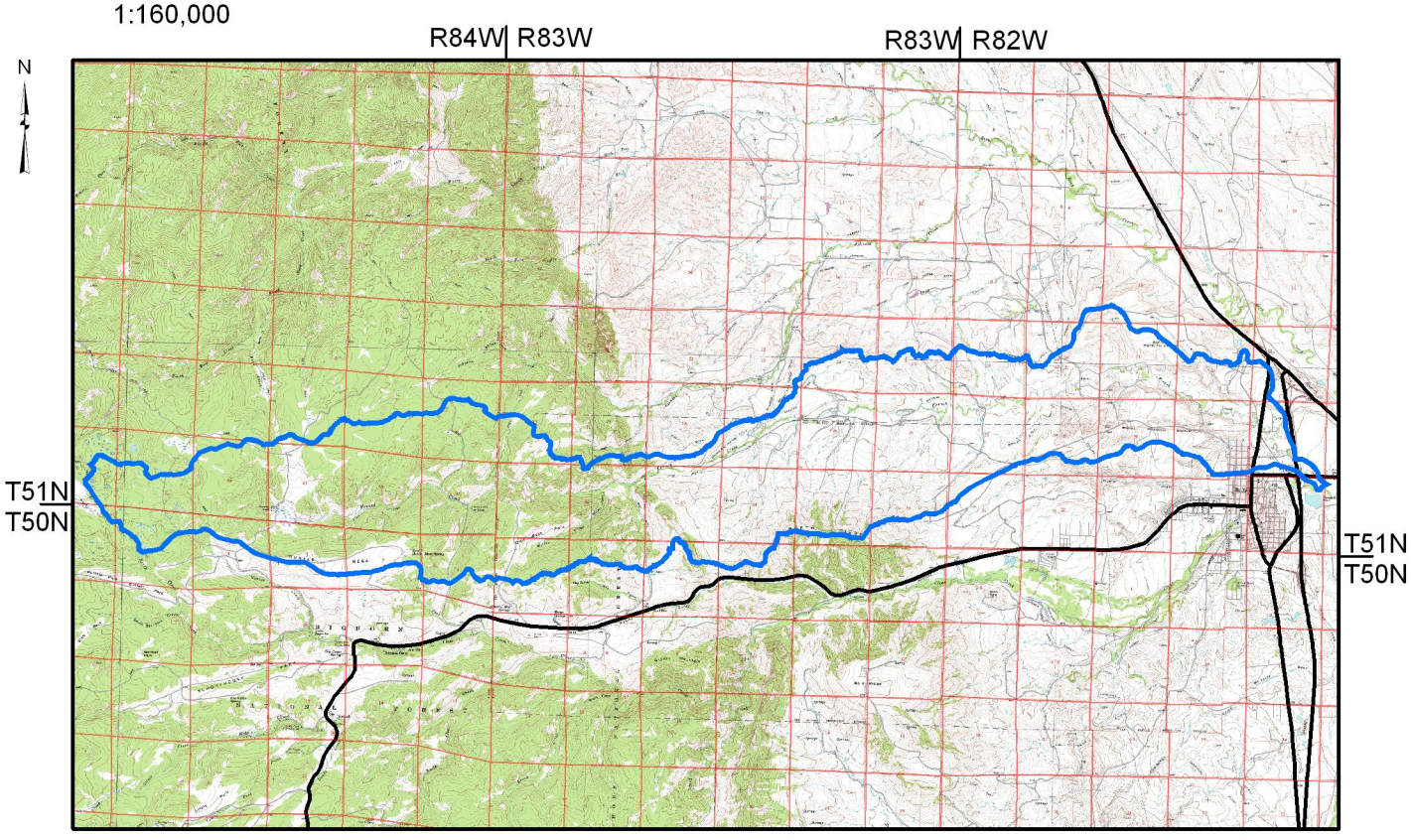
Wyoming



Johnson County

French Creek Boundary

1:160,000

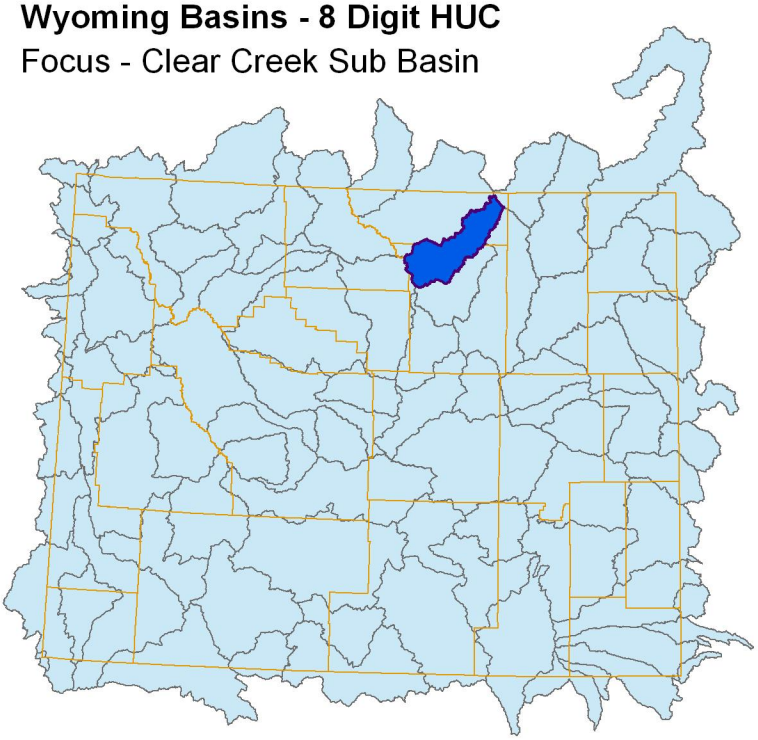


Map 2

French Creek Watershed - Project Area

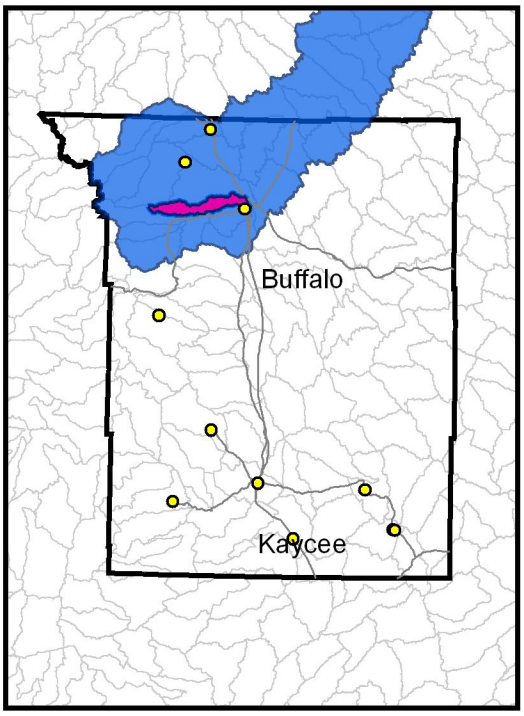
Wyoming Basins - 8 Digit HUC

Focus - Clear Creek Sub Basin



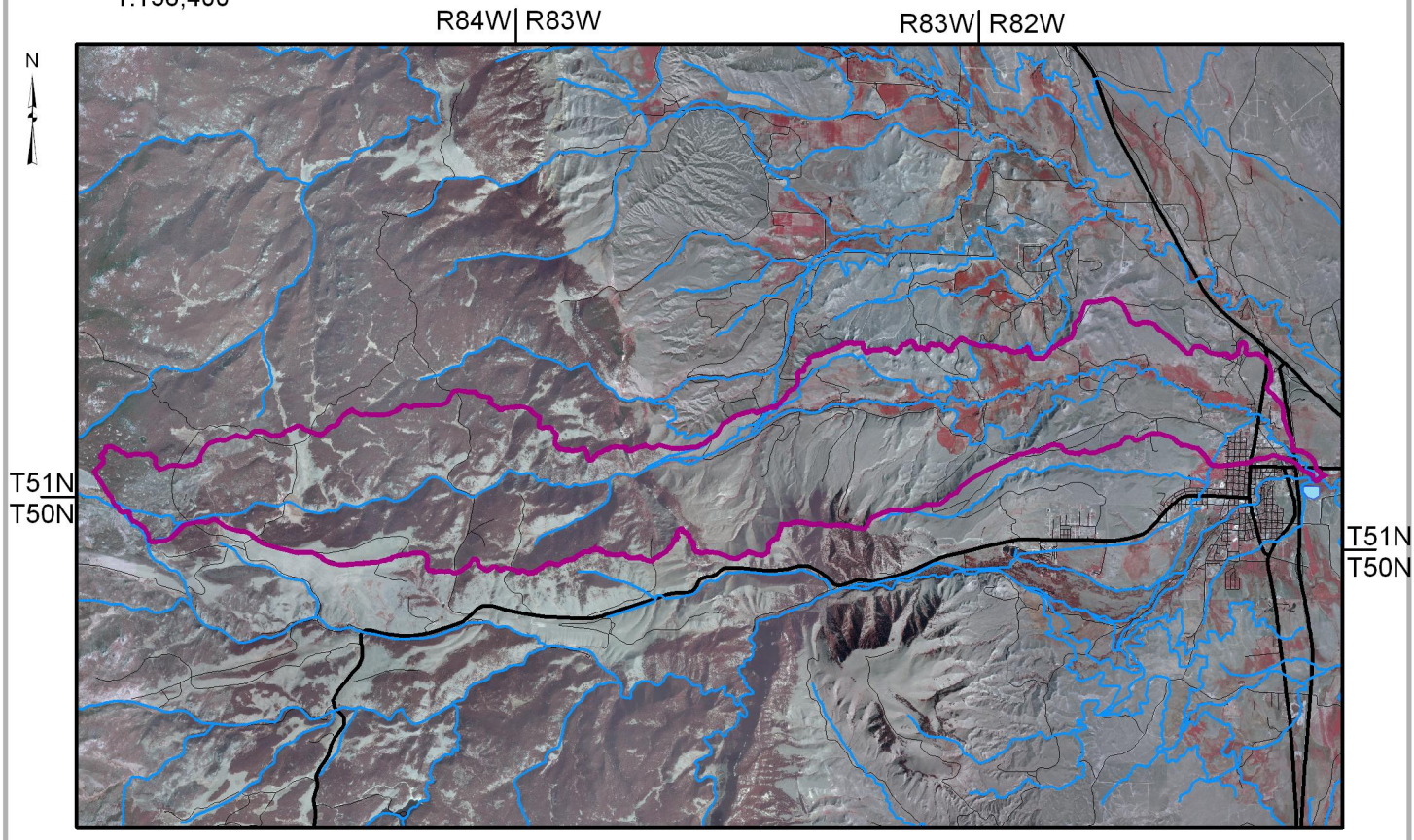
Johnson County Basins - 12 Digit HUC

Focus - French Creek Watershed



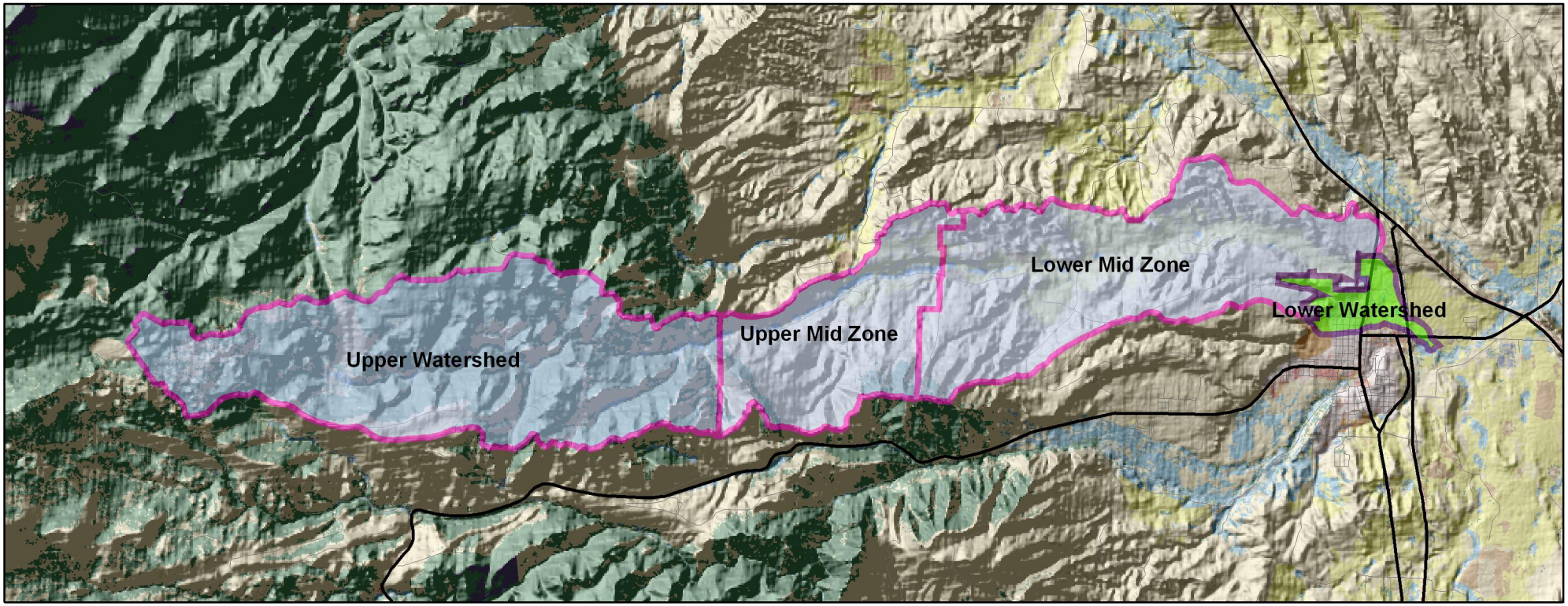
French Creek Watershed - Project Area

1:158,400



Project Area

French Creek Watershed



N
W
E
S

1 inch equals 10,000 feet

20,000 10,000 0 20,000 Feet

Legend

Current Project Area

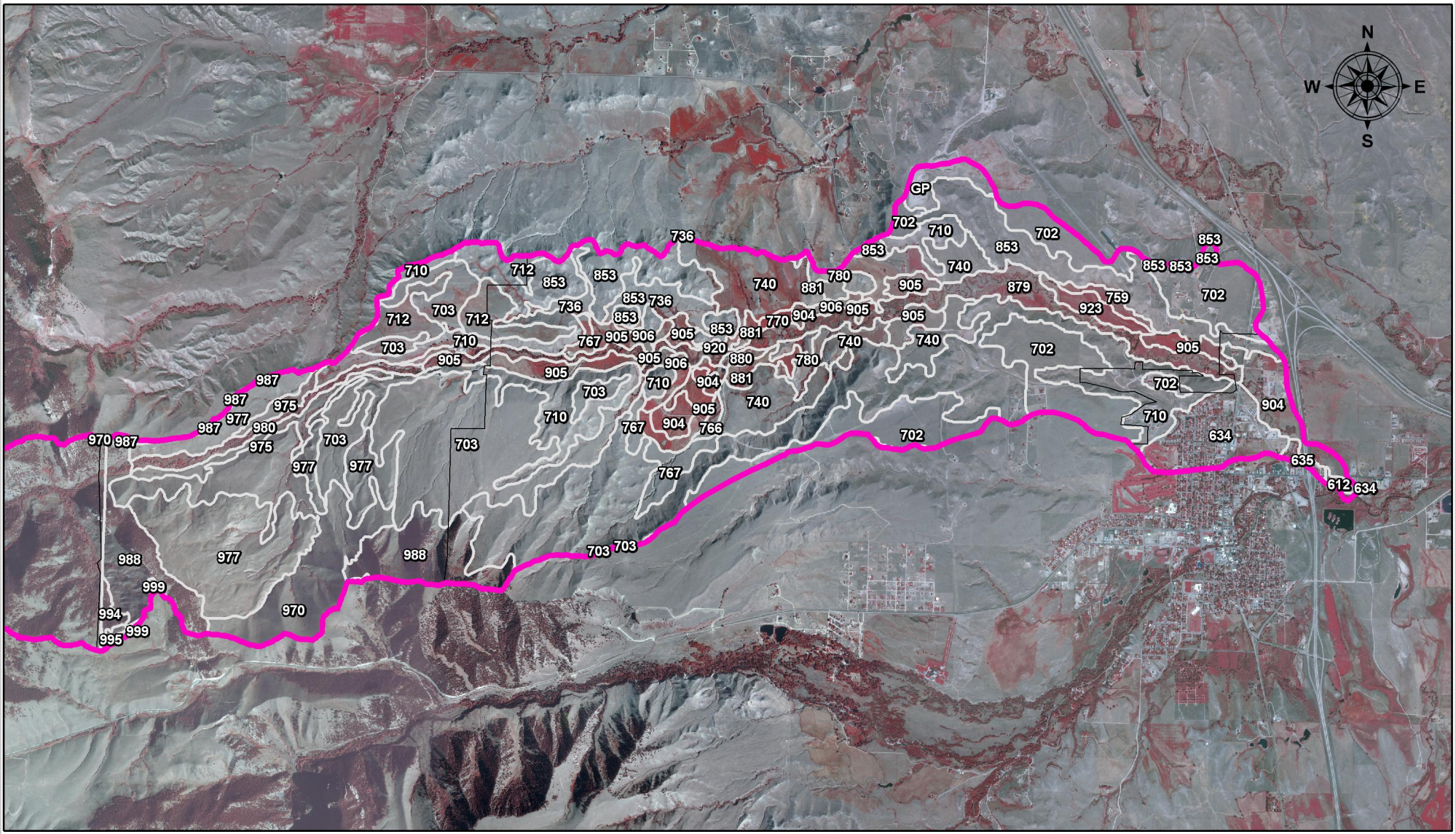
Text

Potentential Future Project

Map 3

French Creek Watershed

Available Soils Interpretations - Preliminary



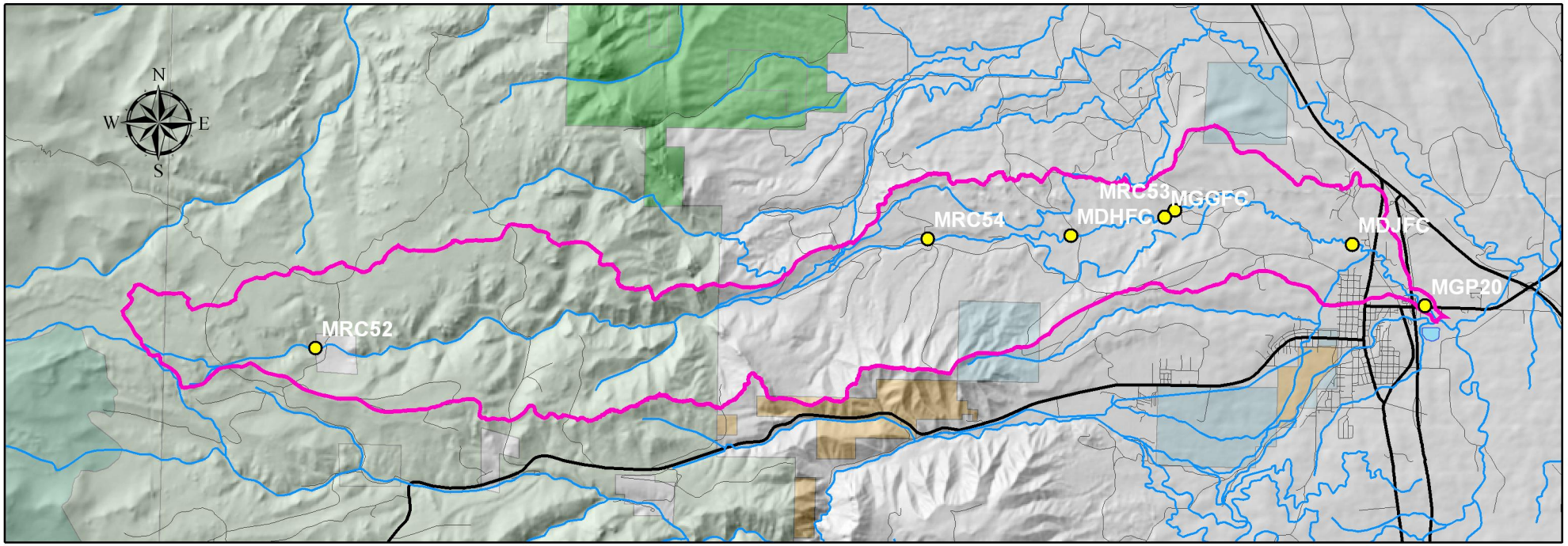
1:63,360

1 0.5 0 1 Miles

Note: The soil interpretations are not final or official.
This information is supplied for referance only.

Map 4

DEQ Monitoring Sites



ID_Code	Pointtype	Reach_Name	Lat	Lon
MGP20	DEQ 1998	Buffalo	44.354526	-106.683776
MRC54	DEQ 1998	Sanders	44.364725	-106.809167
MRC52	DEQ 1998	Above Paradise Guest Ranch	44.342452	-106.962564
MRC53	DEQ 1998	Goddard Ranch	44.370795	-106.747242
MDJFC	FC-LDCD	Low Reach	44.365367	-106.702535
MGGFC	FC-LDCD	Middle Reach	44.369548	-106.749817
MDHFC	FC-LDCD	Top Reach	44.365850	-106.773308

1 inch equals 10,000 feet

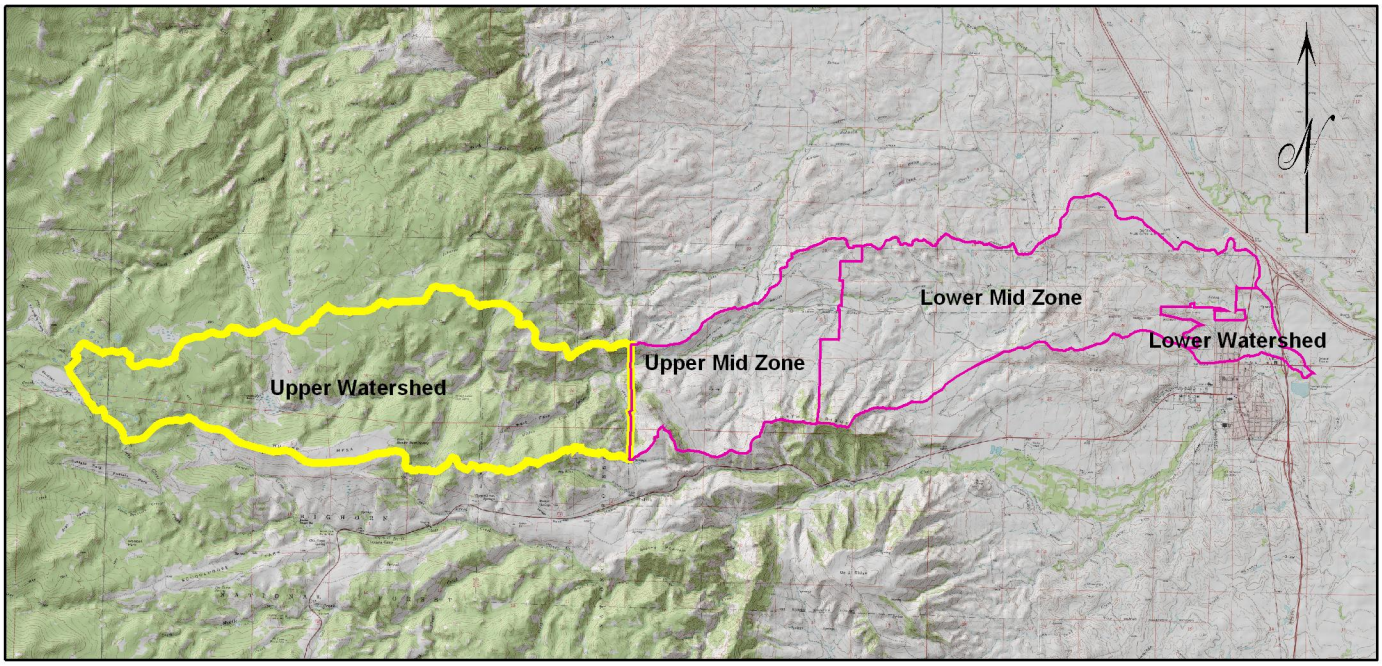
10,000 5,000 0 10,000 Feet

Legend

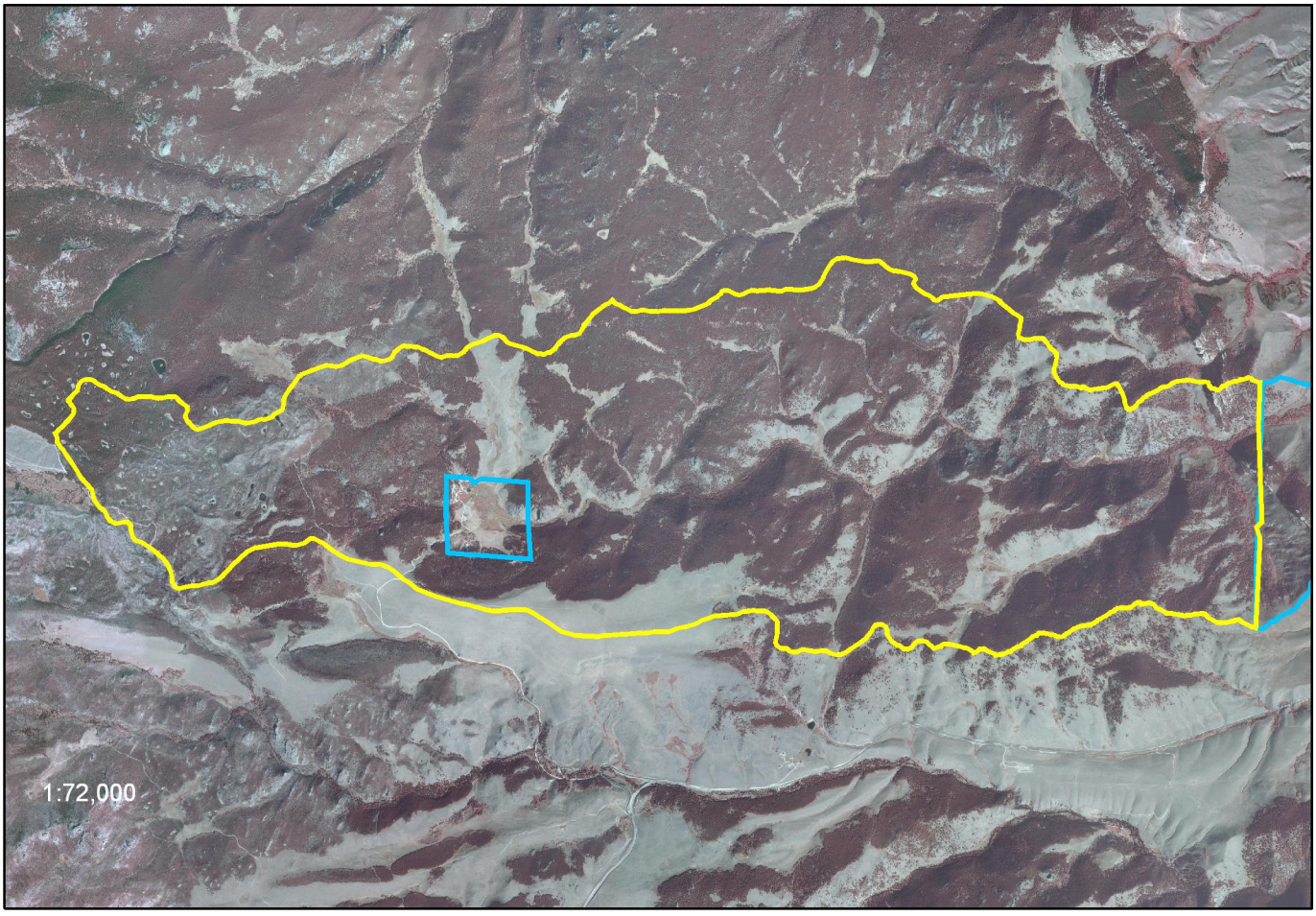
- Water Sample Points
- Streams
- Watershed Boundary
- Primary Roads
- Lakes
- Secondary Roads

Map 5

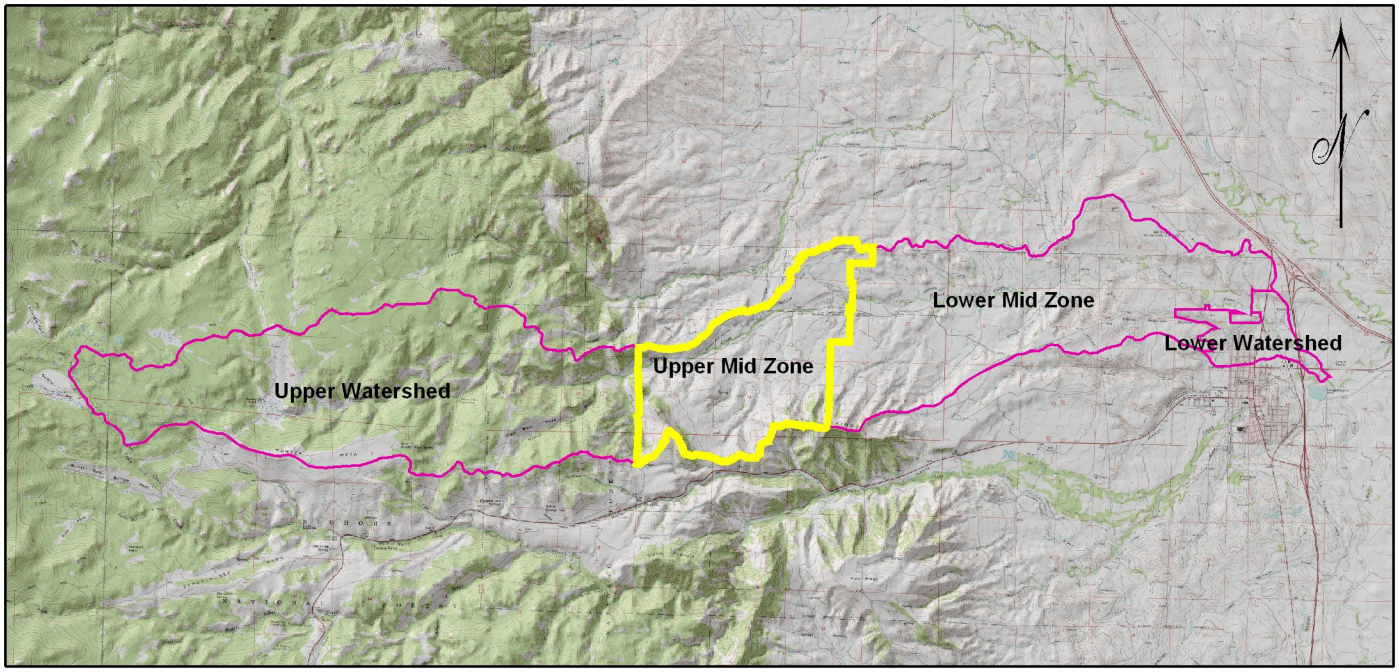
Watershed Zones - Upper Watershed



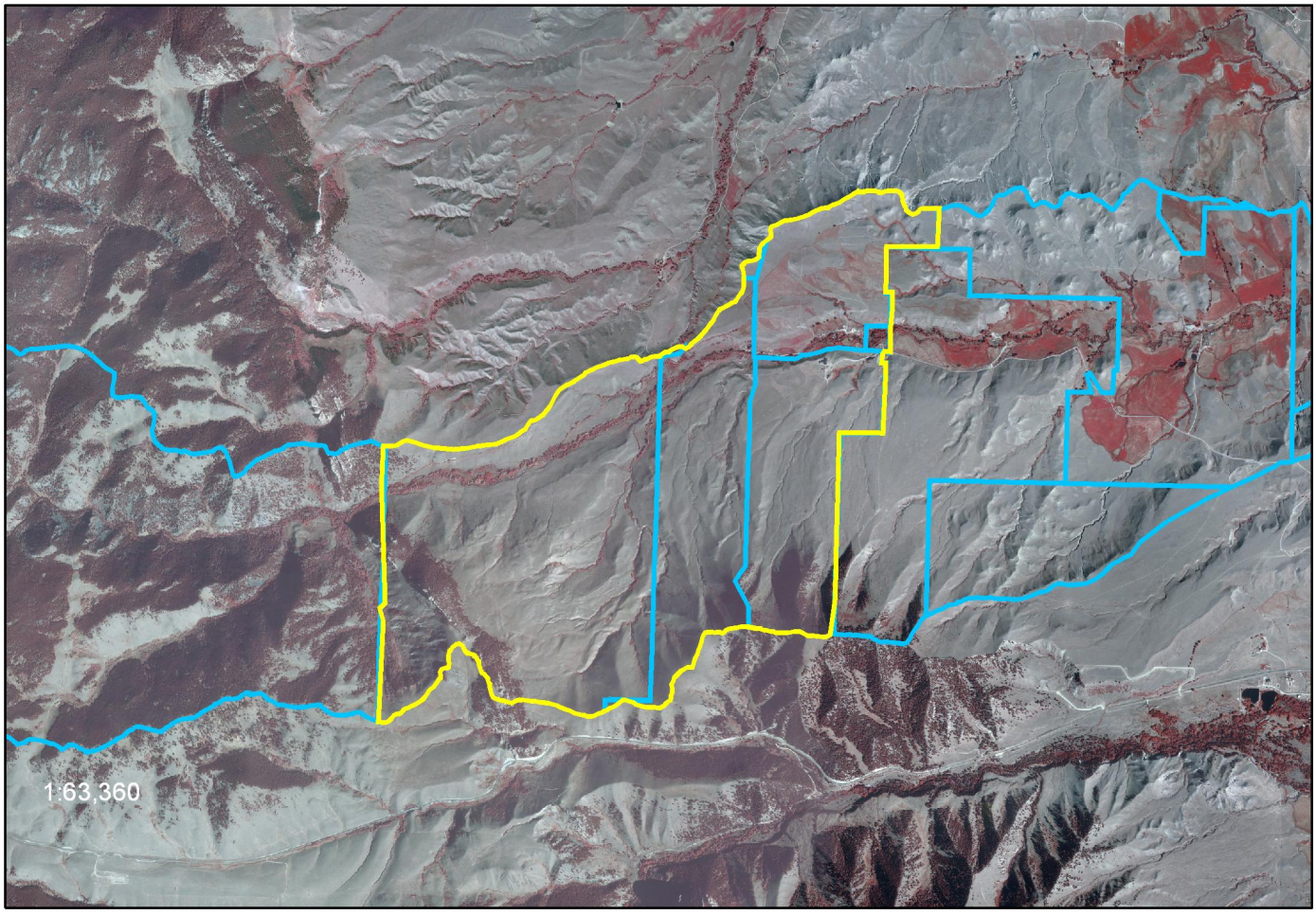
Upper Watershed and Ownership



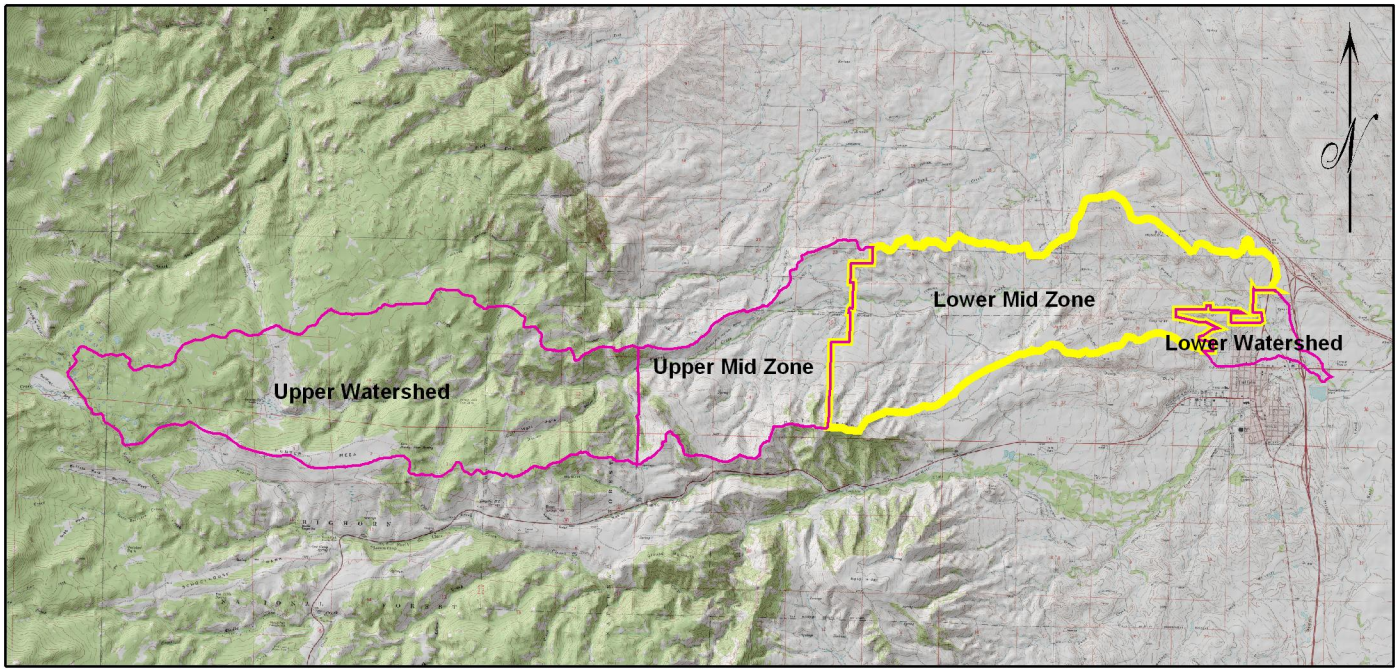
Watershed Zones - Upper Mid-Zone



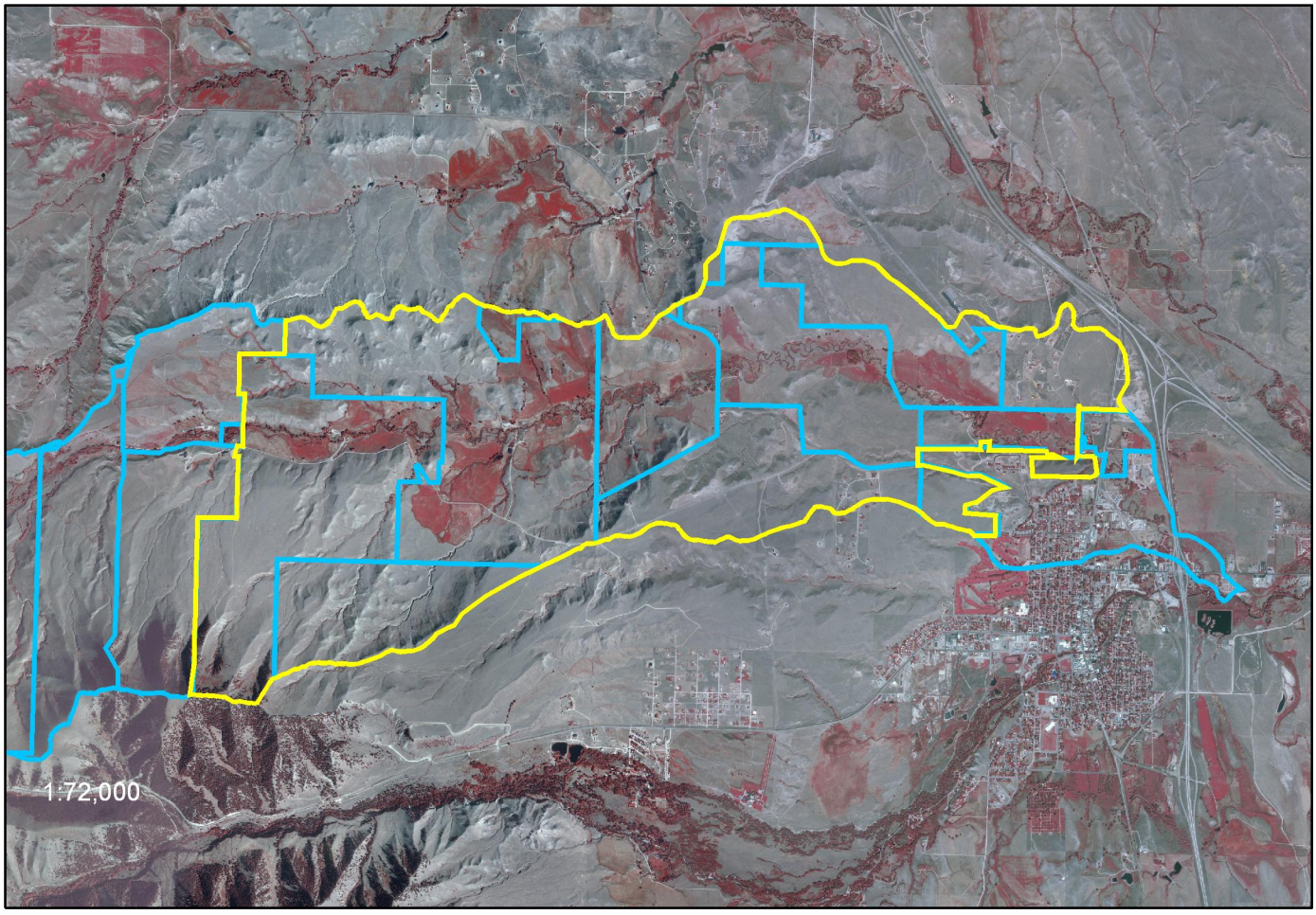
Upper Mid-Zone Agricultural Units



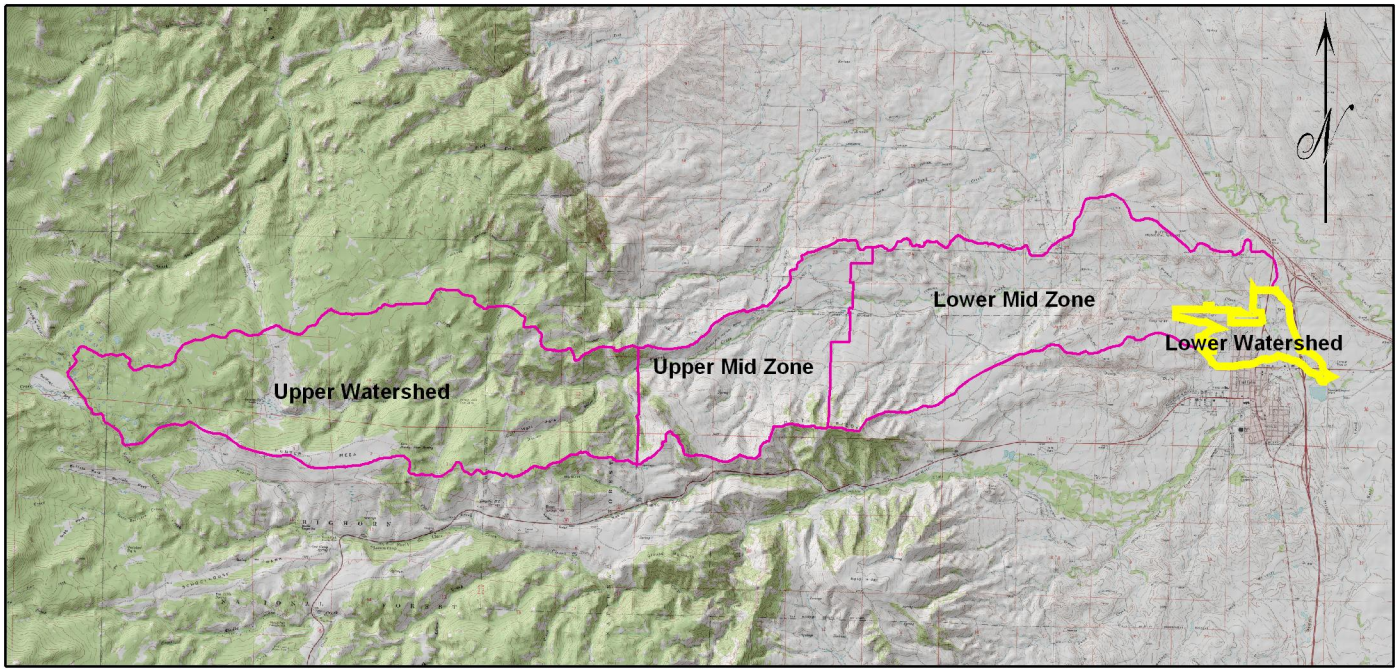
Watershed Zones - Lower Mid-Zone



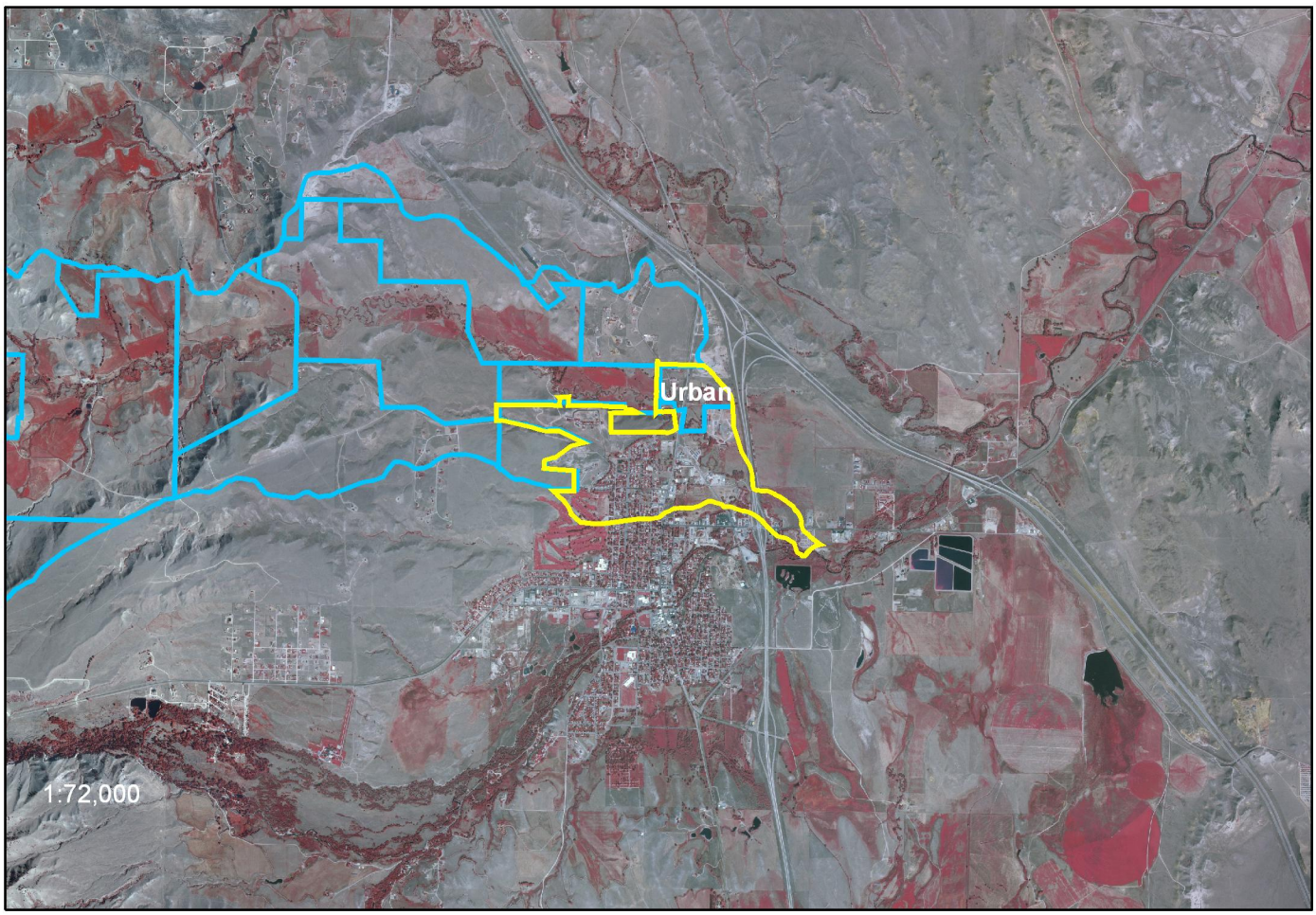
Lower Mid-Zone Agricultural Units



Watershed Zones - Lower Watershed



Lower Watershed



APPENDIX H.

Average Monthly Temperature and Precipitation Data

BUFFALO, WYOMING (481165)

Period of Record Monthly Climate Summary

Period of Record : 8/ 1/1948 to 12/31/2005

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	36.3	39.9	47.1	56.9	66.8	76.6	85.8	84.9	73.8	61.6	45.9	38.6	59.5
Average Min. Temperature (F)	10.0	14.5	21.4	30.6	39.5	48.3	54.5	52.6	42.4	32.0	20.2	12.7	31.6
Average Total Precipitation (in.)	0.50	0.45	0.73	1.55	2.29	2.27	1.39	0.83	1.30	1.00	0.56	0.43	13.30
Average Total SnowFall (in.)	5.7	5.9	5.1	2.5	0.6	0.0	0.0	0.0	0.1	1.9	4.9	6.3	33.0
Average Snow Depth (in.)	1	1	0	0	0	0	0	0	0	0	0	1	0

Percent of possible observations for period of record.
Max. Temp.: 83.8% Min. Temp.: 83.7% Precipitation: 89.7% Snowfall: 66.6% Snow Depth: 56.4%
Check Station Metadata or Metadata graphics for more detail about data completeness.

Western Regional Climate Center, wrcc@dri.edu

APPENDIX I.

Explanation of Soil Types Map

Component Legend

Johnson County Area, Wyoming, Northern Part

Map unit symbol and name	Pct. of map unit	Component name	Component kind	Pct. Slope		
				Low	RV	High
612:						
Clarkelen fine sandy loam, 0 to 3 percent slopes						
	80	Clarkelen	Series	0	2	3
634:						
Urban land-Vonalee complex, 0 to 3 percent slopes						
	80	Urban land	Miscellaneous area	0	2	3
	20	Vonalee	Series	0	2	3
635:						
Urban land-Haverdad complex, 0 to 3 percent						
	70	Urban land	Miscellaneous area	0	2	3
	30	Haverdad	Series	0	2	3
640:						
Forkwood-Cushman loams, 6 to 15 percent slopes						
	50	Forkwood	Series	6	9	15
	30	Cushman	Series	6	11	15
	5	Hiland	Series	6	9	15
	5	Shingle	Series	6	11	15
	5	Theedle	Series	6	11	15
	5	Zigweid	Series	6	9	15
644:						
Moskee sandy loam, dry, 3 to 6 percent slopes						
	85	Moskee, dry	Series	3	4	6
	15	Recluse, dry	Series	3	4	6
645:						
Hiland fine sandy loam, 0 to 3 percent slopes						
	80	Hiland	Series	0	1	3
652:						
Hiland fine sandy loam, 0 to 6 percent slopes						
	85	Hiland	Series	0	3	6

Component Legend

Johnson County Area, Wyoming, Northern Part

Map unit symbol and name	Pct. of map unit	Component name	Component kind	Pct. Slope		
				Low	RV	High
652:						
Hiland fine sandy loam, 0 to 6 percent slopes						
	4	Forkwood	---	---	---	---
	4	Moskee	---	---	---	---
	4	Vonalee	---	---	---	---
	3	Maysdorf	---	---	---	---
653:						
Hiland fine sandy loam, 3 to 6 percent slopes						
	80	Hiland	Series	3	5	6
656:						
Hiland-Bowbac fine sandy loams, 6 to 15 percent slopes						
	45	Hiland	Series	6	11	15
	35	Bowbac	Series	6	11	15
	4	Decolney	---	---	---	---
	4	Maysdorf	---	---	---	---
	4	Terro	---	---	---	---
	4	Vonalee	---	---	---	---
	4	Worf	---	---	---	---
702:						
Featherlegs-Naturita-Willowman complex, 0 to 6 percent slopes						
	50	Featherlegs	Series	0	3	6
	15	Naturita	Series	0	3	6
	15	Willowman	Series	0	3	6
	8	Moskee	Series	0	3	6
	7	Recluse	Series	0	3	6
	5	Nuncho	Series	0	3	6

Component Legend

Johnson County Area, Wyoming, Northern Part

Map unit symbol and name	Pct. of map unit	Component name	Component kind	Pct. Slope		
				Low	RV	High
703: Featherlegs-Moskee complex, 6 to 15 percent slopes						
	50	Featherlegs	Series	6	10	15
	30	Moskee	Series	6	6	15
	10	Wolf	Series	---	---	---
	5	Recluse	Series	---	---	---
	5	Willowman	Series	---	---	---
710: Aridic Argiustolls-Treoff-Featherlegs complex, 10 to 55 percent slopes						
	30	Aridic Argiustolls	Family	20	40	50
	25	Treoff	Series	20	30	50
	20	Featherlegs	Series	10	20	30
	10	Willowman	Series	20	30	50
	8	Schamber	Series	40	45	55
	7	Moskee	Series	10	15	30
711: Turnercrest-Keeline-Taluce fine sandy loams, 6 to 30 percent slopes						
	35	Turnercrest	Series	6	15	30
	30	Keeline	Series	6	10	15
	15	Taluce	Series	6	20	30
	5	Bowbac	Series	6	10	15
	5	Terro	Series	6	15	30
	5	Tullock	Series	6	18	30
	5	Vonalee	Series	6	15	15
712: Featherlegs-Moskee complex, 0 to 6 percent slopes						
	50	Featherlegs	Series	0	3	6

Component Legend

Johnson County Area, Wyoming, Northern Part

Map unit symbol and name	Pct. of map unit	Component name	Component kind	Pct. Slope		
				Low	RV	High
712: Featherlegs-Moskee complex, 0 to 6 percent slopes						
	30	Moskee	Series	0	3	6
	5	Aridic Haplustolls	Family	0	3	6
	5	Recluse	Series	---	---	---
	5	Willowman	Series	---	---	---
	5	Wolf	Series	---	---	---
726: Shingle-Taluce, cobbly, complex, 6 to 40 percent slopes						
	30	Shingle, cobbly	Series	6	23	40
	25	Taluce, cobbly	Series	6	23	40
	15	Badland	Miscellaneous area	6	23	40
	15	Theedle	Series	6	23	40
	10	Turnercrest	Series	6	18	30
	5	Keeline	Series	6	23	40
759: Hargreave-Moskee association, 3 to 9 percent slopes						
	45	Hargreave	Taxadjunct	3	6	9
	30	Moskee	Series	3	6	9
	13	Noden	Series	---	---	---
	12	Hiland	Series	---	---	---
766: Moskee fine sandy loam, 0 to 6 percent slopes						
	85	Moskee	Series	0	2	6
	3	Arwite	Series	0	2	6
	3	Decolney	Series	0	2	6
	3	Hiland	Series	0	2	6

Component Legend

Johnson County Area, Wyoming, Northern Part

Map unit symbol and name	Pct. of map unit	Component name	Component kind	Pct. Slope		
				Low	RV	High
766:						
Moskee fine sandy loam, 0 to 6 percent slopes						
	3	Julesburg	Series	0	2	6
	3	Recluse	Series	0	2	6
767:						
Moskee fine sandy loam, 6 to 15 percent slopes						
	80	Moskee	Series	6	8	10
	8	Arwite	---	---	---	---
	8	Elwop	---	---	---	---
	4	Areas with 10-15 percent slope	---	---	---	---
877:						
Quarterback fine sandy loam, 0 to 3 percent slopes						
	90	Quarterback	Series	0	1	3
	10	Manter	Series	0	1	3
887:						
Nuncho clay loam, 0 to 3 percent slopes						
	80	Nuncho	Series	0	3	3
904:						
Moskee sandy loam, 0 to 3 percent slopes						
	80	Moskee	Series	0	2	3
905:						
Moskee sandy loam, 3 to 6 percent slopes						
	80	Moskee	Series	3	5	6
906:						
Moskee sandy loam, 6 to 9 percent slopes						
	80	Moskee	Series	6	8	9
923:						
Recluse loam, 0 to 3 percent slopes						
	70	Recluse	Series	0	1.5	3

Component Legend

Johnson County Area, Wyoming, Northern Part

Map unit symbol and name	Pct. of map unit	Component name	Component kind	Pct. Slope		
				Low	RV	High
923:						
Recluse loam, 0 to 3 percent slopes						
	8	Moskee	Series	---	---	---
	8	Nuncho	Series	---	---	---
	7	Wetterdon	Series	---	---	---
	7	Wolf	Series	---	---	---
939:						
Disturbed land						
	100	Disturbed land	Miscellaneous area	---	---	---
969:						
Jarre-Pachel-Geohrock, noncalc., complex 6 to 50 percent slopes						
	35	Jarre	Series	10	18	35
	25	Pachel	Series	6	12	18
	20	Geohrock, noncalcareous	Series	20	30	50
975:						
Bronec-Foreleft complex, 3 to 15 percent slopes						
	45	Bronec	Series	3	4	6
	35	Foreleft	Series	3	4	15
	15	Calcidic Argiustolls, very deep	Family	---	---	---
	5	Whitesage	Series	---	---	---
977:						
Skelridge-Delridge-Yamacall complex, 10 to 50 percent slopes						
	30	Delridge	Series	10	10	50
	30	Skelridge	Series	10	43	50
	20	Yamacall	Series	10	34	50
	10	Cabbart	Series	---	---	---
	5	Riedel	Series	---	---	---
	5	Varney	Series	---	---	---

Component Legend

Johnson County Area, Wyoming, Northern Part

Map unit symbol and name	Pct. of map unit	Component name	Component kind	Pct. Slope		
				Low	RV	High
980:						
Nesda-Dalecreek complex, 0 to 6 percent slopes						
	50	Nesda	Series	0	4	6
	35	Dalecreek	Series	0	4	6
987:						
Mantlemine-Crago complex, 3 to 25 percent slopes						
	45	Mantlemine	Series	3	3	25
	35	Crago	Series	3	3	25
	5	FINE-LOAMY HAPLOCALCIDIC HAPLUSTEP	Family	---	---	---
	5	LOAMY-SKELETAL ARIDIC USTORTHENT	Family	---	---	---
	5	LOAMY-SKELETAL CALCIDIC HAPLUSTALF	Family	---	---	---
	5	Whitesage	Series	---	---	---
988:						
Cloud Peak-Dullknife complex, 10 to 60 percent slopes						
	60	Cloud Peak	Series	10	25	60
	20	Dullknife	Series	10	20	30
	---	Lithic Haplocryalfs	Family	10	25	35
	---	Typic Haplustalfs	Family	10	20	30
	---	Ustic Haplocryalfs	Family	10	35	45
994:						
Rock outcrop-Agneston-Rubble land association, 5 to 60 percent slopes						
	35	Rock outcrop	Miscellaneous area	5	30	60
	30	Agneston	Series	5	28	50
	20	Rubble land	Miscellaneous area	5	30	60
	8	Granile	Series	---	---	---

Component Legend

Johnson County Area, Wyoming, Northern Part

Map unit symbol and name	Pct. of map unit	Component name	Component kind	Pct. Slope		
				Low	RV	High
994:						
Rock outcrop-Agneston-Rubble land association, 5 to 60 percent slopes						
	7	Agneston, non-clayey subsoil	Series	5	28	50
995:						
Fourmile sandy loam, 6 to 25 percent slopes						
	100	Fourmile	Series	6	10	25
999:						
Leavitt-Passcreek association, 2 to 30 percent slopes						
	40	Leavitt	Series	2	16	30
	35	Passcreek	Series	2	16	30
	10	Nathrop	Series	---	---	---
	4	Leavitt, darker surface	Series	---	---	---
	4	Passcreek, reddish clayey soils	Series	---	---	---
	4	Starley	Series	---	---	---
	3	Rock outcrop	Miscellaneous area	---	---	---

APPENDIX J.

Photographs

Site No. 1 – Looking downstream

Site No. 1 – Left abutment (left foreground), right abutment (right side)

Site No. 1 – Slump upstream of right abutment

Site No. 1 – Moeller supply ditch upstream of reservoir – erosion

Site No. 3 – Looking downstream

Site No. 3 – Right abutment (background)

Site No. 3 – Left abutment (background)

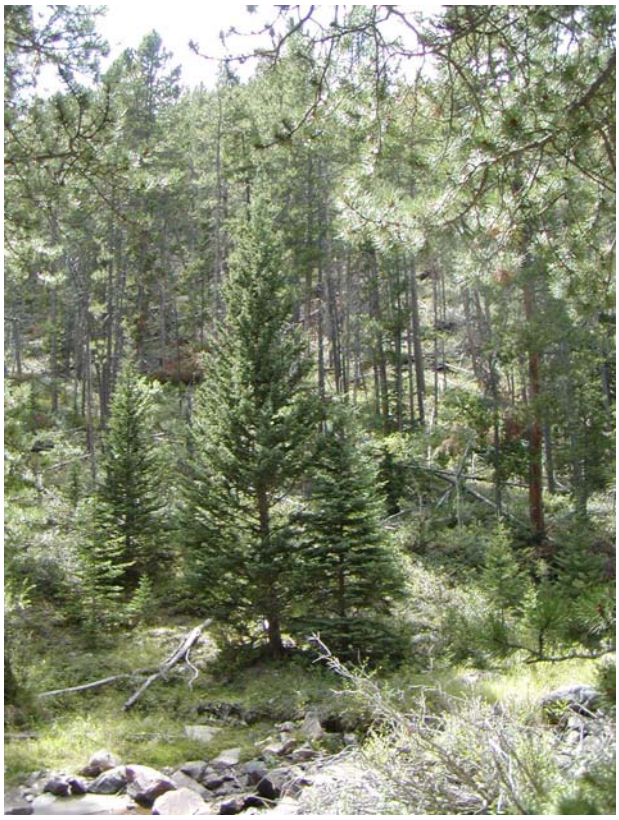
Site No. 3 – Pool area

4 Lakes and French Creek Diversion – Headgate

4 Lakes and French Creek Diversion – Flume

Site No. 4 – Looking downstream

Site No. 4 – Left abutment



Site No. 4 – Right abutment

Site No. 5 – Looking downstream

Site No.5 – Left abutment

Site No. 5 – Right abutment

Site No. 5 – Pool area (fen wetland)

APPENDIX K.

Temporary Stream Gauging Protocol

Temporary Stream Gauging Protocol

Justification

Sufficient stream flow data and diversion records, necessary to adequately locate and size dams and reservoir facilities without risk of forgoing storage opportunities, are lacking throughout much of Wyoming. This lack of data is particularly troublesome in Wyoming headwaters and areas that are tributary to Wyoming's major rivers. Furthermore, manmade water developments that have occurred over history have decreased the amount of water that may be legally stored. No longer can a determination of average annual stream flow coupled with demand based upon crop irrigation requirements guarantee that dam and reservoir construction will proceed. In fact such an analysis would likely forego opportunities. The physical supply is simply not available during much of the irrigation season without accounting for a smaller time interval, which necessary to determine the volume of water that may be stored. Wyoming direct flow water rights are for a prescribed rate of flow; not a specified volume. Flows in excess of the prescribed flow rate may be stored.

Due to recent developments in instrumentation, continuous stream flow and diversion records can be economically acquired. With the installation of relatively inexpensive data loggers and pressure transducers, the resulting continuous record would reveal times when water may be stored that may have been masked by an analysis employing either annual or monthly time steps. To advance a potential reservoir site, stream flow and diversion data would need to be collected and refinements would need to be made to the reservoir hydrology and basin needs. The following plan outlines the procedures and recommended locations for future stream flow gauging and data collection.

Procedure

The collection of stream flow data could be obtained using a temporary stream gage consisting of a water level sensing pressure transducer and data collector. First a suitable reach must be found. The gauged reach should be straight with well-defined, steep banks that will contain a reasonably high flow and have a stable stream bed. The stream bed should be cross sectioned and the flow measured using procedures discussed in the publication series "Techniques of Water Resources Investigations of the U.S. Geological Survey." The pressure transducer and data collector should be calibrated and installed in the gauged section. Flow measurements should be taken at the gauged section at varying flow rates to develop a rating curve relating water depth to flow rate for the section. When an accurate rating curve is established for the section, flow rate can be determined based on water level data collected by the pressure transducer and data collector. Data stored in the data collector will need to be periodically downloaded and the lithium batteries will need to be replaced. This interval is dependant upon the equipment used, data collection interval, battery life, gauging operation plan, and the accessibility of the installation. Pressure transducers should be calibrated yearly prior to spring runoff. Additional field visits may be required during high flows to ensure gage installation integrity is maintained.

The water level sensing pressure transducer and data collector type temporary stream gages are relatively inexpensive and easy to deploy and maintain. The pressure transducer could however be damaged and fail if allowed to freeze into ice. Deployment of this type of equipment should occur in moving water. The pressure transducer and data collector may need to be removed during the winter low flow months. Data collection for these installations will likely begin in early spring and run through mid fall. As weather conditions allow, it is important to have equipment installed before the onset of the irrigation season. Early season runoff is typically the season when most flows accrue to reservoirs.

Alternatives to level sensing pressure transducer stage measurement are bubbler water level sensing systems and stilling well level sensing systems. These two systems require a more substantial power source i.e. solar panel and a protective enclosure. These two systems are more permanent installations and prudent for longer term stage measurement.

Locations

Potential locations for installation of data loggers and pressure transducers include tributaries and major diversions (or stream measurement upstream and downstream of a major diversion) within reaches of a watershed or a major stream that are currently unmeasured. Ideally each tributary and diversion within the reach of interest should be measured. Realistically, measuring of all diversions will not be possible. The opportunity to measure diversions will likely be limited to cooperating landowners. However, measuring a few diversions may sufficiently describe diversion patterns, which would assist engineers with establishing reservoir location and yield. Those diversions selected for measurement should be representative of the reach of interest.

Prior to stream gauge installation, appropriate clearances should be obtained from the landowner or managing agency. Installing temporary, non-destructive, level sensing pressure transducer stream flow gages on National Forests or on lands managed by the Bureau of Land Management will require a Special Use Permit or categorical exclusion authorizing the installation for scientific study. There should be no fee for these permit or licenses. It is estimated that the permit/license will take two months to obtain. Stream gauge installation on State owned land requires a Temporary Use Permit from the Office of State Lands and Investments. A Notification and Impact form must be sent to and approved by the leasee. Upon approval from the leasee, the signed Notification and Impact form, a Temporary Use Permit, and a fee of $25 must be sent to the Office of State Lands and Investments for approval. Stream gauge installation on private land requires permission from the landowner.

To better administer the State's water resources, the State Engineer's Office has begun a program to install additional permanent facilities to measure stream flow and diversions. To avoid duplication of efforts, installation of temporary gauges should be coordinated with the State Engineer's Office Division Superintendents.

Costs

The following costs are based on the temporary installation of level sensing pressure transducer stream flow gages.

- Each water level sensing pressure transducer and data logger setup costs approximately $900.
- Deployment requires two techs approximately three hours per location.
- Each stream gage should be visited and maintained. The time interval of site visits varies with each installation. Data sampling interval, ease of access, battery life, site specific constraints, and overall gauging goals all influence the maintenance routine. It is estimated that for these installations, visits every three months should be sufficient. Additional field visits may be required during high flow to ensure gage installation integrity is maintained. Maintenance requires two techs approximately one hour per location.
- Removal of gages requires two techs approximately one hour per location.

Results

The additional data acquired by the temporary installation of devices to measure stream flow and diversions can be used to supplement existing stream flow records. Hyrdologic models may still be operated on a monthly time step to identify the most likely locations for construction of new dams and reservoirs. However, the temporary installation of gauges will provide additional data that may justify additional analysis of stream flow on either a weekly or daily time step, which would provide engineers additional information to maximize the size of the reservoir and to better describe reservoir operations. For instance, a daily time step analysis of the Roach Gulch Dam and Reservoir, revealed large diurnal fluctuations in stream flows that required irrigators to constantly change the elevation of the diversion structures. The "leveling" of the river due to construction and operation of Roach Gulch Dam and Reservoir eliminated the constant adjustment of headgates. The daily time step analysis and stream leveling were key reasons that irrigators supported construction of the project. Data collection term could vary depending on the type of water year collected i.e. wet, normal, or dry year, parameters of the modeling effort, and the overall goals of the project. Reservoir yields are calculated based on the reservoir facility's ability to store water in normal and dry years. Temporary stream flow gauging in wet years may not produce results to accurately predict reservoir yield. Data collection during dry and normal water years is preferred, and when correlated with long term gauging stations, estimates of basin and reservoir yield can be more accurately determined. It is estimated that three to five years of data collection could produce beneficial results for basin hydrology and reservoir modeling efforts.

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