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Final Report

Sublette Creek Reservoir and Covey/Mau Canal Rehabilitation Project, Level II Study

Submitted to:
Wyoming Water Development Commission

Submitted by:
Short Elliott Hendrickson Inc.
In association with:
Sunrise Engineering, Inc.

February 9, 2009
I hereby certify that all portions of this report except as noted below were prepared by me or under my direct supervision, and that I am a duly Licensed Professional Engineer under the laws of the State of Wyoming.

Douglas M. Yaden

Date: February 6, 2009          Lic. No.: PE-4650

I hereby certify that Sections 5.0 and 6.0 of this report were prepared by me or under my direct supervision, and that I am a duly Licensed Professional Engineer under the laws of the State of Wyoming.

Forrest D. Kennington

Date: February 6, 2009          Lic. No.: PE-9585
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Final Report
Sublette Creek Reservoir and Covey/Mau Canal Rehabilitation Project, Level II Study
Prepared for Wyoming Water Development Commission

1.0 Introduction

1.1 Purpose and Scope

The primary purposes of the Sublette Creek Reservoir and Covey/Mau Canal Rehabilitation Project, Level II Study are to:

- Inventory conditions in the watershed relevant to identification and characterization of water storage related issues and opportunities.
- Review the status of relevant water rights, agreements and the Bear River Compact relevant to the project.
- Review and compile available information on easements and rights-of-way relevant to the Covey and Mau Canals.
- Perform a baseline evaluation of the existing Covey and Mau Canals and prepare a rehabilitation plan to address any necessary and/or recommended repairs, replacements, and/or upgrades.
- Identify and screen alternative surface water dam and reservoir storage sites in the Sublette Creek watershed to identify one or more preferred sites for further evaluation.
- Develop conceptual-level estimates of the costs of the preferred dam and reservoir project(s) identified in the screening study.
- Assess the potential environmental issues or constraints that may affect the alternatives identified; and characterize the permits/clearances and any associated environmental studies and/or mitigation that may be required for the preferred alternative(s).
- Identify and describe potential funding sources for the preferred alternative(s).

The scope of this study addresses each of the above primary purposes in turn, and is fully responsive to the Scope of Services in Exhibit “A” of the Consultant Contract for Services.

1.2 Responsibility

This project was authorized by the Consultant Contract for Services effective June 7, 2007 between the Wyoming Water Development Commission (WWDC) and Short
Elliott Hendrickson Inc. (SEH). The official contractual representative for the WWDC was Michael Purcell, Director of the Wyoming Water Development Office (WWDO). Steve Muth served as the WWDO Project Manager and primary point of contact for SEH on both technical and administrative matters.

SEH’s Project Manager for this study was Douglas M. Yadon, Wyoming PE No. 4650, and except as noted below, all engineering work on the project was performed under his responsible charge. Except as described herein, the work for this project was performed by Mr. Yadon and other selected SEH staff including William R. Kelly, PE, Alan C. Jewell, PE, Aaron S. Ritter, EIT, and Christopher Wichmann. Sunrise Engineering, Inc. of Afton, Wyoming performed the canal inventory and rehabilitation plan and easement/rights-of-way tasks, and assisted in completion of the water rights task. The work by Sunrise Engineering was led by Forrest D. (David) Kennington, Wyoming PE No. 9585.

Numerous landowners, irrigators and ranchers, staff of the Wyoming State Engineers Office in Cokeville, Wyoming, and the Kemmerer, Wyoming office of the BLM, and employees of Rocky Mountain Power and PacifiCorp all provided valuable information and assistance throughout the project. The assistance of John Teichert/Cokeville Development Company, DeMont Grandy/NRCS, and Jade Henderson/WSEO was especially helpful. This included but was not limited to: supporting acquisition of site access as necessary, accompanying study team members during site reconnaissance visits, and providing information on key topics.

1.3 Project Meetings

During the course of the study a total of four (4) meetings were held with the Cokeville Development Company and other project stakeholders in Cokeville. These included the scoping meeting on June 14, 2007, project meetings on December 11, 2007 and April 23, 2008, and a results presentation meeting on September 17, 2008. Information presented at these meetings and attendance lists for each meeting are provided in Appendix A - Meetings. In addition to these public meetings, an informal meeting was held with several of the project sponsor representatives on September 24, 2007 during a site reconnaissance visit.

2.0 Review of Background Information

2.1 Overview

Available relevant and applicable background information on the key topics and tasks of this Level II study was identified and compiled. This included, but was not necessarily limited to seeking information from the following sources during the course of this study and/or during work on other recent similar WWDC projects:

- U.S. Bureau of Land Management (BLM)
- U.S. Geological Survey (USGS)
- U.S. Department of Agriculture/Natural Resources Conservation Service (NRCS)
- U.S. Fish and Wildlife Service (FWS)
- Wyoming Water Development Commission (WWDC)
- Wyoming Department of Environmental Quality (WDEQ)
- Wyoming Game and Fish Department (WGFD)
2.2 Project Geographic Information System (GIS)

The results of a portion of the data collection efforts were incorporated into a Geographic Information System (GIS). A GIS can be described as a three-dimensional mapping tool that can be used to evaluate and compare spatial data pertaining to a wide range of topics. Numerous maps can be "stacked" to overlay information; each map (or "theme") incorporates data (or "attributes") pertaining to the theme.

The primary objective of this GIS was to compile the directly relevant available information pertaining to this area and combine it with new GIS data generated within this project. A large amount of spatial data and imagery is available free of charge for download via the Internet from various federal, state, and local agency websites. Additional GIS data was also gathered through personal contact with relevant agencies. Sources included:

- Bureau of Land Management (BLM)
- Natural Resources Conservation Service’s (NRCS) Spatial Data Gateway.
- United States Geological Survey (USGS)
- Wyoming Game & Fish
- Wyoming Geographic Information Science Center (WyGISC)
- Wyoming Natural Diversity Database (WYNDD)
- Wyoming Water Development Commission (WWDC)
These sources were accessed early in the study and a preliminary GIS was constructed upon which all information collected or generated during the investigation was added. Information collected from these sources and incorporated into the project GIS includes, but is not limited to, the following:

- Hydrography;
- Public Lands Survey (PLSS);
- Sage grouse lek buffer zones;
- Historic trails;
- NWI wetlands; and
- Property ownership parcels.

In addition, data collected during the completion of field and office efforts were incorporated into the Project GIS where appropriate. These data sets include, but are not limited to, the following:

- Potential reservoir locations;
- Transmission line locations; and
- Potential alternative access routes.

The Project Data CD contains the GIS coverages included in the Project GIS and their source. An inventory of the GIS coverages is provided in Appendix B – GIS Inventory.

The project GIS was not intended to be a complete and comprehensive collation of all available spatial data. Only those readily available themes deemed pertinent to this Level II Study and themes produced as part of this study were incorporated. Should the project sponsors acquire new GIS data or desire to include additional existing information in the future, it can easily be incorporated at that time at their discretion. In particular, note that GIS data compiled for the Proposed Resource Management Plan and Final Environmental Impact Statement for the Kemmerer Field Office Planning Area (BLM, 2008) covering a wide range of natural resources, cultural resources, and socio-economic themes will become available after issuance of the Record of Decision (ROD).

### 3.0 Watershed Description and Inventory

#### 3.1 Land Uses and Management Activities

##### 3.1.1 Land Ownership and Administration

The total land area within the Sublette Creek watershed is 19,315 acres (30.2 square miles), all located within Lincoln County. The distribution of land ownership within the watershed is shown on Figure 3.1-1 – Land Ownership and is summarized on Table 3.1-1 – Land Ownership. The source of the land ownership information is WyGISC.

Most of the private ownership is located in the northwestern portion of the watershed along Stoffer Ridge north of lower Sublette Creek and in Sublette Flat to the east. The uplands to the east of Sublette Flat and south of the divide between Ryan and Lost Creeks and lower Sublette Creek, and the southern extension of Stoffer Ridge are largely BLM lands. State lands occur both as irregular parcels generally between
the private and BLM lands and as full or partial “school sections” in the north-central portion of the watershed. The BLM lands make up the largest percentage of lands within the watershed (at about 52 percent); private lands comprise about 36 percent of the area, with the remaining approximately 12 percent owned by the state. All of the BLM lands, and certain private lands within the Lost Creek Cooperative Management Unit (see Section 3.1.2 following), are administered and/or managed by the Kemmerer District. State lands are mostly surface leased to private entities for agricultural use (livestock grazing) under the administration of the State Lands and Investment Board (SLIB). Some of the state lands carry subsurface leases for oil and gas (see Section 3.1.6).

3.1.2 Lost Creek Cooperative Management Unit

The Lost Creek Cooperative Management Unit (LCCMU) is an area of 8,321 acres on the Lost Creek and Ryan Creek grazing allotments in the central- to southeastern portion of the Sublette Creek watershed. Private land holdings aggregating 2,931 acres within what is now the LCCMU were purchased by the Rocky Mountain Elk Foundation (RMEF) in 1996 and 1999, and transferred to BLM ownership in 2003 (WGFD, 2005). The need to address potential effects of water storage projects in the Sublette Creek watershed on the LCCMU is discussed in Section 9.1.

3.1.3 Transportation and Energy Infrastructure

3.1.3.1 Transportation

The primary transportation routes providing access to and/or traversing the Sublette Creek watershed are shown on Figure 3.1-2 – Existing Infrastructure. These major routes and other non-maintained dirt roads and two tracks are described in the following paragraphs.

Railroads. Rail access to the watershed area is via the Union Pacific Railroad line traversing the Bear River Valley. A small rail yard with sidings is located in Cokeville near the northwest corner of the watershed.

Paved and Maintained Gravel Roads. The only through-going paved road providing access to the watershed area is US Highway 30 which parallels the Union Pacific Railroad in the Bear River Valley just east of the watershed. Highway 30 connects Cokeville with Kemmerer to the southwest and Soda Springs, Idaho to the northwest.

The unpaved, but maintained Stock Driveway Road provides managed seasonal access to the Sublette Creek watershed from Wyoming Highway 232 just east of Cokeville (approximately 1.5 miles up the Smiths Fork) to the crest of Stoffer Ridge along the western side of the watershed. The road continues to the south along the ridge beyond the watershed.

Other Roads and Two-Tracks. In addition to the paved state highway and maintained unpaved roads there are a number of dirt roads and two-tracks traversing various portions of the watershed (see Figure 3.1-2). These include the Underwood Canyon road which provides access from the Stock Driveway Road to Rock Creek Ridge and then Dempsey Ridge and Basin in the Tunp Range at the east side of the watershed.
3.1.3.2 Energy Infrastructure

**Electric Power Transmission Lines.** As shown on Figure 3.1-2, a high-voltage electric power transmission line corridor passes through the Sublette Creek watershed from southeast to northwest. The corridor currently contains three (3) 345 kV lines, two (2) owned and operated by Rocky Mountain Power (RMP, a PacifiCorp subsidiary) and the other owned and operated by Idaho Power Company (IPC). A plan is underway by RMP and IPC to add 500 kV of additional transmission capacity between Populus, Idaho and Aeolus Station, Wyoming (Jim Bridger Power Plant) as Segment 4 of the Gateway West Transmission Project. Information about the Gateway project is presented in Appendix C – Electric Power Transmission Corridor.

The routing of Segment 4 is still in the planning and early environmental evaluation stage. It is our understanding that the applicants proposed route was the existing corridor passing through the Sublette Creek watershed (Dale Raugutt/RMP, Personal communication, October 10, 2007; Tetra Tech, 2008). Given the potential for significant negative impact of an additional transmission line or lines in the existing corridor to the sizing of a reservoir on lower Sublette Creek, calls were made to various RMP representatives. In a call with Mr. Witbeck (Vance Witbeck/RMP, Personal communication, November 6, 2007) we were assured that the Cokeville Development Company’s plans regarding a potential water supply reservoir on lower Sublette Creek would be conveyed to the appropriate planning staff and the recently hired third-party environmental impact statement (EIS) consultant. An email summary of the proposed Sublette Creek reservoir project including a number of questions and requests for information was sent to Mr. Vance Witbeck/RMP on November 8, 2007 (see copy in Appendix C).

The Scoping Report on the Gateway West Transmission Line Project (Tetra Tech, 2008) includes the following comment under Section 3.4.3 Specific Routing Requests: “Avoid the proposed irrigation water storage reservoir on Sublette Creek southeast of Cokeville, Wyoming.” Subsequent to publication of the Scoping Report, several alternative routes for portions of Segment 4 have been identified for detailed study. In the most current information available at the time of publication of this report an alternative more or less parallel to US Highway 30 (from south of Kemmerer to south of Sage Junction and then north down the Bear River Valley) has been identified for detailed study. This alternative route would replace the portion of the originally proposed route of Segment 4 passing through the Sublette Creek watershed. The public is welcome to comment on the ongoing EIS process as noted in the information provided in Appendix C. Current information about this process is available online at: [http://www.wy.blm.gov/nepa/cfodocs/gateway_west/](http://www.wy.blm.gov/nepa/cfodocs/gateway_west/), which is the source of the summary information regarding the EIS process provided herein.

**Oil and Gas Pipelines.** No existing oil or gas pipelines are known to traverse the Sublette Creek watershed.

3.1.4 Irrigation

There are a total of approximately 986 acres of mapped irrigated lands within the Sublette Creek watershed (see Figure 3.1-3 – Irrigated Lands). This includes lands irrigated by: center pivots at the north-central boundary of the watershed that are supplied by well; diversions on Sublette, Ryan, Lost and Trail Creeks in Sublette Flat; diversion on lower Sublette Creek; and turnouts on the Covey Canal and Mau Lateral at the lowermost portion of the watershed.
The Covey Canal and Mau Lateral provide irrigation water to approximately 6,290 acres located within the Bear River Valley (Sunrise Engineering, Inc., 2004; see Figure 3.1-3). Except for the center pivots noted above, all irrigation within the watershed and supplied by the Covey Canal and Mau Lateral is by traditional flood methods.

3.1.5 Grazing

Federal Grazing Allotments. Essentially all of the federal (BLM) lands within the Sublette Creek watershed are managed for seasonal livestock (cattle) grazing under all or a portion of ten (10) different allotments.

State Grazing Leases. Most of the state lands within the Sublette Creek watershed are surface leased to private landowners for livestock (cattle) grazing. These leases are issued by the Board of Land Commissioners and administered by the Office of State Lands and Investments (OSLI).

Grazing on Private Lands. Most of the privately owned and managed lands within the Sublette Creek watershed are used for seasonal livestock (cattle) grazing.

3.1.6 Oil and Gas Resources

The Sublette Creek watershed falls within a broad area in the western overthrust belt of Wyoming that is generally classified as having moderate potential for oil and gas. However, there are no existing oil or gas fields and no known active, dormant or abandoned oil or gas wells within the watershed. There are federal oil and gas leases on Sections 29, 31 and 32, T24N, R118W and Sections 5 and 8, T23N, R118W in the southeastern corner of the watershed, and state subsurface (oil and gas) leases on Sections 16, 19 and 30, T24N, R118W in the eastern part of the watershed.

Given the substantial historic and still active oil and gas development in adjacent portions of the overthrust belt and Green River Basin, it is judged unlikely that oil and/or gas development would occur within the Sublette Creek watershed any time soon. Furthermore, based on the location of current oil and gas leases, the most interest is along the eastern margin of the watershed in the Tunp Range (Rock Creek Ridge) remote from the potential surface water dam and reservoir sites identified in this study.

3.1.7 Mining and Mineral Resources

No active or significant mining activity is known within the Sublette Creek watershed. The potential for occurrence of commercial minerals within the watershed is discussed in the following paragraphs.

Coal. The potential for the occurrence of coal is low in most of the Sublette Creek watershed as shown on Figure 3.1-4A – Mineral Resource Potential - Coal. Moderate potential for the presence of coal occurs in rocks of the Lower Cretaceous-age Cokeville Formation and immediately overlying Lower Cretaceous Sage Junction Formation (see Figures 3.2-6A and 3.2-6B). However, even though a moderate potential exists for the presence of some coal, the likelihood of development of this potential resource is judged very low in the watershed. This is due to the much higher quality and quantity coal deposits in other parts of Wyoming and Utah. Locally and historically significant coal mining from which Cokeville derived its name occurred in the Cokeville Formation just east of Big Hill and Rocky Point. This mining was mainly associated with early railroading that made coking coal
production in the area practical, but that was small in scale and relatively short-lived (http://www.wyomingtalesandtrails.com/cokeville.html).

**Phosphorous.** As shown on Figure 3.1-4A – Mineral Resource Potential - Phosphorous, the potential for the occurrence of phosphorous within the Sublette Creek watershed is moderate in most of the watershed, except for the northeastern most portion where potential is high. The high potential occurs in the Permian-age Wales Peak Phosphatic Shale Member of the Phosphoria Formation and the underlying Wells Formation of Permian to Pennsylvanian-age.

Some historic mining of phosphate by the Cokeville Phosphate Company occurred in the vicinity of Cokeville (http://www.wyomingtalesandtrails.com/cokeville.html). However, given the presence of the nearby major, active Western Phosphate Field in southeastern Idaho, it is judged unlikely that future development (or redevelopment) of these local phosphate occurrences would happen anytime soon.

### 3.2 Natural Environment

#### 3.2.1 Climate

**Overview.** The average climate of the Sublette Creek watershed is classified as semiarid. The definition of semiarid adopted herein is a climatic zone with annual precipitation between 10 and 20 inches, and where the predominant vegetation is drought-resistant short grasses and the area is especially susceptible to severe droughts. The climate in the highest portions of the watershed is classified as sub-arid to sub-humid, characterized by greater than 20 inches of precipitation, most of the precipitation occurring as snow, and mixed grasses and forest vegetation. (Thornthwaite, 1931)

Temperature and precipitation vary substantially both seasonally and with elevation within the watershed. The summer months are typically warm and pleasant with cool evenings; July and August experience the highest average daily temperatures. During the fall the days are considerably cooler and by late September average lows are below freezing. Winter in the watershed is cold and harsh with limited access to the higher elevations due to heavy snows. The growing season in the lower portions of the Smiths Fork and Bear River drainages, including the Sublette Creek watershed runs from April to September.

**Drought.** The Sublette Creek watershed lies within a larger area that had until this year been experiencing severe drought conditions since about 2000. At the time of writing of this report the Sublette Creek watershed fell within an area of drought intensity D1 – moderate per the US Drought Monitor for Wyoming: http://drought.unl.edu/dm/DM_state.htm?WY,W. It is not known if 2008 represents the end of the recent period of severe drought or whether this is only a temporary wetter interval in a longer duration drought. Research based on interpretation of tree ring data in the northern Rocky Mountains as reported by the U.S. Geological Survey (2004) indicates that nine droughts of 15-20 years duration and four droughts of greater than 20 year duration have occurred during the past approximately 800 years. This averages to about one to two long-term droughts per century.

**Weather Stations and Records.** As shown on Figure 3.2-1 – Climatology, there are two locations in the general vicinity of the Sublette Creek watershed that have been recording weather conditions for a number of years. The now abandoned Sage 4 NNW station operated for 78 years ending in 2001, while the active Fossil Butte
station has been operating for 18 years. Note that both of these stations are at slightly lower elevations than the average elevation within the Sublette Creek watershed. Average and extreme precipitation and temperature data for these two stations are summarized on Table 3.2-1 – Climate Data Summary. Complete data from both stations is included in spreadsheet format in the Project Notebook.

**Temperature.** Monthly high temperatures average about 55°F in the summer and monthly low temperatures of about 22°F occur in the winter. Annual precipitation at these lower elevation stations has averaged about 10 inches over the periods of record. Note that nearly twice as much of the total precipitation occurs as snowfall at the Fossil Butte station at approximately elevation 6,700 feet as compared to the Sage 4 NNW station at approximately elevation 6,200 feet.

**Precipitation.** Isohyetals of mean annual precipitation are shown on Figure 3.2-1 (http://www.wcc.nrcs.usda.gov/climate/prism.html). As expected, the amount of precipitation is strongly correlated to elevation. The lower portion of the watershed including Sublette Flat and the hills to the west averages about 12-14 inches, while the slopes of the Tunp Range at the east vary from about 16 inches at the base of the slope to 24 inches or more at the watershed divide. Comparison of the isohyetal contours of precipitation with the mean annual values summarized in Table 3.2-1 indicates at least a local over-prediction of 2-4 inches using the isohyetal.

### 3.2.2 Vegetation and Land Cover

Natural vegetation in the large majority of the Sublette Creek watershed is most broadly classified as dryland (rangeland) vegetation; forestland vegetation is present in the northeastern-most, higher elevation areas. The transition between these two major classifications occurs at about the 22-inch precipitation isohyetal shown on Figure 3.2-1. Existing vegetation land cover types as classified by the Wyoming Gap Analysis (GAP) program are shown on Figure 3.2-2 – Land Cover/Vegetation. The classification scheme in the GAP program “organizes vegetation communities into a hierarchical structure with classes based on gross physiognomy at the coarsest level (also referred to as level 1), and community types based on dominant species composition at the finest level (level 6).” More information on the Wyoming Gap Analysis program and the various relevant work products produced to date are available at the following website: http://www.wygisc.uwyo.edu/wbn/gap.html.

Review of Figure 3.2-2 shows that the most common vegetation class in the watershed is Wyoming big sagebrush (which is also the dominant class for the entire state). Except for irrigated or sub-irrigated areas, Wyoming big sagebrush occupies all of the lands from the lower slopes of the alluvial terrace/fan deposits at the east side of Sublette Flat to the western boundary of the watershed. The upper terrace/fan slopes and adjoining lower slopes of the Tunp Range (Rock Creek Ridge) are characterized by xeric upland shrub with interfingered Wyoming big sagebrush. Mountain big sagebrush occurs on the upper slopes of Rock Creek Ridge to the watershed divide, except within the upper reach of Sublette Creek (Sublette Canyon).

Areas of Douglas fir, aspen and lodgepole pine forest are present within or adjacent to the Sublette Canyon reach of Sublette Creek up to the highest elevations in the watershed. These forested lands are locally interrupted by zones of Mountain big sagebrush. The distribution of vegetation types in this portion of the watershed results from the subtle, but important local variations in a number of habitat
conditions including but not limited to slope aspect (the direction the slope faces), slope inclination, and geology (soils and bedrock types).

The north-central portion of Sublette Flat, the middle to lower reaches of Sublette Creek, and the lower reaches of Ryan, Lost and Trail Creeks are mapped as “irrigated crops” in the GAP classification. Comparison with Figure 3.1-3 suggests either that significantly more lands within the central portion of the watershed were being irrigated at the time the imagery used in the GAP analysis was acquired, or that the GAP mapping includes some lands naturally irrigated/sub-irrigated by spring flows, rainfall runoff and possibly seepage from the several small reservoirs along the east side of Sublette Flat north and east of Sublette Creek.

3.2.3 Topography

The topography of the Sublette Creek watershed varies from the steep canyon reach of Sublette Creek in the highest portion of the watershed to the broad, gently sloping floodplain of the Bear River Valley where Sublette Creek confluences with the Bear River (see Figure 3.2-3 - Topography). The total relief in the watershed is 2,725 feet from the top of Cook Mountain at 8,890 feet to the Bear River at 6,175 feet.

The overall topographic grain of the watershed is strongly oriented north-south, reflecting the underlying bedrock and overall geologic structure described in Section 3.2.5. The east side of the watershed is characterized by the north-south trending, west facing slope of Rock Creek Ridge (a portion of the north-south Tunp Range). This remarkably uniform slope is only interrupted at its northern end by the incision of Sublette Creek forming a steep walled canyon in the slope. The central portion of the watershed is characterized by a moderately to gently west sloping old alluvial terrace/coalescing alluvial fan surface in the southern portion of the watershed, and a broad gently sloping surface developed on old alluvium (Sublette Flat) in the northern portion of the watershed, both of which terminate against the toe of the east-facing slope of Stoffer Ridge. Stoffer Ridge is a prominent north-south trending bedrock ridge that separates the lower elevation Sublette Flat/southern terrace/fan surface in the central watershed from the broad Bear River Valley to the west. This otherwise through-going ridge is breached by Sublette Creek in its lowermost reach where it joins the Bear River floodplain.

3.2.4 Soils

Soils mapping covering the Sublette Creek watershed is still in progress and is not available from NRCS in paper or digital/GIS format. Contact the local NRCS office in Cokeville at 307.279.3652 for available information. Check the following NRCS web links to determine if tabular and/or mapping data has become available online since publication of this report: http://soildatamart.nrcs.usda.gov/ – Download Site http://websoilsurvey.nrcs.usda.gov/app/ – Interactive Site.

3.2.5 Geology

The geology of the Sublette Creek watershed is described in the following subsections on surficial and bedrock units, geologic structure, slope stability (landsliding), and seismotectonics (faults and earthquakes). Geologic conditions most relevant to potential surface water storage alternatives are further discussed in Section 7.6 and 8.1.1 below.
3.2.5.1 **Surficial Units**

The distribution of surficial geologic deposits in the Sublette Creek watershed is shown on Figure 3.2-4 – Surficial Geology. Most of the central portion of the watershed is covered with surficial deposits ranging from relatively shallow depths (a few feet) on flanking colluvial slopes to apparently very significant depths (>100 feet) in the alluvium/alluvial fan deposits underlying much of Sublette Flat. Deep alluvium is inferred from available well data presented in Section 3.3.5 and based on regional mapping by Rubey, et al. (1980). These inferred deep alluvial/alluvial fan deposits do not appear to have all formed due to local erosion of Rock Creek Ridge and deposition in Sublette Flat. The available drainage areas to the east appear too small to have contributed the very significant volumes of alluvium present beneath Sublette Flat. Review of regional drainage patterns at a broader scale suggests the possibility that a geologically earlier version of the Smiths Fork once flowed south from its current valley through Sublette Flat and beyond. This would provide a much larger source for the deep alluvium underlying this area. In this interpretation, Smiths Fork was captured sometime later by head cutting from the Bear River at Cokeville and no longer flowed through Sublette Flat. On a much smaller scale, the drainage from Sublette Flat and the canyon reach on Rock Creek Ridge is inferred to have been eventually captured by the Bear River by headcutting, forming what is now Sublette Creek. Ongoing erosion in Sublette Creek and the various other smaller streams draining Rock Creek Ridge (e.g., Ryan, Lost, Trail and Wyman Creeks) and deposition of alluvium at the toe of the ridge resulted in the coalescing fans marking the boundary between Sublette Flat and Rock Creek Ridge.

Surficial deposits on Stoffer Ridge bounding the west side of the watershed are highly variable in type and depth. These deposits are absent in patchy to locally more extensive areas of outcropping bedrock on the ridge crest and steeper slopes. In some areas the bedrock units are weathered to in-place soil referred to as residuum. In other areas the bedrock has weathered and moved downslope forming a blanket of slopewash or colluvium. These deposits are typically from a few inches to a few feet thick, but may be up to 10 or more feet thick locally. Some of these colluvial/slopewash deposits and possibly underlying shallow residuum and weathered bedrock have failed as landslides. These landslide deposits are locally present on the east facing slope of Stoffer Ridge north and south of Sublette Creek (see related discussion in Section 3.2.5.4).

Outcropping bedrock is predominant on the west facing slope of Rock Creek Ridge and within the steep upper reaches of the Sublette Creek drainage (Sublette Canyon). Slopewash and colluvium are locally present, but typically only to relatively shallow depths. An area of residuum (weathered in place bedrock) occurs at the crest of Rock Creek Ridge in the northeastern corner of the watershed. See related discussion of bedrock in Section 3.2.5.2 following.

3.2.5.2 **Bedrock Units**

The bedrock geology exposed at or near the surface and underlying the Sublette Creek watershed to great depths spans a substantial portion of geologic time from the Mississippian/Pennsylvania boundary through as young as the Pliocene (+ 315 million years). Figure 3.2-5 – Bedrock Geology is a GIS-based product derived from the 1:500,000 scale Geologic Map of Wyoming (Love and Christenson, 1985) showing the general distribution of outcropping or near surface bedrock (and major surficial geologic units) within the watershed. Copies of relevant portions of other
geologic maps reviewed during the course of this study are provided in Appendix D – Geologic Maps. More detailed mapping (1:62,500 scale) of all but the southern-most portion of the watershed is shown on Figure 3.2-6A – Geologic Map and the accompanying Figure 3.2-6B – Geologic Section A-A’ and Figure 3.2-6C – Geologic Units Key derived from Rubey, et al. (1980). The following discussion of bedrock geology is based on this more detailed mapping. See Section 3.2.5.1 for a discussion of surficial geology.

The bedrock units exposed within or underlying the Sublette Creek watershed are listed from youngest (Gooseberry Member of the Fowkes Formation) to oldest (Amsden Formation) in Figure 3.2-6A, together with a brief description of each unit. All of these bedrock units are comprised predominantly of sedimentary rocks (claystone, mudstone, siltstone, shale, sandstone, and conglomerate). Most of the units are calcareous, many contain interbeds of limestone/marlstone, and some are predominantly limestone. The older units (including the Phosphoria and especially the Wells and Amsden Formations) are typically comprised of harder, more erosion resistant rock, including some to common chert and/or quartzite. In contrast, the youngest sedimentary units tend to be relatively weak and prone to more rapid, deeper weathering.

These bedrock units have significant effects on the watershed because they are at or near the surface. They influence the nature and distribution of surficial geologic units, which in turn influence soil development. As discussed further in Section 7.6, some of these units will form the foundation at alternative dam sites and/or provide a resource of earth or rockfill for dam construction.

3.2.5.3 Structure

The Sublette Creek watershed lies within the Wyoming salient of the Western Overthrust Belt of Dixon (1982). This is a regional structural province characterized by a series of west-dipping thrust faults, contemporaneous and later normal faults, and associated folding interpreted as having formed by overall east-west compression of the earth’s crust. Of significance to this study are the results of the long history of structural deformation on the rocks at potential dam and reservoir sites in the watershed as discussed here, and the ongoing structural (seismotectonic) activity discussed in Section 3.2.5.5.

As shown on Figure 3.2-6A in plan and Figure 3.2-6B in section, there are five significant bedrock faults present within the boundary of the Sublette Creek watershed. These include the west side up Crawford, Stoffer Ridge and Tunp thrust faults and two unnamed west side down normal faults, all of which trend more or less north-south. As shown most clearly on Figure 3.2-6B, the tectonic (earth) forces that formed these faults also resulted in significant folding of the sedimentary rocks between faults. Folding west of the Stoffer Ridge Fault has resulted in beds that are now locally overturned at and near the surface (i.e., have been bent so far from their original horizontal position that they now dip in the opposite direction – to the east – of the deeper portions of the same unit). When sedimentary rocks are deformed to the degree common within the watershed (and especially on Stoffer Ridge) joints, fractures and small-scale, local faults are the result. These discontinuities in the rock mass tend to be more open at and near the surface and tighter to closed at depth. Where more open, the broken rock mass is weaker, prone to more rapid weathering (deterioration), and more permeable (allows easier passage of water through the rock
mass). The potential effects of these conditions on dam and reservoir siting and design are discussed in Section 7.6 below.

3.2.5.4 **Slope Stability**

Landsliding of any potentially significant scale and/or density of occurrence is largely confined to the lower, east facing slopes of Stoffer Ridge as shown on Figure 3.2-7 – Landslides (and in less detail on Figure 3.2-4). All of these mapped landslides occur within the Gooseberry Member of the relatively young Fowkes Formation. This unit is comprised of relatively hard pebbles and cobbles in a much softer matrix of silty to tuffaceous (altered volcanic ash) limestone. The depth, age of original movement, and degree of recent or current activity for the mapped landslides is unknown. The only other mapped landslide occurs within an area of unconsolidated colluvial debris high in the watershed that is adjacent to Sublette Creek and overlies the potentially active Rock Creek Fault.

Potential triggering mechanisms that could explain the existing landslides within the watershed and conceivably accelerate or reactivate movement on these features include: unloading (undercutting) the toe of the slope by natural erosion; periods of intense and/or sustained precipitation increasing the unit weight of and pore pressures within the susceptible soil and/or rock mass; and/or strong ground shaking from nearby earthquakes (as discussed further in Section 3.2.5.5). These mechanisms can also result in new landsliding of susceptible deposits where none was present before.

3.2.5.5 **Seismotectonics**

The Sublette Creek watershed is an area of only low to moderate historically recorded seismicity, but an area subject to potentially quite high earthquake-induced ground motions due to a number of nearby known and potentially active faults.

**Seismicity.** The historic seismicity of Lincoln County, including the Sublette Creek watershed, is summarized by Case, et al. (2002) in a report titled Basic Seismological Characterization for Lincoln County, Wyoming (copy included in Appendix E – Seismotectonics). Most of the historically recorded earthquakes in Lincoln County have occurred in Star Valley and further north, more than about 40 miles (65 km) from the center of the Sublette Creek watershed. The next most common area of historic earthquakes is north and east of Kemmerer. A few other minor events have been recorded mostly in the southwest portion of Lincoln County, but these are a small minority of the total number of historically recorded earthquakes. (Case, et al., 1997; [http://www.wrds.uwyo.edu/wrds/wsgs/hazards/quakes/quake.html](http://www.wrds.uwyo.edu/wrds/wsgs/hazards/quakes/quake.html)) A total of 99 earthquakes have been recorded within 50 km of the approximate center of the Sublette Creek watershed since 1873, with 65 of these recorded since 1975 (see NEIC Earthquake Search Results in tabular form in Appendix E). The approximate locations of these earthquakes are shown on Figure 3.2-8 – Historic Seismicity. The largest recorded earthquake within the search area was a magnitude 4.8 event on November 19, 1988 located just west of Bear Lake on the Idaho-Utah border. The closest earthquake to the study area was a magnitude 2.6 event located approximately 6 miles southwest of the center of the watershed in the Bear River Valley (note that the uncertainty in location of an event this small can be significant such that the event may have occurred within the watershed or a number of miles further away). ([http://neic.usgs.gov/neis/epic/epic_rect.html](http://neic.usgs.gov/neis/epic/epic_rect.html))

It is important to recognize that the low to moderate historic seismicity near the Sublette Creek watershed is not necessarily a reliable indicator of the potential future
scale of earthquake hazard. The fact that the first historically reported earthquake in Lincoln County, a modest intensity IV event near Bedford, occurred on March 31, 1915 is evidence of the brevity of the historic earthquake record for the study area (i.e., only 93 years). This is an extremely brief period relative to even the recent geologic past that is relevant to the potential for damaging future earthquakes in or near the study area.

**Known and Potentially Active Faults.** Earthquakes and the accompanying strong ground motions and secondary seismic effects (e.g., landsliding, soil liquefaction, etc.) are produced by movement on active faults within the earth’s crust. Sufficiently large earthquakes can result in enough movement on the causative fault to produce offset at the ground surface. Thus, it is important to evaluate the presence, and if present, the potential activity of faults in the area within and surrounding the Sublette Creek watershed. Figure 3.2-9 – Seismotectonic Map shows the location of mapped faults within approximately 50 km of the Sublette Creek watershed that are judged to be of Quaternary age or younger (movement within the last approximately 1.6 million years) and thus classified as active or potentially active. Table 3.2-2 – Quaternary Fault Data summarizes key information for these potential earthquake producing structures. (See the following websites for the sources of the data shown on Figure 3.2-9 and summarized in Table 3.2-2: for static maps see http://earthquake.usgs.gov/regional/qfaults/wy/index.php; for interactive maps see http://gldims.cr.usgs.gov/qfaultviewer.htm)

In terms of potential for surface ground rupture that might affect any of the alternative dam and reservoir sites identified in this study, the only fault of potential concern is the Sublette Flat fault. The Sublette Flat fault is a 36-km long, west-dipping normal fault underlying Sublette Flat and bounding the west side of Rock Creek Ridge and the southern part of the Tunp Range. The age of last movement of this fault is not well constrained, but there is some evidence of offset of Quaternary-age deposits and poorly expressed scarps at the surface. Thus, this fault is considered as potentially active and would require further investigation if any critical facilities were planned over or in the immediate vicinity of this structure.

Of the other faults shown on Figure 3.2-9 those judged most likely to produce future earthquakes that would result in potentially strong ground motions within the Sublette Creek watershed are the Rock Creek fault and the Crawford Mountains (west side) fault due to their proximity and estimated age of last movement (see Table 3.2-2). The Eastern Bear Lake fault (central and southern sections), Grand Valley fault (Star Valley section) and the Western Bear Lake fault show evidence of relative recent movement, but are much further removed from the watershed. The potential for future ground motion within the watershed from these faults is judged similar, but of significantly lower magnitude than from the Rock Creek and Crawford Mountains faults. More detailed information on the above noted faults, and the Sublette Creek fault, is included in Appendix E.

**Random Earthquakes.** Because fairly large earthquakes can and do occur where no known source structure (e.g., an active fault or fold) is known to be present, it is prudent to design critical structures such as high hazard dams assuming that a “floating or random” earthquake could occur near the facility. A previous study for the Bureau of Reclamation (Geomatrix Consultants, Inc., 1988) recommended that a M6.25 event be assumed at a distance of 15 km to address this potential in the seismotectonic province that includes the Sublette Creek watershed. Such an event
would result in peak horizontal accelerations on the order of 0.15g in the site area. (Case, et al., 2002) This level of shaking could result in some effects such as triggering metastable landslides or weakening loose, saturated silty to sandy soils. However, as discussed in the next section strong future strong ground motion in this area will more likely be controlled by the nearby active and potentially active faults than by a random earthquake event of the size estimated here.

**Probabilistic Ground Motions.** The U.S. Geological Survey has developed an interactive program that predicts probabilistic levels of ground shaking in a given area based on the presence of the surrounding known or suspected active earthquake generating structures and the potential for a floating or random earthquake event. This program can be accessed at the following interactive website: http://earthquake.usgs.gov/research/hazmaps/products_data/2008/ . For the purposes of this study, a map showing the predicted peak horizontal ground accelerations within the Sublette Creek watershed with an annual probability of 2 percent of not being exceeded within any 50-year period was generated (see Figure 3.2-9). The recurrence interval for ground shaking of this probability of occurrence is 2,500 years. This probability of occurrence, although very low, is considered appropriate as a basis for earthquake-resistant design of critical facilities (including high hazard dams).

Maximum predicted accelerations in all but the eastern- and western-most portions of the watershed are in the range of 0.80-1.20g as shown on Figure 3.2-9. Slightly lower accelerations are predicted for the eastern- and western-most areas of the watershed (0.60-0.80g). These are very strong ground motions and will require full attention to earthquake resistant design of any significant to high hazard dam in the watershed.

### 3.3 Watershed Hydrology
#### 3.3.1 Hydrologic Regions and Stream Types

The study area comprises the combined drainage basins of Sublette Creek and its primary tributaries Ryan Creek, Lost Creek, Trail Creek and Wyman Creek. The location and extent of the Sublette Creek watershed, the major creeks and tributaries, secondary tributaries, and existing reservoirs are shown on Figure 3.3-1 – Hydrographic Features. This figure also shows the locations of groundwater wells and springs discussed later in Section 3.3.5.

The Sublette Creek watershed falls within the Mountainous and High Desert hydrologic regions as defined by Lowham (1988). The boundary between these regions is taken as approximately the upper west facing slope to crest of Rock Creek Ridge along the east side of the watershed. Elevations in the Mountainous region range from approximately 7,000 feet to a high of 8,890 feet at the summit of Coke Mountain. The High Desert region extends to the west edge of the watershed at the confluence with the Bear River at elevation 6,175 feet.

Streamflows in the Mountainous and High Desert regions are dominated by snowmelt runoff in the spring and early summer. Discharges from springs and seeps and summer rainfall events dominate flows in the summer and fall. Flows are lowest in the winter. As a result of these sources, streamflows in the Mountainous and High Desert regions are typically characterized by relatively smaller peak flows but higher annual runoff than streams at lower elevations.
Sublette Creek and its larger tributaries with headwaters in the Mountainous region tend to be perennial to intermittent streams, while some smaller, lower elevation tributaries and reaches are intermittent to ephemeral. The perennial stream reaches in the watershed are the result of higher precipitation (including greater snowpack) and greater groundwater recharge that, in turn, result in higher spring time runoff flows and sustained seep and spring discharge to these stream reaches through the summer and fall.

3.3.2 Existing Lakes and Reservoirs

There are no natural lakes within the Sublette Creek watershed. There are only two small, non-stock reservoirs, Larson Reservoir and an unnamed reservoir, in the watershed (see Figure 3.3-1). A search of the Wyoming State Engineer’s Office (WSEO) water rights database (http://seo.state.wy.us/wrdb/PS_TnsRngSec.aspx) revealed the following information on these two small reservoirs:

**Larson Reservoir** – Official name Igo Number Two Reservoir; Permit No. PP0005428.0R; permit status – expired; permitted uses – stock watering, irrigation; priority date - 12/5/1930; permit amount - 3.42 ac-ft; source – North Fork Sublette Creek

**Unnamed Reservoir** – Official name Igo Number 1 Reservoir; Permit No. PP0005427.0R; permit status – expired; permitted uses – stock watering, irrigation; priority date - 12/5/1930; permit amount – 71.13 ac-ft; source – North Fork Sublette Creek

Based on field reconnaissance and review of topographic mapping it appears that the permitted storage amounts may be transposed, or that the physical storage capacities (whether utilized or not) are different than the permitted amounts. Regardless, these reservoirs are so small as to not be relevant in terms of this study.

3.3.3 Gaging/Sampling Stations

3.3.3.1 Overview

There are three gaging stations most relevant to this study: U.S. Geological Survey (USGS) gaging station 10035000 on Smiths Fork near its confluence with the Bear River; USGS gaging station 10032000 located approximately 12 miles upstream of the Covey Canal diversion on Smiths Fork; and a seasonal gage operated by WSEO on Sublette Creek. The lower Smiths Fork and Sublette Creek gage locations are shown on Figure 3.3-2 – Gage Stations and Sampling Sites. Given the specific scope of this study, data based on gage 10032000 was used as described in Section 6.0. Data from gage 10035000 was not compiled or used in this study, but will be important for canal diversion and reservoir operations studies in a subsequent study should the project advance. All measured streamflow data for these USGS gages can be found by starting at the following website, entering the site number where indicated, and selecting the appropriate choices and/or filling in whatever other necessary information is required: http://waterdata.usgs.gov/nwis/si. Data for the Sublette Creek gage is described in the following subsection.

In addition to the stream flow gaging stations noted above, several surface water quality sampling sites have been identified within and around the Sublette Creek watershed as shown on Figure 3.3-2. Location and flow data for these sites is compiled on Table 3.3-1 – Surface Water Sampling Sites and Flow Data.
3.3.3.2 Sublette Creek Gage

The only available gage data within the Sublette Creek watershed was collected between 1958 and 2004 at a seasonally installed gage on lower Sublette Creek. The drainage area reporting to this gage is approximately 29.3 mi². As discussed later in Section 4.1, there are a total of twelve (12) surface water diversion rights above the Sublette Creek gage location with a combined decreed flow of 10.31 cfs to irrigate 722 decreed acres. There are also two small reservoirs as discussed in Section 3.3.2 above this gage location. Complete flow records from 1958 through 2004 for this gage are included in the Project Notebook.

Streamflows were typically measured once per day at the seasonally installed weir on Sublette Creek between June 1 and September 30 in 1958 and 1959 and between May 1 and September 30 from 1960 through 2004. The Sublette Creek gage data are plotted graphically on Figure 3.3-3 – Sublette Creek Gage Record. The top plot shows the entire history of gage readings. As seen in this plot flows were typically less than 5 cfs, but occasionally reached or exceeded 10 cfs. On two occasions in the mid-1980s flows between 25 and 30 cfs were recorded. The middle plot on Figure 3.3-3 shows the seasonal nature of the record and some of the monthly variation in flows during the irrigation season. The bottom plot shows the 1970 irrigation season in detail as an example of the variation that can occur in a given season.

3.3.4 Groundwater

Potential for groundwater development within the Sublette Creek watershed was not evaluated in detail as part of this study as the scope of work focused on potential development of surface water supplies. However, available information on groundwater wells and springs within the watershed was compiled and is presented in Table 3.3-2 – Groundwater Well Data and Table 3.3-3 – Spring Characteristics. The location of these and other groundwater wells and springs within and around the watershed are shown on Figure 3.3-1.

Brief review of relevant available references and the data compiled as noted above suggests that there may be potential for groundwater development to serve some of the current irrigation needs in the watershed, thereby freeing up a commensurate amount of the surface water currently consumed for local irrigation. This preliminary assessment is based mainly on the reported yield of 1000-1350 gpm from a single irrigation well supplying center pivot irrigation that was apparently completed in deep alluvial deposits underlying Sublette Flat (see the groundwater well numbered 1 on Figure 3.3-1 and related discussion in Section 3.2.5.1). This yield is similar to yields achieved in the deep alluvium of the adjacent Bear River Valley from which Robinove and Berry (1963) indicate that large quantities of groundwater can be obtained for irrigation and/or other uses.

Potentially significant concerns with large-scale groundwater development from deep, older alluvium under Sublette Flat or deep alluvium in the Bear River Valley include: the rate at which depletions of the aquifer would be recharged; the effect that geologic structure (faults, shear zones, steeply dipping beds) may have on deep recharge from adjacent, upgradient bedrock aquifers; and the potential for groundwater from younger and possibly older alluvium to be found tributary to surface water and thereby subject to depletion allocations under the Amended Bear River Compact.
Regardless of the concerns noted above, the alternative of local groundwater development within the Sublette Creek watershed, as well as the potential for additional groundwater development for irrigation of lands within the Bear River Valley currently served by the Covey Canal and Mau Lateral, may need to be further evaluated as part of NEPA permitting should this project advance to the next level of study.

### 3.4 Water Quality

#### 3.4.1 Suitability for Agricultural Use

**Water Quality Criteria.** The objectives of the water quality evaluations conducted for this study of the Sublette Creek watershed are to compile selected available surface and groundwater quality data and assess the suitability of those waters for agricultural uses (i.e., irrigation and livestock watering).

Criteria for suitability of water for irrigation and livestock watering were compiled from several sources and are shown on Table 3.4-1 – Water Quality Criteria for Agricultural Uses. The criteria shown on Table 3.4-1 were selected from the source documents to be as applicable as practical to the crops and livestock present in the watershed and/or in the areas of the Bear River Valley that could be served by releases from a new reservoir in the Sublette Creek watershed. Although they are believed to be generally applicable, some of the criteria may be somewhat conservative for these crops and livestock.

**Surface and Groundwater Suitability.** The locations of surface and groundwater quality sampling of Sublette Creek, Smiths Fork, the Bear River, and springs/wells judged representative of potential source water for a new reservoir in the Sublette Creek watershed, or currently used to irrigate the lands in the watershed or under a new reservoir, are shown on Figures 3.3-1 and 3.3-2; location and other basic information for these sampling sites is provided on Tables 3.3-1, 3.3-2 and 3.3-3.

The results of the surface and groundwater quality sampling described above relative to assessing suitability for agricultural uses are summarized on Table 3.4-2 – Surface and Groundwater Quality/Suitability. Note that any analytical results that exceed one or more of the criteria presented on Table 3.4-1 would be highlighted on Table 3.4-2. As suggested above, the fact of an exceedance (if any) does not necessarily mean that the water is not suitable for the intended use. It does indicate that less tolerant plants (e.g., early growth or growth in otherwise less than ideal soils) or livestock (e.g., calves, nursing cows) may be less productive than they might otherwise be.

No exceedances of applicable water quality criteria were found in the available surface and groundwater quality data compiled on Table 3.4-2. Based on these results, it is concluded that available surface and groundwater sources for agricultural uses are fully suitable for irrigation and livestock watering.

#### 3.4.2 Stream Classifications

All streams named on the U.S. Geological Survey 1:500,000 scale hydrologic map of Wyoming and other selected streams have been classified for protection of one or more designated uses by the Water Quality Division of the WDEQ. The only stream classification applicable to the Sublette Creek watershed as noted in Table A of the latest Wyoming Surface Water Classification List (WDEQ, 2001) is Class 2AB for Sublette Creek and its perennial tributaries and adjacent wetlands. Other streams in the watershed not listed on Table A but listed on Table B (Wyoming Game and Fish
Department “Streams and Lakes Inventory” database dated June 2000) include Birch Creek (tributary to Trail Creek) and Ryan Creek. Both of these streams are classified 3B. The definitions of Class 2AB and Class 3B as quoted from the Water Quality Rules and Regulations, Chapter 1, Wyoming Surface Water Quality Standards (WDEQ, 2007) follows:

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

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

As part of protecting the designated uses by class noted above, the stream classifications control the allowable effluent limits for point source discharges and the best management practices (BMPs) for non-point discharges to these streams.

3.4.3 Waters Requiring TMDLs

There are no listings of streams within the Sublette Creek watershed on Table A: 2006 303(d) Waters with Water Quality Impairments as published by WDEQ (2006).

4.0 Review of Water Rights

The fundamental concept of surface water storage within the Sublette Creek watershed as proposed by the current project sponsor (Cokeville Development Company, in cooperation with the Town of Cokeville and Lincoln County) is summarized as follows:

- Principle source of supply is Smiths Fork; a small supply may be able to be derived from Sublette Creek drainage only if necessary and to the extent available;

- Storage in Sublette Creek watershed to be considered as “off-channel” to Smiths Fork;

- Minimum desired storage is 4,100 ac-ft (Original Bear River Compact right as discussed below); and
Maximum desired storage is 14,520 ac-ft (including additional storage potentially available under Amended Bear River Compact and State Allocation Plan as discussed below).

Water rights within Sublette Creek and existing and potential storage rights (including under the Bear River Compact) relevant to this storage concept are discussed in the following subsections.

4.1 Sublette Creek Water Rights

A total of 11 surface water diversion rights were found within the Sublette Creek watershed in the State Engineer’s online database and one additional 0.2 cfs right is included in the earlier published Tabulation of Adjudicated Water Rights of the State of Wyoming – Water Division Number 4, Surface Water (WSEO, 1999). Key information regarding these water rights is summarized on Table 4.1-1 – Surface Water Diversion Rights. Copies of the Tabulation and online database containing information on these rights are provided in Appendix F – Water Rights.

The points of diversion for all but one of the 12 rights noted above are located above a seasonal gage operated by WSEO (see Section 3.3) and above the lowermost alternative dam and reservoir site considered in this study (Site 1 – Lower Sublette Creek; see Section 7.0). The total decreed flow of rights above the gage/Site 1 is 8.31 cfs; with the 8.94 cfs decree below the gage/Site 1 the total decreed flow in the watershed is 17.25 cfs (34.2 ac-ft/day). Assuming a 150 day irrigation season, the maximum seasonal diversion for the total decreed flow is 5,131 ac-ft. See Section 7.4.2 for discussion of estimated storable flows on Sublette Creek.

4.2 Bear River Compact

The Amended Bear River Compact addresses interstate control of the distribution and use of flows of the Bear River and its tributaries among Wyoming, Idaho and Utah to benefit the significant agricultural interests and other water users in the basin. The history of the original Compact and the 1980 Amendment are discussed in Sunrise Engineering, Inc. (2004) and Forsgren, et al. (2001). The primary provisions of the Amended Compact most relevant to this study include the following:

- The Sublette Creek watershed lies within the Central Division, one of three divisions under the Bear River Compact.
- When either the divertible flow (the sum of all diversions in Wyoming and Idaho within the Central Division and flow in the Rainbow Canal and of the Bear River passing downstream from Stewart Dam in Idaho) is less than 870 cfs, or the flows of the Bear River at Border Gauging Station (at the Wyoming – Idaho border) is less than 350 cfs, a water emergency shall exist.
- Under a water emergency, Wyoming’s share of divertible flow shall be limited to not exceed 43 percent of the total divertible flow (with the remaining 57 percent of divertible flow allocated to Idaho’s benefit); these allocations shall be administered in accordance with the respective state water law.
- Wyoming’s pre-Compact storage rights recognized under the original Compact totaled 2,150 ac-ft; the Original Compact grants an additional 17,750 ac-ft of storage rights to Wyoming for use by Wyoming; all such additional rights are subordinate to existing direct flow rights and to pre-existing storage rights above Stewart Dam.
■ A further Amended Compact storage entitlement of 35,000 ac-ft was made to Wyoming with the provision that such storage shall not result in depletion in Wyoming in excess of 13,000 ac-ft per year from rights put to beneficial use after January 1, 1976, including depletions from tributary groundwater used for other than domestic and stock watering uses.

■ No Amended Compact storage is allowed when the water surface elevation of Bear Lake is below elevation 5911 feet.

■ Should Bear Lake be full, additional rights to store water that would otherwise bypass Bear Lake were granted above Bear Lake in the Upper and Central Divisions with Idaho receiving 6 percent and Utah and Wyoming each receiving 47 percent.

4.3 State Allocation Plan
As a result of the Amended Bear River Compact, the State of Wyoming adopted an original allocation plan for its share of the water in 1983. The allocation plan divided the additional storage and depletion limits between Upper and Lower Allocation Areas. The allocation was further divided among several existing and potential projects in each area. In the case of the Lower Allocation Area, most of the water considered available for storage was allocated to the Town of Cokeville and the Cokeville Development Association for a project in the Smiths Fork drainage, mainly for use by agriculture and otherwise for municipal uses. The original allocation of storage to the Town of Cokeville/Cokeville Development Association is summarized as follows:

<table>
<thead>
<tr>
<th>Town of Cokeville/Cokeville Development Association</th>
<th>1983 Allocations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1958 Original Compact</td>
<td>1980 Amended Compact</td>
</tr>
<tr>
<td>Storage (ac-ft)</td>
<td>4,100</td>
</tr>
<tr>
<td>Depletion (ac-ft)</td>
<td>2,200</td>
</tr>
</tbody>
</table>

Subsequent to 1983 several updates (new allocations or reallocations) have been made by WSEO in the Upper and Lower Allocation Areas. In the Lower Allocation Area a total of 367.5 ac-ft of unallocated storage under the original 1958 Compact was held as follows: 62.5 ac-ft to Keith Putnam for a proposed project on Rabbit Creek; 55 ac-ft for an undesignated future project on Thomas Fork; and 250 ac-ft for Woodruff Narrows Reservoir for a planned enlargement of Wyoming’s storage share. Subsequent to the 1983 allocations, the 62.5 ac-ft and 55 ac-ft allocations have been reallocated to the Town of Bear River, and the 250 ac-ft allocation for the Woodruff Narrows enlargement has been made. (Personal communication, Sue Lowry/WSEO, August 26 and October 21, 2008) None of these reallocations affect the original allocations to the Town of Cokeville/Cokeville Development Association.
Two allocations of 50 ac-ft each (Town of Bear River and Coy Reservoir) have been made from the 1980 Amended Compact allocation (Personal communication, Sue Lowry/WSEO, August 26 and October 21, 2008). These allocations would presumably reduce the original allocation of 10,420 ac-ft to the Town of Cokeville/Cokeville Development Association by 100 ac-ft to 10,320 ac-ft. The overall allocation (original and amended) to the Town of Cokeville/Cokeville Development Association would then total 14,420 ac-ft (4,100 ac-ft + 10,320 ac-ft). Of this total, 4,100 ac-ft can be stored without the Amended Compact constraints noted above, including without a depletion requirement. This minor assumed reduction in allocation and the assumed accompanying slight reduction in depletion allocation subsequent to 1983 are not significant in terms of the alternatives being considered in the current study.

No formal or informal requests for significant new allocations or reallocations that would directly impact the current allocations to the Town of Cokeville/Cokeville Development Association have been identified (Personal communication, Sue Lowry/WSEO, August 26 and October 21, 2008). However, more recent correspondence from the WSEO to the Cokeville Development Company provides that “if a Smith’s Fork project does not materialize by December 31, 2015, it is likely that the 4,100 AF of the Original Compact storage would become available for reallocation to a more feasible project elsewhere in the Bear River Basin in Wyoming.” (WSEO, 2005; see copy in Appendix F). It is our understanding that an extension of this deadline would likely only be considered if continuous due diligence is demonstrated and that the need for the extension involved one or more factors beyond the control of the applicant (e.g., an ongoing extended NEPA permitting process) (Personal communication, Sue Lowry/WSEO, August 26 and October 21, 2008).

5.0 Easement and Right of Way Review

Extensive research of deeds and right of way widths and easements were beyond the scope of this study. The Covey Canal crosses approximately 60 parcels of land held by various owners including some State and BLM parcels. The Mau Lateral crosses 27 parcels. It is assumed that there are easements for the canals and maintenance activities to occur from at least the downhill side of the canal bank. The easements may not, however, encompass much land on the uphill side of the canals where no maintenance activities have historically taken place. This easement configuration, if correct, does present potential issues with regard to the liner options that require a key trench on the uphill side of the canal. Construction of the key trench will require equipment to access both sides of the canal and additional easement acquisition will be required on the uphill side in areas where a synthetic liner is used.

The use of PAM is the best alternative when trying to remain within existing historic canal and canal maintenance limits. Preparation for the PAM is similar to historic canal maintenance activities and will not require additional access.

In the case of a piped section it is anticipated the work could be completed using the existing canal and lee (downslope) bank where maintenance has historically occurred to complete the pipe installation. In areas where the canal circumvents deep draws it may be advantageous to bypass the draw with the new pipe in which case additional easement will be required for the installation of the pipe across the draw and a flushing drain at the low point in the pipe.
Given the complexities and common uncertainties regarding rights, responsibilities and easements related to irrigation canals/ditches, a pamphlet titled *Legal Aspects Relating to Irrigation Ditch Rights and Easements* (WSEO, 1994) is provided for reference in Appendix G.

### 6.0 Canal Evaluation

#### 6.1 Background

The Cokeville Development Company (CDC), under the current State Allocation Plan, has the opportunity to store and utilize 4,100 acre feet of Original Bear River Compact Water not subject to the Compact and 10,320 acre feet of amended compact water subject to the terms of the Compact (see related discussion in Section 4.0). The long-standing intent of the CDC has been to construct a reservoir using Smiths Fork water. Previous studies have focused on sites on Smiths Fork or tributaries to Smiths Fork, including most recently a study by Sunrise Engineering, Inc. (2004).

Because of the Covey Canal route to Sublette Creek, and the piped inverted siphon section across Sublette Creek, the use of a lower Sublette Creek site for a reservoir appears quite favorable (see related discussion in Section 7.0). The use of the existing Covey Canal to convey flows to the reservoir overcomes a major hurdle (the cost and permitting of a major conveyance) that precluded other offstream sites in previous studies. The remainder of this evaluation of the Covey/Mau Canal system assumes that it is intended to use the Covey Canal as the supply conveyance to a reservoir sized to use at least all of the 4,100 acre feet of Original Compact water. As discussed further in Section 7.5.4, a target storage capacity of 5,000 ac-ft was established for such a reservoir on lower Sublette Creek, with a variant located just downstream that could hold approximately 9,000 ac-ft.

It is first necessary to determine the technical and operational feasibility of diverting and conveying 5,000 ac-ft from the Smiths Fork to a lower Sublette Creek reservoir. This evaluation begins with an assessment of the average monthly flows on Smiths Fork flows as summarized on Table 6.1-1 – Smiths Fork Average Monthly Flows.

The flows in Table 6.6-1 were taken from a USGS gauging station (USGS 10032000) located 12 miles upstream of the Covey Canal diversion. Although these flows may somewhat understate the flow at the diversion due to incoming side channels, they are believed reasonably representative of the Smiths Fork flows at Covey Canal Diversion especially in the winter months.

A probable in-stream flow requirement of 65 cfs for the Smiths Fork mainstem was identified in the previous Level I study (Sunrise Engineering, 2004). Wyoming Game and Fish Department (WGFD) caution that this recommendation was preliminary, and that a project-specific instream flow requirement, likely with a seasonally appropriate instream flow regime, would need to be developed should the project advance (WGFD, 2008). However, in order to evaluate the conceptual-level feasibility of using the Covey Canal to supply a new storage reservoir in lower Sublette Creek drainage, the 65 cfs value is assumed to not be diverted. The result of this assumption is that during the winter months there is only enough flow in Smiths Fork to satisfy this assumed in-stream flow requirement and no diversions to storage can be made.

WSEO records identify direct flow water rights associated with the Covey Canal/Mau Lateral system comprising about 70.5 cfs. At the time of this study, these
rights are assumed to be distributed evenly along the canal system resulting in decreasing flow and required capacity to the south. The canal system must continue to deliver these flows to the existing users.

6.2 Covey Canal Diversion Structure

Further evaluation of the potential to use the Covey Canal as a source of supply to a 5,000 ac-ft reservoir on lower Sublette Creek must begin with an assessment of the existing diversion structure on Smiths Fork.

The Covey diversion structure is a dual headgate diversion using two rectangular gates each 5’-2" in width (see Figure 6.2-1A – Canal Diversion on Smiths Fork). The gate opening height is 4 feet. The most prominent feature of the diversion is the low vertical faced ogee crested weir that spans the entire stream channel at about 65 feet in width (estimated from aerial photography). The ogee crest is about 6 inches higher than the bottom of the diversion headgates. This provides at least 6 inches of head at the diversion before water flows over the ogee crest and down Smiths Fork. Diverted flows are continuously gaged at a flume downgradient of the diversion structure (see Figure 6.2-1B – Flume below Diversion).

The diversion capacity relative to the flow over the ogee crest is provided in Table 6.2-1 – Smiths Fork Diversion Capacities. This table, in conjunction with the historic stream flow data in Table 6.1-1, demonstrates the difficulty with late season diversion. The best opportunity to divert flow occurs in April, possibly May, September and October. During April, September and October, the potential diverted flow is diminished by the excess flow over the ogee weir. For instance, in April there is potentially 94 cfs (i.e., 159 cfs – 65 cfs) available for diversion (assuming downstream users holding diversion rights approve and the assumed in-stream flow requirement is appropriate and is met). However, in order to divert 94 cfs the water level would have to be raised to about 19 inches over the current ogee crest (see Table 6.2-1). Under current conditions all of the 65 cfs assumed in-stream flow and about 50 cfs of the desired 94 cfs diversion is lost downstream. In reality only about 45 cfs could be sent through the existing diversion in April and meet the assumed in-stream flow requirement. A similar situation applies to September and October.

During the early irrigation season (May-June) there is enough water that the head on the existing ogee crest is high enough to divert additional water. The problem is that the existing canal capacity is already used by the irrigators. Thus, increased diversion and canal capacity would be required to divert Smiths Fork water to storage during the irrigation season. It is also important to recognize that flows to the Mau Lateral are initially diverted from the same diversion structure described previously that supplies the Covey Canal. The Mau Lateral flows are turned out of the Covey Canal into the Spring Creek channel, flow down that channel, and then are re-diverted into the Mau Lateral through the double 36-inch headgate structure located on the north side of Big Hill.

One potential modification to mitigate the existing diversion/canal capacity limitations would be to block a portion of the ogee crest during the early or late season to increase depth over the weir and head on the diversion. This alternative adds maintenance issues not presently required at the ogee weir. Another option would be to install a third gate.
6.3 Covey Canal

6.3.1 Canal Configuration

The Covey Canal runs about 53,000 feet from the diversion on Smiths Fork to Sublette Creek at an average slope of about 0.0008 ft/ft. Around Big Hill there is a 54” diameter piped section about 3,400 feet long (see Figure 6.3-1A – Inlet to Big Hill Piped Section). The canal is generally in good condition with a width of 10 to 12 feet. The canal has adequate capacity to carry approximately 100 cfs at a flow depth of about 4.25 feet. The piped section around Big Hill has an estimated capacity of just over 60 cfs that increases to about 108 cfs with about 3 feet of head at the inlet. There are also several smaller culvert crossings. The canal configuration could be modified if necessary to convey additional flows to serve as a source of supply to a reservoir on lower Sublette Creek during the irrigation season. The major factors are in place, namely rights of way, a diversion, and public acceptance of the canal. After Sublette Creek, the canal extends another 15 channel miles south continually decreasing in size.

6.3.2 Available Canal Capacity

During the irrigation season, the capacity of the Covey Canal is reportedly fully used if water is available and all irrigators are using the water. In order to fill a lower Sublette Creek reservoir, water will need to be conveyed before the irrigation season, after the irrigation season and possibly during the irrigation season if capacity is available. The out of season conveyance times would probably be the most easily implemented. If the canal could be placed in operation to convey storage flows about April 1 and run until irrigation demands use up available capacity, there may be a period of six (6) weeks in which flows could be stored. At 50 cfs this period would allow storage of 4,165 acre feet. Additionally, in the fall, extending the period of diversions for storage until freezing conditions prevent operation could add an additional 4,000 or 5,000 acre feet. Potential seepage and losses over the winter from the reservoir may dictate that spring and summer is the best time to store the water.

In summary, if the reservoir is in the 5,000 to 9,000 acre foot range the existing canal will be adequate to fill the storage. If the reservoir size grows to larger than 10,000 acre feet the canal in its present configuration will limit storage. Improvements to the canal could increase capacity and would need to be considered as part of the project cost for reservoirs larger than 10,000 acre feet.

6.4 Field Observations

6.4.1 Covey Canal

Overall Condition. During November of 2007 the Covey Canal was observed on several days operating with only stock water flows in the canal. The entire reach from Big Hill to the Bennion Ranch south of Sublette Creek was walked as well as several sections north of Big Hill and south of the Bennion Ranch. Access to some areas was limited, however observations were made from adjacent rights of way. During the review headgates were inventoried, the general condition of the canal was observed, and areas of potential leakage were identified.

Overall the canal cross section is in good condition with adequate freeboard and dike width on the downhill side. Along the North Side of Big Hill the canal is piped using a 54-inch CMP. The headwall at the outlet was installed in 1966 (Figure 6.3-1B – Headwall Outlet of Big Hill Piped Section). A typical section near Big Hill has about a 12-foot bottom width with 4- to 6-foot high banks. The banks are relatively steep
and grass covered. During maintenance the grass is removed leaving soil banks. The off (downslope) bank is typically 10- to 12-feet wide and well graded (see Figure 6.3-1C – Typical Covey Canal Section). This section description is accurate for most of the length to Sublette Creek. South of Sublette Creek the section continues but diminishes in width at the extreme southern end of the canal.

**Leakage/Seepage.** Leakage on the Covey Canal is apparent in some areas. Steeper areas such as Big Hill are an obvious challenge to the canal and its maintenance. Over the years various efforts to prevent leakage and stabilize the off bank have included piping a section around Big Hill as well as synthetic liner in some areas. Near the outlet of the Big Hill pipe, there is a section lined with a synthetic liner. Judging from the lack of apparent leakage at this location, the liner was largely successful despite its weathered and damaged condition.

Leakage along the entire length of the canal is believed to be relatively constant with the exception of a few areas where the canal passes through fractured rock ledges having nearly vertical bedding (see Figure 6.4-1A – Canal through Fractured Rock). Observations along the canal indicate that areas where the canal circumvents draws tend to have higher apparent leakage. In some draws the areas below the canal were characterized by an abundance of grass, and in extreme cases peat moss and willows (see Figure 6.4-1B – Peat Moss and Standing Water and Figure 6.4-1C – Willows below Canal). Even with only stock watering flow levels, there were some short stretches with standing water in the grass. These areas were relatively short but did exhibit leakage that will worsen with higher head under irrigation flows in the canal.

The leakage at the draws could be more readily apparent due to the fact that the incoming and outgoing sections of the canal provide a double dose of leakage to the draw. This creates the appearance that leakage in the draws is greater than other areas when it may in fact not be greater.

During observations on November 8, 2007, the flows at the culvert near the intersection of the Stock Driveway Road and the Smiths Fork Road were compared with the flows estimated at the south end of the siphon at Sublette Creek. At the upper end of this section, the flow through the culvert was estimated at 12 cfs. At the siphon outlet at Sublette Creek the flows on the same afternoon were estimated at 6 to 10 cfs. These estimated flows indicate the canal was loosing between 2 and 6 cfs along the 36,500-foot reach. This equates to between 0.3 and .9 cfs per mile or 2 percent to 7 percent of the flow per mile. This reach was walked the same day during which less than 0.1 cfs was observed leaking through all of the various headgates combined.

On November 14, 2007 the estimated flows at the Stock Driveway Road intersection with the Smiths Fork Road were estimated at 11 cfs. At the turnout where the Covey Canal crosses to the west side of Highway 89 at the Buckley Ranch the flow over the weir was estimated at about 2 to 3 cfs. The length of this reach was 106,000 feet. The average losses were therefore 0.4 to 0.44 cfs per mile or 3 percent per mile. Applying the 3 percent loss rate to the flows for the 23 mile length of the canal, results in a total estimated loss of 36 percent of the stock watering flows to seepage.

The above leakage estimates were conducted under stock watering flows. Under higher irrigation flows the leakage will increase although the percentage of total flow as leakage will probably decrease. As discussed earlier much of this seepage is
beneficial when not in excess as it reduces the amount of headgate releases for irrigation of lands downslope of the canal than would otherwise be required.

Table 6.4-1 – Covey Canal Seepage attempts to quantify potential canal seepage based on an estimated 3 percent and 2 percent loss per mile. The table assumes a linear reduction in flow along the length of the canal to supply head gates of about 5 cfs per mile.

Based on the estimates provided in Table 6.4-1, the amount of water that could potentially be saved by a lining system is probably less than 40 cfs but more than 25 cfs. A piped alternative results in the highest savings while a liner or soil treatment option would result in a lower water savings. It is important to remember that the estimated losses in Table 6.4-1 are averages and actual seepage is higher in some areas and lower in other areas.

As noted previously, not all leakage due to seepage results in lost production since the leakage apparently contributes to the growth of good pasture in many areas. The leakage is, however, difficult to account for from a water rights standpoint and could be benefiting areas that do not necessarily have the right to the water. Excess leakage is apparent in several areas and these high seepage areas should probably be the initial focus of any conservation efforts.

6.4.2 Mau Lateral

Overall Conditions. During June of 2008 the Mau Lateral was observed on several days operating with irrigation flow in the canal. The entire reach from Big Hill to the wildlife refuge south of Sublette Creek was walked. During the review, headgates were identified, the general condition of the ditch was observed, and areas of potential leakage were identified.

Overall the canal cross section is in good condition with adequate freeboard and dike width on the downhill side. A typical section near Big Hill has about a 10-foot bottom width with 3- to 4-foot high banks. The banks are relatively steep and grass covered. In a few areas access by stock has reduced the bank height and potential capacity of the canal. This section description is accurate for most of the length to Sublette Creek.

As noted previously, the canal re-diverts at a double 36-inch headgate structure located on the north side of Big Hill adjacent to and on the north side of Highway 232 (see Figure 6.4-2 – Upstream Side of Inlet Gates to the Mau Lateral). The canal immediately crosses under Highway 232 and parallels the Covey Canal which is higher on the slope.

Leakage/Seepage. Leakage on the canal is apparent in some areas and evidence of seepage is present along most of the canal. Steeper areas south of Cokeville and downhill from the Mau exhibit evidence of seepage in the form of sedges, willows, and other high water demand plants. In other areas saturated soils downhill of the canal indicate seepage is an issue.

Leakage as opposed to seepage along the length of the canal is also evident at various points. In addition, seepage and leakage from the Covey Canal is evident at the Mau Lateral in the form of small flows entering the Mau Lateral over the upper bank. Observations along the canal indicate that areas where the canal circumvents draws tend to have higher apparent leakage. In some draws the areas below the canal had
an abundance of grass, and in extreme cases sedges, peat moss and willows. The
seepage at the draws could be more readily apparent due to the fact that the incoming
and outgoing sections of the canal provide a double dose of seepage to the draw.
This creates the appearance that leakage in the draws is greater than other areas when
it may not be greater.

During the June 2008 reconnaissance of the canal, it was also observed that there is
leakage around many closed head gates. There were also identified two areas of
leakage estimated at 10 and 15 gallons per minute (gpm). Of interest was that there
were eight (8) areas identified where seepage from the upper Covey Canal was
flowing into the lower Mau Lateral. The flows at most of these sites were on the
order of about five gpm with two in the 10 to 15 gpm range. These seeps were
identified in general terms as being present during the initial review of the Covey
Canal in November of 2007. The actual quantity of seepage is from the Covey Canal
is now better understood as a result of the reconnaissance of the Mau Lateral.

It appears that in the case of both the Covey Canal and the Mau Lateral that the
seepage occurring is due primarily to the characteristics of the soils and rock units
traversed. These soils are not completely self-sealing and necessary and appropriate
maintenance can re-open areas that have at least partially sealed. Seepage is
probably relatively constant throughout the length of the Mau Lateral, except where it
may be concentrated at draws by the ditch routing into and out of the draw. A
portion of the seepage from the upper Covey Canal is recovered by the Mau Lateral
but the seepage from the Mau Lateral is not recovered and is evidenced by the sedges
and heavy water tolerant grasses downhill of the Mau Lateral.

Much of the seepage appears to be beneficial in terms of producing grass and hay. It
is, however, probably under-accounted in terms of water rights. The excess seepage
also tends to produce less desirable vegetation and ground conditions for stock. The
excess seepage is water that could have been put to better use further down the canal.
A key goal of any conservation or rehabilitation program should be to eliminate
excess seepage. A further step would be to eliminate seepage that may be impeding
downstream water rights.

6.5 Proposed Maintenance And Rehabilitation

Possible improvements to both the Covey Canal and Mau Lateral fall into two
categories with different levels of effort, effect and cost. The first category includes
repairs of a maintenance-type nature. These include removing obstructions to flow,
maintaining freeboard on the lee (downhill) ditch bank, and keeping head gates in
good working condition, including the bedding and backfill around the gate structure.
The maintenance-type repairs generally address obvious leaks and visually deficient
sections of banks. These types of repairs do not, however, address or modify the
larger concepts and operations of the canals.

The second level of improvements includes those that could be carried out along
significant lengths of the canals and that may modify the way maintenance and
operations are conducted in the future. These types of remedial improvements
include reducing the overall seepage losses in the canals by various means including
soil or polymer based amendments or coatings, synthetic liners, concrete lining,
and/or piping of sections of the canal. One or more of these approaches could be
used on sections of the canals beginning with those sections where excessive seepage
is obvious as evidenced by sedges and saturated soils, followed by those sections
where the geology such as vertical fractured, bedded rock tends to indicate a high potential for seepage. As previously discussed, at an estimated 3 percent seepage loss per mile, 36 percent of the flows are lost or at least applied in an uncontrolled manner. If roughly half of a 3 percent loss could be saved this would amount to recovering about 18 percent of the initial flow. A number of potential seepage reduction alternatives are identified and characterized in the following paragraphs.

**Polyacrylamide (PAM).** One first, maintenance-level method that can be applied at a relatively low cost is the application of polyacrylamide (PAM) based products. This material is applied by a spray-on surface slurry method and/or granular surface method, and acts as a flocculent on the soil surface forming a layer on the canal invert that slows exfiltration (seepage). This “gel” layer is not permanent and must be re-applied; in some cases more than once per year. There is minimal preparation required for application of the PAM and it is not intended to withstand future maintenance and cleaning activities. The low cost of PAM and its temporary nature make it attractive from a test case standpoint. Test sections can be constructed with minimal investment and there is little restoration or cleanup. It is best applied after grass and moss have been removed from the section during routine maintenance. One drawback is that historic routine maintenance usually only covers a section of the canal and may not cover the entire canal section to be treated. The cost of this material or similar materials is in the 1 to 3 cent per square foot range to treat. This cost is about 26 to 78 cents per running foot not including preparation. Preparation could add another $2.00 per foot for each application.

Tests conducted on this material thus far have proved inconclusive as to the effectiveness of the product. Variability in the procedures and the methods of preparation and application, along with soil variability probably lead to the inconclusiveness rather than the products themselves. Further testing of these materials is certainly warranted. Dr. Michael Allen Urynowicz of the University of Wyoming has conducted a recent study on the use of PAM titled *Reducing Water Seepage With Anionic Polyacrylamide: Application Methods And Turbidity Effects* (Urynowicz, 2008). Field tests and evaluations of field application methods and preparation have been conducted on the Green River Supply Canal (Nelson Engineering, Inc., 2004).

**Synthetic and Manufactured Earthen Liner.** The next level of improvements to prevent seepage include a synthetic liner type system such as EPDM (ethylene propylene diene monomer), HDPE (high density polyethylene), or a composite bentonite/geotextile-type manufactured geocomposite liner (GCL) such as Bentomat or Claymax, any of which are installed in a prepared canal section. This concept is similar to the liner section installed just downstream of the Big Hill piped section of the Covey Canal. These liner systems are permanent and once installed preclude using heavy equipment to remove material from the liner. In some cases a partial burial of the liner will prevent livestock from puncturing the liner and protect the liner from UV damage. If installed on the surface these liners are susceptible to both types of damage. Synthetic liners in the 35 to 45 mil thickness range will cost in the range of $0.90 to $1.10/sq-ft for the material and installation which equates to about $26 per running foot for the 12-foot wide section of the Covey Canal. This cost does not include the preparation work or covering the liner.

Installation of the liner typically requires a key trench on each side to anchor the liner in place. On steep banks such as are present on much of the Covey Canal and parts
of the Mau Lateral the installation will be difficult and in some cases not feasible due
to the amount of material that would have to be moved to construct and backfill the
area of the key trench.

**Polypropylene/Polyurea Synthetic Liner.** A relatively recent addition to the suite
of liner alternatives is a dual layer synthetic liner consisting of a 6 oz polypropylene
mat base followed by a spray-on polyurea coating of 40 mils. The liner is typically
placed on a prepared soil bed but can also be run over rock ledges and difficult
terrain with success. Roughness in the prepared surface will reflect up to the final
product. It appears to be a promising and durable alternative with accelerated life
tests surpassing 40 years. The estimated cost of the material and labor to install the
liner is between $1.50 and $2.00 per square foot or about $40 to $50 per running foot
for the 12-foot wide portions of the Covey Canal.

This method still requires the key trench on both sides and in the case of the Covey
Canal and Mau Lateral will be difficult to construct on the uphill side. It is notable
that in rock the manufacturer has successfully installed an adequate key trench using
a handheld grinder to cut a 3 to 5 mm keyway in the rock to anchor the liner. The
liner is then sprayed with polyurea to blend it into the rock and provide the
waterproofing. Of the open channel liner alternatives, polypropylene/polyurea
appears to have the best chance of succeeding when crossing the various rocky ledges
found along the Covey Canal.

**Concrete Liner.** Concrete is a third lining material that is widely used on canals.
The Mau Lateral has a short concrete section located where it first passes west of the
highway. Depending on the type of construction joints used, concrete can furnish a
relatively impermeable surface. A concrete-lined section requires no keyway as is
the case with the synthetic liners and consequently can be placed on the uphill side of
the canal from the lee side without requiring access to the uphill side.

Concrete lining is relatively costly compared to other alternatives and in the case of
the Covey Canal and Mau Lateral may exceed the performance actually desired of
the lining system. The estimated cost for a 10- to 12- foot wide concrete section 5
feet deep (w/sloped sides) will be in the order of $150 per running foot. Concrete
could have application in isolated areas of the Covey Canal where rock ledges are
crossed.

**Piping.** From a water conservation standpoint, piping of a canal or ditch can have
the greatest return in terms of reduced infiltration and evaporation. In addition, the
piped canal has the potential to provide pressurized flow and a shorter route by
eliminating the necessity of maintaining the constant grade of the canal. The Sublette
Creek inverted siphon is an example of this concept.

Placing the canal in a pipe does not solve all problems but on balance reduces the per
mile cost of maintenance of the conveyance system. If the piping option was selected
there would be new infrastructure required at the pipe intake in terms of removing
grass, moss and sticks/twigs and insuring a relatively debris-free water supply to the
pipeline. If the piping were discontinuous with alternating sections of open channel
and pipe there would be increased maintenance at each pipe entry point to remove
debris. If pressure were developed in the pipeline a pipe smaller than the current
culverts and Big Hill pipe could be used, perhaps something in the range of 48-inch
diameter. For a welded steel pipe with coating the cost would be in the range of $100
per foot which translates to roughly $4.00 per square foot if it were compared to liner
cost. There will also be an initial installation cost of about $50 per foot of pipe. Downstream sections of the pipe may be telescoped to smaller sizes to reduce cost. The very southern end could be as small as 12- to 16-inch diameter.

6.6 Alternative Costs

Estimated costs have been developed for each of the alternative lining methods described in Section 6.5 applied to the Covey Canal as a basis of comparison among the methods. These costs are summarized on Table 6.5-1 – Alternative Canal Rehabilitation Costs. The bases of these costs are described in the following paragraphs. Unit costs for the Mau Lateral would likely be somewhat less than for the Covey Canal, but total costs would depend on how much of the total length of the ditch was lined or piped.

PAM. Investigation of the lowest cost alternative provides a means to judge the feasibility of any action. Upon consideration of the wide range of costs for the various alternatives and the limited ability of the irrigators to pay for any alternative, the lowest cost alternative of a PAM-type liner in combination with the polypropylene/polyurea liner appears attractive. The use of these two alternatives offers a way to address seepage in the rocky ledge areas using the more costly polypropylene followed by the PAM in soil and gravelly/cobbly areas. This will maintain the open channel nature of the canal. The total length of the Covey Canal is approximately 123,000 feet. If 4,000 feet of this distance is assumed to be crossing rocky ridges and areas the following is the estimated first year cost of a PAM and polypropylene/polyurea liner system is estimated to be $208,760.

Because a new coating of PAM must be installed every year it is necessary to evaluate the net present value (NPV) of an estimated program length. For comparison to other alternatives such as pipe or a synthetic liner which have longer service lives, the NPV of a suggested PAM program length of 50 years will be evaluated.

Using a cost inflation rate of 3 percent on future applications of PAM and a discount rate of 6 percent on source funds the net present value of a 50-year PAM program is $4,215,000 + $20,000 = $4,235,000.

If the PAM is 80 percent effective at blocking seepage the estimated water savings would be on the order of 32 cfs. In terms of NPV, this amounts to about $132,000 for every cfs saved. An additional benefit of the PAM option is the ability to change course without abandoning or reworking existing major capital facilities.

Total costs for the local installation of polypropylene/polyurea lining have not been made pending further definition of areas where this application may have merit. To provide an order of magnitude idea of the potential cost using this method, lining 1,000 running feet of canal in areas of rock outcrop and especially coarse, permeable soils would cost on the order of $45,000, not including any necessary preparation work.

Steel Pipe. Assuming piping of the majority of the Covey Canal with half of the pipe 48-inch diameter and half 16-inch diameter, the initial (first year) cost of the pipe would be $14,145,000 as shown on Table 6.5-1. Of course this high first year cost provides a water conveyance system with very low leakage and the potential for pressure irrigation. The estimated leakage saved amounts to 40 cfs or about $353,000 per cfs saved. Note also that the pressure application of water would allow
increased efficiencies that are not accounted for in this analysis. Cost to put the Mau Lateral flows into pipe would be less but of a similar order of magnitude.

**Concrete Liner.** The cost of a concrete-lined canal section depends on several variables such as labor costs that can fluctuate widely. For a 4-inch thick concrete liner in a section with a 10-foot width and 5-foot high sidewalls approximately 0.3 cubic yards per foot of concrete are required. A typical Covey Canal section on the upper end will be wider than 10 feet while on the lower end it will be narrower. Assuming a 10-foot average width, the cost of lining the full length with concrete is roughly $19,065,000 as shown on Table 6.5-1.

If this lining were 97 percent effective in stopping seepage, the estimated savings of 39 cfs would cost about $489,000 per cfs. It is apparent that this alternative over the full length of either the Covey Canal or Mau Lateral is unfeasible.

### 7.0 Water Storage Site Evaluation

#### 7.1 Needs for Surface Water Storage

Identification and evaluation of opportunities to develop new surface water storage in the Sublette Creek watershed is a key objective of this Level II study. The primary need for new storage is for supplemental irrigation water to address seasonal and dry year shortages in Wyoming on the lower Bear River and Smiths Fork.

The need for new storage in Wyoming utilizing Smiths Fork water has been clearly established in a number of previous reports including most recently Sunrise Engineering, Inc. (2004). In that study, a total of 4,563 acres were identified as being supplied by diversions on the Bear River below the confluence with Smiths Fork. Smiths Fork diversions supply an additional 15,848 acres, of which 6,290 acres are the lands in the Bear River Valley supplied by the Covey Canal/Mau Lateral system which diverts from Smiths Fork approximately six (6) miles above the confluence with the Bear River. Thus, a total of 10,853 acres in the Bear River Valley could be (or are currently being) served by Smiths Fork water. Under current irrigation practices, modeling by Sunrise Engineering, Inc. (2004) estimated that general shortages occur in about two out of three years and individual shortages occur more frequently, especially for users at the downstream end of the system. This modeling suggested that the upper limit of storage capacity on the most downstream Smiths Fork sites studied was about 14,000 acre feet as that is the point at which 80 percent irrigation reliability was achieved for the users.

Although based on somewhat different data and performed for different purposes, similar conclusions are derived from brief review of the two most relevant studies previous to the Sunrise Engineering, Inc. (2004) study, Forsgren, et al. (2001) and Banner Associates, Inc. (1983).

#### 7.2 Irrigation Water Delivery Concepts

A variety of concepts appear technically feasible for delivery of Smiths Fork (and potentially some Sublette Creek) water stored in a new reservoir at a site within the Sublette Creek watershed. Although detailed evaluation of this topic is beyond the scope of the current study, a number of potential concepts have been identified and are briefly described below. Further evaluation and design of one or more delivery concepts appropriate to a preferred dam and reservoir site will be required should the project advance to the next level of study.
Lands within the lower Bear River Valley below (north of) the Sublette Creek confluence could be served by direct (gravity) release to lower Sublette Creek and thereby to the Bear River from any proposed new reservoir in the Sublette Creek watershed. Lands under the Mau Lateral upstream (or south) of the Sublette Creek confluence with the Bear River could also be served by direct (gravity) release from any new reservoir to the ditch.

Lands served by the main Covey Canal in the Bear River Valley (upstream or south of Sublette Creek) could be served by direct (gravity) release to the existing canal from any new reservoir in the Sublette Creek watershed whose outlet invert is higher than the canal invert at the down-ditch end of the siphon across lower Sublette Creek.

Lands under the Covey/Mau Canal system in the Bear River Valley downstream (or north) of Sublette Creek could be served by gravity release from any reservoir whose outlet invert is higher than the diversion invert to be served. This service would require construction of a new supply canal above the Covey Canal (or at least above the Mau Lateral) on the west facing slope of Stoffer Ridge north of Sublette Creek. In the case of a reservoir on lower Sublette Creek to be supplied by the Covey Canal, it would be necessary to either siphon or pump reservoir water to serve the new canal north of Sublette Creek.

Finally, lands in the Bear River Valley higher than a lower Sublette Creek reservoir outlet, and possibly some lands on Smiths Fork, may also be able to be served indirectly by exchange (although detailed evaluation of this potential was beyond the scope of the current study).

### 7.3 Potential Secondary (Multiple) Benefits of Storage

In addition to meeting present irrigation needs, a number of other potential benefits of new storage in the Sublette Creek watershed have been identified during the course of this study and are recommended for more detailed evaluation should a storage project advance to the next level of study. These potential benefits include, but are not necessarily limited to, the following:

- Enhancement/establishment of late-season stream flows on Sublette Creek to benefit aquatic and wildlife species and riparian habitat;
- Provision of an additional direct wildlife/livestock watering opportunity at the reservoir site;
- Reduction of local flooding impacts to the aquatic and riparian habitats downstream on Sublette Creek;
- Establishment of a lake fishery and associated aquatic habitat;
- Development of seasonal waterfowl habitat; and/or
- Development of seasonal recreational opportunities (consistent with meeting other needs and achieving other benefits including the primary need for providing supplemental irrigation water).

It is important to note that the degree to which any one or some combination of these secondary benefits could be attained would depend on the results of more detailed evaluations that should accompany the next level of study.
7.4 Surface Water Availability

The primary source of water for storage in a new reservoir within the Sublette Creek watershed is envisioned to be the storage allocation(s) currently held by the Town of Cokeville/Cokeville Development Association (now Company). In addition to the discussion of this source in Section 7.4.1, relevant discussion is included in Sections 4.0 and 6.1. The potential for storage of excess Sublette Creek flows was also evaluated to the extent feasible given the available hydrologic data and is discussed in Section 7.4.2.

7.4.1 Smiths Fork

The water available from Smiths Fork flows for storage in a reservoir in the Sublette Creek watershed is subject to several limitations. As discussed in Section 4.3, the maximum amount of potentially storable Smiths Fork water under the terms of the Amended Bear River Compact and the State Allocation Plan is 14,420 ac-ft. Of this amount, 4,100 ac-ft of Original Compact storage is not encumbered by the 2,200 ac-ft depletion allowance on rights put to beneficial use after January 1, 1976 (including depletions from tributary groundwater used for other than domestic and stock watering uses) that applies to the other 10,320 ac-ft of Amended Compact storage being held under the State Allocation Plan. In addition to the depletion allocation, storage allocated under the Amended Compact is also constrained by the requirement that no storage is allowed when the pool level in Bear Lake is below elevation 5911 feet. This constraint would have reportedly occurred in the 1930’s (5 years), 1940’s (4 years), and 1990’s (3 years) and was the situation during the early to late 2000s drought (Sunrise Engineering, Inc., 2004), including this year (2008). The 4,100 acre feet allocated to the Town of Cokeville/Cokeville Development Association under the Original Compact is not subject to this restriction. Finally, the Amended Compact also limits diversions and storage when the Bear River flows measured at the Border Gauging Station fall below 350 cfs or the total Central Division divertible flow falls below 870 cfs. Under such a “water emergency”, Wyoming’s share of the divertible flow under the diminished natural flow condition is limited to no more than 43 percent of the total divertible flow.

At this level of study, it is conservatively assumed that annual average flows in the range of 4,100 ac-ft/yr to 14,420 ac-ft/yr are available for storage in a new surface water storage reservoir in the Sublette Creek watershed. Detailed hydrologic and water rights modeling of the Smiths Fork, lower Bear River and Sublette Creek, and operations modeling of one or more selected alternative storage reservoirs will be required in a subsequent level of study to refine this estimate as a basis for final design and permitting.

7.4.2 Sublette Creek

The spreadsheet hydrology model from the Bear River Basin Plan (Forsgren, et al., 2001) was first reviewed to determine if Sublette Creek had been included in the model node network. As anticipated, Sublette Creek is not explicitly included in the model presumably due to the negligible effect its very small natural flows and diversions would have on the overall basin modeling results.

Estimates were then made of the potential storable flows on Sublette Creek that could be stored in a new reservoir in the Sublette Creek watershed using two different approaches. These estimates, including key assumptions, are provided in Table 7.4-1 – Estimated Sublette Creek Storable Flows. The first approach was to interview the
WSEO Division 4 staff and seek their opinion as to the “typical or average” excess annual flows (i.e., flows not diverted under existing direct flow rights) on Sublette Creek and its tributaries (Personal communication, Kevin Payne, September 24, 2007). As shown in the top portion of Table 7.4-1, estimated excess flows for the irrigation season and the spring runoff period were provided by WSEO and converted to annual storable amounts of 297 ac-ft and 833 ac-ft, respectively. This results in an order of magnitude estimate of 1,100 ac-ft/yr of storable flows.

The second approach involved an evaluation of the existing surface water diversion rights and the available gage data on lower Sublette Creek (see Sections 3.3.3.2 and 4.1 for additional relevant discussion and information). As seen in the lower portion of the table, a range of cases was considered resulting in an estimated range of annual storable flows from zero (0) to 970 ac-ft. The minimum (zero) storage case assumed that all current direct flow rights were fully utilized for the entire irrigation season of 150 days and that only gaged flows in excess of those diversions could be stored. It also assumed that all natural flows were left in the stream during the non-irrigation season (i.e., October through April). The maximum storage case assumed that all irrigation season excess flows at the gage and those direct flows otherwise diverted below the gage were stored. It further assumed that all winter flows (assumed as indicated on Table 7.4-1) were also stored. Given the seasonal nature of the gage data and the absence of detailed diversion data, it is cautioned that the results of this approach are at best only order of magnitude. It is of some interest, however that the estimates from both approaches (using the maximum case for the second approach) were about the same.

Based on the above evaluations, it appears that on the order of 1,000 ac-ft/yr may be available from Sublette Creek and its tributaries for storage within the Sublette Creek watershed. However, for the purposes of this study this potential additional source is only considered for two of the alternative dam and reservoir sites as discussed in Section 7.5.

7.5 Identification of Alternative Storage Sites

7.5.1 Approach and Methodology

Based on the needs and estimated annual storable flows presented in Sections 7.1 through 7.4, potential dam and reservoir sites ranging in size from about 1,700 ac-ft to as large as about 15,000 ac-ft were targeted in the Sublette Creek watershed. The identification of potential storage sites in this capacity range involved the following sometimes iterative steps:

- Interview locally knowledgeable stakeholders
- Review Wyoming State Engineers Office (WSEO) water rights and dams databases
- Review previous studies of storage potential in the Smiths Fork and lower Bear River basins
- Review topographic mapping and digital aerial photography
- Conduct initial reconnaissance of potential alternative sites

Discussions with local stakeholders confirmed their interest in a site on lower Sublette Creek that could be supplied by the existing Covey Canal. No permits for abandoned or proposed new storage sites were found in review of the WSEO
databases. Digital U.S. Geological Survey (USGS) 7.5-minute topographic mapping was reviewed as part of initial site identification utilizing DeLorme XMap® 5.0 GIS Editor software. Aerial photography available on Google Earth was also reviewed. Potentially favorable dam sites were identified primarily based on site topography and location relative to potential source(s) of supply. Potential reservoir sites identified during interviews and in the office utilizing topographic mapping and aerial photography were then viewed in the field during a site visit to ground-truth the site identification process.

7.5.2 Existing Reservoirs
The two small existing reservoirs described in Section 3.3.2 were found not suitable for direct enlargement given their very small size in comparison with the much larger storage capacity desired in this study.

7.5.3 Previous Storage Site Investigations
No previous studies were found that included consideration of new surface water storage in the Sublette Creek watershed. However, the latest previous study of storage within the Smiths Fork drainage by Sunrise Engineering, Inc. (2004) evaluated a total of six sites in that adjacent basin. As shown on Figure 7.5-1 – Previously Investigated Storage Site Alternatives, four of these sites are on the mainstem Smiths Fork below the Hobble Creek confluence, one on Hobble Creek, and the other on Smiths Fork above the confluence. Although not directly related to this study, it may be appropriate to include one or more of these sites in subsequent environmental permitting under NEPA as alternatives to a proposed site in the Sublette Creek watershed as basically the same purpose and need would be served.

7.5.4 Identified Alternative Sites
Employing the approach and methodology described above, a total of five (5) alternative new surface water dam and reservoir sites were identified within the Sublette Creek Watershed (see Figure 7.5-2 – Alternative Surface Water Storage Sites). These sites and the rationale for their selection as alternatives are briefly described in the following paragraphs.

Site 1 – Lower Sublette Creek. The Lower Sublette Creek site is located in a narrow portion of the lower Sublette Creek valley where it can be directly supplied by the existing Covey Canal. Given the invert elevation of the canal and the topography of the valley upstream, the storage capacity of this site is limited to approximately 5,000 ac-ft. As discussed in more detail later, an existing high voltage transmission line corridor at the upstream end of the reservoir also constrains this site from further enlargement without significant cost to relocate the three lines in the corridor. As noted in Section 7.2, a reservoir at this site can supply the existing Mau Canal south of Sublette Creek and diversions on the Bear River north of Sublette Creek by direct release. Supplying the Covey Canal south of the site would require either siphoning or pumping.

A variant of this site identified as Site 1A would be located just downstream at the next narrowing of the valley. This reservoir has a maximum capacity estimated as about 9,000 ac-ft and would operate essentially the same as the smaller Site 1 reservoir. A significant drawback to this site is the loss of the existing prime pasture, corrals, ranch buildings and home that occupy this portion of the Sublette Creek valley.
Site 2 – Upper Sublette Creek. This alternative site was included for initial evaluation to represent a higher elevation site to be supplied only by the portion of the watershed with the greatest unit yield. The storage capacity was set at 1,700 ac-ft to represent total estimated average annual yield of this portion of the watershed (without regard to existing downstream water rights) and some carry-over capacity.

Site 3 – Larson Reservoir Expansion. The base alternative at this site would involve constructing a 5,000 ac-ft capacity reservoir that would inundate the existing very small Larson Reservoir without utilizing any portion of the existing dam. The source of supply for this alternative would be either a new diversion on the Smiths Fork and a 26 mile long supply canal or a pumping plant with the associated diversion on the Smiths Fork, an inlet canal and a supply pipeline located closer to the site. The site is located to take advantage of the topography where the east facing slope of Stoffer Ridge meets the gently west sloping floor of Sublette Flat. This site is also considered offstream in terms of potential perennial stream-related environmental issues. Gravity releases from Site 3 flowing in existing channels to Sublette Creek would be able to serve both the Covey Canal and Mau Lateral south of Sublette Creek. Flows would either have to be routed through or around the existing Unnamed Reservoir located at Site 4. A cursory review suggests that it may also be technically feasible, albeit costly, to construct a canal or pipeline from Site 3 to Big Hill to supply the Mau Lateral (and the Covey Canal) north of Sublette Creek if necessary or desirable. Note that this conveyance is not considered in the characterization and screening of alternatives in Sections 7.6 and 7.7.

A variant of this site designated Site 3A would be located at the same centerline as the base Site 3 but with a higher dam to provide a total of 15,000 ac-ft of storage capacity. This alternative variant is intended to provide an order of magnitude idea of the technical and permitting feasibility and cost of storing all of the Town of Cokeville/Cokeville Development Association combined Original and Amended Compact allocations currently being reserved by the WSEO.

Site 4 – Sublette Flat. The Sublette Flat site is quite similar in most respects to Site 3, but was included in the initial storage site evaluations to provide for the potential of storing incrementally more local runoff at less cost than for Site 3 and to avoid or minimize potential impacts to a historic trail (as discussed more later).

Site 5 – Trail Creek. The Trail Creek site is similar in many respects to Sites 3 and 4. It was initially included for evaluation due to the potential to capture most of the natural runoff within the Sublette Creek watershed to supplement the primary Smiths Fork supply at less cost for the collection infrastructure or than would be technically feasible for Site 2, 3 or 4 due to their location and topographic setting. An interception ditch could be constructed from Sublette Creek crossing the Ryan and Lost Creek drainages to Trail Creek at relatively low elevation in these tributary drainages. In addition, Wyman Creek would be captured by the selected location for Site 5. The interception ditch would also function as the additional constructed conveyance required to carry the primary source of supply from Smiths Fork from the vicinity of Site 3 to the Trail Creek site. In order to limit the cost of this additional required infrastructure, only a 5,000 ac-ft capacity was evaluated at Site 5.

7.6 Characterization of Alternatives

A wide array of relevant information about the five initially selected alternative storage sites and the three larger capacity variants was compiled from the results of
the watershed description and inventory described in Section 3.0 and from information on environmental issues identified as part of the work documented in Section 9.0. This information is compiled on Table 7.6-1 – Alternative Surface Water Storage Sites (see entries above the heading Dam Characteristics and Hydraulic Structures), and the sites are shown on Figure 7.5-2. This table is derived from an Excel spreadsheet that links the compiled site information to a number of equations and algorithms that support the screening-level conceptual design and costing provided in the lower portions of the table (including and below the heading Dam Characteristics and Hydraulic Structures).

Key factors influencing the screening-level conceptual design (and estimated cost) include reservoir capacity and dam size, new facilities necessary to supply water to a given reservoir, anticipated geological conditions, flood hydrology and the associated spillway sizing, and permitting and environmental considerations and mitigation. The first of these factors was discussed in Section 7.5; the next three factors are discussed in this section, and permitting and environmental considerations are discussed in Section 9.0. A series of figures is presented illustrating the general dam and reservoir layout for each of the alternative dam and reservoir sites relative to local site topography (Figures 7.6-1 through 7.6-10 – Site # - name Layout followed by Site # - name Photograph).

**New Conveyance Facilities.** As discussed previously in Section 7.5.4, the primary source of supply to either Site 3/3A or Site 4/4A is the Smiths Fork. Due to the elevation of these sites within Sublette Flat, it would be necessary to construct new conveyance to fill them with Smiths Fork flows. Two concepts were considered and briefly evaluated at this level of study to gain an order of magnitude idea of the associated technical feasibility, permitting issues and costs. The first concept is a new diversion and supply canal similar in concept to the existing Covey Canal/Mau Lateral system. Given the much higher elevation of Sites 3/3A and 4/4A than the existing Covey/Mau system, it is necessary to locate a gravity diversion approximately 10 miles up the Smiths Fork from the existing Covey Canal diversion (to Button Flat just above the Coal Creek confluence). The resulting new supply canal is approximately 26 miles long and would cross numerous tributaries, roads, and other existing irrigation ditches (see Figure 7.5-2 which shows the downstream last several miles of this alignment). At the downstream end of the canal a tunnel or deep cut would be required to breach a saddle at the north end of Stoffer Ridge and avoid an even longer canal.

Given the very high capital cost, anticipated environmental and easement/right of way issues, and long-term operational challenges and costs clearly associated with the canal concept, a pumping concept was developed and evaluated. As shown on Figure 7.6-5, this would involve an inlet canal to carry flow from a new diversion located about a mile downstream of the existing Covey Canal diversion to a pumping station located near the intersection of the Smiths Fork Road and Stock Driveway Road. From the pumping station a pipeline would be constructed through a saddle at the north end of Stoffer Ridge and down the slope to the proposed Site 3/3A reservoir. Flows to Site 4/4A would either be within the existing intermittent drainage or could be conveyed in a lined canal or pipe to minimize losses. Pumping capacities in the range of 25 to 50 cfs were evaluated to supply Smiths Fork flows during the shoulders of the irrigation season to a reservoir with a storage capacity of 5,000 or 15,000 ac-ft, respectively.
Note that costs for both of these concepts are included on Table 7.6-1. The pumping concept cost includes both capital cost and the estimated present value of power costs assuming a 30-year project life. Other operations, maintenance and replacement costs were not estimated for either the canal or pumping concepts as they are judged of a similar order of magnitude and thus will not unduly affect a cost comparison of the two concepts. As anticipated, the pumping option ranges from only about 30 percent to 70 percent of the canal cost, with the higher percentage applicable to the higher pumping rate. It is also apparent that permitting and easement/right of way issues would be much more manageable for the pumping concept as compared to the canal concept.

**Geologic Conditions.** Geologic conditions anticipated at each of the alternative dam and reservoir sites as summarized on Table 7.6-1 and briefly described in this section are based on the geologic mapping and characterization presented and discussed in Section 3.2.5 and geologic reconnaissance of the sites conducted during this study.

In general terms, Sites 1 and 1A are mostly underlain near the surface by recent, unconsolidated alluvium and colluvium to depths estimated as deep as 30 feet in the valley section. Bedrock crops out locally higher on the valley slopes. Bedrock at Sites 1/1A is predominantly sedimentary, ranging from very fine-grained claystone to cobble-pebble conglomerate, with all intermediate gradations present to one degree or another (i.e., mudstone, siltstone and sandstone). Some limestones and calcareous sedimentary units are also locally present. The bedrock underlying Site 1/1A has been faulted and folded so that beds are now very steeply dipping, in fact vertical to overturned locally. This degree of structural deformation has resulted in significant jointing and fracturing of the rocks, with resulting relatively deep weathering and opening of joints/fractures near surface. Note that a more detailed description of anticipated geologic conditions at Site 1 is provided in Section 8.1.1.

Site 2 is characterized by very thin to patchy alluvium, colluvium and locally talus with extensive exposed outcropping bedrock on the steep canyon slopes and locally in the narrow valley floor. Bedrock at the proposed dam site is comprised mostly of thin-bedded sandy limestone and calcareous siltstone; more massive oolitic limestone (oolitic is descriptive of the spherical calcareous concretions comprising much of the rock) also occurs in this unit. Moving upstream through the proposed reservoir area the following bedrock types are encountered: quartzite and sandstone of the Nugget formation; interbedded sedimentary and limestone units of the Ankareh Red Beds; and silty limestone of the Thayne Limestone at the head end of the reservoir. Dips are steep to the west and the relatively hard but brittle bedrock is commonly jointed and fractured, and moderately weathered near surface.

Geologic conditions at Sites 3/3A, 4/4A and 5 are generally quite similar due to their common location along the base of Stoffer Ridge at the west edge of Sublette Flat. Relatively thin alluvium and colluvium are present at each of these sites, with alluvium most prevalent at Site 5 and absent at Sites 3/3A. The west abutment of all three sites is underlain by conglomerate of the Gooseberry Member of the Fowkes formation comprised mostly of cobble-pebble sized hard rock pieces of varied lithology in a silty and tuffaceous (volcanic ash) limestone matrix. The main dam section and east abutment at all three sites is underlain by older alluvium comprised of unconsolidated, crudely stratified deposits of boulder- to pebble-sized rock pieces/gravel, sand, silt and clay (see related discussion of this unit in Section 3.2.5.1.
In addition to these general characterizations, estimates of required depths of excavation beneath the core and shells and required grouting of the underlying rock foundations at each alternative dam site have been entered into the design portion of the spreadsheet model behind Table 7.6-1 so that these factors are appropriately reflected in the screening-level, comparative costs.

**Flood Hydrology/Spillway Sizing.** Inflow design flood (IDF) flows at this level of study are estimated in the spreadsheet model behind Table 7.6-1 utilizing the approaches and methodologies described in some detail in Section 8.1.2. The data used in these evaluations and the resulting estimates of IDF and other recurrence interval flood flows are presented on Table 7.6-1 under the heading Basin Characteristics and Hydrology. As shown on the table, PMF IDF peak flow ranges from 11,000 cfs at the offstream Site 3 – Larson Reservoir Expansion to 41,000 cfs at Site 1 – Lower Sublette Creek located onstream at the lowest part of the watershed. The 100-year IDF peak flows for these sites are 682 cfs and 1,835 cfs, respectively. Site 2 – Upper Sublette Creek is estimated to have a lower 100-year IDF (at 170 cfs) than Site 3, but a slightly higher PMF IDF at 13,000 cfs. These differences are attributable to the differing watershed characteristics at the two sites.

### 7.7 Screening of Alternatives

A comparative ranking of selected parameters/conditions for each of the alternative sites is shown by the color-coding on Table 7.6-1. Because of the differences in size, infrastructure associated with the Smiths Fork source of supply, and the conceptual operations for each alternative and variant, it is not feasible or appropriate to perform a direct, quantitative to semi-quantitative screening methodology as the basis to select one or more preferred alternatives. Rather, the data compiled and coding applied in Table 7.6-1 has been carefully reviewed to assess the relative degree to which each site may be impacted by various factors and how well the sites are suited to their intended roles.

Site 1 – Lower Sublette Creek at 5,000 ac-ft storage capacity was selected as the site and size that best balanced the wide variety of factors involved in the decision, including but not necessarily limited to:

- Utilization of the least encumbered 4,100 ac-ft Original Compact storage allocation and potentially available storable flows from the Sublette Creek watershed;
- Ability to use the existing Covey Canal with only modest upgrades to the existing diversion to convey Smiths Fork supply, and thereby avoid extremely costly alternative supply options (new canal or pumping plant/pipeline);
- Judged more likely to be permitted than Site 2 or Site 5, but with somewhat greater known or potential dam and reservoir site challenges than Sites 3 and 4 (including specifically wetlands impacts and mule deer migration); much more favorable relative to environmental issues considering the new canal or pumping station/pipeline needed to supply Sites 3 and 4;
- Generally comparable in terms of existing infrastructure/utilities conflicts, except for required replacement of a section of the Stock Driveway Road;
- Comparable to Sites 3 and 4 and much more favorable than Sites 2 and especially 5 in terms of land ownership and current uses and management;
Generally competitive to more favorable storage efficiency (ac-ft of storage gained per cubic yard of fill required) than other sites (except for Site 1A);

Costs for larger required spillway capacities due to location at lower end of the watershed largely compensated by use of excavated material in dam construction; and

Least total cost for 5,000 ac-ft of storage and lowest overall cost per ac-ft of storage in spite of larger capacity spillways

The recommendation to focus conceptual design and cost estimating on a 5,000 ac-ft reservoir at Site 1 – Lower Sublette Creek was presented at a project meeting on April 23, 2008 and was endorsed by the project sponsors and WWDO.

8.0 Conceptual Level Designs and Cost Estimates

8.1 Key Design Considerations

Conceptual designs were prepared for each of the alternative dam and reservoir sites identified in Section 7.0 as discussed previously, with somewhat more detailed design of the primary features of the preferred alternative dam and reservoir at Site 1 – Lower Sublette Creek at a storage capacity of 5,000 ac-ft. These conceptual designs are based on information developed throughout the project under various work tasks and significant prior experience in the planning, design and/or construction oversight of numerous dam and reservoir projects in Wyoming over the past 25 years.

8.1.1 Anticipated Geologic Conditions

Anticipated geologic conditions at all of the alternative dam and reservoir sites suitable for use in the screening level designs and cost estimates included on Table 7.6-1 were discussed previously in Section 7.6. The remainder of this section deals in more detailed with the preferred alternative at Site 1 – Lower Sublette Creek.

Geologic conditions at Site 1 – Lower Sublette Creek are shown on Figure 8.1-1 – Site 1 Geologic Map (after Rubey, et al., 1980). Most of Site 1 is underlain by recent alluvium in the valley bottom and colluvium/slopewash on the valley slopes. The depths of these deposits are not known due to the absence of subsurface exploration at this level of study. Based on the topography and geomorphology of the site and experience at other similar sites, it is estimated for purposes of this study that the alluvium is a maximum of about 30 feet deep and that the colluvium varies from about 5-10 feet maximum depth. The gradation of the alluvium is known only at the near surface where it is typically silt to silty fine sand with some clay; it is assumed that the alluvium is at most only moderately dense where deepest. Given the nature of the surrounding bedrock, it is not anticipated that clayey alluvium will be abundant although it may be locally present. Given these anticipated conditions and the very high potential ground motions at the site as discussed in Section 3.3.4.5, complete removal of alluvium and colluvium beneath the footprint of the dam is assumed. Alluvium in the reservoir area should be preserved as necessary to minimize potential seepage into the steeply dipping, fractured underlying bedrock.

Portions of the proposed emergency spillway alignment will be underlain by unconsolidated wind-deposited sand and silt deposits called loess. Although these deposits have been reported to depths up to about 100 feet, it is estimated that the loess at the Site 1 emergency spillway location is significantly less where it is immediately adjacent to outcropping bedrock. Regardless, the conceptual design of
the emergency spillway will take this material and its potential implications into consideration.

Bedrock underlying the dam and reservoir site from upstream to downstream includes: conglomerates/puddingstones of the Gooseberry Member of the Fowkes formation comprised of cobble and pebbles of resistant rock in a silty, tuffaceous limestone matrix; sedimentary rocks including claystone, mudstone, siltstone, fine- to medium-grained sandstone, pebble conglomerates and common thin porcelanite beds of the Sage Junction formation; interbedded siltstone, claystone and fine sandstone of the Preuss Red Beds; claystone, siltstone, fine sandstone and limestone of the Stump formation; and mudstones, sandstones and pebble conglomerates of the Bechler and Ephraim Conglomerates and intervening Peterson Limestone of the Gannet group.

Bedrock beneath the dam footprint and the service spillway alignment is anticipated to be interbedded sedimentary rocks and limestone of the lower Gannet group (most likely the lower Ephraim Conglomerate and possibly the Peterson Limestone). Bedding at the dam site is typically steep to locally vertical and overturned. Bedrock where exposed is weathered and commonly fractured/jointed along bedding and at two or more other orientations. As noted above, these units will be exposed beneath the dam footprint by excavation of overlying alluvium and colluvium thereby facilitating appropriate surficial foundation treatment including application of slush grout and placement of dental concrete in open joints/fractures. Given the sedimentary nature of most of the rock at the dam site and the jointing and fracturing present at the surface and to at least some depth, foundation preparation is assumed to also include conventional cement grouting to a depth equal to the height of the dam.

8.1.2 Flood Hydrology and Spillway Sizing

**Dam Safety Classification and Inflow Design Flood Requirements.** Requirements for dam safety, including inflow design flood (IDF) size, for any jurisdictional dam and reservoir project are promulgated and administered by the Safety of Dams Program, Surface Water Division of the Wyoming State Engineer’s Office. The size of the IDF required for any new storage reservoir is determined by the hazard classification of the dam. There are four classifications (I through IV) based on the potential for loss of life and/or significant property damage in the event of dam failure. For the purposes of hazard classification, an assumption is made that the dam under review fails in a clear weather breach. The likely consequences of that failure are then evaluated to arrive at the dam’s classification. The definitions for each of the four classes are as follows:

- A “Class I” dam is a dam for which loss of human life is expected in the event of the failure of the dam.
- A “Class II” dam is a dam for which significant damage is expected to occur, but no loss of human life is expected in the event of failure of the dam. Significant damage is defined as damage to structures where people generally live, work, or recreate, or public or private facilities exclusive of non-primary roads and picnic areas. Damage means rendering the structures uninhabitable or inoperable.
- A “Class III” dam is a dam for which loss of human life is not expected, and damage to structures and public facilities as defined for a “Class II” dam is not expected in the event of failure of the dam.
A “Class IV” dam is a dam for which no loss of human life is expected, and for which damage will occur only to the dam owner’s property in the event of failure of the dam.

**Conceptual-Level Hazard Classification.** Hazard classification requires determination of the potential for inundation of existing structures, recreational areas or primary roads. Completing such a classification rigorously requires dam break analysis and routing of flood waters and is beyond the scope of this study. Accordingly, judgment has been used to “select” an appropriate hazard classification and provide an initial basis for sizing the IDF and thereby the conceptual spillway types and sizes. In general, sparsely populated areas with structures well out of the flood plain and/or significantly downstream from the reservoir (enabling dissipation of a flood wave), and/or small reservoirs which would provide minimal impacts on failure offer a reduced threat to property and human life. Based on this concept and a review of topographic mapping downstream from Site 1 a conservative classification of Class I is assumed. This is also conservatively assumed for the other alternatives and variants characterized and evaluated in Sections 7.6 and 7.7.

**Inflow Design Flood Determination.** The required IDF for both Class I dams is the Probable Maximum Flood (PMF), unless an incremental damage/loss of life analysis (IDA) demonstrates that a lesser IDF is applicable. At this level of study it is not practicable to perform a detailed and fully defensible IDA. Accordingly, the IDF was conservatively assumed to be the PMF for the assumed Class I dams. Because the consequences of the potentially significant conservatism inherent in this assumption can be substantial in terms of the cost of the spillway capacity required, it would be appropriate to evaluate the IDF further in a subsequent study if this alternative continues to be found favorable. However, given the relatively close proximity of the Town of Cokeville and its location on the Bear River/Smiths Fork floodplain the IDA approach may or may not result in a lesser IDF.

**Probable Maximum Flood Estimation.** At this level of study it is not warranted to perform the extensive and detailed analyses necessary to most accurately determine the characteristics of a PMF at the preferred Site 1 let alone at each of the other alternative sites. Instead, estimates of PMF peak flows were made from correlations of peak flow versus drainage area based on past studies of other sites in Wyoming. Initially, data on a total of 27 dam sites for which previous estimates of PMF peak flow had been made by others were compiled and evaluated. The source of the data for these previous PMF study results was the U.S. Bureau of Reclamation and other projects completed for WWDC. Correlations of peak flow versus drainage area were investigated using this complete data set and various subsets of the data to determine if a reasonably reliable correlation could be derived.

Reasonable correlations (i.e., with relatively high $R^2$ values) were found once obvious outliers were excluded from the data set, leaving 23 data points with areas ranging from 1.3 sq miles to nearly 20,000 sq miles. Because the majority of sites on this project have quite small drainage basins, the analysis was limited to sites with smaller areas, leaving 14 data points for which the following regression equation was determined:

$$Q_{PMF} = 5755(A^{0.58}),$$

where $Q$ is peak PMF discharge in cfs and $A$ is drainage area in mi$^2$. 
The estimated peak PMF discharge utilizing this methodology is 41,000 cfs for Site 1. Because the equation above was derived from sites with drainage basins up to 200 mi², it is possible that it over predicts PMF peak discharges on the much smaller basins for other alternative sites. A more detailed evaluation of PMF peak discharge is recommended should this project advance to the next level of study.

100-Year Flood Estimation. Peak 100-year flood discharges were estimated for Site 1 and the other alternative sites as a basis for sizing a service spillway. These estimates were made using the methodology of Lowham (1988). This methodology is based on regression equations using data from numerous gaged sites in hydrologically similar regions of Wyoming as applicable to these sites. The regression equations used for this study were those requiring input of the drainage area above the site of interest and the average annual precipitation over the drainage area. The resulting estimated peak flow for Site 1 is 1,835 cfs.

8.2 Conceptual Design Methodology

The bases for establishing conceptual-level dam and reservoir size and spillway capacity for all of the dam and reservoir site alternatives has been described previously in Section 7.0, with additional detail on the IDF and spillway sizing methodology provided in Section 8.1.2. These parameters and others relevant to the conceptual design and cost estimating of the preferred alternative Site 1 – Lower Sublette Creek (dealt with in more detail this Section 8.0) are among the key information summarized on Table 7.6-1 that will have to be appropriately modified should further studies regarding needs, reservoir operations, and site-specific hydrologic and geologic/geotechnical conditions be undertaken.

In particular, final storage capacity should be tied to the desired reservoir yield and operations, and spillway capacity should reflect appropriate project-, site- and/or region-specific analyses to account for factors such as IDF determination, reservoir routing and attenuation (i.e., flood storage), incremental downstream damage/loss of life potential, and practicality of downstream warning/evacuation. Finally, note that the storage capacities reported for each alternative site, including the preferred Site 1, are assumed to include normal storage, carry-over storage (to the degree needed), and a modest minimum pool to accommodate sedimentation, recreation, fishery maintenance, and perhaps other operational or environmental factors. More detailed evaluation of the need and required capacity for each of these storage components should be carried out if this project is advanced to the next level of study.

Earth Dam/Abutment Spillway Concept. The approach to the conceptual design of the dams, spillways and outlet works for the alternatives characterization stage of this study involved first establishing a “typical design” representative of an assumed concept involving a zoned earth dam with abutment spillways and an upstream controlled outlet works. The typical design was then applied to each alternative site as appropriate utilizing the conceptual design algorithms in the spreadsheet model behind Table 7.6-1. This concept was then developed in more detail for the preferred alternative, Site 1 – Lower Sublette Creek as described herein still utilizing the spreadsheet model as appropriate as the primary design tool.

8.3 Site 1 Conceptual Design

8.3.1 Overview

The overall design concept and layout of features and facilities is shown in plan view on Figure 8.3-1 – Site 1 – Lower Sublette Creek Dam and Reservoir Layout and in
more detail on Figure 8.3-2 - Site 1 – Lower Sublette Creek Dam and Appurtenances Plan. As shown, the major components of this design include:

- Reservoir
- Dam
- Service and emergency spillways
- Outlet works
- Miscellaneous appurtenances
- Roads

Each of these major components is described below together with the bases for key elements of their design.

8.3.2 Reservoir
The reservoir at Site 1 is sized at approximately 5,000 ac-ft at normal high water level (NHWL). NHWL is set at elevation 6,260 feet, the approximate invert elevation of the Covey Canal on the north side of the proposed dam site. This NHWL will allow the Covey Canal to be used to supply Smiths Fork water to the reservoir as described previously in this report. At the proposed NHWL the reservoir pool will extend to, and may locally lie beneath, the existing high-voltage transmission lines passing through the Sublette Creek watershed. At NHWL the maximum water depth will be approximately 45 feet, and the average depth of the reservoir will be about 17 feet. The surface area at NHWL is approximately 291 acres.

8.3.3 Dam
Given the currently anticipated geologic and seismotectonic conditions at the site a zoned earthfill dam is proposed, and the remainder of this section is based on this assumption. However, if this project advances to the next level of study, it may be worthwhile to evaluate the potential for a roller compacted concrete (RCC) dam. The technical and cost feasibility of this dam type cannot be determined without adequate subsurface exploration and refinement of the required emergency spillway capacity. At a minimum, this concept would require the removal of all unconsolidated surficial deposits beneath the dam footprint. Normally this would be prohibitive at an alluvial valley site, but as discussed in the next paragraph, it may be necessary due to anticipated high seismic design loadings at the site.

Foundation Treatment. It is conservatively assumed that all unconsolidated alluvial and colluvial materials will first be excavated from beneath the entire dam footprint (see Figure 8.1-4 – Site 1 – Lower Sublette Creek Dam Maximum Section). This is to provide for the potential that these deposits would lose significant strength (if not liquefy) under the very strong design basis ground shaking identified in Section 3.2.5.5 if they were left in place beneath the dam. Any deeply weathered and/or intensely fractured bedrock beneath the alluvium/colluvium would also be excavated to adequately competent rock.

Upon completion of the foundation excavation a grout curtain would be constructed beneath the upstream portion of what will be the overlying central core of the dam. The grout curtain is assumed for purposes of this conceptual design to extend into the exposed rock foundation a depth approximately equal to the full height of the dam,
tapering to appropriately shallower depths in the dam abutments. The deep curtain is assumed to be formed by grout holes at 10-foot centers. A secondary, shallower curtain, or split spacing holes along the alignment of the deep curtain, is proposed to extend to depths approximately half the depth of the corresponding portion of the deep curtain. This grouting is intended to mitigate the potential for relatively intense fracturing to at least tens of feet depth associated with the bedrock structure previously described at the site.

Upon completion of, or contemporaneous with, construction of the grout curtain, slush grout and dental concrete will be applied to any open joints, fractures, fault zones or other openings found in the exposed bedrock at foundation excavation grade.

**Embankment Dam.** As shown on Figure 8.3-1, the maximum total structural height of the dam (including the portion below original grade) will be approximately 90 feet. The dam height above original ground is about 60 feet. Outside slopes of 2H:1V downstream and 3H:1V upstream are judged adequately stable given that the embankment will be fully founded on competent bedrock. A crest width of 20 feet is provided to allow the crest to be used for access onto and across the dam. The proposed internal zoning and its rationale are summarized as follows:

- **Downstream slope stability shell** – coarse, strong, erosion resistant soil/rock fill to minimize raveling and shallow slope failures and protect heterogeneous, potentially weaker, more erodible rock to be used in shell

- **Shells** – common soil and/or rock fill as derived from required excavations (service and emergency spillways, dam foundation, etc.); well compacted to prevent loss of significant shear strength and potential settling or slope failure under earthquake shaking

- **Upstream slope protection** – riprap (or soil cement) erosion protection on mid to upper slope to prevent wave erosion, underlain by drain rock and earth filter to prevent potential for rapid drawdown or earthquake-induced shallow to moderate depth failure of erosion protection layer or upstream slope

- **Upstream slope stability shell** – same as for downstream slope stability shell on portion of upstream slope not otherwise protected as described above; also provides strong foundation for overlying slope protection zones

- **Core** – A central zone core constructed of well-compacted, relatively fine-grained soils of sufficiently low permeability to serve as the primary waterstop for the dam; carried down to positive connection with sound, seepage-resistant bedrock (improved as necessary with slush grout and dental concrete)

- **Downstream chimney filter/drain** – specially designed gradation of hard, durable aggregate to prevent piping (internal erosion) of core material into the downstream shell under normal seepage or at any local cracks that may occur in the core; with adequate drainage capacity to convey seepage or crack flow to a safe exit at the toe of the dam via the blanket drain without allowing saturation of the overlying downstream shell

- **Upstream filter** – specially designed gradation of hard, durable fine aggregate sized to clog any cracks that may form in the core as a result of earthquake shaking, non-uniform settling of, or some other unanticipated defect in the core zone; also known as a crack stopper
- Blanket drain – horizontal layer of highly permeable coarse aggregate to cobbles to provide for positive relief of excess pore pressures that may form in the foundation, and conduit for seepage water collected in the chimney filter/drain zone; protected top and bottom by filter/drain material to prevent piping of adjacent shell material into drain zone.

8.3.4 Service and Emergency Spillways

As shown on Figure 8.3-2, a service spillway is located in the left (south) abutment of the dam, and an emergency spillway is sited in an existing topographic saddle approximately 1,600 feet south of the dam.

Service Spillway. The service spillway is sized to accommodate an estimated 100-year peak inflow of 1,835 cfs. At this level of study, no credit in the conceptual design has been taken for attenuation of this peak flow in the reservoir. The approximate spillway width is 60 feet, and a maximum head of four (4) feet is provided to pass the peak flow. A fully concrete lined structure with a horizontal controlled crest section (likely and ogee section) and downstream energy dissipation at the discharge end is envisioned. The area below the discharge end of the emergency spillway will be graded if/as necessary to ensure that peak discharges from the spillway do not present any greater risk of damage to the existing ranch facilities downstream than a natural flood of comparable peak flow at this location would.

Emergency Spillway. The emergency spillway is planned as a broad crest overflow channel constructed as an earth/rock cut through an existing saddle in the crest of Stoffer Ridge. A channel width of approximately 200 feet and a maximum flow depth of 15 feet were chosen to safely pass the estimated peak PMF flow of 41,000 cfs. Given the relatively low adverse grade of the approach channel from the reservoir pool to the control section at the crest of the saddle, velocities will be low even at maximum discharge and major erosion protection or lining is not anticipated as necessary even where loess will be encountered near the reservoir (see Figure 8.1-1). If necessary depending on the thickness and nature of the loess deposits, this material could be removed and replaced with excess cut material from the spillway excavation. Most of the spillway channel excavation is anticipated to be in rock (see Figure 8.1-1). The spillway crest will be located at the bottom of an approximately 40-foot deep rock cut at the crest of Stoffer Ridge. The spillway crest will be shaped to provide relatively uniform flow into the chute section on the west slope of the ridge, and will be protected from any possibility of back-cutting erosion by grouting or installation of a concrete cut-off wall if necessary (depending on the nature of the rock encountered). The chute section is also anticipated to be founded almost entirely in rock. There is, however, a possibility that the lower south slope of the chute may encounter loess (see Figure 8.1-1). If necessary, the cut slope in loess would be laid back to a stable angle and the lower portion of the slope subject to flow at maximum discharge would be armored as necessary (e.g., with riprap, grouted riprap, shotcrete or some other suitable material).

During later design it will be important to work toward optimizing the cut required to form the emergency spillway relative to the amount of fill required to construct the dam. At this level of study, a substantial overall excess of required cut over fill is apparent.
8.3.5 Outlet Works
The outlet works is assumed to be a conventional low-level structure comprised of an upstream trashrack-protected gated inlet, a horizontal steel pipe, a downstream energy dissipation structure, and a flow measurement weir to track reservoir releases. The outlet pipe will be founded on a bedrock ledge to be excavated at the design minimum pool invert elevation in the right abutment as part of foundation excavation and treatment described previously. Hydraulic control of a single slide gate is assumed, with the operator stem mounted on the upstream slope of the dam and operated from the dam crest. Manual control is assumed given the relative easy access to the site, although automated remote control could be provided if necessary or desirable. The outlet will be sized to meet WSEO requirements for emergency lowering of the reservoir and to provide for maximum anticipated irrigation releases. If necessary to meet environmental mitigation requirements related to the temperature of reservoir releases, consideration should be given to a multiple-level outlet should this project advance to the next level of study.

8.3.6 Miscellaneous Appurtenances
Special provisions will be made during final design at several locations, including but not limited to the following:

- Construction of a new inlet channel and control structure to pass Covey Canal flows into the proposed new reservoir, including a provision for monitoring of flows into the reservoir (and if necessary) past the reservoir in the Covey Canal
- Replacement of the existing siphon pipe at the downstream toe of the dam with steel pipe and concrete inlet and discharge structures
- Special protection of and provision for clean-out access to the siphon at the crossing beneath the service spillway
- Special design of the Covey Canal crossing of the emergency spillway (but assuming that the canal could be repaired if a major storm event resulted in significant spillway discharges)
- Protection if/as necessary of transmission line tower foundations and/or guy anchorages for any of these facilities potentially inundated or saturated by groundwater, and provision for maintenance or emergency access to these facilities by power company personnel comparable to present access

8.3.7 Roads
A new section of access road to and across the proposed dam will be provided as shown conceptually on Figure 8.3-1. This road would connect to the existing Stock Driveway Road both north and south of the dam site on the crest of Stoffer Ridge. This road would be graded and surfaced to provide seasonal access to the dam and to maintain current seasonal access across the Sublette Creek valley on the Stock Driveway Road. Guardrail would be provided on both sides of the dam crest. The crossing of the service spillway is assumed to be a bridge structure elevated sufficiently above the spillway channel as to not obstruct the flows or risk capturing debris. The emergency spillway crossing would be at grade with ramps into and out of the earthen channel.

A new road will also be constructed south of the dam and reservoir site to provide access from the current Stock Driveway Road on the crest of Stoffer Ridge to the existing road at the east toe of the ridge along Trail Creek. This will provide
continued seasonal access to the Underwood Canyon Road and beyond to the Tunp Range and Dempsey Basin.

If desired and permitted by the dam owners/operators, these new sections of access road could be used to move livestock across the Sublette Creek valley. Alternatively, a route such as that shown on Figure 8.3-1 as Proposed Relocated Stock Driveway could be constructed. Such a relocation would use existing dirt roads and two-tracks to the maximum extent feasible to minimize ground disturbance and cost.

Although not shown, consideration should be given to emergency and maintenance access to the dam from Highway 30, through the ranch just downstream of the dam, and up the swale adjacent to the proposed emergency spillway. If controlled access can be negotiated, this would provide a much quicker and more convenient way to get to the dam and reservoir than having to use the Stock Driveway Road from its connection with the Smiths Fork Road.

8.4 Cost Estimates

Conceptual level estimates for each of the surface water storage alternatives identified in Section 7.5 and characterized in Section 7.6 were prepared by use of a similar approach. This approach first involved estimation of construction costs for each of the major project components (i.e., dam, spillway and outlet works, conveyance canals/pipelines, etc.), appurtenant and miscellaneous items (e.g., access roads, mobilization/demobilization, etc.), and known interferences from existing infrastructure such as road relocation. Indirect costs (i.e., construction engineering and contingency) were then added as a percentage of the construction cost estimate.

The construction cost estimating approach included preparation of a conceptual layout/design as described in Section 7.6 for all alternatives to support screening level estimates and in Section 8.3 for the more detailed conceptual design of the preferred alternative (Site 1 – Lower Sublette Creek). It is important to note that all of the conceptual designs were based on the available USGS topographic mapping (at either 20 ft or 40 ft contour interval depending on the site). Volumes of earthwork and storage capacity were calculated at the selected dam heights (using multiple sections) to provide an approximate curve of dam height versus storage capacity and excavation/fill requirements. The overall dam volume was apportioned based on dam geometry (i.e., average dam height and length) to estimate various materials requirements such as riprap, core, shell, drain, etc.

The estimated construction cost for the service spillway was based on a formula used to estimate the approximate concrete volume considering dam height, head on the spillway, slope of abutment, and spillway width. The derived formula was then checked against prior dam construction projects. The emergency spillway cost was based on construction of a concrete crest (cutoff wall) and open cut rock/earth spillway in one of the abutments. If estimated earthwork cut volumes for the spillway exceeded that required for construction of the dam embankment, an additional cost was added to cover hauling this material to a local waste fill assumed to be within the reservoir area or immediate vicinity of the dam and reservoir.

The outlet works estimate for new reservoirs was based on a formula which related outlet works size to storage volume (and associated dam safety drawdown requirements) and height of dam (which is related to conduit diameter and length).
The generalized formula was then checked for reasonableness against costs from prior projects.

Costs were also included on a case by case basis to provide an allowance for other items such as site access, supply canal and/or wetlands mitigation, as appropriate.

Costs for the non-project component items (i.e., preparation of final design and specifications, construction engineering, contingency, legal fees, acquisition of access and rights of way, and environmental permitting and mitigation) were included as a percent of construction cost based on average percentages of these costs on prior project estimated and actual costs, or based on WWDC contract-designated percentages where appropriate.

The conceptual-level estimated project costs for each of the alternatives and their variants are presented in Table 7.6-1. This table includes a breakout of costs for either new canal or pumping facilities where required, a total project cost without the canal or pumping costs, and a total project cost with the canal or pumping costs where appropriate. Costs per cubic yard of fill and per ac-ft of storage are also provided on Table 7.6-1.

A more detailed breakout estimate for the preferred Site 1 is presented in Table 8.4-1 – Conceptual-Level Cost Estimate – Site 1 – Lower Sublette Creek in the contract-required WWDC format. All cost estimates are based on 2008 dollars. Note that the costs for final design, specifications, contract documents and permitting eligible for inclusion as Phase III of Level II are deducted from the Project Cost Total to arrive at the Level III Project Cost Total. This is the amount that would then be subject to a grant/loan mix under WWDC funding as described in Section 10.1.3.

It is important to understand that these opinions of cost are very preliminary, and that a number of potentially significant factors must be further investigated to support refinement of these costs. At this level of study, the opinions of cost are estimated to be within +50 to –30 percent of the actual costs.

9.0 Permitting and Mitigation
9.1 Environmental Considerations
9.1.1 General Site Description

Section 3.0 presents a description and inventory of a wide array of water resource related conditions and resources within the Sublette Creek watershed. These include: land uses and management activities (land ownership, energy infrastructure, irrigation, grazing, and mineral resources); the natural environment (climate, vegetation/land cover, topography, and geology); and watershed hydrology (hydrologic regimes, stream types, existing reservoirs, gaging/sampling sites/data, groundwater resources, and water quality in terms of suitability of surface and groundwater for the intended agricultural uses).

9.1.2 Preliminary Consultations

A memorandum was prepared and submitted on November 14, 2007 to several resource agencies describing the general location, size and nature of the alternative new dam and reservoir sites in the Sublette Creek watershed under preliminary evaluation and seeking initial feedback as to potentially significant environmental issues and related permitting requirements. Agencies contacted included the U.S. Fish and Wildlife Service (FWS), the Wyoming Game and Fish Department
Sublette Creek Reservoir and Covey/Mau Canal Rehabilitation Project, Level II Study
Wyoming Water Development Commission

(WGFD), and the U.S. Bureau of Land Management (BLM). FWS responded to the memorandum by letter dated December 5, 2007 (U.S. Fish and Wildlife Service, 2007; copy provided in Appendix I). A meeting was held on December 12, 2007 with six (6) resource staff of the BLM’s Kemmerer Field Office to discuss the ongoing evaluation of potential new dam and reservoir sites under this study, review relevant in-progress and archival information, and receive initial input from BLM as to potentially significant issues related to the proposed alternatives (see attendance list included in Appendix I). A response to the November 14, 2007 memorandum was received from WGFD by letter dated December 14, 2007 (WGFD, 2007; copy provided in Appendix I).

The Draft Report dated September 3, 2008 was sent to each of the agencies noted above for their further review. Responses were received from FWS by letter dated October 2, 2008 (FWS, 2008; copy provided in Appendix I) and from WGFD by letter dated October 6, 2008 (WGFD, 2008; copy provided in Appendix I).

Identification of potential environmental issues and related permitting considerations described in the following subsections are based on the results of these initial consultations and on compilation and review of other relevant publicly available information.

9.1.3 Animal and Plant Resources

Locations of known occurrences of rare plant and animal species in Wyoming are compiled in the Wyoming Natural Diversity Database (WYNDD). Figure 9.1-1 – Rare Species is a compilation of such locations within the Sublette Creek watershed. Known or potential issues related to these and other important species are discussed in the following paragraphs. See Section 9.4 for related discussion on potential mitigation related to animal and plant resources.

Proposed, Threatened and Endangered Species. The responses from FWS noted above identified and characterized the listed species that if potentially affected by any of the project alternatives would trigger a requirement for formal consultation with FWS under the Endangered Species Act (ESA). These include the black-footed ferret (status – endangered), Canada lynx (status - threatened), gray wolf (status – experimental), and Ute Ladies’-tresses (status – threatened). Although requiring further evaluation at a subsequent level of study, the potential for significant impacts to any of these species at any of the alternative dam and reservoir sites under consideration in this study is judged low with the possible exception of the gray wolf.

Bald Eagle. Bald eagles are known as year round residents of Wyoming. Their main food sources are fish, carrion, and small to medium sized mammals. They tend to be associated with riparian areas, lakes and reservoirs where mature trees provide roosting opportunities. Winter roosting occurs in areas with high density of large mature trees that protect them from the prevailing winds. If the proposed or an alternative dam and reservoir site contains suitable habitat, a bald eagle survey may be needed prior to any construction activities occurring. As seen on Figure 9.1-1, the presence of bald and golden eagles may be anticipated within the watershed, even though no known raptor nesting areas have been identified.

Although recently removed from the list of threatened and endangered species, bald eagles are still protected under the provisions of the Bald and Golden Eagle Protection Act (BGEPA) and Migratory Bird Treaty Act (MBTA). FWS publishes...
national guidelines to advise land managers when and under what circumstances the provisions of these acts may apply to activities under their jurisdiction. FWS, in cooperation with WGFD, is preparing local guidelines and has proposed a permit structure under BGEPA for implementation when impacts to either bald or golden eagles are unavoidable.

Other Animal Species of Concern. The Wyoming Natural Diversity Database (WYNDD) identifies occurrences of several other species of concern within the Sublette Creek watershed, including some within or in the vicinity of the alternative project area sites as shown on Figure 9.1-1. These include:

- **Birds** – Forster’s tern, long-billed curlew, osprey, sandhill crane, short-eared owl, snowy egret, white-faced ibis, and whooping crane
- **Mammals** – Idaho pocket gopher, and pygmy rabbit
- **Fish and other aquatic species** – bluehead sucker, leatherside chub, western pearlshell (see discussion below on Fisheries and Other Aquatic Resources regarding the Bonneville or Bear River cutthroat trout and northern leopard frog)

The potential exists for some of these species to occur within appropriate habitats within the study area or to be impacted outside of the study area by changes in flows in Sublette Creek. Although none of these species currently receive federal or state protection, it may be necessary and appropriate to further evaluate their occurrence and potential impacts from the preferred dam and reservoir storage alternative should the project continue.

Sage Grouse. Sage grouse are identified as a sensitive species/species of concern and merit special attention as discussed in some detail in the following paragraphs. The two-mile radius buffers around a number of sage grouse leks (breeding grounds) as shown on Figure 9.1-2 – Sage Grouse Leks is a clear indication that this species utilizes a significant portion of the Sublette Creek watershed as habitat.

The greater sage grouse (Centrocercus urophasianus) is a native species to much of Wyoming including the Sublette Creek watershed. This species is almost totally dependent on open sagebrush plain as its primary habitat. The males will gather in the early spring to lek (breeding ground) locations to start their elaborate courtship rituals (strutting). They are considered omnivores, eating insects, sagebrush and seeds; but are most reliant upon sagebrush for both cover from predators and for food.

The greater sage grouse is listed as a sensitive species by the BLM, and a species of concern by WGFD. The BLM definition of a sensitive species is as follows: species that could easily become endangered or extinct in the state, including: (a) species under status review by the FWS/National Marine and Fisheries Service; (b) species whose numbers are declining so rapidly that Federal listing may become necessary; (c) species with typically small or fragmented populations; and (d) species inhabiting specialized refugia or other unique habitats. WGFD lists the greater sage grouse as: species that are widely distributed, with population status or trends unknown but suspected to be stable; habitat restricted or vulnerable but no recent or on-going significant loss; species likely sensitive to human disturbance. The sage grouse is not listed as a Threatened or Endangered species and does not receive any protections from the Endangered Species Act; however, BLM and WGFD have developed restrictions/recommendations to help protect the sage grouse.
BLM has recommended that there be no surface occupancy within 0.25-mile radius of any known lek location or a 2-mile radius during the breeding season (March 15 to July 15), on BLM land or lands adjacent to BLM lands. Recent studies have shown that the 2-mile radius may not be sufficient, showing declines in the number of males returning to the leks with activities occurring beyond the 2-mile radius. Thus, the current recommendations may change over time.

It is recommended that close coordination with BLM and WGFD occur regarding any proposed or alternative project that has the potential to impact sage grouse habitat.

**Rare Plant Species of Concern.** The WYNDD has only two known sensitive plant species of concern located in the watershed area: beaver rim phlox and Dorn's twinpod. Although the potential exists for these species to occur within appropriate habitats within the project area, neither species currently receives federal or state protection.

**Big Game.** The Sublette Creek watershed contains portions of crucial big game habitat for mule deer and elk as seen on Figure 9.1-3 – Crucial Big Game Habitat, and also moose as reported by WGFD in their response letters noted previously. WGFD maps the seasonal ranges by herd unit for each big game species and makes special note of areas listed as crucial habitat. Crucial habitat or range is defined as those seasonal ranges or habitats (mostly winter range) that have been documented as the determining factor in a population’s ability to maintain itself at a certain level over a long period of time. The alternative dam and reservoir project sites are all located in delineated big game seasonal ranges. Site 5 and a very small portion of Site 1 are also located within portions of the Lost Creek Cooperative Management Unit (LCCMU) noted in Section 3.1.2. Of particular concern to WGFD in the Sublette Creek watershed are potential impacts to the Wyoming Range mule deer, West Green River elk, and Lincoln moose herd units. In particular, WGFD notes that a large percentage of the deer in the Wyoming Range herd unit move directly through the proposed alternative reservoir areas and the LCCMU from summer to winter ranges.

Ongoing coordination with WGFD will need to occur in order to fully assess and evaluate potential impacts and potential mitigation measures for crucial big game habitat/range should the project advance to the next level of study.

**Fisheries and Other Aquatic Resources.** As discussed in Section 3.4.2, Sublette Creek is classified 2AB by WDEQ and WGFD. This classification applies to streams that are known to support game fish populations or spawning and nursery areas at least seasonally, and provides protection to game fisheries, nongame fisheries and aquatic life other than fish among other uses. Streams within and potentially impacted by the Sublette Creek watershed also fall within the range-wide Bonneville cutthroat trout and leatherside chub conservation agreements, and the WGFD Comprehensive Wildlife Conservation Strategy (CWCS) plan.

WGFD states in their previously noted first response letter that Sublette Creek was sampled in 2005 and that nongame populations of sculpins, redside shiners, longnose dace, speckled dace, and most importantly leatherside chubs were found. Electrofishing and amphibian surveys conducted in 2008 found three species of concern within the project area: northern leatherside chubs, Bonneville cutthroat trout and northern leopard frogs.
WGFD provides background discussion on the three species of concern in their second response letter (WGFD, 2008). They note that disruption of access by leatherside chubs to diverse stream habitats and replacement of flowing water by standing water, both of which would result from construction of a reservoir, will likely have negative consequences for this species. WGFD is of the opinion that although impacts to Bonneville cutthroat of a dam on Sublette Creek will not be of the scale of a dam on Smiths Fork, those impacts will still outweigh any positive impacts to the aquatic community that a new dam and reservoir may provide. WGFD states that direct and indirect negative impacts from a dam and reservoir on Sublette Creek to the Northern leatherside chub will be greater than to the Bonneville cutthroat trout. Northern leopard frogs are reportedly found throughout the project area, including the proposed reservoir area at Site 1 – Lower Sublette Creek. FWS suggest close coordination with WGFD regarding potential impacts to and mitigation for the northern leopard frog (Rana pipiens) for which FWS has not yet completed a finding on a petition for listing under the ESA.

It will be especially important to continue ongoing communication and coordination with WGFD on fisheries and aquatic concerns should the project advance. It is also recommended that consideration be given to supporting to the degree and by the method(s) appropriate additional sampling of Sublette Creek to provide additional data on these issues. Finally, the recommendations in the range-wide conservation agreements and CWCS plan should be considered for relevance to any project proposed within the watershed.

9.1.4 Wetland Resources

Formal wetland delineation in accordance with the Corps of Engineers guidelines was beyond the scope of this study and was not conducted. GIS digital mapping from the National Wetland Inventory (NWI) was acquired to preliminarily identify wetland habitats in the study area. The various locations identified as potential alternative reservoir storage sites are all located on what are considered intermittent to perennial riverine systems. These systems are associated with streambeds and their associated wetland/riparian habitat. Riparian habitats are considered to be valuable habitat for both mammals and birds, along with assisting in reducing flooding. The creation of a reservoir on the drainage would inundate the basin bottoms changing the landscape/habitat.

The wetland habitats inferred to be present within the project area based on NWI mapping are shown on Figure 9.1-4 – NWI Wetlands. The total acreage of NWI-mapped wetlands within the preliminary footprint of each of the dam and reservoir storage project alternatives has been calculated and is presented in Table 7.6-1.

Some of the areas identified on the NWI maps as wetlands may in fact not qualify as jurisdictional wetlands upon subsequent detailed examination in the field. This is due to inherent limitations in the aerial photography-based methodology used to prepare the NWI maps. In general, estimates of wetland acreage based on the NWI maps tend to be conservative and actual acreage of jurisdictional wetlands may be less.

Formal wetlands delineation would be necessary prior to construction at any proposed reservoir storage site, and in any other areas of proposed disturbance (e.g., off-site borrow areas or quarries) to determine the level of impacts to wetlands located in the alternative project area and to identify and quantify any necessary mitigation of those impacts. Preliminary consultation should be initiated with COE.
in the next level of study to ensure wetlands delineations are acceptable and to begin
discussing the nature and extent of any required mitigation. Consultation should also
be carried forward with WGFD who have expressed significant concern with the
potential ripple effects of loss of wetland or riparian habitat on mule deer (parturition
or birthing habitats), songbirds, raptors, and other species.

9.1.5 Other Related Considerations

In their response to a memorandum requesting early input on potential environmental
issues with the alternative dam and reservoir projects under study identified three
other related considerations of significant concern (WGFD, 2007; see copy in
Appendix I):

- Impacts to seasonal public access to large blocks of public land under federal
  jurisdiction, including inundation of the Underwood Canyon Road;

- Inundation of lands that have undergone significant cooperative habitat
  improvement, including lands within the Lost Creek Cooperative Management
  Unit; and

- Increased public access during crucial winter months following reservoir
  construction, resulting in increased stress and winter losses of wintering wildlife.

An initial attempt to at least partially mitigate these concerns has been made in this
study by selection of Site 1 – Lower Sublette Creek as the preferred alternative, and
by including new access road alignments to maintain full access through Underwood
Canyon as described in Section 8.3.7.

Additional potential project-related effects were identified by WGFD (2008) in their
review comments on the Draft Report (see Appendix I). These are discussed in some
detail in those comments and only briefly summarized here:

- Affects on flowing streams (seasonal and other hydrologic patterns, stream
  connectivity, geomorphology, biology, and water quality);

- Loss of Bonneville cutthroat trout into the Covey/Mau Canal diversion on Smiths
  Fork, especially given the timing and scale of future diversions to supply a
  reservoir in the Sublette Creek watershed;

- Effects on upstream migration of Bonneville cutthroat trout and native non-game
  species past the existing Smiths Fork diversion;

- Elevated water temperature in the reservoir and in the Smiths Fork due to
  diversions to fill a proposed reservoir;

- Benefit to Bonneville cutthroat trout that may help preclude future ESA listing by
  removal of nonnative trout present in the project area;

- Potential for undesirable channels in stream geomorphology resulting from
  reservoir releases to Sublette Creek, including potential for accelerated channel
  and bank erosion; and

- Anticipated impacts both to riparian/wetland habitat in the area of reservoir
  inundation, as well as both upstream and downstream due to changes in stream
  hydrology.

- Potential effects on receiving streams of increased return flow quantity and
  quality resulting from supplemental irrigation water supply;
Close communication and coordination should be maintained with WGFD should this project advance to the next level of study in order to further evaluate these potential impacts and seek to develop acceptable mitigation measures.

9.2 **Cultural Resources**

Cultural resources in the context of the proposed alternative dam and reservoir sites being evaluated include prehistoric and historic cultural resources, paleontologic resources, and natural history resources. The only currently known cultural resources of some significance within the Sublette Creek watershed are the three alignments of the Sublette Cut-off trail shown on Figure 9.2-1 – Historical Trails. Evaluation of potential impacts to these trails will involve assessment of the trails themselves (e.g., the presence of original, undisturbed ruts) and the setting within which the trail exists (including unobstructed vistas comparable to those at the time of historical use of the trail). Further study will be required to assess potential impacts. However, it appears that the potential for impact to the portion of the southern trail within the area of disturbance of Site 1 – Lower Sublette Creek will likely be low given that this reach has been used and maintained as a through-going vehicle access road for many years and occurs within a setting that includes the transmission line corridor and existing active ranch at the site.

The Covey Canal is of some historical significance given its age and role in the development of agriculture in the lower Bear River Valley. As noted in Section 6.5, only maintenance-type improvements are currently recommended for the Covey Canal and Mau Lateral. If more extensive rehabilitation is considered, then it will be necessary to further assess potential cultural resource impacts. Impacts to Native American cultural resources are also judged not likely to be significant, in part due to the fact that no sensitive sites were identified within the Sublette Creek watershed by the Tribes involved in studies related to the recently completed Kemmerer Area Resource Management Plan (Bureau of Land Management, 2008). (Personal communication, Lynn Harrel/BLM, December 12, 2007)

Further communication and coordination with BLM archaeological resource specialists should be implemented if the project advances to the next level of study. This should include identifying any cultural resource surveys that may have been performed as part of previous studies for the existing transmission line corridor (if any) and recent or ongoing studies associated with the Gateway Transmission Project EIS.

9.3 **Permitting and Mitigation Process Evaluation**

The following discussion presents the results of an early regulatory process analysis for the alternative dam and reservoir projects identified and characterized in Section 7.0, including the preferred alternative further evaluated in Section 8.0. The purpose of this analysis is to characterize the known and likely environmental processes, permits and related requirements and conditions associated with the alternative projects, including identification of environmental documentation, permits, agency clearances and approvals, and agency coordination steps that would be required for implementation of the proposed actions and alternatives.

Any of the potential projects described in this plan would be subject to the National Environmental Policy Act (NEPA) and other federal environmental regulations administered by federal agencies such as the EPA, Bureau of Land Management (BLM), Army Corps of Engineers (COE), and/or the U.S. Fish and Wildlife Service
(FWS). The Wyoming agencies which may have environmental, land use, and other regulatory approval requirements include, but are not necessarily limited to the Department of Environmental Quality (WDEQ), State Engineer's Office (WSEO), State Historic Preservation Officer (SHPO), Board of Land Commissioners through the State Lands and Investments Board (SLIB), and Game and Fish Department (WGFD).

NEPA compliance and documentation is presented in Section 9.3.1, permitting and approvals are discussed in Section 9.3.2, and environmental issues were discussed in Section 9.1. Cultural resources were addressed in Section 9.2 and mitigation is discussed in Section 9.4. These discussions are based upon various assumptions about the proposed actions and alternatives. These assumptions may change as project planning progresses from this study. Ultimately, the applicability of the individual federal and Wyoming permits, clearances and approvals to the project(s) will depend upon the alternative(s) selected and their implications.

9.3.1 NEPA Compliance And Documentation

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

For this project, it is likely that COE would be the lead federal agency for implementation of the NEPA process given the known impacts to wetlands at each of the alternative sites, with BLM as a cooperating agency representing the interests of potentially impacted resources on and around lands under their administration.

The following discussion characterizes the basic steps of the NEPA process applicable to a reservoir storage project.

Prepare a Purpose and Need Statement for the Project. It is important to develop an accurate and defensible Purpose and Need statement for the project as one of the first steps in the NEPA process. The Purpose and Need statement provides an overall or basic purpose for the proposed action and presents details supporting various needs for the project. The Purpose and Need statement should provide enough information to develop and support a “reasonable range” of alternatives. More specifically, the Purpose and Need statement guides the alternative development and screening process. With the COE as the lead agency, the Purpose and Need would include a reference to finding the “least damaging practicable alternative.” This reference relates to the Clean Water Act Section 404 requirements that are under the jurisdiction of the COE and is an important part of the NEPA process for a reservoir storage project. Additional details about the Section 404 process are provided in Section 9.3.2. The project sponsor, WWDC, other project participants, and the public should all be part of the process of defining the Purpose and Need statement.

Develop Project Alternatives and NEPA Documentation Determination. The NEPA process requires analysis of the No Action alternative and a reasonable range of alternatives that fully address the project’s purpose and need. The reasonable range of alternatives may include one or more “build” alternatives, depending on the
nature and extent of anticipated project impacts and level of NEPA documentation to be provided.

For a new reservoir storage project, key issues associated with alternative development will or may include:

- Loss of wetland and riparian habitat from direct inundation by the reservoir;
- Indirect effects on wetland and/or riparian habitat upstream and/or downstream of the reservoir due to changes in stream flows associated with reservoir operations
- Potential impacts on threatened and endangered species;
- Potential impacts on fish and other aquatic species; and
- Potential impacts on other wildlife (e.g., sage grouse; big game)

Given these issues and risk management considerations, the project team anticipates that an EIS will likely be the appropriate NEPA documentation for reservoir storage projects. An EIS involves analysis of more than one build alternative and may take up to several years to complete. An Environmental Assessment (EA) may or may not involve analysis of more than one build alternative and can typically be completed in less than 18 months. The outcome of an EA is either a Finding of No Significant Impact (FONSI) or a recommendation to prepare an EIS. If an EA is prepared, there is a possibility that the outcome might be that an EIS is needed. This could occur as a result of “significant impact findings” or as a result of substantial public controversy over the project’s effects. If this occurs at the end of the EA process, the EIS process would need to start from the beginning, wasting a considerable amount of time and money. At this time, it appears it would be prudent to assume that an EIS process would be applicable, while leaving the option open for an EA/FONSI, rather than to proceed with an EA and take the risk that an EIS will ultimately be needed. This decision should be reviewed during a subsequent study (should the project advance) when more detailed information is available on a preferred proposed action and its appropriate alternatives.

Conduct a Proactive Public Involvement Program. The NEPA process begins with public and agency outreach and related input focused on alternatives and potential impacts. Education about the project’s purpose and need, project details and issues is provided and input is solicited in various ways. It is very important that the public have a clear understanding of the benefits and potential adverse impacts of the proposed action and alternatives. Public involvement is continuous throughout the project and can influence alternative development, alternative screening, issues addressed, mitigation measures, the level of NEPA documentation to be prepared (EA or EIS), and the selection of the preferred alternative.

Collect and Analyze Environmental Baseline Data. It is important to carefully identify environmental constraints and considerations early and incorporate them into alternative development efforts as a means of avoiding and minimizing potential impacts. Early field investigations and agency consultation and coordination efforts help to focus this effort and streamline subsequent analysis methods, schedule needs, and budget requirements. Creating “self-mitigating” alternatives is highly advantageous and fully consistent with the intent of NEPA.
Many NEPA analyses relate to compliance with various laws and regulations. Integrating the NEPA, National Historic Preservation Act, Endangered Species Act and other compliance processes will reduce overall permitting timeframes and costs, and streamline agency decision-making. These issues are discussed in Section 9.3.2.

**Prepare the Draft and Final Environmental Impact Statement.** The Draft EIS would be prepared in two versions. A Preliminary Draft EIS would be prepared for internal review. The Draft EIS would respond to comments on the Preliminary Draft EIS. The Draft EIS would be circulated for public review and would be the subject of a public hearing. The Final EIS would also be prepared in two versions. A Preliminary Final EIS would be prepared for internal review. The Final EIS would respond to comments on the Preliminary Final EIS. The Final EIS would be circulated for public review and would be the subject a public hearing. A Record of Decision would be prepared to complete the NEPA process.

### 9.3.2 Permitting/Clearances/Approvals

Presented below are the primary permits, clearances and/or approvals that would be required for any of the alternative dam and reservoir projects under consideration.

**Section 404 Permit.** Like all water development projects, any dam and reservoir storage project in the Sublette Creek watershed (within the larger Bear River basin) will face environmental permitting issues. Typically, a very significant environmental permit to be secured is a Section 404 Dredge and Fill permit from the U.S. Army Corps of Engineers (COE), Omaha District. Even when impacts are anticipated to be modest, the process of obtaining a Section 404 permit for new storage projects may take several years from initiation of the NEPA process.

The primary guidance in embarking on the permitting process for a new dam and reservoir storage project is the development of a defensible Purpose and Need for the project. The NEPA process dictates that the least environmentally damaging practicable alternative that addresses the purpose and need be pursued. This is the alternative most likely to be successfully permitted.

**Endangered Species Act (Section 7 Consultation).** The lead agency would prepare a biological assessment to determine project effects on threatened and endangered plant and animal species listed or proposed for listing (candidate species) under the Endangered Species Act (16 U.S.C. § 1531 et seq.). U.S. Fish and Wildlife Service (FWS) would then issue an opinion on whether federal actions are likely to jeopardize the continued existence of a threatened or endangered species, or destroy or adversely modify critical habitat. FWS must approve the preparation of a biological assessment to comply with the Endangered Species Act in order to render its decision. If FWS determines that the preferred alternative would jeopardize the continued existence of a species, it may offer a reasonable and prudent alternative that would preclude jeopardy.

**Fish and Wildlife Coordination Act.** The Fish and Wildlife Coordination Act requires federal agencies involved in actions that will result in the control or structural modification of any natural stream or body of water for any purpose to take action to protect the fish and wildlife resources which may be affected by the action. It requires federal agencies or applicants to first consult with state and federal wildlife agencies to prevent, mitigate and compensate for project-caused losses of wildlife resources, as well as to enhance those resources.
Laws and Regulations Addressing Cultural Resources. Because federal approvals are likely involved with any of the identified alternatives, a consideration of effects on cultural resources must be undertaken (Section 106 consultation), as required under the following laws and regulations: the National Historic Preservation Act (NHPA) of 1966 (16 U.S.C. § 470 et seq.); the National Environmental Policy Act (NEPA) of 1969 (42 U.S.C., § 4321); the Archaeological Resources Protection Act (ARPA) of 1979 (16 U.S.C. § 470aa et seq.); the National Park Services (NPS) procedures concerning the National Register of Historic Places (NR) (36 CFR Part 60); the Advisory Council on Historic Preservation's Procedures for the Protection of Cultural Properties (36 CFR Part 800); the Treatment of Archaeological Properties of 1980: Determination of Eligibility for Inclusion in the NR (36 CFR 63); the Secretary of Interior’s Standards and Guidelines for Archaeological Historical Preservation of 1983; Reservoir Salvage Act of 1960; and the l974 Amendment to the Reservoir Salvage Act of 1960. The State of Wyoming Historic Preservation Office (SHPO) coordinates with federal agencies in determining the significance of cultural resources potentially affected by ground disturbing activities.

In addition, consultation with relevant Native American groups concerning traditional cultural properties is required under the American Indian Religious Freedom Act of 1978 (AIRFA, P.L. 95-341.42 U.S.C. § 1996) and Section 4 of ARPA of 1979. Guidelines for evaluation of traditional cultural properties are contained in Bulletin 38 issued by the National Park Service.

Wyoming Board of Land Commissioners. The Wyoming Board of Land Commissioners through the State Lands and Investments Board (SLIB) is responsible for regulating all activities on state lands, including granting of rights-of-way. Any facility, utility, road, railroad, ditch or reservoir to be constructed on state or school lands must have a right-of-way, as required in the “Rules and Regulations Governing the Issuance of Rights Of Way” (W.S. 36-20 and W.S. 36-202).

Wyoming State Engineer’s Office Surface Water Permits. The State Engineer’s Office administers the water rights system of appropriation within the state. The Applicant must obtain the necessary water rights permits from the State of Wyoming for the diversion and storage of the State’s surface water, and filing of one or more exchange petitions depending on the final operational plan for the preferred reservoir.

Wyoming State Engineer’s Office Permit to Construct/Dam Safety Review. The Wyoming Dam Safety Law (W.S. 41-3-301 et seq.) requires that any persons, public company, government entity or private company who proposes to construct a dam which is greater than 20 feet high or which will impound more than 50 acre-feet of water, or a diversion system which will carry more than 50 cubic feet of water per second, must obtain approval for construction of the dam or ditch from the Wyoming State Engineer's Office. The approval by the State Engineer's Office of a dam's construction is contingent upon the Office's review and approval of all dam plans and specifications, which must be prepared by a registered professional engineer licensed in Wyoming. Design, construction, and operation of jurisdictional dams must also comply with dam safety regulations promulgated pursuant to the Dam Safety Act. At present, these regulations are in final draft form and formal issuance is anticipated in the not distant future.

Wyoming Department of Environmental Quality – National Pollution Discharge Elimination System (NPDES) permit and Section 401 Certification. The federal
Clean Water Act is administered in Wyoming by the Department of Environmental Quality (WDEQ), Water Quality Division (WQD) consistent with the Wyoming Environmental Quality Act. The Section 401 Certification is the State’s approval to ensure that the activities authorized under Section 404 meet state water quality standards and do not degrade water quality. Any discharge of pollutants into the broadly defined “waters of the state” requires application to and permit issuance by WQD in accord with WQD’s Rules and Regulations. This body of regulations sets forth classification of surface and groundwater uses and establishes water quality standards (Wyoming Water Quality Standards). The WQD administers the NPDES permit system including storm water permits and construction-related, short-term discharge permits. EPA has oversight responsibility for federal Clean Water Act programs delegated to and administered by the State Water Quality Division. EPA also may intervene to resolve interstate disputes where discharges of pollutants in an upstream state may affect water quality in a downstream state.

**Wyoming Department of Environmental Quality - WYPDES Individual Storm Water Permit.** Any of the alternative dam and reservoir storage projects evaluated during this study would classify as a large construction activity for purposes of storm water permitting since the overall area of land disturbance is greater than five (5) acres. As a result, an individual WYPDES discharge permit from WDEQ will be required. The application and implementation requirements for this permit are provided in W.S. 11-10-2004, Chapter 2 – Permit Regulations for Discharges to Wyoming Surface Waters.

**Mining Permit.** A Wyoming mining permit is not required for development of an aggregate and/or borrow material source solely for use in construction of one of the various reservoir alternatives and whose product is not for commercial sale. Commercial sources of aggregate, rock, or other mined materials are responsible for obtaining and maintaining all required permits and clearances for their operations.

**Special Use Permits/Rights-of-Way/Easements.** Special use permits, rights-of-way (ROW) or easements will be required wherever access across the lands of others (private, state or federal) is needed for construction and/or operation of the project facilities. These may be temporary (e.g., access to a temporary borrow area or quarry site to be closed and reclaimed; construction of a new haul road; etc.) or permanent (e.g., construction of a dam and its appurtenant structures, relocation of an existing road or construction of a permanent new road). Usually privately owned lands that will be rendered permanently unavailable (such as the dam and reservoir footprint of a storage project) would be purchased unless the owner desired (and the sponsoring entity agreed) to a permanent easement. Permanent use of BLM lands would most likely be administered under a grant with an appropriate term issued under their ROW process. The specific requirements for rights-of-way, special use permits and easements vary widely and should be determined as part of the early stages of planning for a specific proposed project. This will help to avoid the potential for significant project delay, higher costs, or required changes in location/alignment or design during project development and implementation.

**Other.** In addition to the above, there may be other permits and clearances required for a given dam and reservoir project. These might include permits typically required to be provided by the construction contractor (e.g., air quality permit; trash/slash burning permit; etc.).
9.4 Mitigation

Based on prior experience and preliminary consultation with various agencies as discussed previously, mitigation could be required at any of the identified alternative dam and reservoir sites to address impacts to wetlands, riparian vegetation, stream channel habitat, big game resources, aquatic species and possibly threatened, endangered or experimental status species. As noted previously, it is preferred to avoid the need for mitigation of a potentially significant impact by relocation and/or “self-mitigating” design if technically and economically feasible.

Detailed mitigation plans would need to be prepared and approved to replace any lost wetlands identified and quantified by formal wetlands delineation, and riparian vegetation communities. However, given the relatively small acreages of wetlands at the alternative dam and reservoir sites (ranging from 5 to 38 acres for reservoirs not exceeding 5,000 ac-ft storage capacity, and up to 84 acres for reservoir variants of 15,000 ac-ft capacity), it is anticipated that mitigation of this resource will be possible at any of the sites by constructing additional wetlands nearby, ideally in a comparable environment as the area impacted.

Mitigation of potential raptor impacts would generally involve control of certain construction activities during sensitive time periods, and avoidance of direct disturbance of the subject species. Mitigation of potential impacts to sage grouse leks/habitat, aquatic species of special concern, and big game crucial habitat and migration will be given special consideration as discussed previously. If any T&E species were encountered at a given site special consultation with FWS would be required to determine if appropriate mitigation could be implemented. In general, any such impacts would be avoided to the greatest extent possible by relocation of site facilities.

In regard to potential impacts to sensitive fish species, FWS (2008) has suggested consideration of several mitigation measures summarized as follows:

- Siting a reservoir as high in the watershed as possible to reduce amount of stream habitat obstructed by the dam;
- Installation of fish screens at the existing or any proposed new diversion on Smiths Fork; and
- Installation of fish ladders or other means (e.g., engineered side channel) to provide for fish passage around the dam.

WGFD (2008) has suggested consideration of the following additional mitigation measures:

- Chemical treatments of the Sublette Creek drainage to remove non-native trout and restore a genetically pure population of native trout and other native fish species;
- Salvage native fish species from renovated stream segments (or collect them in other streams) and reintroduce them into restored stream habitats;
- Provide a minimum fishery pool (possibly on the order of 30 percent of the storage at maximum pool);
- Provide fish passage from the Bear River to the reservoir, and a fish ladder to bypass the reservoir;
- Re-evaluate the instream flow requirement on Smiths Fork; and
- Implement instream channel improvements in tributaries entering the reservoir to improve spawning and rearing habitat for all native species, and consider upland habitat improvements to restore, maintain or enhance habitat conditions for native fish species.

Additional cultural and historic resource fieldwork would need to be completed to identify and document any such resources that would be inundated or otherwise impacted as a result of constructing any one of the alternative dams and reservoirs studied herein. This would include, in turn, a class I (literature search) survey, a class II (reconnaissance inventory) survey, and if needed, a class III (intensive inventory) survey. Ultimately, a mitigation plan for cultural resources would be developed which would culminate in a Memorandum of Agreement (MOA) between the Wyoming SHPO and the lead federal agency with concurrence by the project sponsor(s), and any affected Native American tribes (if any). The agreement would ultimately require approval from the Advisory Council on Historic Preservation.

### 10.0 Project Financing

Potential sources of funding for the preferred alternative surface water storage project identified in Section 7.7 are identified and characterized in this section of the report. Based on this evaluation, it is apparent that the primary source of potential funding will be the Wyoming Water Development Commission (WWDC) as discussed in Section 10.1. The level of potential funding available from WWDC will depend in part on whether or not the proposed project can develop water in excess of the sponsors present and future needs to provide one or more of the potential secondary (multiple) benefits identified in Section 7.3.

Regardless of whether secondary benefits are documented that would justify WWDC funding of the portion of the project promoting those benefits, some other potential funding sources discussed in Section 10.2 may be able to provide some additional monetary and/or in-kind contribution supportive of the overall proposed project. It is not anticipated, however, that any of these potential sources would be able to fund other than a very small part of the overall sponsor’s share of total project cost.

It is important to understand that the potential sources identified herein are not necessarily exhaustive of the resources that may be available, that existing programs change and sometimes disappear over time, new programs arise, funding levels vary year to year, and competition for many of the programs is significant. Also, contact information for various programs and key people can also change.

Key aspects and information about the funding programs identified are discussed in the following sections and summarized in a matrix format (Table 10.1-1 – Potential Funding Sources).

#### 10.1 Wyoming Water Development Program

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

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

The main Wyoming Water Development Program encompasses new development,
rehabilitation, water resources planning, and master planning. Of most relevance to
the Sublette Creek watershed in terms of implementing the preferred alternative dam
and reservoir storage project is the Dam and Reservoir Program. The Rehabilitation
Program would be a potential source of funding for any significant rehabilitation or
upgrades to the existing Covey Canal/Mau Lateral system. Information regarding
these programs is available in the Operating Criteria of the Wyoming Water
Development Program dated June 5, 2008 which can be downloaded at the following
website: [http://wwdc.state.wy.us/opcrit/final_opcrit.pdf](http://wwdc.state.wy.us/opcrit/final_opcrit.pdf) and from a WWDC form
titled Information for New Applicants which is available for download at:
[http://wwdc.state.wy.us/projappl/New_Ap_Info.pdf](http://wwdc.state.wy.us/projappl/New_Ap_Info.pdf). The WWDC Dam and
Reservoir Program and the Rehabilitation Program are discussed further in Sections
10.1.1 and 10.1.2, respectively.

It is important to ensure that the most current information on funding is reviewed
prior to making an application as WWDC’s policies and procedures can and do
change over time in response to legislative direction and/or Commission action.
Review of information available at the above websites and contact with the staff of
the WWDO (307.777.7626) is recommended prior to beginning the application
process.

### 10.1.1 Dam and Reservoir Program

This program provides technical assistance and funding to develop dam and reservoir
projects to store waters of the state that are unused and/or unappropriated at present.
WWDC has developed priorities relative to the types of projects the program should
pursue to utilize available program funds effectively and efficiently. Relevant to dam
and reservoir projects, priority is given to:

- Multipurpose Projects (including those serving agriculture, municipal, industrial,
rural domestic, recreation, environmental, flood control, erosion control), and
hydropower functions
- Storage Projects (dams and reservoirs that store water during times of surplus for
use later when needed)

These project types are given highest priority by WWDC when determining what
projects to pursue among all of the applications received for funding.

Two important criteria that apply specifically to eligible dam and reservoir projects
are:

- “Level II, Phase III – Dam and Reservoir Program only  This phase of
development pertains to projects that enlarge existing storage projects by 1,000
acre-feet or greater or for proposed new dam and reservoirs with a capacity of
2,000 acre-feet or greater. Work included under this phase includes final
engineering design reviews required by the National Environmental Policy Acts
consultations required by the Endangered Species Act, and acquisition of state
and federal permits.”
“The WWDC may accept applications related to the construction of dams and reservoirs from applicants that are not public entities. As the evaluations of the feasibility of new dams are complex, this will allow the applicant to know if the proposed reservoir is feasible prior to becoming a public entity. However, the applicant must be a public entity before applying for Level II, Phase III funding.”

10.1.2 Rehabilitation Program
The Rehabilitation Program addresses the improvement of water projects completed and in use for at least fifteen years in order to assist in keeping existing water supplies effective and viable for the future. Relevant to the Covey Canal/Mau Lateral system, the Rehabilitation Program can improve existing agricultural conveyance systems to insure safety, decrease operation and maintenance (O&M) costs, and increase the efficiency of agricultural water use. If upgrades to the existing conveyance system are directly related to serving as the source of supply to the proposed dam and reservoir storage project, it may be possible to include such work as part of a project under the Dam and Reservoir Program. Clarification should be sought from WWDO if such a plan is contemplated. Otherwise, improvements whose primary or sole purpose is to promote conservation and conveyance efficiency for water delivered for direct irrigation would fall under the Rehabilitation Program.

An application may be made to proceed directly to Level II for eligible projects under the Rehabilitation Program. If the project is found technically and economically feasible the project can advance to construction.

10.1.3 Financial Plan
The current standard terms of the Wyoming Water Development Program financial plan for Level III (construction phase) funding are summarized as follows:

- Sixty-seven (67) percent grant to thirty-three (33) percent loan mix
- Maximum grant of 75 percent only where severe financial hardship has been successfully demonstrated to WWDC by applicant
- Minimum four (4) percent loan interest rate (current rate is 4 percent, but legislature may increase rate)
- Maximum 50-year term of loans; standard loan term is 30 years; term shall not exceed economic life of project
- Payment of loan interest and principal may be deferred up to 5 years after substantial completion at WWDC’s discretion under special circumstances

Special financial plan considerations for dams and reservoirs are summarized as follows:

- WWDC may recommend grant/loan mix based on sponsor’s ability to pay a portion of project costs and all operation, maintenance and replacement (OM&R) costs
- As noted previously, WWDC may recommend that program pay for final design and permitting costs
- WWDC may recommend that program pay for storage capacity needed to provide water for environmental mitigation and enhancement, thereby by reducing cost applied to grant/loan mix
WWDC may recommend any combination of the above considerations.

The Commission will evaluate whether or not a project will be funded for Level III construction following review of the results of Level II studies. If the Commission determines that the project should not advance due to any of a number of considerations regarding the merits of the project and the ability and willingness of the applicant to assume their share of financial responsibility for the project, the sponsor has the option of making a formal presentation to WWDC relative to the sponsor’s ability and willingness to pay. This presentation must address the need for the project, the direct and indirect benefits of the project, and any other information the sponsor feels is relevant to the Commission’s final decision.

10.2 Local Agencies

The Lincoln Conservation District (LCD) can help serve as a liaison between local landowners and resource users and state and federal government agencies in relation to potential secondary environmental and agricultural benefits that may be provided by the proposed project. In addition to its many other roles and responsibilities, the LCD can also provide funding-related assistance as follows:

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

The LCD would also implement the grant program being developed by the Wyoming Association of Conservation Districts (WACD) to address locally driven watershed efforts.

10.3 Other State Agencies

10.3.1 Wyoming Department of Environmental Quality

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

The Bureau of Land Management (BLM) in Wyoming is partnering in the implementation of several section 319 watershed plans statewide as part of their Watershed and Water Quality Improvement efforts. Given the distribution of private, state and federal (primarily BLM) lands within the Cottonwood/Grass Creek watershed, this type of partnering may be applicable to future BMP projects that might best be implemented across land ownerships.
10.3.2 **Wyoming Game and Fish Department**

The following summary of funding assistance available from the Wyoming Game and Fish Department (WGFD) is quoted from the Water Management & Conservation Assistance Program Directory (WWDC, 2005):

“The Wyoming Game and Fish Department offers a funding program to help landowners, conservation groups, institutions, land managers, government agencies, industry and non-profit organizations develop and/or maintain water sources for fish and wildlife. This program also provides funding for the improvement and/or protection of riparian/wetland areas for fish and wildlife resources in Wyoming. Applications for projects are accepted any time with approval on January 1 and August 1 of each year.

**Riparian Habitat Improvement Grant.** The purpose of this program is to improve or maintain riparian and wetland resources. Fencing, herding, stock water development, streambank stabilization, small damming projects and beaver transplanting are a few examples of efforts that qualify under this program. Permits, NEPA compliance, construction, maintenance, access and management planning are all grantee responsibilities. There is $10,000/project maximum available with 50% cash or in-kind required from grantee.

**Water Development/Maintenance Habitat Project Grant.** The purpose of this program is to develop or maintain water for fish and wildlife. Spring development, windmills, guzzlers, water protection and pumping payments are examples of the extent of this program. Permits, NEPA compliance, maintenance, access and water rights are responsibilities of the grantee. There is a maximum of $10,000/project and 50% cash or in-kind contribution required from the grantee.

**Upland Development Grant.** The purpose of this program is to develop upland wildlife habitat. Example project include management, grazing systems, prescribed burning, wildlife food plots such as oat, millet or corn plantings, range pitting and range seeding. Permits, NEPA compliance, maintenance, access and management planning are responsibilities of the grantee. There is a maximum of $10,000/project and 50% cash or in-kind contribution required from the grantee.

**Fish Wyoming.** The purpose of this program is to develop public fishing opportunities. Examples of projects within this effort are boat ramps and fishing access. This program provides a 50% match of funding which is channeled through a private organization or municipality.”

**Wyoming Sage Grouse Conservation Fund.** WGFD also administers the Wyoming Sage-Grouse Conservation Fund (WSGCF); [http://gf.state.wy.us](http://gf.state.wy.us). The WSGCF is a special fund established by the Wyoming State Legislature to support the efforts of Local Sage-Grouse Working Groups (LWGs). The applicable LWG for the Cottonwood/Grass Creek watershed is the Big Horn Basin Sage-Grouse Local Working Group (BHLWG). The WSGCF funding is intended to promote conservation of sage grouse populations and habitat (sagebrush ecosystems), including socio-economic and human use of the habitat. The BHLWG has recently completed the Sage-grouse Conservation Plan for the Big Horn Basin (BHLWG, 2007) to identify and guide implementation of these objectives.

Requests for WSGCF funding must be made on a Project Proposal Form available at: [http://gf.state.wy.us/wildlife/wildlife_management/sagegrouse/BigHornBasin/BHB%](http://gf.state.wy.us/wildlife/wildlife_management/sagegrouse/BigHornBasin/BHB%).
Funding is normally considered for projects ranging between $5,000 and $50,000, with priority given to those with matching funds, established partnerships, multi-species benefits, management relevance and consistency with the local sage-grouse conservation plan, highest wildlife impact, appropriate budgets, landscape scale, and a lasting legacy of benefits. Evaluation criteria include: consistency with the local plan, likelihood of project success, project readiness, availability of matching funds, multiple species benefits, significance at local/state/regional level, duration of benefits, and adequacy of funding.

Application may be made at any time, but should be made by February 1 to receive first round consideration. Funds awarded must be expended between July 1 of the year received and September 30 of the second year after award. The funds are normally distributed as reimbursable grants (i.e., payments are made for expenses incurred and not “up-front”). Requests for funding of habitat improvement projects, including water developments, must include a livestock grazing management plan. A Project Close-out Report must also be submitted upon completion to allow tracking of expenditures and tracking of results.

**10.3.3 Wyoming Wildlife and Natural Resource Trust**

The Wyoming Wildlife and Natural Resource Trust (WWNRT) was formed by the state legislature in 2005 to preserve and enhance Wyoming’s wildlife and natural resources. Projects funded by WWNRT must provide a public benefit such as continued agricultural production to maintain open space and healthy ecosystems, enhancements to water quality, and maintenance or enhancement of wildlife habitat. Allowable projects under this program that are potentially relevant to this watershed management plan study include:

- Improvement and maintenance of existing aquatic habitat necessary to maintain optimum fish populations.
- Conservation, maintenance, protection and development of wildlife resources, the environment, and Wyoming’s natural resource heritage.
- Participation in water enhancement projects to benefit aquatic habitat for fish populations and allow for other watershed enhancements that benefit wildlife.

Funding is by grant with no matching funds required. Non-profit and governmental organizations (including watershed improvement districts, conservation districts, etc.) are eligible for funding by WWNRT. Projects will be funded in July and January. Applications may be filed any time, but must be filed within 90 days of the next funding cycle to receive consideration in that cycle.

**10.4 Federal Agencies**

**10.4.1 Bureau of Land Management**

The Bureau of Land Management (BLM) administers the Riparian Habitat Management Program. The goals of this program are to maintain, restore, improve, protect and expand riparian-wetland areas to achieve “proper functioning condition for their productivity, biological diversity, and sustainability.” Funding is available (subject to budget allocations) for projects which include partnering with non-BLM interests.

BLM also administers rangeland improvement projects on their lands under a Cooperative Agreement for Range Improvements. Range improvement projects
can include development of water through the construction of small reservoirs, pits, springs developments, and wells including any associated distribution pipelines. BLM’s share of funding comes from their range improvement fund which is generated from grazing fees and to a lesser degree from general rangeland management appropriations. Participation by livestock operators generally is in-kind labor and sometimes a portion of material costs. Monetary support sometimes is available from conservation/environmental interests.

As noted previously, BLM also participates in the implementation of a number of section 319 watershed plans statewide.

10.4.2 Bureau of Reclamation
The Bureau of Reclamation (BOR) administers the Water 2025 Challenge Grant Program. This program provides funding on a competitive basis for projects focused on water conservation, efficiency and water marketing. Preference is given to projects that can be completed within 24 months that will help to prevent crises over water in areas identified as “hot spots” where potential for conflict is judged to be moderate to highly likely by 2025. Because the Sublette Creek watershed is not located in or near a BOR-defined “hot spot” and the primary purpose of the proposed project is water storage for agricultural beneficial use, it would appear that the chances of successfully competing for a grant under this program are slim.

10.4.3 Environmental Protection Agency
The Targeted Watershed Grants Program administered by the Environmental Protection Agency (EPA) “encourages watershed practitioners to examine local water related problems in the context of the larger watershed in which they exist, to develop solutions to those problems by creatively applying the full array of available tools, including general, state and local programs, to restore and preserve water resources through strategic planning and coordinated project management that draw in public and private sector partners...” as described in the following program website: http://www.epa.gov/twg/2006/2006faq.html#intro.

Organizations eligible for funding include nonprofits, tribes, and local governments. The assistance provided consists of grants for up to 75 percent of the total project costs. A match of at least 25 percent is required. The typical median amount awarded is $700,000 with a typical range of $300,000 to $900,000. It is important to note that application must be made by the governor, and that the competition for these grants is keen.

10.4.4 Fish and Wildlife Service
Technical and financial assistance are available to private landowners, profit or non-profit entities, public agencies and public-private partnerships under several programs addressing the management, conservation, restoration or enhancement of wildlife and aquatic habitat (including riparian areas, streams, wetlands and grasslands). These programs include, but are not necessarily limited to:

- **Partners for Wildlife Habitat Restoration** – technical and financial assistance to private landowners through Wildlife Extension Agreements (WEA) to implement and maintain restoration projects while the landowner retains full control of the land.

- **North American Wetlands Conservation Act Grant Program** – grant program promoting long-term conservation of wetlands ecosystems and the species that
depend on them; requires cost-share partners to provide non-federal matching funds at least equal to the grant amount. Small Grants are typically for $50,000.

- **Landowner Incentive Program (Non-Tribal).** This program provides funding directly to the lead state wildlife service agency (WGFD in Wyoming) for programs addressing the issues noted previously.

### 10.4.5 Natural Resources Conservation Service

The Natural Resources Conservation Service (NRCS) administers a number of funding and technical assistance programs applicable to many of the alternative projects identified in Section 3.0. These programs are briefly described below and summarized in Table 6.4-1. Additional information on these programs is included in Appendix J.

**Environmental Quality Incentives Program.** The Environmental Quality Incentives Program (EQIP) is a voluntary program available to agricultural producers that provides technical assistance, cost sharing and incentive payments for projects and practices that improve water quality, enhance grazing lands, and/or increase water conservation. Current priorities used by NRCS in allocating EQIP funds that are applicable to the Cottonwood/Grass Creek watershed include reduction of non-point source pollution of surface waters, reduction in soil erosion and sedimentation from agricultural lands, and promotion of at-risk species habitat conservation.

Non-federal landowners (including American Indian tribes) that engage in livestock operations or agricultural production are eligible for funding. Eligible land includes cropland, rangeland, pasture, forestland, and other farm and ranch lands. Eligibility also requires that the applicant develop an EQIP plan of operations that becomes the basis of the cost-sharing agreement between NRCS and the participant.

Funding assistance may include cost-sharing, incentive payments and technical assistance. Cost-sharing can provide up to 75 percent of the costs of eligible conservation practices important to improving and maintaining the health of natural resources in the area. The term of cost-sharing contracts is from one (1) to ten (10) years. Incentive payments may be made for up to three (3) years to encourage land, integrated pest, irrigation, and/or wildlife management practices. The maximum aggregate limit of cost-sharing and incentive payments to an individual or entity is $450,000 for all contracts entered into during FY 2002-2007.

Detailed information about the EQIP program is available at the following website: [http://www.nrcs.usda.gov/PROGRAMS/EQIP/](http://www.nrcs.usda.gov/PROGRAMS/EQIP/).

**Watershed Protection and Flood Prevention Program.** Also known as the “Small Watershed Program” or the “PL 566 Program,” this program provides technical and financial assistance to address resource and related economic problems on a watershed basis. Projects related to watershed protection, flood prevention, water supply, water quality, erosion and sediment control, wetland creation and restoration, fish and wildlife habitat enhancement, and public recreation are eligible for assistance. Technical and financial assistance is also available for planning and installation of works of improvement to protect, develop, and use land and water resources in small watersheds.

Applicants eligible for funding through this program that are potentially relevant to the Cottonwood/Grass Creek watershed include: local or state agencies, counties, conservation districts, or other subunits of state government (e.g., watershed
improvement, water conservancy and irrigation districts) with the authority and capacity to carry out, operate, and maintain installed works of improvement. Projects are limited to watersheds containing less than 250,000 acres.

The assistance provided consists of technical assistance and cost sharing (amount varies) for implementation of NRCS-authorized watershed plans. Technical assistance is provided on watershed surveys and planning. Although projects vary significantly in scope and complexity, projects receiving $3.5 million to $5 million in federal financial assistance are not uncommon.

**Other NRCS Programs.** Other programs administered through NRCS that may be relevant to certain of the alternative projects discussed in Section 3.0 include, but are not necessarily limited to the following:

- Wildlife Habitat Incentives Program (WHIP)
- Wetlands Reserve Program (WRP)
- Grassland Reserve Program (GRP)
- Conservation Security Program (CSP)
- Farm and Ranchlands Protection Program (FRPP)
- Emergency Watershed Protection (ERP)
- Small Watershed Rehabilitation Program
- Sage Grouse Restoration Project (SGRP)
- Grazing Lands Conservation Initiative (GLCI) Grants
- Cooperative Conservation Partnership Initiative (CCPI)

### 10.5 Non-Profit and Other Organizations

**Ducks Unlimited.** Ducks Unlimited, Inc. (DU) is a potential funding source for wetlands and waterfowl restoration projects. Although direct grant funding is limited (to the extent that there is generally about $20,000 to $30,000 available annually statewide), in-kind assistance may be available from the local chapter of DU.

Additional information on DU’s funding programs and opportunities is available in the Water Management & Conservation Assistance Program Directory referenced previously.

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

**National Fish and Wildlife Foundation.** The National Fish and Wildlife Foundation (NFWF) is a private, non-profit, tax-exempt organization chartered by Congress in 1984 to sustain, restore and enhance the Nation’s fish, wildlife, plants and habitats. NFWF provides grant funding on a competitive basis through their Keystone Initiative Grants and Special Grant Program. Some of the grants/programs that may be applicable to potential projects in the Cottonwood/Grass Creek watershed include, but are not limited to the following:
Pulling Together Initiative - provides support on a competitive basis for the formation of local Weed Management Area (WMA) partnerships that engage federal resource agencies, state and local governments, private landowners, and other interested parties in developing long-term weed management projects within the scope of an integrated pest management strategy; minimum 1:1 non-federal match is required.

Native Plant Conservation Initiative – funding preference for "on-the-ground" projects that involve local communities and citizens volunteers in the restoration of native plant communities.

Bring Back the Natives Grant Program – funds to restore damaged or degraded riverine habitats and their native aquatic species provided by BLM, Bureau of Reclamation, FWS, Forest Service, and NFWF; minimum 2:1 non-federal match required.

Five-Star Restoration Program - provides modest financial assistance on a competitive basis to support community-based wetland, riparian, and coastal habitat restoration projects that build diverse partnerships and foster local natural resource stewardship through education, outreach and training activities; average grant is $13,000.

Information about all of these and other NFWF grants/programs is available at their website: http://nfwf.org/.

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

Trout Unlimited. The Wyoming Council of Trout Unlimited (TU) provides funding and volunteer labor for a variety of stream and watershed projects such as erosion control and fish habitat structures, willow and other riparian plantings and stream protection fencing. Embrace-A-Stream grants are available for up to $10,000 per project. Partnerships are encouraged and can include local conservation districts and state and federal agencies.

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

Wildlife Heritage Foundation of Wyoming. The Wyoming Wildlife Heritage Foundation is an independent, charitable organization whose purpose is to provide financial support, through philanthropy, to critical wildlife conservation efforts in Wyoming. (see: http://whfw.org)

11.0 Conclusions and Recommendations
Summary conclusions and recommendations are presented below relative to the key elements of this study including: watershed description and inventory, water rights, canal system evaluation, water storage site evaluation, conceptual designs and costs of storage alternatives, permitting and mitigation, and project financing.
11.1 Conclusions

Watershed Description and Inventory

- Land ownership and administration in the Sublette Creek watershed are especially important in terms of current land uses and management practices related to agriculture (irrigation and livestock grazing) and cooperative resource management (including the Lost Creek Cooperative Management Unit), and how these uses and management may be impacted by or impact future surface water storage in the watershed.

- The existing multiple-line, high voltage transmission line corridor passing through the watershed poses constraints on the feasible size of a storage reservoir in the lowermost reach of Sublette Creek; there is a current proposal to add an additional 500 kV line to this corridor, although the ongoing EIS scoping process has identified an alternative route that is reportedly favored by the agencies.

- Although some mineral resources (coal, phosphorous) are present and there are a number of current state and federal oil and gas leases within the watershed, there is judged little practical potential for development of mineral or oil and gas production in the watershed.

- The Sublette Creek watershed lies within a tectonically active area that is subject to potentially very strong earthquake-induced ground shaking that must be taken fully into account in the design of any dam and reservoir project.

- The potential for development of surface water storage from runoff generated within the Sublette Creek watershed is limited both by the natural climate and hydrology of this dominantly High Desert area, the relatively small size of the watershed, and existing diversion rights.

- Although there appears to be some potential for additional groundwater development within the watershed, there are several concerns with this concept including potential for aquifer depletion, inefficient natural recharge, and possible connection of alluvial groundwater to surface water (with the associated water rights implications).

- Both surface and groundwater quality from the Sublette Creek watershed, Bear River and its valley alluvium, and Smiths Fork flows appear fully suitable for the intended agricultural uses (irrigation, livestock watering).

Water Rights

- A total of 11 surface water diversion rights (12 including one supplemental right) are present within the Sublette Creek watershed representing a total decreed flow of 17.25 ac-ft serving a total of 1,208 decreed acres.

- A current storage allocation of 4,100 ac-ft is available to the Town of Cokeville/Cokeville Development Company (Association); this allocation is not subject to the various controls on storage or a depletion allocation imposed under the Amended Bear River Compact.

- The Wyoming State Engineer has stated that the current allocation of 4,100 ac-ft being held for the Association may be made available to other applicants after December 31, 2015 unless a storage project has been constructed or is moving strongly forward with all due diligence.
An additional 10,320 ac-ft of storage is also allocated to the Association, but is subject to the Compact controls and depletion allowance.

Canal Evaluation

The existing Covey Canal has found capable of supplying up to approximately 10,000 ac-ft/yr to a new storage reservoir located on lower Sublette Creek, with the provision that some modifications may have to be made to the existing diversion structure and the understanding that diversion for reservoir supply would occur in April-early May and/or late September/October to avoid conflicts with historic irrigation deliveries.

The Covey Canal and Mau Lateral and their appurtenances (piped section, headgates, culverted crossings, etc.) are in generally good overall structural condition.

The primary issue with both the Covey Canal and Mau Lateral is leakage/seepage; it is estimated that on the order of 30-40 percent of the water delivered at the Covey Canal diversion is lost to seepage/leakage over the nearly 23 mile length of the canal; although not measured, losses in the Mau Lateral are estimated to be of the same order of magnitude if not somewhat greater.

Although the current leakage/seepage in fact provides some benefits to lands downslope of the areas of loss, there is a potential issue of water rights accounting and application of the diverted water to its rightful use, and some areas of more concentrated seepage produce less desirable vegetation and livestock grazing conditions.

A range of technically feasible alternatives to reduce or for some alternatives effectively eliminate seepage losses was evaluated, including periodic application of PAM, EPDM or GCL liner, polypropylene/polyurea liner, concrete liner and piping.

The approximate first year cost of alternative methods to reduce canal seepage on the Covey Canal ranges from a low of approximately $210,000 for application of PAM to a high of about $9,100,000 for a full-length concrete lining; the accompanying range of net present value cost per ac-ft of water saved ranges from $32,000 to $89,000, respectively.

Water Storage Site Evaluation

The need for storage to provide supplemental late season and dry year irrigation water to lands in the lower Bear River Valley and Smiths Fork basin is well established in earlier studies.

A number of preliminary concepts have been developed to confirm the feasibility of delivering water from a Sublette Creek reservoir to lands experiencing shortage either by direct (gravity release), siphoning/pumping, or exchange.

Potential secondary (multiple) benefits of storage within the Sublette Creek watershed were identified, including various environmental enhancements (both instream and reservoir-related), wildlife/stock watering, reduction of local flooding impacts on Sublette Creek, and seasonal recreation.

Review of previous studies confirms that water from Smiths Fork should, on average, be available annually for storage in a Sublette Creek reservoir in the range of 5,000 to as much as 15,000 ac-ft storage capacity.
Excess storable flows on Sublette Creek are very preliminarily estimated as on the order of 1,000 ac-ft per year; however, given the uncertainties with this estimate the evaluation of storage alternatives did not rely on this source (except for Site 2 – Upper Sublette Creek that was screened out as not feasible early in the study).

A total of five potential surface water dam and reservoir alternatives and three variants were identified, characterized and screened to arrive at a single preferred alternative. Although technically feasible, all but the preferred alternative proved much more costly due mainly to required new conveyance by canal or pumping from Smiths Fork; this was due to their location at significantly higher elevation than the preferred alternative which can be served by the existing Covey Canal.

Estimated total costs for the alternative dam and reservoir storage projects (assuming pumping where new supply conveyance was required) ranged from a low of $11,500,000 to a high of $64,000,000 (considering a pumped supply versus canal supply except for Sites 1/1A); comparison of only alternatives providing 5,000 ac-ft of storage (again assuming pumped supply) ranged from $15,800,000 to $29,800,000; unit costs per ac-ft of storage capacity for ranged from $2,300 to $6,000 and $3,200 to $6,000, respectively.

Conceptual Designs and Cost Estimates

A surface water storage dam and reservoir of 5,000 ac-ft capacity located in lowermost Sublette Creek and supplied by the existing Covey Canal appears technically feasible.

Geologic conditions at the site, although not ideal, appear adequate assuming thorough site investigation is conducted as a basis to identify conditions that require design mitigation (e.g., foundation rock permeability, depth and character of alluvium, etc.).

The potentially very strong earthquake-induced design basis ground motions have been accommodated at this level of study by assuming that all of the alluvial and colluvial deposits under the dam footprint will have to be removed and suitable fill placed to high standards of compaction to provide a stable foundation for the assumed zoned earth dam.

Foundation treatment including slush grout/dental concrete application and deep curtain grouting are included in the conceptual design to mitigate potentially high joint/fracture permeability.

The conceptual designs of hydraulic structures (service spillway, emergency spillway and outlet works) appear feasible and reasonably efficient; no fatal flaw or exceptionally costly conditions related to these facilities have been identified.

A new section of unpaved access road and potential local realignment of the existing Stock Driveway Road are included in the conceptual design, together with several other miscellaneous appurtenant measures.

The total project cost of the preferred alternative project at Site 1 – Lower Sublette Creek is $15,843,000; the Level III cost considering WWDC payment for final design and permitting would be $13,444,000.
Permitting and Mitigation

- A number of known and potential environmental issues and considerations have been identified by review of available relevant information and data and preliminary consultation with selected agencies, including: possible seasonal presence of gray wolf and bald eagles; potential presence of various currently unprotected species of state and/or federal special concern; presence of sage grouse habitat and leks; presence of big game (mule deer, elk and moose) crucial habitat and seasonal migration routes; reported presence of Northern leatherside chub and Bonneville cutthroat trout in Sublette Creek; presence of northern leopard frog throughout the project area; presence of assumed jurisdictional wetlands at all alternative sites; and access and impacts to lands managed under existing cooperative habitat improvement and protection programs.

- The potential for cultural resources impacts appears to focus on three variants of the historic Sublette Cut-off trail system; the potential for significant impacts to these or other cultural resources appears relatively low.

- Although there are a number of very important environmental and cultural resources issues that will require thorough study and consultation with the relevant state and federal land management and resource agencies, it appears at this stage that a 5,000 ac-ft reservoir on lower Sublette Creek has a reasonable prospect of ultimately being permitted with appropriate negotiation and mitigation of known and potential impacts. The scope and cost of mitigation for this alternative cannot be accurately estimated at this level of study, but will likely be significant.

- Other of the alternative dam and reservoir sites may or may not be able to be permitted; in particular, it does not appear feasible at this time that the Trail Creek site could be permitted due to a number of known and potential impacts that would be very difficult to mitigate.

Project Financing

- The primary source of funding for a new surface water storage dam and reservoir project is the WWDC’s Dam and Reservoir Program; no other funding sources were identified that would be able to provide significant funding for this type of project.

- The primary source of funding for any major canal rehabilitation or upgrades that may be envisioned is the WWDC’s Rehabilitation Program; depending on the nature and extent of work contemplated, funding assistance may also be available from NRCS.

- Standard financing under the WWDC programs includes: a 67/33 percent grant/loan mix (or up to 75/25 percent if extreme financial hardship can be demonstrated); 4 percent interest and 30-year term on the loan portion (with a maximum possible term of 50 years); and potential deferment of loan payments for up to 5 years under special circumstances.

- Special financing considerations apply to funding under the WWDC Dam and Reservoir Program, including: grant/loan mix based on sponsor’s ability to pay a portion of project costs and all operation, maintenance and replacement (OM&R) costs; program payment of final design and permitting costs; and program
payment for storage capacity needed to provide water for environmental mitigation and enhancement, thereby by reducing cost applied to grant/loan mix.

- Other potential funding sources identified are all related to opportunities for possible implementation of environmental enhancements associated with the proposed storage project.

11.2 Recommendations

- The ongoing EIS process for the Gateway West Transmission Project should be followed and comments offered at all appropriate opportunities opposing the addition of an additional high-voltage transmission line within or adjacent to the existing corridor passing through the Sublette Creek watershed.

- Contact should be maintained with the Wyoming State Engineer’s Office documenting that all due diligence is being applied to move a project forward to store at least the Original Compact allocation of 4,100 ac-ft currently held by the Town of Cokeville/Cokeville Development Company (Association).

- A trial program of seepage reduction in the Covey Canal and Mau Lateral is recommended utilizing PAM application generally and polypropylene/polyurea lining in areas of concentrated seepage, including areas crossing fractured rock.

- The preferred alternative Site 1 – Lower Sublette Creek should be pursued to the next level of study under the WWDC’s Level II program; special attention should be given to modeling of supply availability and irrigation need and geologic/geotechnical investigation of this site in Phases I and II, respectively.

- Ongoing communication and coordination should be maintained with selected natural resources and land management agencies regarding known and potential environmental/cultural resources issues and potential mitigation, including but not necessarily limited to Wyoming Game and Fish Department, Fish and Wildlife Service, Bureau of Land Management and Corps of Engineers.

12.0 References


Harrel, Lynn. 2007. Personal communication by Doug Yadon/SEH with Lynn Harrel/BLM. December 12.


Lowry, Sue. 2007. Personal communications by Doug Yadon/SEH with Sue Lowry/WSEO. August 26 and October 21.


Wyoming Game and Fish Department (WGFD). 2007. Letter re: Sublette Creek Reservoir and Covey/Mau Canal Rehabilitation Project, Level II Study (WER 11715) from Vern Stelter for John Emmerich/WGFD to Chris Wichmann/SEH. December 14.

Wyoming Game and Fish Department (WGFD). 2008. Letter re: Sublette Creek Reservoir and Covey/Mau Canal Rehabilitation Project, Level II Study (WER 11715) from Vern Stelter for John Emmerich/WGFD to Doug Yadon/SEH. December 14.


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Land Ownership

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<tr>
<th>Class/Entity</th>
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<th>Percentage of Total Area</th>
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<td>State</td>
<td>2,405</td>
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<td>Private</td>
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<td><strong>Total Area</strong></td>
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## Table 3.2-1
### Climate Data Summary

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<td>101</td>
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<td>7/26/1931</td>
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Quaternary Fault Data

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<td></td>
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<td>W</td>
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<td>Grand Valley fault, Star Valley section</td>
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<td>W</td>
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### Table 3.3-1
Surface Water Sampling Sites and Flow Data

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<th>RNG</th>
<th>Sec</th>
<th>Date Sampled</th>
<th>Discharge (cfs)</th>
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<td>1</td>
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<td></td>
<td>119</td>
<td>5ad</td>
<td>4/13/1956</td>
<td>20</td>
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<tr>
<td>2</td>
<td>1963, Robinove</td>
<td></td>
<td>Bear River at Cokeville</td>
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<td></td>
<td>119</td>
<td>7ad</td>
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<td>400</td>
<td></td>
<td></td>
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<td>3</td>
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<td>Bear River at Cokeville</td>
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<td>119</td>
<td>7ad</td>
<td>6/22/1956</td>
<td>425</td>
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<td></td>
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<tr>
<td>4</td>
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### Table 3.3-2

**Groundwater Well Data**

**Source:** WSEO Database via WWDC Bear River Basin Plan

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<th>Section</th>
<th>Quarter</th>
<th>Quarter-Quarter</th>
<th>Status</th>
<th>Use</th>
<th>Actual Yield (cfs)</th>
<th>Well Depth (ft)</th>
<th>Static Water Depth (ft)</th>
<th>Depth to Top of Main Water Bearing Zone (ft)</th>
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<td>1</td>
<td>P613W</td>
<td>5/15/1961</td>
<td>24</td>
<td>N</td>
<td>119</td>
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<td>4</td>
<td>NASENE</td>
<td>IRR</td>
<td>1000</td>
<td>403</td>
<td>120</td>
<td>150</td>
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<td>2</td>
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<td>12/31/1986</td>
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<td>N</td>
<td>119</td>
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<td>15</td>
<td>NASWSE</td>
<td>UNA STO DOM</td>
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<td>5</td>
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<td>8</td>
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<td>W</td>
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<td>16</td>
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<td>UNA STO</td>
<td>25</td>
<td>8</td>
<td>5</td>
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<td>8</td>
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**Source:** Lines & Glass, 1975

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<td>12ad1</td>
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Spring Characteristics

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<th>Range</th>
<th>Range Suffix</th>
<th>Section</th>
<th>Quarter-Quarter</th>
<th>Altitude</th>
<th>Geologic Code</th>
<th>Aquifer Code</th>
<th>Date Discharge Measured</th>
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<td>7000</td>
<td>@ad</td>
<td>WDSD</td>
<td>6/11/1995</td>
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<td>Woodside Formation</td>
<td>Mainly red and orange partly anhydritic siltstone and mudstone, and some orange fine-grained sandstone. Mostly impermeable; and in most areas they are probably capable of only yielding small quantities of water, (Lines and Glass, 1975).</td>
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<td>Mainly red and orange partly anhydritic siltstone and mudstone, and some orange fine-grained sandstone. Mostly impermeable; and in most areas they are probably capable of only yielding small quantities of water, (Lines and Glass, 1975).</td>
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<td>6305</td>
<td>Tf</td>
<td>FWKS</td>
<td>5/18/1994</td>
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<td>Fowkes Formation</td>
<td>Light-colored tuffaceous sandstone and siltstone, locally conglomeratic. Locally designated by some as Norwood Tuff. Tuffaceous sandstone in the Fowkes is probably capable of yielding small quantities of water to wells. (Lines and Glass, 1975).</td>
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Source: USGS Groundwater Site Inventory Database via WWDC Bear River Basin Plan

Source: Lines and Glass, 1975
### Table 3.4-1
Water Quality Criteria for Agricultural Uses

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Units</th>
<th>Irrigation</th>
<th>Livestock Watering</th>
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</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>µg/L</td>
<td>--</td>
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</tr>
<tr>
<td>Arsenic</td>
<td>µg/L</td>
<td>--</td>
<td>100</td>
</tr>
<tr>
<td>Boron</td>
<td>µg/L</td>
<td>--</td>
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</tr>
<tr>
<td>Chloride</td>
<td>mg/L</td>
<td>--</td>
<td>100</td>
</tr>
<tr>
<td>Cobalt</td>
<td>µg/L</td>
<td>--</td>
<td>50</td>
</tr>
<tr>
<td>Copper</td>
<td>µg/L</td>
<td>--</td>
<td>200</td>
</tr>
<tr>
<td>Fluoride</td>
<td>µg/L</td>
<td>--</td>
<td>1000</td>
</tr>
<tr>
<td>Iron</td>
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<td>5000</td>
</tr>
<tr>
<td>Lead</td>
<td>µg/L</td>
<td>--</td>
<td>5000</td>
</tr>
<tr>
<td>Lithium</td>
<td>µg/L</td>
<td>--</td>
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<tr>
<td>Magnesium</td>
<td>mg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Manganese</td>
<td>µg/L</td>
<td>--</td>
<td>200</td>
</tr>
<tr>
<td>Mercury</td>
<td>µg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>µg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Nickel</td>
<td>µg/L</td>
<td>--</td>
<td>200</td>
</tr>
<tr>
<td>Nitrate (NO₃-N)</td>
<td>mg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Nitrite (NO₂-N)</td>
<td>mg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>(NO₃+NO₂)-N</td>
<td>mg/L</td>
<td>--</td>
<td>5-30²</td>
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<tr>
<td>Selenium</td>
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<td>--</td>
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<tr>
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<td>mg/L</td>
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<td>--</td>
</tr>
<tr>
<td>Vanadium</td>
<td>µg/L</td>
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<td>100</td>
</tr>
<tr>
<td>Zinc</td>
<td>µg/L</td>
<td>--</td>
<td>2000</td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>mg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Radium 226 and Radium 228</td>
<td>pCi/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Total Strontium 90</td>
<td>pCi/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Gross alpha particle radioactivity (including Radium 226 but excluding Radon and Uranium)</td>
<td>pCi/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>TDS</td>
<td>mg/L</td>
<td>--</td>
<td>450-2000²</td>
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<tr>
<td>pH</td>
<td>Standard units</td>
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<tr>
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<td>mg/L</td>
<td>--</td>
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</tr>
<tr>
<td>SAR</td>
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<td>--</td>
<td>8</td>
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<tr>
<td>Specific Conductance</td>
<td>µS/cm</td>
<td>2000</td>
<td>--</td>
</tr>
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</table>

1. Low value is maximum for sensitive crops; high value is maximum for tolerant crops
2. Range is for slight to moderate restriction on use; i.e., no restrictions on use for lower values, severe restrictions on use for higher values
3. Range for which alfalfa is tolerant; wheat requires less than 760-1000 µg/L boron
4. Range at which moderately tolerant plants show injury; foliar damage to alfalfa occurs from saline sprinkler water when Cl is in the range of 351-700 mg/L
5. Lower bound salinity is acceptable for all crops; upper bound salinity requires adequate drainage to mitigate potential salt accumulation in soil
### Table 3.4-2
Surface and Groundwater Quality/Suitability

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Units</th>
<th>Surface Water Suitability</th>
<th>Groundwater Suitability</th>
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<td></td>
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<tr>
<td>Aluminum</td>
<td>µg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Arsenic</td>
<td>µg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Beryllium</td>
<td>µg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Boron</td>
<td>µg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Cadmium</td>
<td>µg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Chloride</td>
<td>mg/L</td>
<td>9.5</td>
<td>30</td>
</tr>
<tr>
<td>Chromium</td>
<td>µg/L</td>
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<td>--</td>
</tr>
<tr>
<td>Cobalt</td>
<td>µg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Copper</td>
<td>µg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Fluoride</td>
<td>µg/L</td>
<td>--</td>
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</tr>
<tr>
<td>Iron</td>
<td>µg/L</td>
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<td>20</td>
</tr>
<tr>
<td>Lithium</td>
<td>µg/L</td>
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</tr>
<tr>
<td>Magnesium</td>
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<td>31</td>
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<tr>
<td>Manganese</td>
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</tr>
<tr>
<td>Mercury</td>
<td>µg/L</td>
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<tr>
<td>Molybdenum</td>
<td>µg/L</td>
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<td>--</td>
</tr>
<tr>
<td>Nickel</td>
<td>µg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Nitrate (NO₃-N)</td>
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<td>2.6</td>
<td>1.3</td>
</tr>
<tr>
<td>Nitrite (NO₂-N)</td>
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<td>--</td>
<td>--</td>
</tr>
<tr>
<td>(NO₃+NO₂)-N</td>
<td>mg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Selenium</td>
<td>µg/L</td>
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<td>--</td>
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<td>73</td>
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</tr>
<tr>
<td>Zinc</td>
<td>µg/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>mg/L</td>
<td>--</td>
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<tr>
<td>Radium 226 and Radium 228</td>
<td>pCi/L</td>
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<tr>
<td>Total Strontium 90</td>
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<td>Gross alpha particle radioactivity (including Radium 226 but excluding Radon and Uranium)</td>
<td>pCi/L</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>TDS</td>
<td>mg/L</td>
<td>--</td>
<td>--</td>
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<tr>
<td>pH</td>
<td>Standard units</td>
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<td>7.7</td>
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<tr>
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<td>--</td>
<td>--</td>
</tr>
<tr>
<td>SAR</td>
<td>n/a</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Specific Conductance</td>
<td>µS/cm</td>
<td>431</td>
<td>683</td>
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</table>

**Bold italics indicate one or more criteria are exceeded**

**Italics indicate only one criterion is exceeded by a relatively small amount**

See Figure 3.3.1 - Hydrographic Features and Figure 3.3-2 - Gages and Sampling Stations for locations of water quality sampling sites
Table 4.1-1
Sublette Creek Surface Water Diversion Rights

<table>
<thead>
<tr>
<th>Name</th>
<th>Priority Date</th>
<th>Source</th>
<th>Decreed Flow (cfs)</th>
<th>Decreed Acres</th>
<th>Maximum Diversion Rate (ac-ft/day)</th>
<th>Maximum Diversion (ac-ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Above Gage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stoffers</td>
<td>1/1/1882</td>
<td>Sublette Creek</td>
<td>0.71</td>
<td>50</td>
<td>1.4</td>
<td>211</td>
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<tr>
<td>Ryan Irr</td>
<td>7/19/1886</td>
<td>South Fork Sublette Creek</td>
<td>0.85</td>
<td>60</td>
<td>1.7</td>
<td>253</td>
</tr>
<tr>
<td>Frederick No. 1</td>
<td>3/7/1907</td>
<td>Trail/Underwood Creek</td>
<td>2</td>
<td>140</td>
<td>4.0</td>
<td>595</td>
</tr>
<tr>
<td>Frederick No. 2&lt;sup&gt;2&lt;/sup&gt;</td>
<td>3/7/1907</td>
<td>Wyman Creek</td>
<td>2</td>
<td>140</td>
<td>4.0</td>
<td>595</td>
</tr>
<tr>
<td>Marks No. 1</td>
<td>8/2/1909</td>
<td>Lost Creek</td>
<td>0.21</td>
<td>15</td>
<td>0.4</td>
<td>62</td>
</tr>
<tr>
<td>Marks No. 2</td>
<td>8/2/1909</td>
<td>Lost Creek</td>
<td>0.36</td>
<td>25</td>
<td>0.7</td>
<td>107</td>
</tr>
<tr>
<td>South Sublette Creek No. 1</td>
<td>8/2/1909</td>
<td>South Fork Sublette Creek</td>
<td>0.36</td>
<td>25</td>
<td>0.7</td>
<td>107</td>
</tr>
<tr>
<td>South Sublette Creek No. 2</td>
<td>8/2/1909</td>
<td>South Fork Sublette Creek</td>
<td>0.21</td>
<td>15</td>
<td>0.4</td>
<td>62</td>
</tr>
<tr>
<td>North Fork Sublette (1)</td>
<td>5/3/1910</td>
<td>North Fork Sublette Creek</td>
<td>1.46</td>
<td>102</td>
<td>2.9</td>
<td>434</td>
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<td>12/17/1910</td>
<td>Ryan Creek</td>
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<td>76</td>
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<td>324</td>
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<tr>
<td>V-H House&lt;sup&gt;3&lt;/sup&gt;</td>
<td>11/12/1915</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
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<td>8.31</td>
<td>582</td>
<td>16.5</td>
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</tr>
<tr>
<td>Stoner</td>
<td>2/6/1882</td>
<td>Sublette Creek</td>
<td>8.94</td>
<td>626</td>
<td>17.7</td>
<td>2,659</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>8.94</td>
<td>626</td>
<td>17.7</td>
<td>2,659</td>
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<td><strong>Combined Total</strong></td>
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<td>17.25</td>
<td>1,208</td>
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<td>5,131</td>
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</table>

1. Assumed 150 day irrigation season
2. Supplemental supply; original supply through Frederick No. 1 ditch; values not counted in totals
3. Diversion listed on the “Tabulation of Adjudicated Water Rights of the State of Wyoming - Water Division Number 4”, but not included in the current SEO database.
Table 6.1-1
Smiths Fork Average Monthly Flows

<table>
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<th>Month</th>
<th>Flow (cfs)</th>
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<tr>
<td>February</td>
<td>61.1</td>
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<td>April</td>
<td>159</td>
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<tr>
<td>May</td>
<td>539</td>
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<tr>
<td>June</td>
<td>622</td>
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<td>July</td>
<td>291</td>
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<td>August</td>
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<td>September</td>
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<td>October</td>
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</tr>
<tr>
<td>November</td>
<td>78.3</td>
</tr>
<tr>
<td>December</td>
<td>69.2</td>
</tr>
<tr>
<td>Desired Diversion Flow (CFS)</td>
<td>Required Depth Over Ogee Crest (Inches)</td>
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<tr>
<td>----------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>40</td>
<td>8</td>
</tr>
<tr>
<td>60</td>
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<tr>
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</tr>
<tr>
<td>120</td>
<td>23</td>
</tr>
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<td>140</td>
<td>26</td>
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Table 6.2-1
Smiths Fork Diversion Capacities
Table 6.4-1
Covey Canal Seepage

<table>
<thead>
<tr>
<th>Canal Mile</th>
<th>Estimated Zero Loss Canal Flow Less Diversions</th>
<th>Estimated Seepage Loss @ 3% (CFS)</th>
<th>Flow Remaining in Canal Section After Seepage and Diversions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>115</td>
<td>3.45</td>
<td>106.6</td>
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<td>2</td>
<td>110</td>
<td>3.3</td>
<td>98.3</td>
</tr>
<tr>
<td>3</td>
<td>105</td>
<td>3.15</td>
<td>90.1</td>
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<td>82.1</td>
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<td>66.6</td>
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<td>80</td>
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<td>51.6</td>
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<td>1.8</td>
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<td>55</td>
<td>1.65</td>
<td>16.9</td>
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<td>10</td>
<td>0.3</td>
<td>-19.6</td>
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<tr>
<td>23</td>
<td>5</td>
<td>0</td>
<td>-22.5</td>
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</tbody>
</table>

Total Loss 41.25

<table>
<thead>
<tr>
<th>Canal Mile</th>
<th>Estimated Zero Loss Canal Flow Less Diversions</th>
<th>Estimated Seepage Loss @ 2% (CFS)</th>
<th>Flow Remaining in Canal Section After Seepage and Diversions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>115</td>
<td>2.3</td>
<td>107.7</td>
</tr>
<tr>
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<td>110</td>
<td>2.2</td>
<td>100.5</td>
</tr>
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<td>3</td>
<td>105</td>
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<td>86.4</td>
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Total Loss 27.5
## Table 7.4-1

**Estimated Sublette Creek Storable Flows**

Based on WSEO Division 4 Hydrographer's Estimate

<table>
<thead>
<tr>
<th>Length of Time (days)</th>
<th>Flow (cfs)</th>
<th>Storage (ac-ft)</th>
<th>Comments</th>
</tr>
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<tr>
<td>30</td>
<td>5</td>
<td>297</td>
<td>During irrigation season</td>
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<tr>
<td>14</td>
<td>30</td>
<td>833</td>
<td>During spring runoff</td>
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</table>

**Total:** 1,130

### Based on Sublette Creek Gage Data and Water Rights

<table>
<thead>
<tr>
<th>Scenario (see Definitions below)</th>
<th>Description</th>
<th>Potential Average Annual Storable Flow (ac-ft)</th>
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<tr>
<td>1</td>
<td>Minimum</td>
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<tr>
<td>2a</td>
<td>Intermediate (low)</td>
<td>70</td>
</tr>
<tr>
<td>2b</td>
<td>Intermediate (high)</td>
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<tr>
<td>3</td>
<td>Maximum</td>
<td>970</td>
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</table>

**Definitions:**

Scenario 1 (minimum case): store only Sublette Creek flows after satisfying Stoner & Stoffers downstream right during May through September; assume any flows October-April left in creek as environmental flows

Scenario 2a (intermediate case - low): Scenario 1 total plus assumed April flow per Note 1 plus half of the winter flows assumed per Note 3

Scenario 2b (intermediate case - high): Scenario 2a with assumed April flow per Note 1 plus all of winter flows assumed per Note 3

Scenario 3 (maximum case): store all Sublette Creek flows at gage and assumed April flow per Note 1 plus all of winter flows assumed per Note 3

**Notes:**

1 - April flow taken to be half of May flow
2 - October flow taken to be half of September flow
3 - Winter flow months (Oct-Mar) taken to be half of September flow

**Assumptions:**

1 - Direct flow rights above gage fully utilized when physical flow adequate
2 - Direct flow rights below gage may be foregone in favor of storage
### Table 6.5-1

Alternative Canal Rehabilitation Costs

<table>
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<tr>
<th>Alternative</th>
<th>First Year Cost</th>
<th>NPV of Leakage Savings ($/cfs saved)</th>
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<tr>
<td>PAM</td>
<td>$208,760</td>
<td>$132,000</td>
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<tr>
<td>Steel Pipe</td>
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<tr>
<td>Concrete Liner</td>
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<td>$489,000</td>
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### Table 7.6-1
Alternative Surface Water Storage Sites

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Table 7.6-1
Alternative Surface Water Storage Sites (continued)

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<td>Lower Rasa River Expansion</td>
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<td>Sublette Flat</td>
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<td>Trail Creek</td>
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<td>Entitled Lands (acres)</td>
<td>164</td>
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**Dam Characteristics and Hydraulic Structures**

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<tbody>
<tr>
<td>Freeboard/Head on Service Spillway (ft)</td>
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<td>Freeboard/Head on Emergency Spillway (ft)</td>
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<td>11</td>
<td>6</td>
<td>6</td>
<td>6</td>
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<tr>
<td>Total Elevation Gain (ft)</td>
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<td>6,850</td>
<td>6,416</td>
<td>6,414</td>
<td>6,383</td>
<td>6,413</td>
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<td>Total Crest Length (feet)</td>
<td>1,956</td>
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<td>610</td>
<td>3,716</td>
<td>5,174</td>
<td>2,951</td>
<td>5,585</td>
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<td>270</td>
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<td>Total Earthwork Fill Volume (thousand cy)</td>
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<td>684</td>
<td>933</td>
<td>1,238</td>
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**Supply and Delivery Facilities**

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<tbody>
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<td>Supply Cost - with canal option</td>
<td>$22,168,000</td>
<td>$24,699,000</td>
<td>$22,168,000</td>
<td>$24,699,000</td>
<td>$26,431,000</td>
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<td>Supply Cost - with pumping option</td>
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<td>$17,345,000</td>
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<td>Total Project Cost (with canal delivery option)</td>
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<td>$41,884,000</td>
<td>$29,275,000</td>
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<td>Total Project Cost (with pumping delivery option)</td>
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**Other**

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<td>0</td>
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<tr>
<td>Site Power Extension (mi)</td>
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<td>0.1</td>
<td>1.0</td>
<td>2.0</td>
<td>2.6</td>
<td>2.6</td>
<td>2.6</td>
<td>1.7</td>
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**Costing**

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<th>4</th>
<th>4A</th>
<th>5</th>
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<td>Supply Cost - with canal option</td>
<td>$14,400,000</td>
<td>$15,680,000</td>
<td>$16,142,000</td>
<td>$18,600,000</td>
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<td>$29,275,000</td>
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<td>$25,800,000</td>
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<td>$28,500,000</td>
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</table>

**Legend**

- Excellent or more than adequate
- Favorable or adequate
- Marginal or unfavorable value
- Potential fatal flaw or very unfavorable value

1 Cut volumes estimated
# Table 8.4-1
## Conceptual-Level Cost Estimate
### Site 1 - Lower Sublette Creek

<table>
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<tr>
<th>Cost Item</th>
<th>Cost Estimate</th>
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<tr>
<td>Preparation of Final Designs and Specifications</td>
<td>$1,199,000</td>
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<td>Permitting</td>
<td>$1,151,000</td>
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<td>Mitigation</td>
<td>$824,000</td>
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<tr>
<td>Legal Fees</td>
<td>$96,000</td>
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<tr>
<td>Acquisition of Access and Rights of Way</td>
<td>$386,000</td>
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<tr>
<td><strong>Non-Construction Cost Total</strong></td>
<td><strong>$3,656,000</strong></td>
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<table>
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<th>Project Components</th>
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<tr>
<td>Mobilization</td>
<td>$612,000</td>
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<tr>
<td>Dam</td>
<td>$5,777,000</td>
</tr>
<tr>
<td>Spillways</td>
<td>$610,000</td>
</tr>
<tr>
<td>Outlet Works</td>
<td>$487,000</td>
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<tr>
<td>Other</td>
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</tr>
<tr>
<td><strong>Construction Cost Subtotal #1</strong></td>
<td><strong>$9,595,000</strong></td>
</tr>
<tr>
<td>Engineering Costs = CCS#1 x 10%</td>
<td>$959,500</td>
</tr>
<tr>
<td><strong>Subtotal #2</strong></td>
<td><strong>$10,554,500</strong></td>
</tr>
<tr>
<td>Contigency = Subtotal #2 x 15%</td>
<td>$1,583,175</td>
</tr>
<tr>
<td><strong>Construction Cost Total</strong></td>
<td><strong>$12,138,000</strong></td>
</tr>
</tbody>
</table>

| **Project Cost Total**                                  | **$15,794,000**|
| Less Level II/Phase III Costs †                          | ($2,350,000)   |
| **Level III Project Cost Total**                        | **$13,444,000**|

† Preparation of Final Designs, Specifications, and Contract Documents; and Permitting
<table>
<thead>
<tr>
<th>Agency/Entity</th>
<th>Program Name</th>
<th>Project Type(s)</th>
<th>Internet Site</th>
<th>Telephone</th>
<th>Email</th>
</tr>
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<tr>
<td>Lincoln Conservation District</td>
<td>n/a</td>
<td>Projects to maintain, restore, improve, protect and expand riparian/ watershed areas</td>
<td><a href="http://www.lind.com">http://www.lind.com</a></td>
<td>307.279.3256</td>
<td><a href="mailto:brenda.lazcanotegui@wy.nacdn.net">brenda.lazcanotegui@wy.nacdn.net</a></td>
</tr>
<tr>
<td>Wyoming Game and Fish Department</td>
<td>Riparian Habitat Improvement Grant</td>
<td>Water supply, water quality control, erosion and sediment control, wetland creation and restoration, fish and wildlife habitat enhancement, flood control, public recreation, etc.</td>
<td><a href="http://www.fws.gov/birdhabitat/Grants/NAWCA/index.shtml">http://www.fws.gov/birdhabitat/Grants/NAWCA/index.shtml</a></td>
<td>307.777.5622</td>
<td><a href="mailto:jlawson@gp.usbr.gov">jlawson@gp.usbr.gov</a></td>
</tr>
<tr>
<td>Wyoming Water Development Program</td>
<td>Wyoming Sage Grouse Conservation Program</td>
<td>Habitat improvement, including projects to maintain, restore, improve, protect and expand riparian/wetland areas</td>
<td><a href="http://www.epa.gov/owow/funding/watershedfunding.htm">http://www.epa.gov/owow/funding/watershedfunding.htm</a></td>
<td>307.775.6060</td>
<td><a href="mailto:Rick.Schultz@epa.gov">Rick.Schultz@epa.gov</a></td>
</tr>
<tr>
<td>Wyoming Wildlife and Natural Resource Trust</td>
<td>Wyoming Water Development Program</td>
<td>Planning, design and construction of new reservoir storage and rehabilitation of existing reservoir storage projects</td>
<td><a href="http://www.fws.gov/water2025">http://www.fws.gov/water2025</a></td>
<td>307.277.5101</td>
<td><a href="mailto:wyandt_wmm@fws.gov">wyandt_wmm@fws.gov</a></td>
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<tr>
<td>Bureau of Reclamation</td>
<td>Water Quality Challenge Grant Program</td>
<td>Water supply, water quality control, erosion and sediment control, wetland creation and restoration, fish and wildlife habitat enhancement, flood control, public recreation, etc.</td>
<td><a href="http://www.epa.gov/owow/funding/watershedfunding.htm">http://www.epa.gov/owow/funding/watershedfunding.htm</a></td>
<td>307.332.8719</td>
<td><a href="mailto:thomas.r.mccomb@epa.gov">thomas.r.mccomb@epa.gov</a></td>
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</table>

### Non-Profit and Other Organizations

- **Ducks Unlimited**
  - Program Name: n/a
  - Project Type(s): Aquatic and wildlife habitat improvement, including water developments, prescribed burns, invasive plant control, etc.
  - Internet Site: http://www.ducks.org/Page1856.aspx
  - Telephone: 307.472.6980
  - Email: floyd@trib.com

- **Mule Deer Foundation**
  - Program Name: n/a
  - Project Type(s): Long-term weed management projects
  - Internet Site: http://www.mdefoundation.org
  - Telephone: 307.856.4665
  - Email: brenda.lazcanotegui@wy.nacdn.net

- **National Fish and Wildlife Foundation**
  - Program Name: n/a
  - Project Type(s): Restoration of native plant communities
  - Internet Site: http://www.nfwf.org/AM/Template.cfm?Section=Grants
  - Telephone: 202.857.0166
  - Email: info@nfwf.org

- **Rocky Mountain Elk Foundation**
  - Program Name: n/a
  - Project Type(s): Habitat restoration and improvement projects
  - Internet Site: http://www.rmel.org
  - Telephone: 307.777.5622
  - Email: gbutle@state.wy.us

- **Trout Unlimited**
  - Program Name: n/a
  - Project Type(s): Aquatic and wildlife habitat improvement, including water developments, prescribed burns, invasive plant control, etc.
  - Internet Site: http://www.trout.org
  - Telephone: 307.856.4665
  - Email: brenda.lazcanotegui@wy.nacdn.net

- **Wyoming Wildlife and Natural Resource Trust**
  - Program Name: n/a
  - Project Type(s): Various wetlands conservation projects
  - Internet Site: http://wwnt.state.wy.us/wwnt/home
  - Telephone: 307.332.8719
  - Email: Sheri_K_Hopson@mvf.fws.gov
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Figure 9.1-4 – NWI Wetlands
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SUBLETTE CREEK RESERVOIR AND COVEY/MAU CANALS REHABILITATION PROJECT, LEVEL II STUDY

LAND OWNERSHIP

PROJECT: AWWDC0703.00  DATE: 8/31/08  FIGURE: 3.1-1
Phosphorus Potential

- **HIGH**
- **LOW**
- **MODERATE**

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GEOLOGIC MAP

SUBLETTE CREEK RESERVOIR AND COVEY/MAU CANALS REHABILITATION PROJECT, LEVEL II STUDY

PROJECT: AWWDC0703.00  DATE: 8/31/08  FIGURE: 3.2-6A

Note: Geology by Rubey et al., 1980
SUBLETTE CREEK RESERVOIR AND COVEY/MAU CANALS REHABILITATION PROJECT, LEVEL II STUDY

LANDSLIDES

PROJECT: AWWDC0703.00  DATE: 8/31/08  FIGURE: 3.2-7
1350-1986

1973-present

Center of Sublette Creek Watershed

Note: Search area is 100 km x 100 km square
Peak Acceleration (%g) with 2% probability of exceedence in 50 years

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Figure 6.3-1C – Typical Covey Canal Section

Figure 6.4-1A – Canal through Fractured Rock
Figure 6.4-1B – Peat Moss and Standing Water

Figure 6.4-1C – Willows Below Canal
Figure 6.4-2 – Upstream Side of Inlet Gates to the Mau Lateral
SUBLETTE CREEK RESERVOIR AND COVEY/MAU CANALS REHABILITATION PROJECT, LEVEL II STUDY

ALTERNATIVE SURFACE WATER STORAGE SITES

PROJECT: AWWDC0703.00 DATE: 8/31/08 FIGURE: 7.5-2

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SUBLETTE CREEK RESERVOIR AND COVEY/MAU CANALS REHABILITATION PROJECT, LEVEL II STUDY

SITE 4/4A - SUBLETTE FLAT LAYOUT

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www.delorme.com
Rare Species

Bald Eagle
Beaver Rim Phlox
Bluehead Sucker
Dom's Twinpod
Forster's Tern
Golden Eagle
Gray Wolf
Greater Sage Grouse
Idaho Pocket Gopher
Leatherside Chub
Long-billed Curlew
Osprey
Pygmy Rabbit
Sandhill Crane
Short-eared Owl
Snowy Egret
Western Pearlshell
White-faced Ibis
Whooping Crane

Sublette Creek Drainage Basin Boundary

SUBLETTE CREEK RESERVOIR AND COVEY/MAU CANALS REHABILITATION PROJECT, LEVEL II STUDY

RARE SPECIES

SUNRISE ENGINEERING

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2 mile radius leks

SUBLETTE CREEK RESERVOIR AND COVEY/MAU CANALS REHABILITATION PROJECT, LEVEL II STUDY

SAGE GROUSE LEKS

PROJECT: AWWDC0703.00
DATE: 8/31/08
FIGURE: 9.1-2
CRUCIAL BIG GAME HABITAT

SUBLETTE CREEK RESERVOIR AND COVEY/MAU CANALS REHABILITATION PROJECT, LEVEL II STUDY

PROJECT: AWWDC0703.00 DATE: 8/31/08 FIGURE: 9.1-3

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Sublette Creek Reservoir and Covey/Mau Canals Rehabilitation Project, Level II Study

Scoping Meeting

Presentation for:
Wyoming Water Development Commission
and
Cokeville Development Company
by:
Short Elliott Hendrickson Inc.
Sunrise Engineering, Inc.
Plumley & Associates, Inc.

June 14, 2007
Key Issues/Considerations

• Specific goals and objectives for water storage
• Existing direct flow and storage water rights and Bear River Compact/Amendments
• Dam and reservoir siting criteria; water storage alternatives
• Potential multiple use benefits
Key Objectives

• Watershed description/inventory (GIS)
• Water rights/water availability for storage
• Canal inventory/improvements/enlargement
• Storage site inventory/screening
• Environmental and other permitting, mitigation, and ROW issues/requirements
• Dam and reservoir and canal rehabilitation conceptual designs/cost estimates
• Project financing
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<th>Phone #</th>
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<td>Steve Muth</td>
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Sublette Creek Reservoir and Covey/Mau Canals Rehabilitation Project, Level II Study
Project Status Meeting

Presentation for:
Wyoming Water Development Commission
and
Cokeville Development Company
by:
Short Elliott Hendrickson Inc.
Sunrise Engineering, Inc.
Plumley & Associates, Inc.

December 11, 2007
Agenda

• Project Status
• Key Issues and Preliminary Findings
  – Watershed Inventory
  – Storage Reservoir Alternatives
  – Canal Condition/Capacity
  – Land Ownership and Infrastructure
  – Environmental Issues and Permitting
• Questions/Comments
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<td>Doug Padden</td>
<td>970-484-3811</td>
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<td>Steve Muth</td>
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Sublette Creek Reservoir and Covey/Mau Canals Rehabilitation Project, Level II Study

Project Status Meeting

Presentation for:
Wyoming Water Development Commission
and
Cokeville Development Company

by:
Short Elliott Hendrickson Inc.
Sunrise Engineering, Inc.
Plumley & Associates, Inc.

April 23, 2008
Agenda

• Project Status

• Key Issues and Preliminary Findings
  – Watershed Inventory
  – Storage Reservoir Alternatives
  – Canal Condition/Capacity
  – Land Ownership and Infrastructure
  – Environmental Issues and Permitting

• Questions/Comments
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<td>Carol R. Reed</td>
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Agenda

• Project Status
• Key Issues and Preliminary Findings
  – Watershed Inventory
  – Storage Reservoir Alternatives
  – Canal Condition/Capacity
  – Land Ownership and Infrastructure
  – Environmental Issues and Permitting
  – Conceptual Design of Preferred Alternative
  – Estimated Cost of Preferred Alternative
• Questions/Comments
# Sublette Creek Reservoir and Covey/Mau Canal Rehabilitation - Level II Study

## Results Presentation Meeting Attendance List

**September 17, 2008**

<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
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<tr>
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<td>Box 201 Cokeville, WY</td>
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Appendix B

GIS Inventory
## Appendix B
### GIS Inventory

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<td>Wyoming SEO (via WWDC)</td>
<td>seowells.shp</td>
<td>.shp</td>
<td>Groundwater Wells</td>
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</tbody>
</table>
Appendix C
Transmission Lines
APPENDIX B
SCOPING PACKET
Welcome!

Welcome to this public scoping meeting for the Gateway West Project. At this meeting the Bureau of Land Management (BLM), as the lead agency, would like your input on:

- Human, natural and environmental issues that should be studied
- Proposed corridor and route alternatives that should be studied
- Ways to avoid, minimize or mitigate the effects of the project

This scoping meeting is open house format, with information and staff to help answer your questions. Please take a look at the information provided, ask questions and provide your comments.

Information you will find at this meeting

From the BLM
- Project roles and responsibilities
- An overview of the National Environmental Policy Act (NEPA) process and schedule
- A preliminary list of issues and concerns that will be evaluated as part of the environmental review process
- Preliminary alternatives considered by the BLM, including the proposed corridor
- Maps highlighting preliminary issues and concerns, including biological resources, cultural resources, visual resources, land use and alternatives
- Large maps with information on land ownership, topography and landmarks in both Idaho and Wyoming
- How to provide comments on these materials and this project
- Staff on hand to answer questions regarding the project and resource-specific questions on public lands

From Idaho Power and Rocky Mountain Power
- Project overview
- Maps including service territories for both companies
- Proposed power line structures
- Power line routing and criteria
- Project schedule
- Staff on hand to answer technical questions and questions not related to public lands
Public scoping meeting room layout

BLM Station #7:
Large Format Project Maps

BLM Station #6:
Land Use & Alternatives

BLM Station #5:
Visual Resources

BLM Station #4:
Cultural Resources

BLM Station #3:
Biological Resources

BLM Station #2:
NEPA Overview

BLM Station #1:
Sign-in and Welcome

Companie Station #2:
Corridor, Information, Routing & Criteria

Companie Station #1:
Project, Introduction

Refreshments

Note: Room layout may vary depending on room size
How can you provide comments?

The Bureau of Land Management (BLM) welcomes your comments regarding the Gateway West Transmission Line Project. Your input will help the BLM identify:

- Issues that should be addressed
- Potential impacts and possible mitigation measures
- Additional site-specific information regarding resources along the proposed and alternate routes
- Reasonable alternatives to the proposed action

The scoping comment period is from May 16 to July 3, 2008.

You can provide scoping comments in the following ways

At this meeting

- Complete a paper comment form and drop it in the comment box
- Note your comments on the large format maps
- Fill out an electronic comment form on one of the computers
- Use a tape recorder at the comment table

After this meeting

- Send your comment form and/or letters by U.S. Mail to:
  Bureau of Land Management
  Gateway West Project
  PO Box 20879
  Cheyenne, WY 82003
- Deliver your comments in person or by courier to:
  Bureau of Land Management
  Gateway West Project
  5353 Yellowstone Highway
  Cheyenne, WY 82009
- E-mail your comments to Gateway_West_WYMail@blm.gov
- Submit your comment online at http://www.wy.blm.gov/nepa/cfodocs/gateway_west/

Public scoping is just the beginning of the public participation process. If you would like to be on the BLM mailing list, be sure to indicate that when you sign in, and you will receive periodic project information.

In addition, there will be a formal public comment period for 60 days following the issuance of the Draft EIS, currently planned for early 2009. During that time you can receive and comment on a copy of the document. There will also be a series of public meetings, where you will have a chance to provide further input on the project.
Public Scoping Comment Form
Gateway West Transmission Line Project
Public scoping period: May 16 - July 3, 2008

Date: __________
First Name: ___________________________ Last Name: ___________________________
Organization or Office Name: ______________________________________________________
Mailing Address: ______________________________________________ City: __________ State: ____ Zip: ______
Daytime Phone: _________________________ E-mail: ____________________________

[ ] Please check here if you wish for your personal information to remain confidential

*If you wish for your contact information to remain confidential, BLM will protect the personal information that you
submit to the extent allowed by law. However, the information may be subject to the Freedom of Information Act
(U.S.C. etc.)

How would you like to receive future information:
[ ] Via the BLM Web site at: www.wy.blm.gov/nepa/cfodocs/gateway_west
[ ] Please E-mail me with project updates.
[ ] Please mail project updates to me via the U.S. Postal Service.

Please E-mail your comments by July 3, 2008. Information submitted on this form is being voluntarily
provided solely for the purpose of commenting on the Gateway West Transmission Line Project.

My concerns or comments related to the Gateway West Transmission Line Project are:
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________

To mail comment form please send to:
Bureau of Land Management | Gateway West Project | P.O. Box 20879 | Cheyenne, WY 82003

continued on back
Project purpose and need

Bureau of Land Management and U.S. Forest Service purpose and need and decision

Idaho Power Company and PacifiCorp, collectively known as the companies, applied to the Bureau of Land Management (BLM) for a right-of-way (ROW) grant to use public lands for portions of the Gateway West Transmission Line Project. Because the project also crosses both the Medicine Bow and the Caribou-Targhee National Forests, the companies have applied for a special use permit for each forest. Both agencies use the National Environmental Policy Act (NEPA) process (40 CFR 1500) to assist their decision-making.

The BLM is the lead federal agency for the NEPA process and will coordinate preparation of an environmental impact statement (EIS) and compliance with other federal environmental laws. The BLM will evaluate the ROW application in accordance with its regulations at 43 CFR 2800. The U.S. Forest Service (USFS) will evaluate the special use permit applications in accordance with its regulations at 36 CFR 251.50.

The agencies' purpose and need for preparing the EIS is to:
- Disclose the potential effects of authorizing the proposed transmission line and to examine reasonable alternatives to the proposed action
- Determine if the proposed transmission line is consistent with BLM and USFS land use plans
- Decide if the ROW grant and special use permit should be issued for the transmission line
- Determine the most appropriate location for the transmission line on federal lands, considering multiple use objectives
- Determine conditions (stipulations) that should be applied to the construction, operation and maintenance of the transmission line on federal lands

Idaho Power and Rocky Mountain Power purpose and need for the proposed project

Idaho Power is responsible for providing safe and reliable electrical service to its service area, which includes most of southern Idaho and a portion of eastern Oregon. Idaho Power operates under oversight and regulatory controls of the public utilities commissions of the states of Idaho and Oregon. Rocky Mountain Power is the trade name under which PacifiCorp delivers electricity to customers in the Rocky Mountain Power service area, which includes Utah, Wyoming and Idaho. The Rocky Mountain Power division of PacifiCorp operates under oversight and regulatory controls of the public utilities commissions of the states of Wyoming, Utah and Idaho.

Idaho Power and PacifiCorp are public utilities under the jurisdiction of the Federal Energy Regulatory Commission (FERC) and obligated to expand their transmission systems to provide requested firm transmission service and to construct and place in-service sufficient capacity to reliably deliver electrical resources to customers.
Since 2001 there have been several regional initiatives that evaluated the cost and benefits of the transmission additions from Wyoming to load centers in the west. Two specific studies are the Rocky Mountain Area Transmission Study (RMATS)\(^1\) of 2004 and WECC Seams Steering Group-Western Interconnection (SSG-WI)\(^2\) of 2005. These studies show that the combined cost of generation and transmission investments in Wyoming is typically much less than the cost of providing energy from other locations.

A 2006 U.S. Department of Energy (DOE) study identified the region from Wyoming to the west as a conditional constrained area, meaning that any incremental resources developed in Wyoming would require additional transmission. The DOE study also supports the Gateway West Project concept by stating:

“This area is rich in coal and wind resources that, if developed, could provide important sources of low-cost energy and fuel diversity while improving domestic energy self-sufficiency and enhancing the economic development in the resource areas. This resource development scenario has been thoroughly explored in analyses sponsored by the Western Governors Association.”

Additional planning studies were performed in 2007 through the Northern Tier Transmission Group (NTTG) Fast Track Project Process.\(^3\) The NTTG is a group of transmission providers and customers that are actively involved in the sale and purchase of transmission capacity of the power grid that delivers electricity to customers in the northwest and mountain states. This coordinated regional planning effort indicated a strong need for a series of independent transmission segments, each of which addresses an independent purpose, though all are part of the larger grid.

The Gateway West Project is proposed as a result of that planning effort as one of the components of the needed grid expansion. This project is designed to provide for the delivery of up to 3,000 megawatts (MW) to the service areas of the two companies based on forecast demand. These forecasts are based on the integrated resource plans (IRP) prepared by each company as required to fulfill the regulatory requirements and guidelines established by the public utilities commissions of the states served by the two companies.\(^4\) Each IRP addresses the obligations of each company pursuant to its Open Access Transmission Tariff (OATT) to plan for and expand their respective transmission systems in a non-discriminatory manner based on the needs of their native load customers, network customers and all eligible customers that agree to expand their transmission systems. This includes entities that generate or plan to generate electricity, including coal-fired, natural-gas-fired and renewable energy sources (wind and geothermal).

The Gateway West Project is independent of, and would be built regardless of, any particular new generation project. The transmission grid of which it will become a part can be thought of in terms of “hubs,” “spokes,” and a “backbone” connecting the hubs. Each substation is a “hub” and receives or sends electricity along the “spokes.” For this system to work, a “backbone” high-capacity series of transmission lines are needed to connect the hubs and transport the electricity from where it is or can be generated (in this case, mostly Wyoming but also Idaho and Montana), to where it is needed (in this case, mostly Idaho and Utah, though other markets may also be served).

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\(^1\) Visit http://psc.state.wy.us/htdocs/subregional/FinalReport/ramsfinalreport.htm to download sections of the RMATS Phase 1 Report.

\(^2\) Visit http://wecc.biz/modules.php?op=modload&name=Downloads&file=index&req=viewsdowload&sid=179

\(^3\) The Northern Tier Transmission Group’s Fast Track Study can be found on their website at http://nttg.biz/site/index.php?option=com_frontpage&Itemid=1

and PacifiCorp’s 2007 IRP is found at http://www.pacificorp.com/Navigation/Navigation23807.html
Project description

Please use this written material, the attached table and a project map to help you understand the proposed locations of the project segments and associated alternatives.

The Gateway West Transmission Line Project is composed of 11 segments of high voltage transmission lines that run between proposed or existing substations. These segments start at the proposed Windstar substation close to the Dave Johnston Power Plant near Glenrock, Wyoming and continue west until reaching the Hemingway substation, proposed approximately 20 miles southwest of Boise, Idaho. In addition, the project will include nine substations or expansions of substations and ancillary facilities such as cathodic protection and communication systems.

Segment descriptions

Segment 1W
The proposed segment is a single-circuit 500 kilovolt (kV) transmission line (energized at 230 kV) from the new Windstar substation, located approximately two miles north of Dave Johnston Power Plant at Glenrock, Wyoming, to the new Aeolus substation, located approximately 10 miles west of Medicine Bow, Wyoming. The entire segment is in a proposed Section 386 Energy Act corridor.

Segment 1E
A second single-circuit 500 kV transmission line (energized at 230 kV) is proposed between the Windstar and Aeolus substations. This segment is located to the east of Segment 1W. The segment passes through the Medicine-Bow National Forest but does not cross any federal lands administered by the U.S. Forest Service (USFS). The proposed route is along new alignment.

Segment 2
This segment consists of a single set of lattice structures configured as 230 kV on one side and 500 kV on the other from the Aeolus substation to the new Creston substation, located approximately five miles south of Wamsutter, Wyoming. The route generally follows U.S. Highway 30 and Interstate Highway 80, passing near the towns of Hanna, Sinclair and Rawlins, Wyoming. The proposed route follows an existing 230 kV transmission line for the entire length of this segment. The entire route is generally in a proposed Section 386 Energy Act corridor, diverging only to avoid concentrations of sage grouse leks found within and in close proximity to the corridor.
Segment 3

This segment continues the double-circuit 500 kV transmission line (initially one side will only be energized at 230 kV), from the Creston substation to a new substation just east of the Jim Bridger Power Plant. The route continues to follow an existing 230 kV transmission line for the entire length of the segment, diverging only to avoid areas of wildlife concerns. The route parallels Interstate Highway 80 to the south and generally follows the alignment of a proposed Section 368 Energy Act Corridor. A new substation would be constructed at Jim Bridger prior to the Gateway West Project and then expanded for Gateway West.

Segment 4

This segment consists of a double-circuit 500 kV transmission line from the new substation at the Jim Bridger Power Plant to the new Populus substation west of Downey, Idaho. The proposed route follows existing (either paired or triple) 345 kV transmission lines and passes these points of interest:

- Ten miles north of Rock Springs, Wyoming
- Immediately south of Seedskadee National Wildlife Refuge
- Through the northern part of a trona mining area
- Five miles north of Kemmerer, Wyoming
- Two miles north of the Fossil Butte National Monument
- One half-mile south of Cokeville, Wyoming
- Crosses 0.1 mile of the Cokeville Meadows National Wildlife Refuge
- Three miles south of Montpelier, Idaho
- Across ten miles of the Bear River Range in the Caribou-Targhee National Forest

West of the Caribou-Targhee National Forest, the proposed route leaves the existing 345 kV corridor going west and then angling northwest to the proposed Populus Substation located about one mile west of Downey, Idaho.

Three alternatives are currently identified in this segment. After crossing the Green River, Alternative 4.1 moves approximately five miles south of the proposed route, passing seven miles south of Kemmerer, Wyoming and the Fossil Butte National Monument. This alternative crosses the Utah/Wyoming state line immediately south of Cokeville Meadows National Wildlife Refuge. The route traverses approximately four miles in Utah (0.7 miles of public land) before re-entering Wyoming. This alternative then goes north into Idaho were it rejoins the proposed route. The alternative is approximately 106 miles long (102 miles in Wyoming, four miles in Utah).

Alternative 4.2 leaves the proposed route approximately five miles southeast of U.S. Route 89, east of Montpelier, Idaho and proceeds parallel to an existing 345 kV single-circuit line. Approximately three miles north of Montpelier, this alternative turns west and crosses U.S. Route 30 and the Bear Valley before proceeding west and rejoining the proposed route. This alternative is approximately 18 miles in length and is located entirely on private land. This alternative is being considered to avoid wetlands in the Bear River Valley and to reduce visual impacts.

Alternate 4.3 is located in Idaho where the route crosses the Caribou-Targhee National Forest in the Montpelier Ranger District. This alternative proposed by the USFS is in close proximity to the proposed segment and has a more direct route through the national forest.
Segment 5
This segment consists of a single-circuit 500 kV transmission line from the new Populus substation near Downey, Idaho to the existing Borah substation near American Falls, Idaho. The proposed route follows three existing 345 kV transmission lines northwest toward the Fort Hall Indian Reservation, then turns west along a new alignment, south of the Indian Reservation. West of the Indian Reservation the route turns north (still on a new alignment) to the existing Borah substation.

Segment 6
This segment involves increasing the voltage on an existing line from 345 to 500 kV. No new construction will occur. This segment is between the existing Borah and Midpoint substations.

Segment 7
This segment consists of a single-circuit 500 kV transmission line along mostly new alignment from the existing Populus substation near Downey, Idaho to the new Cedar Hill substation southeast of Twin Falls, Idaho. This segment follows the proposed route for Segment 5 from the Populus substation to a point approximately 13 miles south of American Falls, Idaho. From this point, the segment crosses Cassia County and the Raft River Valley continuing along the western toe of the Albion Mountains then across irrigated agricultural lands and into the Cedar Hill substation.

Two alternatives are proposed for this segment. Alternative 7.1 swings south of the proposed route beginning approximately 10 miles west of Rockland, Idaho to avoid sage grouse leks along the proposed route. The length of this alternative is approximately nine miles. Alternative 7.2 is located further to the west as the proposed route turns to the southwest, and is proposed to avoid sage grouse leks. The length of this alternative is less than a mile.

Segment 8
This segment consists of a single-circuit 500 kV transmission line from the existing Midpoint substation to the new Hemingway substation, approximately 20 miles southwest of Boise, Idaho. The proposed route follows existing 230 kV transmission lines the entire length, except for the last 25 miles which is new alignment. This route travels north of Gooding and Mountain Home, Idaho. It turns west just southeast of Boise, Idaho and comes into the Hemingway substation from the northeast. Approximately 50 miles of this proposed segment is in a proposed Section 368 Energy Act Corridor.

Four alternatives are proposed for this segment. Alternative 8.1 crosses the Birds of Prey National Conservation Area (NCA) area rather than go around it to the north as does the proposed route. This alternative deviates from the proposed route east of the Birds of Prey NCA and continues west, parallel to the north by 1,500 feet an existing 500 kV line, all the way to the Hemingway substation. Alternative 8.1 was developed as a means of avoiding developing residential areas north and west of the Birds of Prey NCA.

Alternative 8.2 involves rebuilding of a portion of an existing 138 kV line to 230 kV (planned for another project) plus the 500kV Gateway West Project line onto a double-circuit 230/500kV tower. This alternative would be shorter than the proposed segment, but crosses a portion of the Birds of Prey NCA.

Alternative 8.3 and 8.4 are more direct routes as the proposed segment approaches the Hemingway substation. They were proposed to minimize impacts to residential and agricultural development in the area.
Segment 9
This segment consists of a single-circuit 500 kV transmission line on new alignment from the new Cedar Hill substation southeast of Twin Falls, Idaho to the new Hemingway substation southwest of Boise, Idaho. The proposed route follows a proposed Section 368 Energy Act Corridor, passing between the northern end of the Saylor Creek Air Force Bombing Range and the southern boundary of Bruneau Dunes State Park. The line then turns northwest and follows the Section 368 Energy Act Corridor through portions of the Bureau of Land Management’s (BLM) Snake River Birds of Prey NCA before terminating at the Hemingway substation.

One alternative is proposed in this segment. Alternative 9.1 is located in the constriction point between Bruneau Dunes State Park and Saylor Creek Bombing Range. This alternative is about six miles in length, more direct than the proposed route, but falls outside the Section 368 Energy Act Corridor. It is proposed to minimize visual impacts from Bruneau Dunes State Park and avoid crossing a portion of Bruneau Dunes State Park.

Segment 10
This segment consists of a single-circuit 500 kV transmission line from the existing Midpoint substation near Jerome, Idaho south to the new Cedar Hill substation southeast of Twin Falls, Idaho. It follows an existing 345 kV transmission line and a proposed Section 368 Energy Act Corridor the entire length.
Construction phase

In addition to the linear right-of-way (ROW) there will be staging areas located at the middle, end and several locations in between on each segment and conductor pulling sites located every one to four miles along the right-of-way. Construction of the proposed 500kv facilities will proceed as follows:

- **Access road development** - Existing roads will be used where practical. Where necessary, Idaho Power and Rocky Mountain Power will develop new access roads ranging in width from 14 to 20 feet wide, preferably within the proposed right-of-way to each structure location. Temporary access may also be required. Where access roads would create excessive disturbance or be excessively expensive, helicopter based construction, operation and maintenance will be employed.

- **Cleaning and grading** - The proposed right-of-way will be cleared and access roads, structure work areas (approximately 100 feet by 100 feet) and staging areas will be graded.

- **Foundation installation** - Typically lattice structures will have four drilled concrete pier foundations, one for each leg. In rock conditions, rock anchoring or mini pile systems will be employed. For the majority of structures, concrete will be delivered by truck.

- **Erecting structures and stringing conductors** - Once foundations are in place, construction crews will erect the proposed structures along the right-of-way. Steel members of the lattice structures will be delivered to each site, assembled using a truck mounted crane and then lifted onto the foundations. Next, insulators will be installed and stringing sheaves (rollers) attached to the insulators.

  The conductors will be strung by pulling a sock line through the stringing sheaves and then pulled and tensioned. Stringing sites located every one to four miles along the right-of-way will provide space for tractors, trailers with spools and tensioning equipment.

- **Clean-up and restoration** - The post-construction right-of-way would be restored as required by the property owner or land management agency. All practical means would be made to restore the land to its original contour and to restore natural drainage patterns along the right-of-way. Because re-vegetation would be difficult in many areas of the project because of low amounts of precipitation, Idaho Power and Rocky Mountain Power will work to minimize surface disturbance.
## Route mileage summary table

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<thead>
<tr>
<th>Segment</th>
<th>Start/End Points</th>
<th>Segment Lengths (miles)</th>
<th>Line Voltage</th>
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<tr>
<td></td>
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<td>Private</td>
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<tr>
<td>1W</td>
<td>Windstar/Aeolus</td>
<td>27 BLM</td>
<td>29</td>
</tr>
<tr>
<td>1E</td>
<td>Windstar/Aeolus</td>
<td>13 BLM</td>
<td>86</td>
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<tr>
<td>2</td>
<td>Aeolus/Creston</td>
<td>37 BLM</td>
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<td>3</td>
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<td>Populus/Cedar Hill</td>
<td>28 BLM</td>
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<td>Cedar Hill/Midpoint</td>
<td>13 BLM</td>
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</tbody>
</table>

Public Scoping Meetings • June 3-12, 2008
Gateway West Project, PO Box 20879, Cheyenne, WY 82003 • Gateway_West_WYMail@blm.gov
www.wy.blm.gov/hep/cladocs/gateway_west • 307-775-6116
Corridor and route selection methodology

The project proponents, Idaho Power and Rocky Mountain Power (the companies), the Bureau of Land Management (BLM) and other federal agencies identified potential proposed and alternative two-mile wide corridors for the Gateway West Transmission Line Project through a series of internal meetings and analysis. These corridors are shown on maps provided at the scoping meetings, and on the BLM's project Web site. These corridors represent the probable alignment, within the two-mile corridor, of the proposed route and alternative corridors that BLM feels, at this time, likely contain routes for full analysis in the draft environmental impact statement (EIS).

The scoping process provides an opportunity for the public and cooperating agencies to provide input to the BLM on these corridors and to suggest other alignments that could be analyzed in the draft EIS. The BLM and the companies will use this information to select 300-foot wide proposed and alternative routes for analysis in the draft EIS.

The three-step process to identify routes for analysis is:
1. Define a study area and collect data
2. Identify and evaluate corridors
3. Identify and evaluate routes within corridors

1. Study area

The BLM and the companies identified a study area based upon proposed substation connections (Windstar, Aeolus, Creston, Jim Bridger, Populus, Borah, Midpoint, Hemingway and Cedar Hill substations), and the existing transmission grid. In total, the study area includes portions of eight counties in Wyoming and 19 in Idaho. Corridor and segment descriptions are identified in the table below.

<table>
<thead>
<tr>
<th>Corridor/route segment</th>
<th>Segment number</th>
</tr>
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<tbody>
<tr>
<td>Windstar – Aeolus East</td>
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</tr>
<tr>
<td>Windstar – Aeolus West</td>
<td>1W</td>
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<tr>
<td>Aeolus – Creston</td>
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</tr>
<tr>
<td>Creston – Jim Bridger</td>
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<tr>
<td>Jim Bridger – Populus</td>
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<tr>
<td>Populus – Borah</td>
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<tr>
<td>Borah – Midpoint</td>
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</tr>
<tr>
<td>Populus – Cedar Hill</td>
<td>7</td>
</tr>
<tr>
<td>Midpoint – Hemingway</td>
<td>8</td>
</tr>
<tr>
<td>Cedar Hill – Hemingway</td>
<td>9</td>
</tr>
<tr>
<td>Midpoint – Cedar Hill</td>
<td>10</td>
</tr>
</tbody>
</table>

For the entire study area, the BLM and the companies collected information on a wide array of natural resources, land use, land ownership and other attributes characterizing the areas traversed by the proposed 230 kV and 500 kV transmission lines.
2. Corridor evaluation

The BLM and the companies used the collected data and other information to map and characterize resources and conditions representing both opportunities and constraints to the location of potential two-mile wide transmission line corridors in the study area. The proposed and alternative corridors were identified by completing the following steps:

Step 1: Evaluation and mapping of constraints and opportunities using ArcGIS geographic information systems (GIS) software. Data sources included federal agencies such as the BLM, U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), Natural Resources Conservation Service (NRCS) and the National Park Service (NPS); Wyoming and Idaho wildlife management agencies, counties and other official sources.

Areas of constraints include
- Jurisdictional land ownership (e.g., special federal and state lands, military facilities, national monuments, special management areas, parks, national wildlife refuges, etc.) and land use (e.g., developed areas, residential areas, agricultural land, mining, oil, gas development and airports)
- Important biological areas (e.g., habitats for special status species, wetlands and riparian areas, habitats for important game species)
- Visual resources (e.g., sensitive areas with high resource value as determined by the BLM and USFS, and sensitive viewing areas)
- Important cultural resource areas (National Historic Trails, National Register of Historic Places sites and other areas with significant and sensitive cultural resources)
- Sensitive soils resources (e.g., soils with high erosion potential, prime farmlands)
- Geological hazard areas (e.g., areas with slope instability) and geologic features

These resources represent constraints because construction of a new transmission line in their vicinity or across them could result in potential impacts, require substantial mitigation or present difficult permitting conditions.

Examples of opportunities include possible corridors adjacent to existing linear facilities (such as other electric transmission lines, pipelines, roads and highways), lower construction cost areas, and location within utility planning corridors identified by entities such as the BLM, USFS, states, counties and in the Draft West-Wide Energy Corridor (WWEC) Programmatic EIS.

Step 2: Identify potential corridors for each segment, with the goals of maximizing the use of opportunities and minimizing crossings of areas with higher-level constraints. This step took into account corridors defined by existing transmission lines and other linear facilities as well as any additional corridors identified to date by the BLM and the companies and the WWEC study.

The BLM and the companies evaluated each corridor for a variety of environmental and engineering factors to identify the proposed and alternate corridors in each segment. This approach included development and use of an attribute matrix and, as appropriate, analysis tools including, GIS based routing and weighting, aerial photography, topographic maps and limited field reconnaissance.

Corridor evaluation resulted in the companies’ proposed corridor and alternative corridors that the BLM feels contain likely routes for full analysis in the draft EIS.
Alternatives

Gateway West Transmission Line Project Public Scoping Meetings, June 3-12, 2008
## Alternatives Proposed For Detailed Study

**“Green Corridors”**

<table>
<thead>
<tr>
<th>Sub-segment</th>
<th>Reference Points</th>
<th>Explanation (Basis for further consideration at this time)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Segment 4 Jim Bridger to Populus</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Kemmerer | 4b, (4h or 4i), 4j | - Southern alternative proposed through the Kemmerer field office.  
- Proposed to avoid the following:  
  o Biological resources having conservation practices with stipulations that limit/restrict seasonal presence and proximity of disturbance (sage grouse and elk calving).  
  o Proximity to high value national historic trails.  
- This alternative avoids the existing utility crossing at the northern boundary of the Cokeville Meadows NWR.  
- This alternative is also further away from Fossil Butte National Monument.  
- Contains a localized alternative (4i) that crosses into Utah to avoid a portion of the Cokeville Meadows National Wildlife Refuge. |
| | 4k, 4l, 4n | - This alternative reduces visual impacts to the Montpelier area.  
- This alternative reduces impacts to wetland and riparian areas in the Bear River Valley. |
| | 4n, 4o, 4p | - This alternative is a new corridor the Cache National Forest which is administered by the Caribou Targhee National Forest. This alternative is more direct and favored by the US Forest Service. |
| **Segment 7 Populus to Cedar Hill** | | |
| Deep Creek | 7e, 7f, 7g | - This alternative avoids biological resources having conservation practices with stipulations that limit/restrict seasonal presence and proximity of disturbance (primarily sage grouse leks). |
| Burley | 7j, 7l | - This alternative avoids biological resources having conservation practices with stipulations that limit/restrict seasonal presence and proximity of disturbance (primarily sage grouse leks). |
| **Segment 8 Midpoint to Hemingway** | | |
| North Snake River | 8g, 8p, 11 | - This alternative follows the existing PacifiCorp 500kV utility corridor.  
- This alternative is designated in the Treasure Valley Electrical Plan.  
- However, it would be a new right of way through the BLM administered Snake River Birds of Prey National Conservation Area (SRBP NCA).  
- The SNBPNCA would require a plan amendment to the recently completed resource management plan (RMP). |
| | 8h, 8i, 8j | - This alternative would involve a rebuild of a portion of an existing 138 kV line to a 230 kV planned for another project plus the 500kV line planned for Gateway West onto a double circuit 230/500kV tower. This alternative would be shorter than the proposed segment, but crosses a portion of the SRBPNCA. |
| | 8j, 8l | - This alternative is more direct.  
- However, this alternative passes through irrigated agricultural lands and rural residential area. |
<table>
<thead>
<tr>
<th>Sub-segment</th>
<th>Reference Points</th>
<th>Explanation (Basis for further consideration at this time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8l, 8n</td>
<td></td>
<td>This alternative is more direct.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>However, this alternative passes through irrigated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>agricultural lands and rural residential area.</td>
</tr>
</tbody>
</table>

**Segment 9 Cedar Hill to Hemingway**

<table>
<thead>
<tr>
<th>Saylor Creek</th>
<th>9i, 9k, 9l</th>
<th>This alternative follows less Section 368 Energy Act Corridor.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>However, it reduces visual impacts from Bruneau Dunes State Park</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and avoids crossing lands managed by Bruneau Dunes State Park.</td>
</tr>
</tbody>
</table>
Vance - Per our discussion by phone on Tuesday, here is a brief introduction to the Sublette Creek Reservoir Project and some potential issues and preliminary questions relative the existing and potential future transmission lines in the preferred site vicinity. I have copied Dale Raugutt on this email as I understand that he would be the primary contact regarding the planning of a new line in the subject corridor.

Background

SEH is conducting a study for the Wyoming Water Development Commission of the feasibility of developing new reservoir storage for irrigation in the Sublette Creek drainage basin. The study area is located just southeast of Cokeville in Lincoln County, Wyoming. The attached Figure 1 below shows the study area and surrounding vicinity (including to Kemmerer, Wyoming to the southeast). At this stage of study a total of five potential alternative dam and reservoir sites have been identified as shown on the attached Figure 1. Note that a new supply canal would be required for alternative Site Nos. 3, 4 and 5. Additional potential sites may be identified as the study progresses, but this is currently judged unlikely.

As seen on Figure 2 below the alternative site and facilities most directly relevant to the existing high voltage transmission lines are Site 1: Lower Sublette Creek Reservoir Site and the required new supply canal to Site 5: Trail Creek Reservoir Site. The reservoir limits shown on Figure 2 for Site 1 are practically constrained by the elevation at which water supplied by the existing Covey Canal would enter the new reservoir. Coincidentally, this constraint results in a reservoir pool that would back up to and only locally under the existing transmission lines. It is judged unlikely, but still possible, that Site 5 would also be further considered to increase the total potential storage in the Sublette Creek basin. If this site were to be used then a new supply canal would be required to supply water to the reservoir. This canal would pass under the existing transmission lines approximately as shown on Figure 2.

Issues

1. The currently envisioned normal high water level (NHWL) pool of the alternative Site 1: Lower Sublette Creek Reservoir would locally encroach under the existing transmission lines at one location as shown on Figure 2. This encroachment is located in Township 24N, Range 119W, NW1/4 of SW1/4 of Section 23. The approximate maximum width of this encroachment would be about 200 feet and the pool would extend about 300 feet to the northeast beyond the lines. Note that these distances are only approximate as they are based on the available 20-foot contour interval U.S. Geological Survey topographic mapping. Actual dimensions could be somewhat more or less, and will not be known until/unless the project advances to the next level of study with more refined site topographic mapping. Also note that temporary increases in pool level could occur during infrequent flood events depending on the final design of the project.

2. As noted above under Background, the potential new supply canal to Site 5: Trail Creek Reservoir Site would pass under the existing transmission lines. The total width of the canal right-of-way is uncertain at this stage in the study, but is not expected to exceed about 100-150 feet (with an
assumed water span of no more than about 50-75 feet). This crossing is located in Township 24N, Range 119W, NE1/4 of NE1/4 and possibly the SE1/4 of NE1/4 of Section 26.

3. If a new transmission line were added to this corridor on the southwest side of the existing lines the encroachments noted above on the west branch channel of Sublette Creek would increase, and additional minor encroachments would occur along the main channel of Sublette Creek and possibly along Ryan Creek. These additional encroachments would likely be located in Township 24N, Range 119W, SW1/4 of Section 23.

Questions

1. Which of the three existing transmission lines are owned by PacifiCorp (Rocky Mountain Power)? Are we correct in believing that the third line is owned by Idaho Power Company? If not, do you know who owns the third line? Do you know a contact person/number for the owner of the third line?

2. Can you provide a general description of the existing and any proposed new PacifiCorp lines in this corridor that would be appropriate for use in our study report (e.g., voltage, tower types/size, tower-arm span, right-of-way width, etc.)?

3. What, if any, issues do you foresee with the potential reservoir pool encroachment and canal crossing with the existing transmission lines as shown on Figure 2? Can you suggest potential mitigation measures to address any such issues (e.g., providing local dirt road access around the upper end of the reservoir in areas of encroachment, avoiding or relocating existing towers (if any) that would otherwise be located in the reservoir pool, providing a crossing of the supply canal within the transmission line corridor, etc.)?

4. Are we correct in assuming that PacifiCorp holds easements (rather than land ownership) in the portions of the corridor potentially affected by this project? (Note that Figure 2 shows ownership by category as supplied by the Lincoln County Assessor's Office)? Assuming there are easements, can you provide us with a brief summary of any terms relevant to the potential reservoir and canal "encroachments" noted above?

5. If a new transmission line is planned to be added to this existing corridor, can it be located and aligned to avoid conflict with the alternative dam and reservoir sites and canal alignment shown on Figures 1 and 2? If planning for a new line is not yet far enough advanced to have identified alternatives and/or a preferred alignment, can you provide an estimate of when such a determination might be made?

6. Is our understanding correct that an EIS is currently planned for the new transmission line? If so, could you provide an estimate of when scoping for the EIS is anticipated and what the overall timeline for the EIS is (especially when a ROD is anticipated)?

7. If it ever became necessary to discuss relocating one or more of the existing transmission line towers and realigning the existing lines in the area(s) of potential reservoir encroachment, could you provide us with an order-of-magnitude estimate of the cost per mile or per foot for such a relocation/realignment?

8. Can you provide us location information for any PacifiCorp/Rocky Mountain Power distribution/service lines within or crossing the Sublette Creek drainage basin as shown on Figure 1? We are aware of a line on the east side of U.S. Highway 30N and assume that there is a service line to the ranch located just east of the highway and south of Sublette Creek. We are also aware of two circular irrigation pivots located just west of Site 2: Upper Sublette Creek Reservoir Site (see Figure 1); does PacifiCorp/Rocky Mountain Power supply service to the pumps for these pivots, and if so what is the alignment of that service line? [Note that we understand that these questions are most likely best dealt with by someone in your distribution group; please forward these questions to the appropriate person with a copy to us so that we know who to contact for follow-up.]

Please call to discuss these matters after you have a chance to review the above information. We appreciate any help you can provide. Please note that we would like to provide our client with a status summary of this matter within the next week or two so that your initial response at your earliest convenience would be most helpful.

Regards,
SUBLETTE CREEK RESERVOIR AND COVEY/MAU CANALS REHABILITATION PROJECT, LEVEL II STUDY

SUBLETTE CREEK SITES RELATIVE TO TRANSMISSION LINES

PROJECT: AWMDC0703.00  DATE: 10/22/07  FIGURE: 2
Gateway West Transmission Project
Idaho Power and Rocky Mountain Power announced plans in May, 2007, to build more than 1,000 miles of 500-kilovolt transmission lines across Wyoming and southern Idaho. Click for a printable map (PDF, 495KB) or fact sheet (PDF, 610KB). To submit comments or questions, visit the Contact Information page.

This project is required to meet customer load growth needs as well as increase transmission capacity and reliability for our respective service areas. Segments are scheduled to be complete in 2012. Click for the proposed project schedule.

Under many conditions, Idaho Power's lines are already at full capacity. As a transmission provider, the company has the obligation to plan and construct transmission facilities to ensure reliable electric service to customers—a process requiring seven to 10 years.

Purpose and Benefits
The proposed Gateway West transmission project will:

- Help meet the growing demand for electricity and economic development in the region;
- Improve transmission system reliability;
- Respond to customer requests for new transmission capacity;
- Respond to customer demand for increasing amounts of renewable energy, particularly wind energy;
- Strengthen the integrated transmission network;
- Relieve congestion on existing facilities.

Environmental Review
Together, Idaho Power and Rocky Mountain Power will conduct all necessary environmental analysis to comply with the National Environmental Policy Act (NEPA) and will work with the Bureau of Land Management to create an environmental impact statement (EIS). The EIS is the basis for the BLM's determination whether to issue right of way grants across federal lands. Additionally, coordination with other Federal and State environmental and permitting agencies will also be required.

The two companies will also conduct public information meetings with various federal, state and local governmental agencies, local property owners and other interested parties as the project develops.

Project Description

Gateway West Transmission Project

Planning studies required by the Western Electric Coordinating Council (WECC), will continue into 2009, evaluating the best way to coordinate the electrical needs of the region.

The list below includes the six segments of 500-kV transmission lines planned, plus additional 230-kV lines; however, the WECC studies could alter these plans.

There are six, 500-kV segments planned at this time:

- The first segment will begin at the proposed Hemingway transmission station, southwest of Boise and will connect to Idaho Power's Midpoint Station north of Twin Falls.
- The second segment will start at the Hemingway Station and connect to the proposed Cedar Hill transmission station south of Twin Falls.
- The third segment will connect the Midpoint Station to the Cedar Hill Station.
- The fourth segment will connect the Midpoint Station to the Populus transmission station in Southeast Idaho.
- The fifth segment will connect the Cedar Hill Station south of Twin Falls to the Populus Station.
- The sixth segment will connect the Populus Station to the Aeolus Station.
- Additional 230-kV lines will connect the Jim Bridger and Dave Johnston generation facilities in Wyoming.

Electric Highways

In order to bring electricity to our customers, Idaho Power needs to transport electrical power from traditional generating resources like hydro-electric dams or thermal power plants as well as other merchant facilities and renewable resources such as wind and geothermal across long distances.

To do that, high voltage transmission lines are used, which would be the equivalent of a freeway system that moves vehicle traffic. Once the electricity arrives at a community, it goes to a substation, where the voltage is stepped down – like an off-ramp from the freeway and slowing down for street traffic. From there it goes out on distribution lines – or feeders – to serve local businesses and homes.

The whole process can take electricity from very high voltages down to the 110 or 220 volts that most residents are familiar with. And it all happens in less than a second!
Proposed Project Schedule
The proposed schedule for the Gateway West Transmission Project follows.

- National Environmental Policy Act (NEPA) Process
  2007-2009

- Western Electric Coordinating Council (WECC) Rating Process
  2007 - 2009

- Bureau of Land Management (BLM) Right of Way Grants
  2009 - 2011

- Right of Way Acquisition
  2007 - 2010

- Permitting
  2008 - 2011

- Engineering
  2008 - 2012

- Construction
  2012 - 2014

- In Service
  2012 - 2014

Contact Information
If you have questions about the Gateway West project, or have information you wish to be considered, contact:

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http://www.idahopower.com/newsroom/projnews/Gateway/contact.htm 8/21/2008
Announced in May, 2007, Idaho Power and Rocky Mountain Power are partnering to build a high-voltage transmission project across southern Wyoming and southern Idaho, linking electric generating resources to customers in the region. This project will address growing demand on the transmission system and increase electric system reliability of the service territories of both companies. In addition, the project will enable delivery of emerging renewable generating resources, such as wind, to more customers in the larger area. Known as “Gateway West,” segments are scheduled to be completed in 2012.

Under certain system conditions, transmission capability in this area is approaching full capacity. This project is needed to meet the projected electrical demand of the future. As transmission providers, both companies have the obligation to plan and construct transmission facilities to ensure reliable electric service to customers and service the needs of others requesting use of the transmission system. With a five to ten year timeframe to complete the project, work has begun to enable the companies to meet their obligation to serve customers in the future.

The completion of this project will:
- bring additional electricity to the area to meet the increasing needs of existing customers and meet the requests of new retail and wholesale customers in the area;
- improve electric system reliability and relieve existing congestion on the transmission network;
- respond to customer demand for more renewable energy, such as wind.

The construction of this transmission project will take place in segments, several of which will occur simultaneously. Below is a map of the general corridor.

More information on the project can be found at www.pacificorp.com or www.idahopower.com. Questions can be directed to Margaret Oler at 1-801-220-2592 or margaret.oler@pacificorp.com or to Lynette Berriechoa at 1-208-388-2407 or lberriechoa@idahopower.com.

Rocky Mountain Power to construct transmission lines through West

SALT LAKE CITY—Rocky Mountain Power today announced plans to build more than 1,200 miles of new 500-kilovolt transmission lines originating in Wyoming and connecting into Utah, Idaho, Oregon and the desert southwest. The two lines are set for completion in year 2014. The $4 billion-plus investment plan includes existing projects in the company’s 10-year business plan and additional investments to address customers’ increasing electric energy use. In addition to improving system reliability, these projects are also aimed at delivering wind and other renewable generation resources to more customers throughout PacifiCorp’s six-state service area and the western region. PacifiCorp, which operates as Pacific Power and Rocky Mountain Power, provides safe, reliable electricity to approximately 1.7 million customers in Oregon, Washington, California, Utah, Wyoming and Idaho.

"We are pleased to announce these projects as a clear signal to our retail customers, regulators and transmission customers that we are taking steps now to ensure our system is adequate and capable of meeting future customer load growth and regional needs," said Richard Walje, president of Rocky Mountain Power. "We are uniquely situated to make these essential investments
in the regional transmission grid, which ensure continued service reliability and access to various generation resources. While designed to provide us with much-needed options in our ability to reliably serve our native retail load, we believe these new projects also provide substantial long-term benefits to the western region by promoting cost-efficient, flexible and diverse resource development."

The new lines will move power to high-growth areas, particularly in Utah and Wyoming. They also will support the needs of the West Coast states including Rocky Mountain Power’s existing customers in Utah, Idaho and Wyoming that are seeking increased use of renewable energy. Much of that renewable energy, particularly wind, is expected to come from Wyoming and adjacent states.

PacifiCorp has entered into a memorandum of understanding with Idaho Power Company to cooperate on the northernmost line, a double-circuit 500-kilovolt transmission line from PacifiCorp’s and Idaho Power’s jointly owned Jim Bridger power plant in Wyoming to southeastern Idaho, with a connection south into Utah along an existing transmission path from southern Idaho into northern Utah (Path C). Another segment of this line will be built west across Idaho and into Oregon. The 600-plus miles of line will be capable of delivering up to 3,000 megawatts of electricity from Wyoming to Idaho into Utah and up to 2,500 megawatts of new incremental capacity from Idaho west into Oregon.

"Idaho Power is pleased to continue our longstanding relationship with Rocky Mountain Power by jointly working to develop regional-scale projects that would serve our growing
customer needs. The flexibility created by the design and location of these proposed facilities would provide our load centers the necessary transmission access to additional resources called for in our Integrated Resource Plan," said LaMont Keen, Idaho Power Idaho Power president and chief executive officer.

Another major line will run from southwestern Wyoming (near the Jim Bridger power plant near Rock Springs) into central Utah at the Mona substation located in Juab County. The 600-mile project will extend from the Mona area into southern Utah and the desert southwest. It will be capable of delivering up to 3,000 megawatts from Wyoming to Mona, and 3,000 megawatts from the Mona area into the desert southwest.

"We believe these new lines will support and help enable these regional project objectives," said John Cupparo, vice president of transmission for Rocky Mountain Power. "As the recently released Frontier Line feasibility study noted, a stronger and less-constrained grid will ease transmission bottlenecks, enhance domestic energy security and enable new markets for clean and renewable energy sources. Taken as a whole, all of the projects are critical to shaping and strengthening the West’s transmission system and ensuring reliable, efficient, coordinated service."

The new lines are a natural extension of the $250 million transmission investment commitments MidAmerican Energy Holdings Company made when it acquired PacifiCorp in 2006. Transaction commitments include a Path C upgrade to alleviate a bottleneck to the flow of electricity during increasingly high-consumption periods, a new transmission line from Mona north
into Salt Lake City to relieve constraints in Utah and a line that will support renewable energy development in Washington.

Rocky Mountain Power also continues to be an active participant in other regional transmission projects, including the Frontier Line and TransWest Express Line.

The new transmission projects announced today are a "hub and spoke" design—creating common points or "transmission hubs" of major interconnection for load and resources. From these hubs, power will be collected then moved in different directions. This comprehensive approach allows the company to deliver power from a variety of generation sources such as coal, gas or wind, to where it is needed.

Both lines will use double-circuit 500-kilovolt construction where feasible to lessen impacts on land use, and also will optimize the use of future and existing transmission corridors where reliability requirements are not impacted.

"We cannot stress enough the need to focus on the long-term needs and benefits required for the region and the Western grid," said Cupparo. "It is this long-term view that will make the difference in how we address the expansion of the grid."

The lines will be the first major projects to be built under the oversight of the Northern Tier Transmission Group, a coalition of investor-owned and public utilities, state government agencies and transmission customers intent on pursuing regional transmission planning and expansion opportunities consistent with Order No. 890 requirements recently adopted by the Federal Energy Regulatory Commission. Northern Tier, formed
in late 2006, will oversee the planning of the two lines and manage the public input process.

Rocky Mountain Power and Idaho Power Company will be working with the Western Electricity Coordinating Council and the Northern Tier Transmission Group through the next steps of the regional planning and rating processes. Northern Tier will work with sub-regional groups including Northwest Transmission Assessment Committee, Columbia Grid, West Connect and others to ensure public and regional coordination is part of the process. Work will also commence soon on route selection and permitting for the two lines.

Transmission expansion plans fact sheet

**About PacifiCorp**

PacifiCorp is one of the lowest-cost electricity producers in the U.S., providing approximately 1.7 million customers with reliable, efficient energy. The company works to meet growing energy demand while protecting and enhancing the environment. PacifiCorp’s electric generating plants have a net capability of more than 8,500 megawatts from coal, hydro, gas-fired combustion turbines and renewable wind and geothermal power. PacifiCorp operates as Pacific Power in Oregon, Washington and California, and as Rocky Mountain Power in Utah, Wyoming and Idaho.

**About Idaho Power**

Idaho Power serves more than 471,000 customers in a 24,000 square-mile area. The company operates its system with 4,629 miles of transmission lines and 25,935 miles of distribution lines.
Idaho Power relies heavily on hydroelectric power for its generating needs and is one of the nation's few investor-owned utilities with a predominantly hydroelectric generating base. The company owns and operates 17 hydroelectric power plants, two gas-fired plants and shares ownership in three coal-fired generating plants. Idaho Power's mission is to prosper by providing reliable, responsible, fair-priced energy services, today and tomorrow.

**About Northern Tier Transmission Group**

The transmission grid delivers the electricity underpinning the Western economy and enabling our quality of life. This indispensable infrastructure is too important to take for granted. The Northern Tier Transmission Group, transmission owners serving the Northwest and Mountain states, are committed, with the active cooperation of state governments, to improving the operations of and charting the future for the grid that links their service territories. Participants in the Northern Tier Transmission Group are committed to working with one another and with affected stakeholders and state officials, to increase efficient use of the grid and to develop the infrastructure needed to deliver new renewable and thermal power resources to consumers. NTTG is focused on action and devoted to a collaborative, step-by-step approach that will deliver results promptly and cost effectively.

Media inquiries: 800-775-7950

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Appendix D

Geologic Maps
GEOLOGIC MAP EXPLANATION

LIST OF MAP UNITS

QUATERNARY UNCONSOLIDATED DEPOSITS
- Alluvium and Colluvium
- Gravel, Pediment, and Fan Deposits
- Glacial Deposits
- Landslide Deposits
- Dune Sand and Loess
- Terrace Gravel (Pleistocene and/or Pleocene)

TERTIARY SEDIMENTARY AND IGNEOUS ROCKS
- Salt Lake Formation - Includes Gooseberry Member of Fowkes Formation
- Teewinot Formation
- Intrusive and Extrinsic Rocks
- Bridger Formation
- Fowkes Formation (Pleistocene and/or Eocene)
- Green River Formation - Laney Member
- Green River Formation - Wilkins Peak Member
- Green River and Wasatch Formations - Including Angelo and Fossil Butte Members
- Wasatch and Green River Formations - New Fork Tongue of Wasatch and Fontenelle Tongue or Member of Green River
- Wasatch Formation - Main body
- Wasatch Formation - Diamictite and sandstone
- Wasatch Formation - LaBarge and Chappo Members
- Conglomerate of Sublette Range
- Evanston Formation

MESOZOIC AND PALEozoIC SEDIMENTARY ROCKS
- Adaville Formation
- Blind Bull Formation
- Hilliard Shale
- Frontier Formation
- Sage Junction, Quealy, Cokeville, Thomas Fork, and Smiths Formations
- Aspen Shale
- Wayan and Smiths Formations
- Bear River Formation
- Gannett Group - Includes Smoot Formation, Draney Limestone, Bechler Conglomerate, Peterson Limestone, and Ephraim Conglomerate
- Stump Formation, Preuss Sandstone or Red beds, and Twin Creek Limestone
- Nugget Sandstone
- Nugget Sandstone and Chugwater and Dinwoody Formations
- Ankaresh Formation, Thaynes Limestone, Woodside Shale, and Dinwoody Formation
- Phosphoria Formation and Related Rocks
- Phosphoria Formation and Related Rocks
- Tensleep Sandstone, and Amsden Formation
- Wells and Amsden Formations
- Madison Limestone and Darby Formations
- Madison Limestone and Cambrian Rocks
- Laretown Dolomite
- Bighorn Dolomite, Gallatin Limestone, Gros Ventre Formation, and Flathead Sandstone

1 The Phosphoria Formation and related rocks in Wyoming is synonymous with the Park City Formation.
### EXPLANATION FOR HYDROGEOLOGIC MAP

**CORRELATION OF MAP UNITS IN HYDROGEOLOGIC DIVISIONS**

#### Sedimentary rocks

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qt</td>
<td>Holocene (order may not reflect relative age)</td>
</tr>
<tr>
<td>Qo</td>
<td>Pleistocene</td>
</tr>
<tr>
<td>Qf</td>
<td>Pliocene</td>
</tr>
<tr>
<td>Oo</td>
<td>Miocene</td>
</tr>
<tr>
<td>Qi</td>
<td>Miocene</td>
</tr>
<tr>
<td>Tt</td>
<td>Eocene</td>
</tr>
<tr>
<td>Td</td>
<td>Eocene</td>
</tr>
<tr>
<td>Tnp</td>
<td>Oligocene</td>
</tr>
<tr>
<td>Tdp</td>
<td>Oligocene</td>
</tr>
</tbody>
</table>

#### QUATERNARY

- **Hydrogeologic Division 8:**
  - Qt, alluvium, includes flood-plain deposits and alluvial fans
  - Qt, terrace deposits
  - Qf, rock debris
  - Qo, glacial deposits

- **Hydrogeologic Division 7:**
  - Tt, Salt Lake Formation
  - Td, Camas Davis Formation
  - To, Browns Park Formation
  - Tb, Bishop Conglomerate

- **Hydrogeologic Division 6:**
  - Tf, Fowkes Formation
  - Tb, Bridger Formation
  - Tgr, Green River Formation
  - Tw, Wasatch Formation
  - Th, Hoback Formation
  - Tke, Evanston Formation
  - Tkw, Fowkes, Green River, Wasatch and Evanston Formations

- **Hydrogeologic Division 5:**
  - Kav, Adaville Formation
  - Kh, Hilliard Shale
  - Kbb, Blind Bull Formation
  - Kf, Frontier Formation
  - Khb, Hilliard Shale, Blind Bull Formation and Frontier Formation
  - Kji, Sage Junction Formation
  - Ka, Aspen Formation
  - Kq, Quincy Formation
  - Kc, Cokeville Formation
  - Kbr, Bear River Formation
  - Kts, Thomas Fork Formation

- **Hydrogeologic Division 4:**
  - Kg, Gannett Group
  - JsP, Stump Sandstone and Preuss Redbeds
  - Tk, Frontier Formation
  - Jtc, Twin Creek Limestone
  - Jst, Stump Sandstone, Preuss Redbeds, and Twin Creek Limestone
  - Jsn, Nugget Sandstone

- **Hydrogeologic Division 3:**
  - Tt, Anakeak Formation and Thaynes Limestone
  - Raw, Ankareh Formation, Thaynes Limestone and Woodside Formation
  - Ps, Phelps and Park City Formations

- **Hydrogeologic Division 2:**
  - Phwa, Wells and Amsden Formations
  - Phma, Temiskaming Sandstone and Amsden Formation
  - Mra, Madison Limestone
  - MdD, Derby Formation
  - Ob, Bighorn Dolomite
  - Gdt, Gallatin Limestone, Gros Ventre Formation, and Flathead Quartzite

- **Hydrogeologic Division 1:**
  - Qt, igneous intrusive and extrusive rocks
  - Qf, metamorphic and igneous rocks

#### TERTIARY

- **Hydrogeologic Division 8:**
  - Qt, alluvium, includes flood-plain deposits and alluvial fans
  - Qt, terrace deposits
  - Qf, rock debris
  - Qo, glacial deposits

- **Hydrogeologic Division 7:**
  - Tt, Salt Lake Formation
  - Td, Camas Davis Formation
  - To, Browns Park Formation
  - Tb, Bishop Conglomerate

- **Hydrogeologic Division 6:**
  - Tf, Fowkes Formation
  - Tb, Bridger Formation
  - Tgr, Green River Formation
  - Tw, Wasatch Formation
  - Th, Hoback Formation
  - Tke, Evanston Formation
  - Tkw, Fowkes, Green River, Wasatch and Evanston Formations

- **Hydrogeologic Division 5:**
  - Kav, Adaville Formation
  - Kh, Hilliard Shale
  - Kbb, Blind Bull Formation
  - Kf, Frontier Formation
  - Khb, Hilliard Shale, Blind Bull Formation and Frontier Formation
  - Kji, Sage Junction Formation
  - Ka, Aspen Formation
  - Kq, Quincy Formation
  - Kc, Cokeville Formation
  - Kbr, Bear River Formation
  - Kts, Thomas Fork Formation

- **Hydrogeologic Division 4:**
  - Kg, Gannett Group
  - JsP, Stump Sandstone and Preuss Redbeds
  - Tk, Frontier Formation
  - Jtc, Twin Creek Limestone
  - Jst, Stump Sandstone, Preuss Redbeds, and Twin Creek Limestone
  - Jsn, Nugget Sandstone

- **Hydrogeologic Division 3:**
  - Tt, Anakeak Formation and Thaynes Limestone
  - Raw, Ankareh Formation, Thaynes Limestone and Woodside Formation
  - Ps, Phelps and Park City Formations

- **Hydrogeologic Division 2:**
  - Phwa, Wells and Amsden Formations
  - Phma, Temiskaming Sandstone and Amsden Formation
  - Mra, Madison Limestone
  - MdD, Derby Formation
  - Ob, Bighorn Dolomite
  - Gdt, Gallatin Limestone, Gros Ventre Formation, and Flathead Quartzite

- **Hydrogeologic Division 1:**
  - Qt, igneous intrusive and extrusive rocks
  - Qf, metamorphic and igneous rocks

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<td>Tdp</td>
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### DESCRIPTION OF MAP UNITS

(See table on sheet for more detail)
EXPLANATION FOR WELL-AND SPRING-DATA MAP

WELL AND SPRING SYMBOLS

<table>
<thead>
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<td>W</td>
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</tr>
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<td>S</td>
<td>Spring</td>
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Other symbols denote multiple sources of water by hydrogeologic divisions (See explanation for hydrogeologic map for color codes).

EXPLANATION FOR SPRING MAP

W2D Depth to water below or level above (>) land surface, in feet, one figure.
W2S Depth of well below land surface, in feet.
F50 Flow of spring or well, in gallons per minute; may not indicate the average flow.
Y300 Yield of pumped well, in gallons per minute; generally sat the maximum amount available from the well; it expected.
CSS Specific capacity of well, in gallons per minute per foot of drawdown.
SC Specific conductance of water, in microsiemens per centimeter.
G5 Geologic source of water. (See explanation for hydrogeologic map and other symbols below.) Quoted where questionable.

Other symbols used for geologic source of water not used on the hydrogeologic map.
Jn. Jurassic Sandstone
Jp. Pennsylvian Sandstone
Ba. Arkose Formation
Br. Tarynsh Limestone
FPW. Wells Formation
Pt. Tonkawa Sandstone
Fle. Atokah Formation

WELL AND SPRING NUMBERING SYSTEM

The numbering of wells and springs is based on the U.S. Land Grant System. The first segment of the number is the township (north); the second segment of the number is the range (east); the third segment of the number is the section, which is followed by a first letter that designates the quarter section, a second letter, if present, that designates the quarter-quarter section, etc. (e.g., N1W1SE1.1). Well 11-20-17, for example, is in the SW1/2 of the N1S1 of section 17, Township 11 North, Range 20 West. The number 7 indicates a second well or spring in the same quarter-quarter section. The first and second segments of the number are not shown on the map where the area has been surveyed and the township-range number is shown. Well 11-20-17, for example, is in a surveyed area and is simply designated 11-20 on the map.

CHEMICAL-QUALITY SYMBOLS

The chemical type of water is shown by segments of a colored circle; the size of the circle denotes the range in total dissolved solids. Segment divisions are diagrammatic with the major cation relations shown in the top half of the circle and the major anion relations shown in the bottom half. The following procedure is used in determining the water type:

1. The sum of major cations—calcium, magnesium, and sodium (or sodium plus potassium)—in milligrams per liter is taken to be 100 percent; and the percentage of each cation is calculated from that base. Similarly, the major anions—bicarbonate (or bicarbonate plus carbonate), sulfate, and chloride—are calculated from a base of 100 percent.

2. Where one cation constitutes 30 percent or more of the total cations and one anion constitutes 50 percent or more of the total anions, that cation and that anion designate the water type. For example, if calcium is 60 percent of the total cations and bicarbonate is 75 percent of the total anions, the water is classified as a calcium bicarbonate type.

3. If no cation constitutes as much as 50 percent of the total cations or anions, the ion with the highest percentage is given two-thirds of the semicircle and is named first, and the ion with the second highest percentage is given one-third of the semicircle and follows as a subsidiary term—for example, sodium bicarbonate or calcium magnesium sulfate bicarbonate type.
## GEOLOGY AND WELLS EXPLANATION

### Contact

**Dashed where approximately located**

- **U**: upthrown side
- **D**: downthrown side

### High-angle fault

- **U**: upthrown side
- **D**: downthrown side

### Thrust fault, concealed

1. on upper plate

### Domestic, stock, or unused well

Upper number is depth of well, in feet; lower number is depth to water below land surface. Ca indicates chemical analysis.

### Well in which periodic water-level measurements are made

- **wagon-wheel**
- **public-supply well**
- **irrigation well**
- **flowing irrigation well**
- **stream sampling point**
- **spring**

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### Explanations

**Quaternary**

- **Artificial fill**: Levels are filled up with debris from erosion or construction activities.
- **Muck**: A mixture of organic materials and soil.
- **Goal**: A type of soil consisting of large particles and gravel.
- **Bog**: An area with a high water table, supporting wetland vegetation.
- **Poisonous**: Areas that may contain hazardous substances.
- **Terrane faults**: Boundaries between tectonic plates.
- **Terrane growths**: Structures resulting from the movement of tectonic plates.
- **Terrane growths and other alluvium**: Sedimentary deposits formed by the movement of terranes.
- **Geological and historical deposits**: Soils and sediments deposited by natural processes.
- **Quaternary sediment**: Sediments deposited in the last 2 million years.

**Tertiary**

- **Apappic formation**: A formation consisting of alluvial deposits.
- **Bonneterie formation**: A formation consisting of alluvial deposits.
- **Rounding and silt**: Sediments deposited by flowing water.
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Appendix E

Seismotectonics
Basic Seismological Characterization
for
Lincoln County, Wyoming

by

James C. Case, Rachel N. Toner, and Robert Kirkwood
Wyoming State Geological Survey
November 2002

BACKGROUND

Seismological characterizations of an area can range from an analysis of historic seismicity to a long-term probabilistic seismic hazard assessment. A complete characterization usually includes a summary of historic seismicity, an analysis of the Seismic Zone Map of the Uniform Building Code, deterministic analyses on active faults, “floating earthquake” analyses, and short- or long-term probabilistic seismic hazard analyses.

Presented below, for Lincoln County, Wyoming, are an analysis of historic seismicity, an analysis of the Uniform Building Code, deterministic analyses of nearby active faults, an analysis of the maximum credible “floating earthquake,” and current short- and long-term probabilistic seismic hazard analyses.

Historic Seismicity in Lincoln County

The enclosed map of “Earthquake Epicenters and Suspected Active Faults with Surficial Expression in Wyoming” (Case and others, 1997) shows the historic distribution of earthquakes in Wyoming. Numerous magnitude 2.0 and greater earthquakes have been recorded in Lincoln County. Most of these were relatively small magnitude events and subsequently, not felt. These earthquakes are discussed below.

The first earthquake that was reported in Lincoln County occurred on March 31, 1915. This intensity IV earthquake, located approximately 3.5 miles northeast of Bedford, shook buildings in the area. No significant damage was reported, however (Humphreys, 1915).

Only one earthquake was recorded in the county in the 1920s. On December 6, 1921, an intensity III earthquake occurred approximately 8 miles northeast of Afton. No damage was reported.
Several earthquakes occurred in Lincoln County in the 1930s. The first took place on June 12, 1930, approximately 9 miles southwest of Afton. This intensity VI, magnitude 5.8 (estimated) event was felt by most residents in the Star Valley and caused damage in Grover. Plaster walls, a brick building, and a swimming pool in the Grover area cracked. Interestingly, this event also stopped clocks on the west walls of buildings. (Neumann and Bodle, 1932). Numerous aftershocks continued in the area through June 16, 1930 (Reagor, Stover, and Algermissen, 1985). Intensity II and intensity III earthquakes occurred in the same area as the June 12 event on September 19, 1930, and September 21, 1930, respectively (U.S.G.S. National Earthquake Information Center). Another intensity III earthquake and another intensity II earthquake were recorded in the same location on November 16, 1930 (Neumann and Bodle, 1932) and June 8, 1932 (U.S.G.S. National Earthquake Information Center), respectively. No damage was reported from any of these events. On October 24, 1936, two earthquakes occurred in western Wyoming. The U.S.G.S. National Earthquake Information Center reported these two intensity III earthquakes as occurring in Sublette County. The original reference and description of these events, however, indicates that these earthquakes originated in the Star Valley of Lincoln County (Neumann, 1936). The epicenter of this earthquake will therefore be tentatively located approximately 6-8 miles northwest of Afton. No damage was reported. The area approximately 9 miles southwest of Afton again experienced intensity III earthquakes on November 29, 1938, December 1, 1938, and December 5, 1938 (U.S.G.S. National Earthquake Information Center). No damage was associated with these events.

On October 8, 1944, an intensity IV earthquake occurred in the same area as the 1930s earthquakes described above. Several residents of Grover felt the event and reported that the earthquake had a trembling motion with an abrupt onset. Loose objects rattled and buildings creaked (Bodle, 1946). The U.S.G.S. National Earthquake Information Center detected an earthquake of no specific magnitude or intensity on September 3, 1949, approximately 14 miles southwest of La Barge. No one reported feeling this earthquake.

Two earthquakes were recorded in northern Lincoln County in the 1950s. A magnitude 3.0 event occurred on May 8, 1955, approximately seven miles east-northeast of Afton. No damage was associated with this earthquake. On November 3, 1957, a magnitude 3.7, intensity IV earthquake was recorded approximately 18 miles south-southwest of Afton. This event was felt by several residents of Geneva, Idaho (Brazee and Cloud, 1959).

Although numerous earthquakes occurred in Lincoln County during the 1960s, none caused any significant damage. Earthquakes of no specific magnitude or intensity were recorded on June 25, 1964, approximately 14 miles northeast of Alpine, and on July 10, 1964, approximately 13 miles east-northeast of Bedford (U.S.G.S. National Earthquake Information Center). On September 17, 1964, a non-damaging magnitude 4.0 earthquake was detected approximately 10 miles northeast of Afton. The U.S.G.S. National Earthquake Information Center recorded another earthquake of no specific magnitude or intensity on May 20, 1965. This event was centered approximately 19 miles east-southeast of Alpine. A magnitude 3.3 earthquake occurred on August 22, 1965, approximately 21 miles west-northwest of La Barge. On October 27, 1965, a magnitude 2.5 event was detected approximately 18 miles southwest of La Barge. A non-
A damaging, magnitude 3.9 earthquake occurred in Lincoln County on December 24, 1965. This earthquake’s epicenter was located approximately 12 miles east-northeast of Afton.

Several earthquakes also occurred in Lincoln County in 1966. The first took place on July 12, 1966, approximately 17 miles northeast of Cokeville. No damage was reported from this magnitude 2.5 earthquake. On October 4, 1966, a magnitude 3.8 earthquake occurred approximately 13 miles south-southwest of Kemmerer. It is suspected that an explosion or seismic line activity may have caused this event. A few days later, a magnitude 4.4 earthquake occurred on October 8, 1966. This non-damaging earthquake was centered approximately 3 miles north-northeast of Alpine. According to the U.S.G.S. National Earthquake Information Center, no one reported feeling this event. Another earthquake attributed to an explosion was recorded on October 14, 1966, approximately 8 miles west-northwest of Kemmerer. This same area experienced a magnitude 3.7 earthquake of tectonic origin on October 27, 1966. On November 3, 1966, a magnitude 2.8 event was detected approximately 14.5 miles north of Kemmerer (University of Utah Seismograph Stations). This event was followed by a magnitude 2.5 earthquake on November 18, 1966. Its epicenter was located approximately 18.5 miles north-northeast of Kemmerer.

The first event to occur in Lincoln County in 1967 took place on February 27, 1967, approximately 18 miles southwest of La Barge. This magnitude 3.7 earthquake was later attributed to an explosion in the area. On March 10, 1967, another magnitude 3.7 earthquake occurred approximately 15.5 miles south-southwest of La Barge. Residents in the area reported feeling this event, but no damage was reported (U.S.G.S. National Earthquake Information Center). A magnitude 4.0 earthquake was detected in northern Lincoln County on June 26, 1967, approximately 5 miles north of Thayne. On August 29, 1967, a magnitude 2.5 earthquake occurred approximately 9 miles north-northwest of Kemmerer. The last event to occur in 1967 took place on September 11, 1967. This earthquake of no specific magnitude or intensity was located in the same area as the June 26 event.

Five earthquakes occurred in Lincoln County in 1968. The first was detected on February 20, 1968. This magnitude 3.7 earthquake was centered approximately 5 miles southwest of Kemmerer. On May 17, 1968, a magnitude 2.8 event occurred roughly 16 miles southwest of La Barge. A magnitude 3.0 earthquake was recorded on June 14, 1968. Its epicenter was located approximately 11 miles northeast of Kemmerer. Magnitude 2.5 and magnitude 2.6 earthquakes occurred in the county on July 30, 1968 and November 14, 1968, respectively. The July 30 event was centered approximately 21 miles west of La Barge, while the November 14 event was centered approximately 19 miles southwest of La Barge. No damage was reported from any of the 1968 events.

Several earthquakes took place in the county in 1969, the first of which occurred on February 4. This magnitude 2.5 event was centered approximately 15 miles north-northeast of Kemmerer. On August 27, 1969, a magnitude 4.2, intensity III earthquake was reported approximately 7 miles east-northeast of Bedford. Residents of Auburn reported feeling this earthquake, but no damage was caused. On the same day, a magnitude 3.9 earthquake was detected roughly 15 miles east-northeast of Thayne. No one reported feeling this event (U.S.G.S. National Earthquake Information Center).
Information Center). A second 3.9 earthquake occurred a few days later on August 30, 1969. This event was located in northeastern Lincoln County, approximately 19 miles southeast of Alpine. Again, no one reported feeling this event (U.S.G.S. National Earthquake Information Center). On December 11, 1969, the University of Utah Seismograph Stations recorded a magnitude 2.5 earthquake approximately 20 miles southwest of La Barge.

The largest earthquake recorded in northern Lincoln County in the 1970s occurred on September 21, 1970. The magnitude 4.4 earthquake, which occurred near the Elbow Campground in the Snake River Canyon, was primarily felt in Teton and Sublette Counties. The Jackson Hole Guide (September 24, 1970) reported that residents from Jackson through the Hoback Canyon to Bondurant felt the earthquake. Some residents in Jackson thought that the event was a sonic boom. At Camp Davis, a resident reported a figurine knocked off a television set and a "vibrating" staircase. Eleven miles south of Jackson, a resident reported rattling windows and a shaking bed. Near Bondurant, a resident reported that windows rattled and her whole house shook.

In 1972, a series of earthquakes occurred in the Cokeville area. The first occurred on February 12, 1972. This magnitude 2.5 earthquake was recorded approximately 19 miles south-southwest of Cokeville. A magnitude 2.6 earthquake occurred in the same area on March 17, 1972. Another magnitude 2.6 earthquake was detected on May 17, 1972, roughly 7 miles southwest of Cokeville. On September 28, 1972, a magnitude 2.5 earthquake occurred approximately 13 miles north of Cokeville. No damage was reported from any of these events.

On November 11, 1975, an earthquake of no specific magnitude or intensity was recorded approximately 4 miles northwest of Kemmerer (U.S.G.S. National Earthquake Information Center). This event was followed by a magnitude 3.1 earthquake on December 27, 1975. Its epicenter was located in the northern part of the county, approximately 14 miles east of Alpine. No damage was reported from either earthquake. A magnitude 3.9 earthquake occurred in far northern Lincoln County on March 17, 1976. It was located on the Lincoln County – Teton County border approximately 18 miles northeast of Alpine. No one reported feeling this event (U.S.G.S. National Earthquake Information Center). On April 14, 1978, a magnitude 2.5 earthquake was recorded approximately 3 miles east of Afton. Residents in the area reported feeling the earthquake (U.S.G.S. National Earthquake Information Center). The last earthquake to occur in the county in the 1970s took place on February 24, 1979. This magnitude 3.5 event was located in the southwestern corner of the county, approximately 26 miles southwest of Kemmerer. No one reported feeling the earthquake (U.S.G.S. National Earthquake Information Center).

The first earthquake recorded in Lincoln County in the 1980s occurred on June 13, 1980. This magnitude 3.1 earthquake, located near Bedford, did not cause any damage.

On March 31, 1981, another magnitude 3.1 earthquake occurred in the southwestern corner of Lincoln County. Its epicenter was located approximately 25 miles west-southwest of Kemmerer. No one reported feeling this event (U.S.G.S. National Earthquake Information Center). On December 15, 1981, two earthquakes were detected an hour apart. They were both centered
approximately 3 miles northeast of Bedford. The U.S.G.S. recorded these earthquakes as being magnitude 2.9, but the University of Utah recorded them as magnitude 2.4 events. Residents in the area did report feeling the earthquakes.

Most of the earthquakes that caused damage or concern in Lincoln County in the 1980s occurred in 1985. On February 28, 1985, two non-damaging earthquakes were recorded in the northern portion of the county. These magnitude 3.5 and 3.1 events were centered approximately 11 miles east-northeast of Thayne. On March 8, 1985, a magnitude 3.4 earthquake occurred in the same area, approximately 15 miles northeast of Thayne. Three earthquakes occurred on March 11, 1985, approximately 10 miles northeast of Thayne. The University of Utah recorded magnitude 3.1, magnitude 3.6 and magnitude 2.6 earthquakes on March 11. The magnitude 3.1 and magnitude 2.6 earthquakes were not felt, but residents in the area reported feeling the magnitude 3.6 event. In August and September of 1985, nine earthquakes occurred in northern Lincoln County. The first earthquake, a magnitude 4.8, intensity V event, occurred on August 21, 1985, approximately 10 miles east of Alpine. It was felt as an intensity V event at Alpine, and intensity IV event at Wilson in Teton County, an intensity IV event at Lander in Fremont County, and was lightly felt in Jackson. No major damage was reported, although the Teton County Sheriff’s Department reported that the earthquake caused a motorist to drive off the highway in the Snake River Canyon (Casper Star-Tribune, August 22, 1985). The second earthquake, a magnitude 4.3 event, occurred on August 22, 1985, approximately twelve miles southeast of Alpine. It was felt as an intensity IV event in Alpine, with no significant damage reported (Laramie Daily boomerang, August 23, 1985). The third and fourth earthquakes also occurred August 22, 1985. These magnitude 3.4 and magnitude 3.2 events were centered approximately 8 miles east of Alpine. The fifth earthquake, a magnitude 4.3, intensity V event, occurred on August 30, 1985, approximately seven miles east of Alpine. It was felt as an intensity V event at Alpine, and was also felt in Jackson. The sixth earthquake, a magnitude 4.6, intensity V event, occurred on September 6, 1985, approximately fifteen miles east-southeast of Alpine. It was felt as an intensity V event at Alpine, and as an intensity IV event in Wilson. An earthquake-induced landslide temporarily closed a portion of U.S. Highway 89 in the Snake River Canyon (Casper Star-Tribune, September 8, 1985). A second earthquake occurred on September 6, 1985 in the same area. No one reported feeling this magnitude 3.6 earthquake. A magnitude 3.5 earthquake, located roughly 5 miles southeast of Alpine, occurred on September 19, 1985. Residents in the area did report feeling this earthquake. The last earthquake to occur in Lincoln County in 1985, took place on September 23, 1985. This magnitude 2.5 earthquake, was centered approximately 18 miles southwest of Kemmerer. No one felt this earthquake.

Two earthquakes occurred in Lincoln County on November 17, 1986, approximately 10 miles east of Alpine. The first was a magnitude 3.9, intensity III event, which was felt by residents in the area. The second, a magnitude 3.7 earthquake, was not felt.

Two earthquakes also occurred in 1988 in northern Lincoln County. A magnitude 2.5 earthquake was recorded on March 21, 1988, approximately 8 miles east-southeast of Alpine. No one reported feeling the earthquake. On November 13, 1988, a magnitude 4.0, intensity V earthquake occurred near Smoot, south of Afton. The earthquake was felt as an intensity V event at Smoot and an intensity IV event at Afton and Fairview. No significant damage was reported.
The 1990s were one of the most active periods on record for the area in and around northern Lincoln County. The first earthquake of significance recorded in northern Lincoln County in this decade was a magnitude 3.5 event that occurred on April 9, 1990. The earthquake, which was located approximately 20 miles east-southeast of Alpine, did not cause any damage. A magnitude 2.6 earthquake was detected on May 20, 1990. It was centered approximately 16 miles south of Afton. No one reported feeling this event. On November 17, 1990, a magnitude 3.1 earthquake occurred roughly 17 miles southeast of Alpine. Again, no one reported feeling this event.

On October 10, 1993, a magnitude 3.1 earthquake occurred approximately 9 miles north-northeast of Alpine. No one reported feeling the earthquake.

Several earthquakes and associated aftershocks in 1994 greatly affected Lincoln County. Because these earthquakes originated in Idaho, however, they are discussed in the following “Regional Historic Seismicity” section.

On February 22, 1995, a magnitude 2.9 earthquake occurred near the Wyoming-Idaho border, approximately 6 miles west of Afton. Residents in the area reported feeling the earthquake. The only other earthquake to occur in Lincoln County in 1995 was recorded on December 16, 1995. This non-damaging, magnitude 3.3 event occurred near Bedford in the vicinity of the Star Valley fault. Because of the lack of seismic stations in the area, the epicenter could not be located accurately enough to determine if it had originated on the Star Valley fault.

The next earthquake in Lincoln County occurred on January 11, 1998. This magnitude 2.7 earthquake was centered approximately 4 miles northwest of Afton. No one reported feeling the event.

A series of seven earthquakes were detected on January 29, 1999 through February 1, 1999 in northern Lincoln County. These events, located approximately 11-14 miles east-southeast of Alpine, ranged from magnitude 2.8 to magnitude 3.9. On June 17, 1999, a magnitude 3.5 earthquake occurred in the same area. No one reported feeling any of these 1999 earthquakes.

On January 8, 2000, a magnitude 3.5 earthquake was recorded approximately 14 miles southwest of La Barge. Two earthquakes occurred in the county on April 20, 2000. These magnitude 2.7 and magnitude 2.3 events were centered approximately 16 miles northeast of Cokeville. The last earthquake to occur in 2000 took place on December 1, 2000. The epicenter of this magnitude 3.2 event was located approximately 13 miles east of Alpine. None of the 2000 earthquakes were felt and no damage was reported.

Only one earthquake occurred in Lincoln County in 2001. A magnitude 3.1 earthquake was detected on April 1, 2001, approximately 5 miles north-northeast of Alpine. Again, no one reported feeling this event.

Several earthquakes have occurred in Lincoln County in 2002. In March 2002, a series of earthquakes were recorded near Alpine. A magnitude 3.4 earthquake occurred on March 24,
2002, approximately 11 miles east of Alpine. This event was followed by magnitude 2.8 and magnitude 3.1 events on March 25, 2002, in the same area. A week later, on March 31, 2002, a magnitude 3.5 earthquake was reported approximately 15 miles east of Alpine. No one felt the March earthquakes and no damage was reported. On May 8, 2002, the U.S. Bureau of Reclamation recorded four earthquakes in the same area as the March events. Again, no one felt these magnitude 3.3, 2.7, 3.2, and 2.3 earthquakes. Most recently, three earthquakes occurred in the Alpine area in October 2002. On October 21, 2002, a magnitude 3.2 earthquake was detected approximately 4 miles northeast of Alpine. This event was followed closely by a magnitude 4.4 earthquake centered approximately 3-4 miles north-northeast of Alpine. Residents in the area reported feeling both of these earthquakes. No damage was reported from either event. On October 23, 2002, a magnitude 3.4 earthquake was reported approximately 4.5 miles north-northeast of Alpine. No one reported feeling this most recent earthquake.

**Regional Historic Seismicity**

Several earthquakes have also occurred near Lincoln County. On October 24, 1936, the Star Valley experienced two intensity II earthquakes, each accompanied by a rumble (Neumann, 1938). The epicenters of these earthquakes were located near Pinedale in Sublette County, approximately 48 miles east-northeast of Bedford (Reagor, Stover, and Algermissen, 1985).

In June of 1945, two earthquakes occurred in western Sublette County. These intensity III earthquakes were recorded on June 7, 1945, approximately 7 miles northwest of La Barge, and on June 23, 1945, approximately 2.5 miles north of La Barge. Although people reported feeling the earthquakes, no damage resulted from them (Casper Tribune-Herald, June, 1945). The earthquakes did cause several camp buildings to creak.

The first earthquake recorded near Lincoln County in the 1960s occurred on October 12, 1963, in southern Teton County. This magnitude 3.9 event was centered approximately 12 miles north-northeast of Alpine. No one reported feeling this earthquake. On February 2, 1964, an earthquake was reported in Idaho, approximately 5 miles west of Alpine. No damage was associated with the magnitude 4.1 earthquake. A magnitude 3.7 earthquake was recorded in southern Teton County on April 13, 1964. No one felt this event that was centered approximately 12.5 miles north-northeast of Alpine. On July 31, 1965, a magnitude 2.8 earthquake occurred in western Sublette County, approximately 12 mile northwest of La Barge. A series of earthquakes occurred in eastern Idaho in June 1966. Magnitude 3.7 and 3.3 events were detected on June 10, 1966, approximately 6 miles southwest of Alpine. The next day, a magnitude 3.4 earthquake and an earthquake of no specific magnitude or intensity were recorded in the same area. No one reported feeling these June 1966 earthquakes. Another earthquake occurred in Sublette County on August 18, 1967. This magnitude 2.7 earthquake was located approximately 11 miles northwest of La Barge. No one reported feeling these Sublette County earthquakes.

Several earthquakes occurred in western Sublette County and southern Teton County in the 1970s. On December 2, 1971, and December 3, 1971, a magnitude 4.1 earthquake and a magnitude 4.2 earthquake were detected in western Sublette County, respectively. The
earthquakes were located approximately 17 miles northwest of La Barge. Two earthquakes of no specific magnitude or intensity occurred in Teton County on March 21, 1976. They were centered approximately 19 miles northeast of Alpine. Approximately 15 miles north-northeast of Alpine, a magnitude 3.3 earthquake was recorded on June 18, 1975. No one reported feeling any of the earthquakes that occurred near Lincoln County in the 1970s.

On March 1, 1982, a magnitude 3.6, intensity V earthquake occurred in eastern Idaho, just west of Freedom, Wyoming. It was felt as an intensity IV earthquake in Freedom, Etna, and Thayne. No damage was reported. On February 8, 1983, a magnitude 4.4, intensity V earthquake occurred in Idaho, approximately twelve miles northwest of Alpine, Wyoming. Although no damage was reported, the earthquake was felt as an intensity IV event at Etna and at Teton Village in Teton County. The U.S. Forest Service reported that the event might have initiated snow avalanches in some areas (Casper Star-Tribune, February 9, 1983). A magnitude 4.5, intensity IV earthquake was recorded on December 20, 1983, in southern Teton County. This earthquake, located approximately 15 miles northeast of Alpine, was felt from Jackson to the palisades Reservoir in Idaho. In Jackson, there were reports of Christmas trees falling over and dishes breaking (Laramie Daily Boomerang, December 21, 1983). The December 20, 1983 event had a number of aftershocks, with one of the largest, a magnitude 3.4 earthquake, occurring on December 22, 1983. On January 5, 1984, another magnitude 3.0 aftershock occurred in the same area. A magnitude 2.8 earthquake was recorded in Teton County, approximately 17 miles northeast of Alpine. Residents in the area reported feeling this event. On July 1, 1985, a magnitude 4.0, intensity IV earthquake occurred in Idaho, approximately 10 miles northwest of Alpine. Although the earthquake was felt in Jackson Hole and Alpine, no damage was reported (Casper Star-Tribune, July 3, 1985). A magnitude 3.5 earthquake occurred in eastern Idaho on June 21, 1986, approximately 13 miles northwest of Afton. The earthquake was felt as an intensity IV event at Auburn.

On August 14, 1991, a magnitude 3.0 earthquake occurred in southern Teton County. No one reported feeling this earthquake that was centered approximately 23 miles northeast of Alpine.

A series of earthquakes that originated in Idaho shook the Star Valley on November 10, 1992. The first earthquake had a magnitude of 4.8 and was felt as an intensity V event at Alpine and Grover, and as an intensity IV event in the rest of the Star Valley. This earthquake was quickly followed by a magnitude 4.7 earthquake that was felt as an intensity V event at Grover, an intensity IV event in the northern portion of Star Valley, and as an intensity III event in the more southern portion of Star Valley. The November 10, 1992, earthquakes did not cause any significant damage in Wyoming.

A magnitude 2.9 earthquake was reported on September 4, 1993, in western Sublette County. No one reported feeling this earthquake that was centered approximately 4 miles northwest of La Barge.

On January 30, 1994, a magnitude 3.3 earthquake occurred in eastern Idaho, west of Afton. No damage was associated with the event. This event was followed by a magnitude 3.5 earthquake on February 1, 1994, and a magnitude 4.0 earthquake on February 2, 1994. The magnitude 4.0
event was felt as an intensity V event at Afton and Freedom, and as an intensity III event at Grover. On February 3, 1994, a magnitude 4.7 earthquake occurred in the same area. This earthquake was soon followed by a magnitude 5.9, intensity VII earthquake that rocked the Star valley. The earthquake’s epicenter was located in the vicinity of Draney Peak in Idaho. The most significant damage from the magnitude 5.9 event occurred at the Auburn Fish Hatchery, located just into Idaho, near Auburn, Wyoming. One wall separated from the roof of that facility. In addition, one home near Auburn had cracks in both the foundation and ceiling. The earthquake also shook dishes off shelves and clocks off walls in Afton and surrounding communities. In Wyoming, the magnitude 5.9 earthquake was felt as far away as Rock Springs. It was also felt in Salt Lake City, Utah, and Grand Junction, Colorado.

The magnitude 5.9 earthquake that occurred on February 3, 1994, was followed by thousands of aftershocks, most of which originated in eastern Idaho. Some of the largest of these aftershocks include magnitude 5.2 and 4.0 earthquakes on February 3, 1994, a magnitude 4.0 earthquake on February 4, 1994, two magnitude 4.2 earthquakes and a magnitude 4.1 earthquake on February 5, 1994, a magnitude 4.8 earthquake on February 6, 1994, a magnitude 4.5 earthquake on February 7, 1994, a magnitude 4.3 earthquake on February 8, 1994, a magnitude 4.4 earthquake on February 9, 1994, a magnitude 5.3 earthquake on February 11, 1994 and a magnitude 4.1 earthquake on February 14, 1994. The February 11, 1994, aftershock did cause some minor structural damage in the Star Valley. In Grover, a resident reported that his house had been damaged to the point where a front door would not close. There was also a report from Grover that a set of concrete steps had pulled away from a house. In Afton, cracks appeared in the walls of some homes. In Fairview, there were reports of lamps tipped over. No other significant damage was associated with what has been called the Draney Peak earthquake sequence.

Large aftershocks continued into March and April, with a magnitude 4.4 earthquake on March 3, 1994, a magnitude 4.1 earthquake on March 10, 1994, a magnitude 3.8 earthquake on April 2, 1994, a magnitude 5.2 earthquake on April 7, 1994, magnitude 4.3 and 4.1 earthquakes on April 8, 1994, and a magnitude 4.6 on February 10, 1994. Several other earthquakes were recorded in the same region through August. Residents in the area did report feeling several of these earthquakes, although none were larger than a magnitude 3.9.

On February 28, 1995, a magnitude 4.0, intensity V earthquake occurred 17 miles south-southwest of Afton. The earthquake was felt as an intensity V event in Afton, and as an intensity IV event in Smoot. No significant damage was associated with the earthquake. On July 25, 1995, two earthquakes occurred in Idaho, approximately 6 miles west of Etna, Wyoming. The first earthquake had a magnitude of 3.0, and was not widely felt. The second earthquake had a magnitude of 4.1, and was felt as an intensity IV event at Thayne. No damage was associated with either earthquake.

On May 16, 1996, a magnitude 4.3, intensity V earthquake occurred 20 miles southwest of Afton, Wyoming. This non-damaging earthquake was felt as an intensity IV event at Afton and as an intensity III event in Auburn, Fairview, Freedom, Grover, and Smoot. This earthquake occurred in the same vicinity as those that caused damage and concern in the Star Valley in 1994.
A magnitude 3.4 earthquake was recorded in Lincoln County on January 4, 1998. It was centered near the Auburn Fish Hatchery, approximately 11 miles northwest of Afton. The earthquake was felt at the fish hatchery, Auburn, and Afton. The Wyoming Emergency Management Agency reported that the earthquake shook walls and moved couches. On June 19, 1998, a magnitude 4.1 earthquake occurred in eastern Idaho, approximately 17 miles southwest of Afton. Residents of Auburn described the earthquake as a heavy truck passing. No damage from this earthquake was reported. The next day, on June 20, 1998, another earthquake was recorded near Camp Davis, approximately 14 miles south-southeast of Jackson. This magnitude 4.7 event was felt at Hoback Junction and Jackson, but no damage was reported.

On July 22, 1999, a magnitude 4.1 earthquake occurred in eastern Idaho, approximately 25 miles north-northwest of Afton. This earthquake was felt at Freedom, where residents reported dishes being rattled. Several aftershocks, including a magnitude 3.6 event, occurred on the same day. No significant damage was associated with the earthquakes.

Most recently, on January 16, 2003, a magnitude 3.4 earthquake was recorded in eastern Idaho, approximately 4 miles west-southwest of Fairview, Wyoming. Residents in Fairview reported feeling this earthquake, but no damage has been associated with it.

Uniform Building Code

The Uniform Building Code (UBC) is a document prepared by the International Conference of Building Officials. Its stated intent is to “provide minimum standards to safeguard life or limb, health, property, and public welfare by regulating and controlling the design, construction, quality of materials, use and occupancy, location and maintenance of all buildings and structures within this jurisdiction and certain equipment specifically regulated herein.”

The UBC contains information and guidance on designing buildings and structures to withstand seismic events. With safety in mind, the UBC provides Seismic Zone Maps to help identify which design factors are critical to specific areas of the country. In addition, depending upon the type of building, there is also an “importance factor”. The “importance factor” can, in effect, raise the standards that are applied to a building.

The current UBC Seismic Zone Map (Figure 1) (1997) has five seismic zones, ranging from Zone 0 to Zone 4, as can be seen on the enclosed map. The seismic zones are in part defined by the probability of having a certain level of ground shaking (horizontal acceleration) in 50 years. The criteria used for defining boundaries on the Seismic Zone Map were established by the Seismology Committee of the Structural Engineers Association of California (Building Standards, September-October, 1986). The criteria they developed are as follows:
Figure 1. UBC Seismic Zone Map.
Zone Effective Peak Acceleration, % gravity (g)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>30% and greater</td>
</tr>
<tr>
<td>3</td>
<td>20% to less than 30%</td>
</tr>
<tr>
<td>2</td>
<td>10% to less than 20%</td>
</tr>
<tr>
<td>1</td>
<td>5% to less than 10%</td>
</tr>
<tr>
<td>0</td>
<td>less than 5%</td>
</tr>
</tbody>
</table>

The committee assumed that there was a 90% probability that the above values would not be exceeded in 50 years, or a 100% probability that the values would be exceeded in 475 to 500 years.

Lincoln County is primarily in Seismic Zones 2 and 3 of the UBC. Since effective peak accelerations (90% chance of non-exceedance in 50 years) can range from 10%g-30%g in these two zones, and there has been some significant historic seismicity in the county, it may be reasonable to assume that a maximum peak acceleration of 30%g could be applied to the design of a non-critical facility located in the county if only the UBC were used. Such acceleration, however, is significantly less than would be suggested through newer building codes. Recently, the UBC has been replaced by the International Building Code (IBC). The IBC is based upon probabilistic analyses, which are described in a following section. Lincoln County still uses the UBC, however, as do most Wyoming counties as of November 2002.

**Deterministic Analysis of Regional Active Faults with a Surficial Expression**

Three active fault systems are present in Lincoln County. The Rock Creek fault system is a north-south-trending normal fault located approximately 15 miles west of Kemmerer, Wyoming, near Fossil Butte National Monument. McCalpin and Warren (1992) found evidence of late-Quaternary movement on this system. Based upon a surface rupture length of 24 miles (38 km) and Quaternary displacement amounts, it has been estimated that the Rock Creek fault is capable of generating a magnitude 6.9 to 7.2 earthquake with an approximate recurrence interval of 600-1500 years (Chambers, 1988; McCalpin, 1993). The most recent events on the Rock Creek fault, however, occurred approximately 3600±300 and 4600±200 years before present (McCalpin, 1993). This suggests that the recurrence interval for this fault system may be variable and an exact interval may be difficult to determine. A maximum magnitude 7.2 earthquake could generate peak horizontal accelerations of approximately 6.3%g at Afton, approximately 2.5%g at Alpine, approximately 29%g at Cokeville, approximately 18%g at Kemmerer and Diamondville, approximately 27%g at Lake Viva Naughton and Kemmerer City Reservoir, approximately 7.2%g at La Barge, approximately 9.1%g at Opal, and approximately 3.9%g at Thayne (Campbell, 1987). These accelerations are roughly equivalent to intensity VII earthquakes at Cokeville, Kemmerer, Diamondville, Lake Viva Naughton and Kemmerer City Reservoir; intensity V earthquakes at Afton, La Barge, Opal, and Thayne; and an intensity IV earthquake at Alpine. Moderate damage could occur at Cokeville, Kemmerer, Diamondville, Lake Viva Naughton and Kemmerer City Reservoir, whereas Afton, La Barge, Opal, and Thayne could sustain light damage. No damage should occur at Alpine.
The second active fault system in Lincoln County is the Grey's River fault system, located on the western side of the Wyoming Range. Evidence of late-Holocene movement has also been identified on this north-south-trending normal fault (Jones and McCalpin, 1992; McCalpin, 1993). Based upon an estimated surface rupture length of 54 km, the Grey's River fault system could potentially generate a magnitude 7.1 earthquake with a recurrence interval of approximately 2970 – 3400 years (Jones, 1995; Jones and McCalpin, 1992). The most recent events on the fault occurred 1910-2110 and 5080-5310 years before present. However, because no movement occurred on the Grey's River fault system between approximately 5000 and 15,000 years before present, this recurrence interval may be variable (Jones and McCalpin, 1992). A magnitude 7.1 earthquake could generate peak horizontal accelerations of approximately 17%g at Afton, approximately 11%g at Alpine, approximately 5.8%g at Cokeville, approximately 3.2%g at Kemmerer and Diamondville, approximately 7%g at La Barge, approximately 2.9%g at Opal, and approximately 14%g at Thayne (Campbell, 1987). These accelerations are roughly equivalent to intensity VI earthquakes at Afton, Alpine, and Thayne, intensity V earthquakes at Cokeville and La Barge, and intensity IV earthquakes at Kemmerer, Diamondville, and Opal. Light damage could occur in Afton, Alpine, and Thayne. Cokeville and La Barge could sustain very light damage. No damage should occur at Kemmerer, Diamondville, and Opal.

The Star Valley fault system is the third active fault system in Lincoln County. This fault system, which has been subdivided into north and south segments, bounds the eastern edge of the Star Valley. Investigations of the Star Valley fault system determined that Holocene and late-Pleistocene offsets exist along the south fault segment (Piety et al., 1986; McCalpin et al., 1990; McCalpin, 1990). Several maximum magnitude earthquakes have been suggested for the Star Valley fault system. Piety and others (1986) proposed that the Star Valley fault system is capable of generating a maximum credible earthquake of magnitude 7.5 with a recurrence interval of 5,000 to 7,000 years. Based upon a surface rupture length of 27 miles, McCalpin and others (1990) determined that the Star Valley fault system could produce a maximum magnitude 7.2 earthquake. When McCalpin (1990) trenched a portion of the Star Valley fault near Afton, he determined that a magnitude 7.3 earthquake with a recurrence interval of 2550-6000 years is possible on this system. Approximately 5,500 years (radiocarbon age) has elapsed since the latest event on the fault system at the Afton locality. Based upon this evidence, the Star Valley fault system is near the maximum limit for the recurrence interval assigned to the system. Because of the extensive seismic activity associated with the area surrounding the Star Valley fault, and because of the close proximity of towns to this fault system, a maximum magnitude of 7.5 will be used for this analysis. It should also be noted that it has been approximately 5500 years since the last confirmed event on the Star Valley fault at Afton. This fault system is therefore nearing its recurrence interval limit. A magnitude 7.5 earthquake could generate peak horizontal accelerations of greater than 80%g at Afton, approximately 79%g at Alpine, approximately 6.6%g at Cokeville, approximately 3.2%g at Kemmerer and Diamondville, approximately 5.2%g at La Barge, approximately 2.9%g at Opal, and approximately 47%g at Thayne (Campbell, 1987). These accelerations are roughly equivalent to intensity IX earthquakes at Afton and Alpine, an intensity VIII earthquake at Thayne, intensity V earthquakes at Cokeville and La Barge, and intensity IV earthquakes at Kemmerer, Diamondville, and Opal. Afton and Alpine could sustain heavy damage. Moderate to heavy damage could occur at Thayne. Light damage could occur at Cokeville and La Barge, but Kemmerer, Diamondville, and Opal should sustain no damage.
Floating or Random Earthquake Sources

Many federal regulations require an analysis of the earthquake potential in areas where active faults are not exposed, and where earthquakes are tied to buried faults with no surface expression. Regions with a uniform potential for the occurrence of such earthquakes are called tectonic provinces. Within a tectonic province, earthquakes associated with buried faults are assumed to occur randomly, and as a result can theoretically occur anywhere within that area of uniform earthquake potential. In reality, that random distribution may not be the case, as all earthquakes are associated with specific faults. If all buried faults have not been identified, however, the distribution has to be considered random. “Floating earthquakes” are earthquakes that are considered to occur randomly in a tectonic province.

It is difficult to accurately define tectonic provinces when there is a limited historic earthquake record. When there are no nearby seismic stations that can detect small-magnitude earthquakes, which occur more frequently than larger events, the problem is compounded. Under these conditions, it is common to delineate larger, rather than smaller, tectonic provinces.

The U.S. Geological Survey identified tectonic provinces in a report titled “Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States” (Algermissen and others, 1982). In that report, Lincoln County was classified as being in a tectonic province with a “floating earthquake” maximum magnitude of 6.1. Geomatrix (1988b) suggested using a more extensive regional tectonic province, called the “Wyoming Foreland Structural Province”, which is approximately defined by the Idaho-Wyoming Thrust Belt on the west, 104° West longitude on the east, 40° North latitude on the south, and 45° North latitude on the north. Geomatrix (1988b) estimated that the largest “floating” earthquake in the “Wyoming Foreland Structural Province” would have a magnitude in the 6.0 – 6.5 range, with an average value of magnitude 6.25.

Federal or state regulations usually specify if a “floating earthquake” or tectonic province analysis is required for a facility. Usually, those regulations also specify at what distance a floating earthquake is to be placed from a facility. For example, for uranium mill tailings sites, the Nuclear Regulatory Commission requires that a floating earthquake be placed 15 kilometers from the site. That earthquake is then used to determine what horizontal accelerations may occur at the site. A magnitude 6.25 “floating” earthquake, placed 15 kilometers from any structure in Lincoln County, would generate horizontal accelerations of approximately 15%g at the site. That acceleration would be adequate for designing a uranium mill tailings site, but may be too large for less critical sites, such as a landfill. Critical facilities, such as dams, usually require a more detailed probabilistic analysis of random earthquakes. Based upon probabilistic analyses of random earthquakes in an area distant from exposed active faults (Geomatrix, 1988b), however, placing a magnitude 6.25 earthquake at 15 kilometers from a site will significantly underestimate the ground acceleration that may actually occur anywhere in Lincoln County.
Probabilistic Seismic Hazard Analyses

The U.S. Geological Survey (USGS) publishes probabilistic acceleration maps for 500-, 1000-, and 2,500-year time frames. The maps show what accelerations may be met or exceeded in those time frames by expressing the probability that the accelerations will be met or exceeded in a shorter time frame. For example, a 10% probability that acceleration may be met or exceeded in 50 years is roughly equivalent to a 100% probability of exceedance in 500 years.

The USGS has recently generated new probabilistic acceleration maps for Wyoming (Case, 2000). Copies of the 500-year (10% probability of exceedance in 50 years), 1000-year (5% probability of exceedance in 50 years), and 2,500-year (2% probability of exceedance in 50 years) maps are attached. Until recently, the 500-year map was often used for planning purposes for average structures, and was the basis of the most current Uniform Building Code. The new International Building Code, however, uses a 2,500-year map as the basis for building design. The maps reflect current perceptions on seismicity in Wyoming. In many areas of Wyoming, ground accelerations shown on the USGS maps can be increased due to local soil conditions. For example, if fairly soft, saturated sediments are present at the surface, and seismic waves are passed through them, surface ground accelerations will usually be greater than would be experienced if only bedrock was present. In this case, the ground accelerations shown on the USGS maps would underestimate the local hazard, as they are based upon accelerations that would be expected if firm soil or rock were present at the surface. Intensity values can be found in Table 1.

Although 2,500-year probabilistic acceleration maps are adequate for designing most structures, more conservative estimates of ground acceleration are usually necessary for dams and associated reservoirs. Because more conservative 10,000-year and 50,000-year acceleration models for do not yet exist for dams in Lincoln County, this report will use the 2,500-year probabilistic map and fault-specific analyses for Lake Viva Naughton and Kemmerer City Reservoir.

Based upon the 500-year map (10% probability of exceedance in 50 years) (Figure 2), the estimated peak horizontal acceleration in Lincoln County ranges from approximately 7%g in the eastern potion of the county to greater than 30%g in the northwestern corner of the county. These accelerations are roughly comparable to intensity V earthquakes (3.9%g - 9.2%g), intensity VI earthquakes (9.2%g - 18%g), and intensity VII earthquakes (18%g - 34%g). Intensity V earthquakes can result in cracked plaster and broken dishes. Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Intensity VII earthquakes can result in slight to moderate damage in well-built ordinary structures, and considerable damage in poorly built or badly designed structures, such as unreinforced masonry. Chimneys may be broken. Kemmerer and Diamondville would be subjected to accelerations of approximately 13%g or intensity VI.

Based upon the 1000-year map (5% probability of exceedance in 50 years) (Figure 3), the estimated peak horizontal acceleration in Lincoln County ranges from approximately 13%g in the southeastern portion of the county to over 40%g in the northwestern and southwestern corners of the county. These accelerations are roughly comparable to intensity VI earthquakes (9.2%g - 18%g), intensity VII earthquakes (18%g - 34%g), and intensity VIII earthquakes (34%g -
Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Intensity VII earthquakes can result in slight to moderate damage in well-built ordinary structures, and considerable damage in poorly built or badly designed structures, such as unreinforced masonry. Chimneys may be broken. Intensity VIII earthquakes can result in considerable damage in ordinary buildings and great damage in poorly built structures. Panel walls may be thrown out of frames. Chimneys, walls, columns, factory stacks may fall. Heavy furniture may be overturned. Kemmerer and Diamondville would be subjected to accelerations of approximately 15-20%g or intensity VI-VII.

Based upon the 2500-year map (2% probability of exceedance in 50 years) (Figure 4), the estimated peak horizontal acceleration in Lincoln County ranges from approximately 17%g in the southeastern corner of the county to over 60%g in the northern part of the county and over 80%g in the northwestern corner of the county. These accelerations are roughly comparable to intensity VI earthquakes (9.2%g – 18%g), intensity VII earthquakes (18%g – 34%g), intensity VIII earthquakes (34%g – 65%g), and intensity IX earthquakes (65%g-124%g). Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Intensity VII earthquakes can result in slight to moderate damage in well-built ordinary structures, and considerable damage in poorly built or badly designed structures, such as unreinforced masonry. Chimneys may be broken. Intensity VIII earthquakes can result in considerable damage in ordinary buildings and great damage in poorly built structures. Panel walls may be thrown out of frames. Chimneys, walls, columns, factory stacks may fall. Heavy furniture may be overturned. Intensity IX earthquakes can cause considerable damage in specially designed structures and great damage and partial collapse in substantial buildings. Well-designed frame structures could be thrown out of plumb. Buildings can be shifted off their foundations. The ground can crack and underground pipes could be broken. Kemmerer and Diamondville would be subjected to accelerations of approximately 20-30%g, or intensity VII. Lake Viva Naughton and Kemmerer City Reservoir would be subjected to accelerations of approximately 40%g or intensity VIII earthquakes. Cokeville and Afton would be subjected to accelerations of approximately 60%g and 50%g, respectively, or intensity VIII. Thayne and Alpine would be subjected to accelerations greater than 60%g, or intensity IX.

As the historic record is limited, it is nearly impossible to determine when a 2,500-year event last occurred in the county. Because of the uncertainty involved, and based upon the fact that the new International Building Code utilizes 2,500-year events for building design, it is suggested that the 2,500-year probabilistic maps be used for Lincoln County analyses. This conservative approach is in the interest of public safety.
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<tr>
<th>Modified Mercalli Intensity</th>
<th>Acceleration (%g) (PGA)</th>
<th>Perceived Shaking</th>
<th>Potential Damage</th>
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<td>Very Light</td>
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<td>VII</td>
<td>18 – 34</td>
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<td>VIII</td>
<td>34 – 65</td>
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<td>IX</td>
<td>65 – 124</td>
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Modified Mercalli Intensity and peak ground acceleration (PGA) (Wald, et al 1999).
# Abridged Modified Mercalli Intensity Scale

**Intensity value and description:**

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<tr>
<th>Intensity</th>
<th>Description</th>
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<td>I</td>
<td>Not felt except by a very few under especially favorable circumstances.</td>
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<tr>
<td>II</td>
<td>Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.</td>
</tr>
<tr>
<td>III</td>
<td>Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing automobiles may rock slightly. Vibration like passing of truck. Duration estimated.</td>
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<tr>
<td>IV</td>
<td>During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing automobiles rocked noticeably.</td>
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<tr>
<td>V</td>
<td>Felt by nearly everyone, many awakened. Some dishes, windows, and so on broken; cracked plaster in a few places; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.</td>
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<td>VI</td>
<td>Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster and damaged chimneys. Damage slight.</td>
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<tr>
<td>VII</td>
<td>Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving cars.</td>
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<td>VIII</td>
<td>Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving cars disturbed.</td>
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<td>X</td>
<td>Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed, slopped over banks.</td>
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<td>XII</td>
<td>Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown into the air.</td>
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Peak Acceleration (%g) with 10% Probability of Exceedance in 50 Years
site: NEHRP B-C boundary
U.S. Geological Survey
National Seismic Hazard Mapping Project
Albers Conic Equal-Area Projection
Standard Parallels: 29.5

Figure 2. 500-year probabilistic acceleration map (10% probability of exceedance in 50 years).
Peak Acceleration (%g)
with 5% Probability
of Exceedance in 50 Years
site: NEHRP B-C boundary

U.S. Geological Survey
National Seismic Hazard Mapping Project
Albers Conic Equal-Area
Projection
Standard Parallels: 29.5

Figure 3. 1000-year probabilistic acceleration map (5% probability of exceedance in 50 years).
Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years
site: NEHRP B-C boundary

U.S. Geological Survey
National Seismic Hazard Mapping Project

Albers Conic Equal-Area Projection
Standard Parallels: 29.5

Figure 4. 2500-year probabilistic acceleration map (2% probability of exceedance in 50 years).
Summary

There have been thousands of historic earthquakes with a magnitude greater than 2.0 recorded in and near Lincoln County. Because of the limited historic record, it is possible to underestimate the seismic hazard in Lincoln County if historic earthquakes are used as the sole basis for analysis. Earthquake and ground motion probability maps and specific fault analyses give a more reasonable estimate of damage potential in Lincoln County.

Current earthquake probability maps that are used in the newest building codes suggest a scenario that would result in moderate to heavy damage to buildings and their contents, with damage increasing from the southeast to the north and southwest. More specifically, the probability-based or fault activation-based worst-case scenario could result in the following damage at points throughout the county:

**Intensity IX Earthquake Areas**

- Afton
- Alpine
- Auburn
- Bedford
- Fossil Butte National Monument
- Grover
- Thayne
- Turnerville

Intensity IX earthquakes can cause considerable damage in specially designed structures and great damage and partial collapse in substantial buildings. Well-designed frame structures could be thrown out of plumb. Buildings can be shifted off their foundations. The ground can crack and underground pipes could be broken.

**Intensity VIII Earthquake Areas**

- Auburn
- Border
- Cokeville
- Fairview
- Kemmerer City Reservoir
- Lake Viva Naughton
- Sage
- Smoot

Intensity VIII earthquakes can result in considerable damage in ordinary buildings and great damage in poorly built structures. Panel walls may be thrown out of frames. Chimneys, walls, columns, factory stacks may fall. Heavy furniture may be overturned.
Intensity VII Earthquake Areas

Elkol
Frontier
Diamondville
Kemmerer
La Barge
Opal

In intensity VII earthquakes, damage is negligible in buildings of good design and construction, slight-to-moderate in well-built ordinary structures, considerable in poorly built or badly designed structures such as unreinforced masonry buildings. Some chimneys will be broken.
References


U.S.G.S. National Earthquake Information Center: http://wwwncic.cr.usgs.gov/

University of Utah Seismograph Station Epicenter Listings:
http://www.seis.utah.edu/HTML/EarthquakeCatalogAndInfo.html


**NEIC: Earthquake Search Results**

**United States Geological Survey**

**Earthquake Data Base**

File Created: Sat Aug 30 17:30:20 2008

Geographic Grid Search Earthquakes= 99

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Catalog Used: SRA
Data Selection: Eastern, Central and Mountain States of U.S. (SRA)

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United States Geological Survey
Earthquake Data Base

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USGS National Earthquake Information Center

USGS Privacy Statement | Disclaimer

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Earthquake Hazards Program

Database Search

Complete Report for Bear Lake (west side) fault (Class B) No. 2531

Brief Report | Partial Report

Compiled in cooperation with the Utah Geological Survey


<p>| <strong>Synopsis</strong> | Poorly understood north-trending east-dipping normal fault bounding the southwest side of the Bear Lake graben. The fault may be a southern extension of the Holocene western Bear Lake fault [622] in Idaho. |
| <strong>Name comments</strong> | Fault ID Comments: Refers to fault number 11-5 in Hecker (1993 #642). |
| <strong>County(s) and State(s)</strong> | RICH COUNTY COUNTY, UTAH |
| <strong>AMS sheet(s)</strong> | Ogden |
| <strong>Physiographic province(s)</strong> | MIDDLE ROCKY MOUNTAINS |
| <strong>Reliability of location</strong> | Good Compiled at 1:42,240 scale. |
| <strong>Comments</strong> | Location of fault traces from Kaliser (1972 #4413). Also mapped by Skeen (1975 #4428), Anderson and Miller (1979 #4494), and McCalpin (1990 #4419, 2003 #6750). |
| <strong>Geologic setting</strong> | North-trending east-dipping normal fault that bounds the southwest side of the Bear Lake graben. The fault may be a southern extension of the Holocene western Bear Lake fault [622] further north in Idaho. |
| <strong>Length (km)</strong> | 5 km. |
| <strong>Average strike</strong> | N3°W |</p>
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**Paleoseismology studies**

McCalpin (1990 #4419, 2003 #6750) excavated two trenches across the central section of the western Bear Lake fault in Idaho, east of the town of Bloomington, about 18 km north of the Utah-Idaho border. The trenches, about 1 km apart, crossed 2- and 6-m-high fault scarps (site 2351-1). The southern trench revealed deformation associated with both fault rupture and monoclinal folding. Stratigraphic evidence indicated a single surface-faulting event, with a poorly constrained minimum age of 1.9 ka and a better constrained maximum age of 6.7-7.4 ka based on radiocarbon dating of bulk soil, organic mud, and peat collected from both the trench exposure and a 1.8-m-deep auger hole. The northern trench exposed only monoclinal folding with no coseismic event horizons, and could not be logged due to rapid ground-water flow and caving problems.

**Geomorphic expression**

The mapped fault is on-trend with the central section of the western Bear Lake fault in Idaho, which has evidence for two faulting events since 13 ka (McCalpin, 1990 #4419, 2003 #6750). However, seismic reflection profiles on the western side of the lake (Skeen, 1975 #4428) do not show any subsurface faults on-trend with the Holocene fault in Idaho. One possibility is that the western side of the Bear Lake graben in Utah is a hinge zone, composed of east- and west-dipping, north-south-oriented normal fault swarms, rather than a discrete zone of faulting (McCalpin, 1990 #4419, 2003 #6750). An increasing eastward tilt of lake-bottom reflectors toward the south end of Bear Lake supports this hypothesis (McCalpin, 1990 #4419). Thus, we consider that structure to be Class B owing to questions about its origin.

**Age of faulted surficial deposits**

Quaternary (?); fault displaces Holocene deposits in Idaho, but displaced Holocene units are not evident in Utah.

**Historic earthquake**

Most recent prehistoric deformation

Quaternary (<1.6 Ma)

*Comments:* Based on association with nearby Quaternary deformation. Although the fault in Idaho has evidence for a Holocene event (younger than 6.7-7.4 ka; McCalpin, 2003 #6750), no such evidence exists for the fault in Utah.

**Recurrence interval**

**Slip-rate category**

Less than 0.2 mm/yr

**Date and Compiler(s)**

2004

Bill D. Black, Utah Geological Survey
Christopher B. DuRoss, Utah Geological Survey
# References

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<td>#4494 Anderson, L.W., and Miller, D.G., 1979, Quaternary fault map of Utah: Long Beach, California, Fugro, Inc, 35 p. pamphlet, scale 1:500,000.</td>
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Database Search

Complete Report for Bear River Range faults (Class A) No. 2410

Compiled in cooperation with the Utah Geological Survey


| **Synopsis** | Poorly understood Quaternary(?) faults in the Bear River Range. There was reportedly a small component of right-lateral coseismic slip as a result of the 1962 Ms 5.7 Cache Valley earthquake. |
| **Name comments** | **Fault ID Comments:**
| | Refers to fault number 11-7 of Hecker (1993 #642). |
| **County(s) and State(s)** | CACHE COUNTY COUNTY, UTAH WEBER COUNTY COUNTY, UTAH |
| **AMS sheet(s)** | Ogden |
| **Physiographic province(s)** | MIDDLE ROCKY MOUNTAINS |
| **Reliability of location** | Good
| | Compiled at 1:250,000 scale.
<p>| | Comments: Mapped or discussed by Sullivan and others (1988 #4508) and Westaway and Smith (1989 #4530). Fault traces from mapping of Sullivan and others (1988 #4508). |
| <strong>Geologic setting</strong> | Generally north-trending normal faults (with a minor strike-slip component) in the Bear River Range. The Temple Ridge fault, the northernmost of the Bear River Range faults, has about 500 m of Miocene to Pliocene throw and is a likely source for the 1962 Ms 5.7 Cache Valley (Logan) earthquake which occurred at a depth of 10 km. |
| <strong>Length (km)</strong> | 63 km. |</p>
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<td><em>Comments:</em> Coseismic slip in the 1962 Ms 5.7 Cache Valley earthquake (Westaway and Smith, 1989 #4530) involved a small component of right-lateral displacement, which may typify the sense of slip on other normal faults in the region. A left-stepping pattern in the trace of the East Cache fault zone [2352] is consistent with right-lateral slip.</td>
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<td><strong>Dip</strong></td>
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<td><strong>Paleoseismology studies</strong></td>
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<tr>
<td><strong>Geomorphic expression</strong></td>
<td>Prominent escarpments are associated with several faults. However, triangular facets are poorly preserved.</td>
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<td><strong>Age of faulted surficial deposits</strong></td>
<td>Tertiary</td>
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<td><strong>Most recent prehistoric deformation</strong></td>
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<td><em>Comments:</em> Based on range-front morphology. The physiography suggests possible late Quaternary displacements on the faults.</td>
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<td><strong>Recurrence interval</strong></td>
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<td><em>Comments:</em> Poor geomorphic expression and relatively small net displacements (500 m) of Miocene-Pliocene beds indicate a low long-term slip rate.</td>
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<td>Bill D. Black, Utah Geological Survey</td>
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<td>Suzanne Hecker, U.S. Geological Survey</td>
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**Synopsis**
Poorly understood range-front and valley-floor normal fault along the western base of the Crawford Mountains and in the Bear River flood plain. The central part of the fault shows evidence for late Pleistocene activity.

**Name comments**

**Fault ID Comments:**
Refers to fault number 11-4 of Hecker (1993 #642).

**County(s) and State(s)**
RICH COUNTY, UTAH

**AMS sheet(s)**
Ogden

**Physiographic province(s)**
MIDDLE ROCKY MOUNTAINS

**Reliability of location**
Good
Compiled at 1:100,000 scale.


**Geologic setting**
Generally north- to northeast-trending range-front normal fault along the western side of the Crawford Mountains. Structurally, the Crawford Mountains are a north-trending tightly folded syncline with normal faults along the east and west flanks. The west fault extends southward into the valley floor and Bear River flood plain.

**Length (km)**
25 km.
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<td>Comments: The range-front fault appears to have a listric subsurface geometry possibly inherited from earlier thrusting (Evans, 1991 #4425; Lamerson, 1982 #4461; F. Royse, in Sullivan and others, 1988 #4508).</td>
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<tr>
<td><strong>Geomorphic expression</strong></td>
<td>Scars are apparently absent on the Bear River flood plain and on young, Holocene (?), alluvial fans. However, older alluvial scars are preserved locally, and faulting appears to truncate many talus slopes along the range front. Late Pleistocene faulting likely extends north of the faulted Bear River terrace to at least where the range front takes a prominent left step, and south for an unknown distance. The impressive steepness and linearity of the range front suggest recurrent late Quaternary faulting, but these characteristics are likely due in part to resistant rock units that dip steeply (50-70°) basinward. The position of the Bear River on the east side of the valley and meander-bend scars adjacent to the range front also suggest recent tectonic tilting.</td>
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<td><strong>Age of faulted surficial deposits</strong></td>
<td>An offset Bear River terrace at the south end of the fault likely dates from Pinedale time (&lt;70 ka), as indicated by weak soil development in a thick loess deposit that overlies fluvial sand and gravel. Scars are apparently absent on the Bear River flood plain and on young, Holocene (?), alluvial fans.</td>
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<td><strong>Historic earthquake</strong></td>
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<td><strong>Most recent prehistoric deformation</strong></td>
<td>Late Quaternary (&lt;130 ka) Comments: A faulted Bear River terrace at the south end of the fault likely dates from Pinedale time (&lt;70 ka), whereas scars are apparently absent in the Bear River flood plain and on young, Holocene (?), alluvial fans.</td>
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Earthquake Hazards Program

Database Search

Complete Report for Eastern Bear Lake fault, southern section (Class A) No. 2364c

Compiled in cooperation with the Idaho Geological Survey and the Utah Geological Survey


Synopsis

| General: | Long, range-front normal fault that bounds the west side of the Bear Lake Plateau and Pruess Range. The fault zone contains multiple fault strands, in some locations, and defines the eastern edge of the Bear Lake graben (an 80-kilometer long north-trending topographic low that extends from Idaho into Utah). The history of this fault is defined by reconnaissance mapping along the northern two sections and additional detailed site studies, including trenching, along the southern section. Earthquake-timing, recurrence-interval, and slip-rate estimates for the southern section of the Eastern Bear Lake fault reported here reflect the consensus values of the Utah Quaternary Fault Parameters Working Group (Lund, 2004 #6733). The preferred values reported in Lund (2004 #6733) approximate mean values based on available paleoseismic-trenching data, and the minimum and maximum values approximate two-sigma (5th and 95th percentile) confidence limits. The confidence limits incorporate both epistemic (e.g., data limitation) and aleatory (e.g., process variability) uncertainty (Lund, 2004 #6733). |
| Sections: | This fault has 3 sections. McCalpin (1990 #4419) divides the fault into a northern, central, and southern segments on the basis of fault-rupture patterns, strike of fault scarps, youthfulness of fault scarps, and subsurface geophysical data. We follow his subdivision of the fault herein except we use the name section instead of segment to maintain consistency in the database. |

Name comments

| General: | The earliest known name for this fault is "Bear Lake |
fault" (Mansfield, 1927 #4416); in this publication he notes "there seems therefore little doubt that this part of the valley wall is determined by fault". Although, on Plate 1 he shows the fault only extending about 9 km south of Dingle. The name "eastern Bear Lake fault" came into use only after detailed fault studies were completed and the nearby western Bear Lake fault [622], which bounds the west side of the valley, was recognized (McCalpin, 1990 #4419). Evans uses the name "East Beat Lake fault". The fault as mapped and described by McCaplin (1990 #4419) extends along the west edge of the Bear Lake Plateau and Preuss Range from about 3.5 km northeast of Georgetown, Idaho, to about 3.6 km south of Laketown, Utah.

Section:
We follow the names established by McCalpin (1990 #4419) for the three parts of the eastern Bear Lake fault; also called the S segment in McCalpin (1993 #796). The southern section extends from the northeast end of Bear Lake south to about 3.6 km south of Laketown, Utah. Southern boundary of fault is from Hecker (1993 #642); however, McCalpin (1990 #4419) shows an inferred extension of the fault extending at least 8.5 km south of Laketown.

Fault ID Comments:
Refers to fault number 24 ("fault east side Bear Lake [east side of graben]") of Witkind (1975 #320) in Idaho. Section 2364c herein refers to fault number 11-8 (" southern segment of the eastern Bear Lake fault") of Hecker (1993 #642).

---

**County(s) and State(s)**

BEAR LAKE COUNTY COUNTY, IDAHO
RICH COUNTY COUNTY, UTAH

**AMS sheet(s)**

Ogden
Preston

**Physiographic province(s)**

MIDDLE ROCKY MOUNTAINS

**Reliability of location**

Good
Compiled at 1:24,000 scale.

*Comments:* Location of fault from 1:24,000 scale maps of Hecker (1987 #4427). Also mapped and discussed by Coogan (1994 #4426).

**Geologic setting**

West-dipping normal (possibly listric) fault bounding the west side of the Bear Lake Plateau in Utah and Preuss Range in Idaho. This fault and the complimentary western Bear Lake fault [622] define the Bear Lake graben, a topographic low extending from Idaho into Utah. These faults are part of a belt of right-stepping en-echelon faults that extend from the northern Wasatch Range in Utah to the Yellowstone area in Wyoming (McCalpin, 1990 #4419). Net Tertiary slip is 1.9-4.0 km (Evans, 1991 #4425).

**Length (km)**

This section is 35 km of a total fault length of 77 km.
<table>
<thead>
<tr>
<th><strong>Average strike</strong></th>
<th>N12°E (for section) versus N1°W (for whole fault)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sense of movement</strong></td>
<td>Normal</td>
</tr>
<tr>
<td><strong>Comments:</strong></td>
<td>(McCalpin, 1990 #4419)</td>
</tr>
<tr>
<td><strong>Dip</strong></td>
<td>60°-70° W.</td>
</tr>
<tr>
<td><strong>Comments:</strong></td>
<td>Above is a near-surface dip based on seismic reflection data reported by Evans (1991 #4425). Evan's interpretation of the seismic data suggest the fault may be listric and that it flattens to 25°-30° at 6 km depth and merges with the Meade thrust near the north end of Bear Lake. The data, however, does not preclude that the eastern Bear Lake fault maintains at least a 40° dip and cuts the Meade thrust at 4 km below the surface (Evans, 1991 #4425).</td>
</tr>
<tr>
<td><strong>Paleoseismology studies</strong></td>
<td>Two trenches were open in June and July of 1989 on the North Eden fan. Both trench sites were on a surface mantled by 9.1-ka loess deposit and both show evidence of the penultimate event that occurred at 2.6-4.6 ka.</td>
</tr>
<tr>
<td>Site 2364-1 herein, is the western trench of McCalpin (1990 #4419; 1993 #796). Log of this trench is shown in figure 2 in McCalpin (1993 #796). Scarp at this site is 8 m high and trench exposed evidence for five to seven faulting events having 23.3 m of total vertical displacement since 40 ka (McCalpin, 1990, 2003 #4419, #6750). A radiocarbon age estimate on a bulk-soil sample from scarp-derived colluvium closely approximates the age of the most recent event on the fault, and a thermoluminescence age estimate from loess at the base of a second colluvial wedge deposit constrains the timing of the penultimate event.</td>
<td></td>
</tr>
<tr>
<td>Site 2364-2 herein, is the eastern trench of McCalpin (1990 #4419; 1993 #796). Log of this trench is shown in figure 3 in McCalpin (1993 #796). Scarp at this site is 14 m high and trench exposed evidence of at least four earthquakes, which ruptured the eastern fault trace prior to two later events on the western fault trace, exposed in the western fault trench (McCalpin, 1990 #4419; 1993 #796; 2003 #6750). A thermoluminescence age estimate from basal scarp-derived colluvium constrains the timing of the youngest fault movement, which is potentially older than the youngest two events identified in the western trench.</td>
<td></td>
</tr>
<tr>
<td><strong>Geomorphic expression</strong></td>
<td>The fault is marked by multiple, parallel to subparallel fault scarps up to 30 m high on Quaternary deposits at the base of a steep escarpment of Mesozoic rocks on the east side of Bear Lake (Williams and others, 1960 #4410; Kaliser, 1972 #4413; Robertson, 1978 #4418; McCalpin, 1990 #4419). Seismic-reflection data show that the lake floor, and reflectors within the Neogene sediments, dip eastward into the eastern Bear Lake fault (Skeen, 1975 #4428), and fathograms of the lake bottom indicate...</td>
</tr>
</tbody>
</table>
that scarp is also present (Williams and others, 1960 #4410). Total throw of the top of the Eocene Wasatch Formation is about 1.5 kilometers at the north end of Bear Lake (McCalpin, 1990 #4419). Displacement from the last two earthquakes on the fault at one site is at least 8.7 m, 4.1-6.1 m from the penultimate event, 4.6 m from the most recent event (McCalpin, 2003 #6750).

### Age of faulted surficial deposits

"Recent sediments" both subaerial and lacustrine (Williams and others, 1962 #4409).

### Historic earthquake

**Most recent prehistoric deformation**

Latest Quaternary (<15 ka)

**Comments:** The most recent event on this part of the fault is clearly Holocene (Robertson, 1978 #4418), but evidence for this event is present only in the western trench (McCalpin, 1993 #796). A radiocarbon age estimate from the base of scarp-derived colluvium in the western trench places the most recent event (event Z) at about 2.1 ka (McCalpin, 2003 #6750). The timing of the penultimate event (event Y) is constrained by a 2.5 ka thermoluminescence age on a loess deposit separating the two youngest colluvial wedges; however, event Y may be as old as 5.0 ka if it correlates with the youngest event in the eastern trench (McCalpin, 1990 #4419; 1993 #796; 2003 #6750). The interval between these events (500-2,900 yr) may be considerably shorter than the prior recurrence interval (assuming event X occurred prior to 15.2 ka, and probably nearer to 23 ka), but the data are insufficient to demonstrate this.

Lund (2004 #6733) reports the following paleoearthquake chronology, which incorporates the trench investigations of McCalpin (1990 #4419; 2003 #6750), with event uncertainties that reflect both geologic and laboratory error:

Western trench Z <2.1±0.2 ka, but >0.6±0.08 ka Y ~5 ka (constraining 2.5 ka TL age estimate considered erroneously young)

Eastern trench Y >5.0±0.5 ka, but likely not much greater X <31±6 ka, but much >15.2±0.8 ka W >31±6 ka, but <39±3 ka V >31±6 ka, but <39±3 ka U >39±3 ka, but likely not much greater

### Recurrence interval

8 k.y. (preferred); minimum 3 k.y., maximum 15 k.y.

**Comments:** McCalpin (1993 #796) states that the most recent recurrence interval is 0.5-2.5 k.y. based on evidence from both trenches that indicate a poorly constrained event occurred about 2.6-4.6 ka. The timing of the penultimate event is based on degree of soil development. However, the recurrence interval
reported above only characterizes the most recent interval. Additional Holocene events have not occurred suggesting that the prior recurrence interval is at least 8.1 to 10.1 k.y. these data lead Hecker (1993 #642) to estimate an average Holocene recurrence interval of greater than 5.3 k.y. for the past 12.7 k.y. Consensus recurrence-interval range reported in Lund (2004 #6733), based on the five most recent recurrence intervals between events U and Z (mean of 7.6 k.y.; McCalpin, 2003 #6750). The broad uncertainty reflects variable recurrence intervals between events Y and Z (~2.9 k.y.) and between X and Y (>10.2 k.y.), and a generally poorly constrained earthquake chronology (Lund, 2004 #6733). Event X appears to be the only event between 15.2 and ~5 ka, although McCalpin (1990 #4419) indicates surface rupture may have occurred on other fault strands.

<table>
<thead>
<tr>
<th>Slip-rate category</th>
<th>Between 0.2 and 1.0 mm/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comments: McCalpin and Forman (1991 #299) first reported a slip rate of 0.8 mm/yr based on about 10 m of offset since 12.3 ka. Hecker (1993 #642) later calculated an equivalent maximum slip rate, based on an average displacement of 4.2 m and her minimum recurrence interval of 5.3 k.y. Evans (1991 #4425) calculates long-term (10 m.y. and 17 m.y.) slip rates of 0.4 mm/yr and 0.25 mm/yr respectively. Lund (2004 #6733) indicates a paleoseismic slip rate of 0.6 mm/yr (preferred), and a consensus minimum-maximum range of 0.2-1.6 mm/yr, based on a cumulative (&gt;22.1 m) slip released in the last five interevent intervals (~38 k.y.) (McCalpin, 2003 #6750). The broad uncertainty reflects variations in slip rate associated with individual interevent intervals (&lt;2.9 to &gt;10.2 k.y.), and a variable amount of slip per event ranging from 1.2 to 6.1 m (McCalpin, 2003 #6750; Lund, 2004 #6733).</td>
<td></td>
</tr>
</tbody>
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<table>
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<tr>
<th>Date and Compiler(s)</th>
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<tr>
<td>Bill D. Black, Utah Geological Survey</td>
<td></td>
</tr>
<tr>
<td>Christopher B. DuRoss, Utah Geological Survey</td>
<td></td>
</tr>
<tr>
<td>Michael D. Hylland, Utah Geological Survey</td>
<td></td>
</tr>
<tr>
<td>Suzanne Hecker, U.S. Geological Survey</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>#4427 Hecker, S., 1987, July 1 and 2 reconnaissance of Bear</td>
</tr>
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</table>
Lake fault by Suzanne Hecker and Gary Christensen: Utah
Geological and Mineral Survey memorandum, 3 p., scale
1:24,000.

#642 Hecker, S., 1993, Quaternary tectonics of Utah with
emphasis on earthquake-hazard characterization: Utah Geological

#4413 Kaliser, B.N., 1972, Environmental geology of Bear Lake
area, Rich County, Utah: Utah Geological and Mineral Survey

#6733 Lund, W.R., 2005, Consensus preferred recurrence interval
and vertical slip rate estimates--Review of Utah paleoseismic-
trenching data by the Utah Quaternary Fault Parameters Working

#4416 Mansfield, G.R., 192, Geography, geology, and mineral
resources of part of southeastern Idaho: U.S. Geological Survey

#4419 McCalpin, J., 1990, Latest Quaternary faulting in the
northern Wasatch to Teton corridor (NWTC): Technical report to
U.S. Geological Survey, under Contract 14-08-001-G1396,
October 1990, 42 p.

#299 McCalpin, J., and Forman, S.L., 1991, Late Quaternary
faulting and thermoluminescence dating of the East Cache fault
zone, north-central Utah: Bulletin of the Seismological Society of
America, v. 81, p. 139-161.

#796 McCalpin, J.P., 1993, Neotectonics of the northeastern Basin
and Range margin, western USA: Zeitschrift fuer Geomorphologie

#6750 McCalpin, J.P., 2003, Neotectonics of the Bear Lake Valley,
Utah and Idaho; A preliminary assessment: Utah Geological
Survey Miscellaneous Publication 03-4, 43 p.

#4418 Robertson, G.C., III, 1978, Surficial deposits and geologic
history, northern Bear Lake Valley, Idaho: Logan, Utah State

#4428 Skeen, R.C., 1975, A reflection seismic study of the
subsurface structure and sediments of Bear Lake, Utah-Idaho:
Salt Lake City, University of Utah, senior thesis, 25 p., 1 pl.

#4410 Williams, J.S., Willard, A.D., and Parker, V., 1960, Late
Pleistocene history of Bear Lake Valley, Utah-Idaho [abs.]:
|-------------------|
Earthquake Hazards Program

Database Search

Complete Report for Eastern Bear Lake fault, central section (Class A) No. 2364b

Brief Report || Partial Report

Compiled in cooperation with the Idaho Geological Survey


| Synopsis | General: Long, range-front normal fault that bounds the west side of the Bear Lake Plateau and Pruess Range. The fault zone contains multiple fault strands, in some locations, and defines the eastern edge of the Bear Lake graben (an 80-kilometer-long north-trending topographic low that extends from Idaho into Utah). The history of this fault is defined by reconnaissance mapping along the northern two sections and additional detailed site studies, including trenching, along the southern section.

Sections: This fault has 3 sections. McCaupin (1990 #4419) divides the fault into a northern, central, and southern segments on the basis of fault-rupture patterns, strike of fault scarps, youthfulness of fault scarps, and subsurface geophysical data. We follow his subdivision of the fault herein except we use the name section instead of segment to maintain consistency in the database.

Name comments | General: The earliest known name for this fault is "Bear Lake fault" (Mansfield, 1927 #4416); in this publication he notes "there seems therefore little doubt that this part of the valley wall is determined by fault". Although, on Plate 1 he shows the fault only extending about 9 km south of Dingle. The name "eastern Bear Lake fault" came into use only after detailed fault studies were completed and the nearby western Bear Lake fault [622], which bounds the west side of the valley, was recognized (McCaupin, 1990 #4419). Evans uses the name "East Beat Lake fault". The fault as mapped and described by McCaupin (1990 #4419) extends along the west edge of the Bear Lake Plateau and Preuss Range from about 3.5 km northeast of Georgetown, Idaho, to...
about 3.6 km south of Laketown, Utah.

**Section:**
We follow the names established by McCalpin (1990 #4419) for the three parts of the eastern Bear Lake fault; also called the C segment in McCalpin (1993 #796). Section extends from about 0.4 km north of U.S. Highway 89, east of Montpelier, Idaho, to the northeast end of Bear Lake. The southern boundary is characterized by a complex zone of left-stepping short echelon fault scarps near Bear Lake Hot Springs.

**Fault ID Comments:**
Refers to fault number 24 ("fault east side Bear Lake [east side of graben]") of Witkind (1975 #320) in Idaho. Section 2364c herein refers to fault number 11-8 ("southern segment of the eastern Bear Lake fault") of Hecker (1993 #642).

<table>
<thead>
<tr>
<th>County(s) and State(s)</th>
<th>BEAR LAKE COUNTY COUNTY, IDAHO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AMS sheet(s)</strong></td>
<td>Preston</td>
</tr>
<tr>
<td><strong>Physiographic province(s)</strong></td>
<td>MIDDLE ROCKY MOUNTAINS</td>
</tr>
<tr>
<td><strong>Reliability of location</strong></td>
<td>Poor</td>
</tr>
<tr>
<td><strong>Comments:</strong> Fault location based on approximately 1:475,000-scale map of McCalpin (1990 #4419).</td>
<td></td>
</tr>
</tbody>
</table>

**Geologic setting**
West-dipping normal (possibly listric) fault bounding the west side of the Bear Lake Plateau in Utah and Preuss Range in Idaho. This fault and the complimentary western Bear Lake fault [622] define the Bear Lake graben, a topographic low extending from Idaho into Utah. These faults are part of a belt of right-stepping en-echelon faults that extend from the northern Wasatch Range in Utah to the Yellowstone area in Wyoming (McCalpin, 1990 #4419). Net Tertiary slip is 1.9-4.0 km (Evans, 1991 #4425).

**Length (km)**
This section is 24 km of a total fault length of 77 km.

**Average strike**
N5°W (for section) versus N1°W (for whole fault)

**Sense of movement**
Normal

**Comments:** (McCalpin, 1990 #4419)

**Dip**
W

**Comments:** Interpretations of the fault geometry are varied. Some investigators document that the fault is high angle (Mansfield, 1927 #4416; Williams and others, 1962 #4409; Armstrong and Cressman, 1963 #4417), and others maintain that it is listric and soles into the Meade thrust at depth (Evans, 1991 #4425).
<table>
<thead>
<tr>
<th><strong>Paleoseismology studies</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geomorphic expression</strong></td>
<td>Youthful scarps are present along most of this part of the fault including across the Bear River alluvium near Dingle, Idaho (McCalpin, 1990 #4419). Mason (1992 #463) further states there are 1.5- to 6.0-m-high scarps on late Pleistocene and Holocene alluvium along the &quot;middle segment&quot;, which we infer to be the central section herein. In addition, Robertson (1978 #4418) indicates that the fault is coincident with steep bedrock escarpments; aligned hot springs, lakes, and ponds; and the scarps are &quot;10 to 20 ft high&quot; (3-6 m).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Age of faulted surficial deposits</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Historic earthquake</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Most recent prehistoric deformation</strong></td>
<td>Latest Quaternary (&lt;15 ka)</td>
</tr>
<tr>
<td><strong>Comments:</strong> McCalpin (1993 #796) documents the presence of Holocene scarps along this part of the fault, but no further studies have been completed. He further suggests the possibility that the rupture of this section could have been coincident with the most recent rupture of the southern section (2.6-4.6 k.y. ago).</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Recurrence interval</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Slip-rate category</strong></td>
<td>Less than 0.2 mm/yr</td>
</tr>
<tr>
<td><strong>Comments:</strong> Little data is available for this part of the fault. The assigned slip-rate category is inferred based on relative height of scarps on this segment versus the scarps reported along the southern section [2364c]. This section is characterized by 1.5- to 6-m-high scarps, and the southern section by scarps at least 14 m high. Slip rates for the southern section are not well constrained, but are reported to be 0.25-0.8 mm/yr. We assign the lowest slip-rate category; however, 0.2-1.0 m/yr may be more appropriate.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Date and Compiler(s)</strong></th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kathleen M. Haller, U.S. Geological Survey</td>
</tr>
<tr>
<td></td>
<td>Reed S. Lewis, Idaho Geological Survey</td>
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</tbody>
</table>

<table>
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<tr>
<th><strong>References</strong></th>
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<tbody>
<tr>
<td>#4416 Mansfield, G.R., 192, Geography, geology, and mineral resources of part of southeastern Idaho: U.S. Geological Survey</td>
<td></td>
</tr>
</tbody>
</table>


Earthquake Hazards Program

Database Search

Complete Report for Eastern Bear Lake fault, northern section (Class A) No. 2364a

Compiled in cooperation with the Idaho Geological Survey


| **Synopsis** | **General:** Long, range-front normal fault that bounds the west side of the Bear Lake Plateau and Preuss Range. The fault zone contains multiple fault strands, in some locations, and defines the eastern edge of the Bear Lake graben (an 80-kilometer-long north-trending topographic low that extends from Idaho into Utah). The history of this fault is defined by reconnaissance mapping along the northern two sections and additional detailed site studies, including trenching, along the southern section.  
**Sections:** This fault has 3 sections. McCalpin (1990 #4419) divides the fault into a northern, central, and southern segments on the basis of fault-rupture patterns, strike of fault scarps, youthfulness of fault scarps, and subsurface geophysical data. We follow his subdivision of the fault herein except we use the name section instead of segment to maintain consistency in the database. |
| **Name comments** | **General:** The earliest known name for this fault is "Bear Lake fault" (Mansfield, 1927 #4416); in this publication he notes "there seems therefore little doubt that this part of the valley wall is determined by fault". Although, on Plate 1 he shows the fault only extending about 9 km south of Dingle. The name "eastern Bear Lake fault" came into use only after detailed fault studies were completed and the nearby western Bear Lake fault [622], which bounds the west side of the valley, was recognized (McCalpin, 1990 #4419). Evans uses the name "East Beat Lake fault". The fault as mapped and described by McCaplin (1990 #4419) extends along the west edge of the Bear Lake Plateau and Preuss Range from about 3.5 km northeast of Georgetown, Idaho, to... |
about 3.6 km south of Laketown, Utah.

**Section:**
We follow the names established by McCalpin (1990 #4419) for the three parts of the eastern Bear Lake fault; also called the N segment in McCalpin (1993 #796). Section extends from about 3.5 km northeast of Georgetown, Idaho, south to about 0.4 km north of U.S. Highway 89, east of Montpelier, Idaho.

**Fault ID Comments:**
Refers to fault number 24 ("fault east side Bear Lake [east side of graben]") of Witkind (1975 #320) in Idaho. Section 2364c herein refers to fault number 11-8 (" southern segment of the eastern Bear Lake fault") of Hecker (1993 #642).

<table>
<thead>
<tr>
<th><strong>County(s) and State(s)</strong></th>
<th>BEAR LAKE COUNTY COUNTY, IDAHO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AMS sheet(s)</strong></td>
<td>Preston</td>
</tr>
<tr>
<td><strong>Physiographic province(s)</strong></td>
<td>MIDDLE ROCKY MOUNTAINS</td>
</tr>
<tr>
<td><strong>Reliability of location</strong></td>
<td>Poor</td>
</tr>
<tr>
<td><strong>Compiled at 1:250,000 scale.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Comments:</strong> In general, the fault is poorly expressed along this section and scarps are discontinuous. Fault location based on approximately 1:475,000-scale map of McCalpin (1990 #4419).</td>
<td></td>
</tr>
<tr>
<td><strong>Geologic setting</strong></td>
<td>West-dipping normal (possibly listric) fault bounding the west side of the Bear Lake Plateau in Utah and Preuss Range in Idaho. This fault and the complimentary western Bear Lake fault [622] define the Bear Lake graben, a topographic low extending from Idaho into Utah. These faults are part of a belt of right-stepping en-echelon faults that extend from the northern Wasatch Range in Utah to the Yellowstone area in Wyoming (McCalpin, 1990 #4419). Net Tertiary slip is 1.9-4.0 km (Evans, 1991 #4425).</td>
</tr>
<tr>
<td><strong>Length (km)</strong></td>
<td>This section is 19 km of a total fault length of 77 km.</td>
</tr>
<tr>
<td><strong>Average strike</strong></td>
<td>N11°W (for section) versus N1°W (for whole fault)</td>
</tr>
<tr>
<td><strong>Sense of movement</strong></td>
<td>Normal</td>
</tr>
<tr>
<td><strong>Comments:</strong> (McCalpin, 1990 #4419)</td>
<td></td>
</tr>
<tr>
<td><strong>Dip</strong></td>
<td>W</td>
</tr>
<tr>
<td><strong>Comments:</strong> Interpretations of the fault geometry are varied. Some investigators document that the fault is high angle (Mansfield, 1927 #4416; Williams and others, 1962 #4409; Armstrong and Cressman, 1963 #4417), and others maintain that it is listric and soles into the Meade thrust at depth (Evans, 1991 #4425).</td>
<td></td>
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<tr>
<td><strong>Paleoseismology</strong></td>
<td></td>
</tr>
<tr>
<td><strong>studies</strong></td>
<td></td>
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<td>---</td>
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</tr>
<tr>
<td><strong>Geomorphic expression</strong></td>
<td>The character of this part of the fault is not well documented; however, McCalpin (1990 #4419; 1993 #796) suggests there are some scarps present.</td>
</tr>
<tr>
<td><strong>Age of faulted surficial deposits</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Historic earthquake</strong></td>
<td></td>
</tr>
</tbody>
</table>
| **Most recent prehistoric deformation** | Middle and late Quaternary (<750 ka)  
*Comments:* Mason (1992 #463) provides this estimate for the timing of movement on the northern end of the eastern Bear Lake fault, the basis for this estimate is unknown. |
| **Recurrence interval** |  |
| **Slip-rate category** | Less than 0.2 mm/yr  
*Comments:* Based on the lack of compelling evidence for late Quaternary movement, a low slip rate is inferred. Evans (1991 #4425) calculates long-term (10 m.y. and 17 m.y.) slip rates of 0.17 mm/yr and 0.1 mm/yr respectively, which are less than half of his long-term rates to the south. |
| **Date and Compiler(s)** | 1999  
Kathleen M. Haller, U.S. Geological Survey  
Reed S. Lewis, Idaho Geological Survey |
| **References** |  
#4419 McCalpin, J., 1990, Latest Quaternary faulting in the northern Wasatch to Teton corridor (NWTC): Technical report to... |
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<tr>
<th>#</th>
<th>Author(s)</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
</table>
**Synopsis**
This is one of many west-dipping normal faults that parallel east-directed thrust faults in this part of the Overthrust Belt. It is generally poorly expressed and is mainly concealed; thus, little is known about its Quaternary history. It is considered to be a Class B structure because age is uncertain.

**Name comments**
The informal name Eastern Bear Valley fault has been applied by J.P. McCalpin to the fault that bounds the east side of Bear Valley, Wyoming. Included here is the northern extension of the fault shown by Witkind (1975 #819) along the west margin of the Sublette Range on its northern end. As such, the fault is entirely in Wyoming, but extends from about the latitude of Geneva, Idaho, south to about 1.5 km east of Eli Hill in Wyoming.

**Fault ID Comments:**
Refers to number 18 (unnamed fault east side of graben, west side of Sublette Range) in Witkind (1975 #819).

**County(s) and State(s)**
LINCOLN COUNTY, WYOMING

**AMS sheet(s)**
Ogden
Preston

**Physiographic province(s)**
MIDDLE ROCKY MOUNTAINS

**Reliability of location**
Poor
Compiled at 1:250,000 scale.

*Comments*: Location of southern 35 km of fault is based on 1:63,360-scale mapping of Rubey and others (1975 #816; 1980 #814), whereas the northern part of the fault is from 1:500,000-scale reconnaissance mapping by Witkind (1975 #819). Fault
traces recompiled at 1:250,000 scale on map with topographic base. Almost the entire length of the fault is mapped as concealed and thus poorly located; its location is largely inferred from geomorphologic relations.

<table>
<thead>
<tr>
<th><strong>Geologic setting</strong></th>
<th>One of many west-dipping normal faults that parallel east-directed Laramide thrust faults in this part of the Overthrust Belt. Fault bounds eastern side of a structural depression that contains the Bear River.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length (km)</strong></td>
<td>47 km.</td>
</tr>
<tr>
<td><strong>Average strike</strong></td>
<td>N2°E</td>
</tr>
<tr>
<td><strong>Sense of movement</strong></td>
<td>Normal</td>
</tr>
<tr>
<td></td>
<td><em>Comments:</em> Shown as normal by Rubey and others (1975 #816; 1980 #814).</td>
</tr>
<tr>
<td><strong>Dip</strong></td>
<td>60°-75°</td>
</tr>
<tr>
<td></td>
<td><em>Comments:</em> Shown in cross sections by Rubey and others (1975 #816) as dipping 60°W; however, they indicated that data are insufficient to determine dip of this fault. To the north, the fault is shown to dip 65°-70° W (Rubey and others, 1980 #814).</td>
</tr>
</tbody>
</table>

**Paleoseismology studies**

**Geomorphic expression**
Fault is inferred to control the alluvium-bedrock contact on the eastern side of valley, but no scarps are known to exist.

**Age of faulted surficial deposits**
Rubey and others (1975 #816; 1980 #814) showed almost all of the fault trace as concealed beneath alluvium. At one location Jurassic bedrock is faulted at the surface (Rubey and others, 1980 #814).

**Historic earthquake**

**Most recent prehistoric deformation**
Quaternary (<1.6 Ma)

*Comments:* Timing of the most recent movement is not constrained. Witkind (1975 #819) showed this fault as late Cenozoic and Rubey and others (1975 #816; 1980 #814) showed the fault as mainly concealed beneath Quaternary alluvium. However, this fault may be as young as the Rock Creek fault [729] (i.e. Holocene) and its inferred young scarps have been buried by aggradation of the Bear River floodplain. Therefore, the fault is considered to be a Class B (suspected Quaternary) structure until further studies are completed.

**Recurrence interval**

**Slip-rate category**
Less than 0.2 mm/yr

*Comments:* No data exist to support a slip rate, but the fault is
herein considered to be in the <0.2 mm/yr slip-rate category. However, the rate could be larger than that of other faults in the vicinity because Cenozoic motion on this fault has created a large, sediment-filled depression (the Bear Valley), whereas others have not. Further work, such as dating of subsurface units needs to be done in order to determine slip rates.

<table>
<thead>
<tr>
<th>Date and Compiler (s)</th>
<th>1994 James P. McCalpin, GEO-HAZ Consulting, Inc.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>References</strong></td>
<td></td>
</tr>
</tbody>
</table>
Earthquake Hazards Program

Database Search

Complete Report for Elk Mountain fault (Class A) No. 736

Brief Report || Partial Report


| **Synopsis** | One of many west-dipping normal faults that parallel east-directed thrust faults in Mesozoic sedimentary rocks in this part of the Overthrust Belt. Little is known about the two west-dipping normal faults that may be a southern continuation of the Rock Creek fault [729]. |
| **Name comments** | Fault unnamed in compilation by Gibbons and Dickey (1983). The informal name Elk Mountain fault has been applied by J.P. McCalpin to this structure after the nearby geographic feature (Elk Mountain). The fault extends from about 0.5 km north of the headwaters of Bullpen Creek southwest to near the headwaters of North Bridger Creek, which forms the northern boundary of the Bear River Divide. |
| **County(s) and State(s)** | LINCOLN COUNTY COUNTY, WYOMING |
| **AMS sheet(s)** | Ogden |
| **Physiographic province(s)** | MIDDLE ROCKY MOUNTAINS |
| **Reliability of location** | Good Compiled at 1:250,000 scale. | Comments: Mapped in reconnaissance mapping (1:100,000 scale) by Gibbons and Dickey (1983 #821); northern branch of fault appears to be from 1:62,500-scale map of Rubey and others (1975 #816). Fault traces recompiled at 1:250,000-scale on map with topographic base. |
| **Geologic setting** | One of many west-dipping normal faults that parallel east-directed thrust faults in Mesozoic sedimentary rocks in this part of the Overthrust Belt. The fault is along western flank of Fossil Ridge and Elk Mountain. |
| **Length (km)** | 8 km. |
| **Average strike** | N20°E |
| **Sense of movement** | Normal |
| **Comments:** Shown as normal by Gibbons and Dickey (1983 #821). |
| **Dip** |
| **Paleoseismology studies** |
| **Geomorphic expression** | No fault scarps are known to exist, but the fault lies at the base of a somewhat linear west-facing escarpment on rocks of the Tertiary Wasatch Formation. |
| **Age of faulted surficial deposits** | Northern half of fault is in Tertiary bedrock (Rubey and others, 1975 #816). |
| **Historic earthquake** |
| **Most recent prehistoric deformation** | Quaternary (<1.6 Ma) |
| **Comments:** Gibbons and Dickey (1983 #821) suggested Quaternary movement, but no specific justification was given. |
| **Recurrence interval** |
| **Slip-rate category** | Less than 0.2 mm/yr |
| **Comments:** Low slip-rate category rate is inferred based on absence of scarps and data to indicate otherwise. |
| **Date and Compiler (s)** | 1994 |
| **References** |
Earthquake Hazards Program

Database Search

Complete Report for Grand Valley fault, Star Valley section (Class A) No. 726d

**Synopsis**

**General:** This long fault extends from Idaho into Wyoming along the western base of the Snake and Salt River Ranges.

**Sections:** This fault has 4 sections. Detailed mapping and limited trenching suggest that the fault has four segments and an additional poorly characterized part of the fault that suggest different rates of Quaternary displacement and apparently different paleoseismic histories. Those segments are herein considered as informally named sections in accordance with this compilation. From north to south they are the Swan Valley section [726a], the Grand Valley section [726b], the Prater Mountain section [726c], and the Star Valley section [726d]. The southernmost, the youngest and most active, records recurrent Holocene movement. The northern part of the fault is outside the Intermountain Seismic Belt and the southern part is within this active belt; furthermore, faulting on the northern part is clearly older and less frequent than to the south.

**Name comments**

**General:** Name of fault and its sections are modified from Piety and others (1992 #538). Earlier workers in the area restricted the use of "Grand Valley fault" to the part of the structure in Idaho, the southern extension in Wyoming was known as the "Star Valley fault." Preference for the single name as used by Piety and others (1992 #538) is given here. The Grand Valley fault extends from about 26 km southeast of Pocatello, Idaho, south to about 22 km south of Afton, Wyoming.

**Section:** The section was defined by Piety and others (1992 #538) as extending from Prater Canyon south to 1 km north of the Salt River (as shown by Warren, 1992 #837). This part of the fault bounds two distinct structural and physiographic basins of
approximately equal size (Piety and others, 1986 #55). Furthermore, the topographic high separating these two basins near "The Narrows" is coincident with a 4-km right step in the trace of the fault. The Star Valley section includes both parts of the Star Valley fault of Witkind (1975 #819) in Wyoming. Piety and others (1986 #55) suggested that the southern 27 km of the Grand Valley fault is characterized by similar faulting histories on either side of the echelon step.

**Fault ID Comments:**
Refers to number 22 (Grand Valley fault, Idaho) of Witkind (1975 #320) and numbers 20 and 21 (Star Valley fault, Wyoming) of Witkind (1975 #819).

<table>
<thead>
<tr>
<th><strong>County(s) and State(s)</strong></th>
<th>LINCOLN COUNTY COUNTY, WYOMING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AMS sheet(s)</strong></td>
<td>Preston</td>
</tr>
<tr>
<td><strong>Physiographic province(s)</strong></td>
<td>MIDDLE ROCKY MOUNTAINS</td>
</tr>
<tr>
<td><strong>Reliability of location</strong></td>
<td>Good</td>
</tr>
<tr>
<td><strong>Geologic setting</strong></td>
<td>Down-to-west range-front normal fault that extends from near the Snake River Plain southward along the western base of the Snake and Salt River Ranges. Basin fill is estimated to be 2 to 3 km thick based on seismic reflection data (Royse and others, 1975 #4391; Dixon, 1982 #4382).</td>
</tr>
<tr>
<td><strong>Length (km)</strong></td>
<td>This section is 52 km of a total fault length of 136 km.</td>
</tr>
<tr>
<td><strong>Average strike</strong></td>
<td>N8°W (for section) versus N22°W (for whole fault)</td>
</tr>
<tr>
<td><strong>Sense of movement</strong></td>
<td>Normal</td>
</tr>
<tr>
<td><strong>Dip</strong></td>
<td>10°-70° W.</td>
</tr>
</tbody>
</table>
| **Paleoseismology studies** | [726-1] Warren (1992 #837) trenched an 11-m-high scarp 0.8 km south of Swift Creek (the Afton trench site). The exposed stratigraphy suggests that three latest Quaternary earthquakes occurred at about 5,540±70 14C yr BP (3 m of slip), 8,090±80 14C yr BP (4 m of slip), and about 12-15 ka (4 m slip). McCalpin (1993 #796) reported that the earliest (third) event at the site...
Isolated fault scarps are present on late Quaternary alluvial fans at the mouths of major valleys (Piety and others, 1992 #538). These scarps tend to fall into one of two size classes: 5-6 m high and 11-15 m high suggesting multiple times of movement on different age landscapes. Elsewhere, the fault is at the abrupt alluvial bedrock contact and few scarps exist beyond the mouths of the narrow channel valleys.

**Age of faulted surficial deposits**
Holocene and late Pleistocene alluvial fans along the eastern margin of Star Valley.

**Historic earthquake**
Latest Quaternary (<15 ka)

*Comments:* Warren (1992 #837) dated the most recent paleoearthquake as mid-Holocene at about 5540±70 14C yr BP; these data are reiterated by McCalpin (1993 #796).

**Recurrence interval**
>5.5 k.y. (<5.5 ka); 2.4-2.7 k.y. (5.5-8 ka); 4-7 k.y. (8 to 14.5-15 ka)

*Comments:* Warren (1992 #837) documented two recurrence intervals from his three dated events. The most recent recurrence interval was 2,400-2,700 14C yr, preceded by a less well constrained interval of about 4-7 k.y. However, since most recent event occurred at about 5,540±70 14C yr BP, the present interval of quiescent suggests that recurrence intervals can be longer than 5.5 k.y., which appears to be the criteria used by Mason (1992 #463) to suggest that the repeat time between earthquakes on this section is 5±2.4 k.y. based on data presented by Piety and others (1986 #55).

**Slip-rate category**
Between 0.2 and 1.0 mm/yr

*Comments:* Warren (1992 #837) reported a late Quaternary slip rate of 0.73-0.91 mm/yr. This rate must be derived from the cumulative slip of the two most recent events (7 m) and the time interval between about 5.5 ka and 12-15 ka. Earlier, Piety and others (1986 #55; 1992 #538) and then Anders and others (1990 #409) suggested that the latest Quaternary (<15 ka) slip rate for the Star Valley section is 0.6-1.1 mm/yr based on 8.3-11.6 m high scarps on 11-15 ka deposits. Interestingly the slip rate on this part of the fault is comparable to that on the Swan Valley section during the interval from 2.0-4.4 Ma. Wong and others (2000 #4484) suggested fault slip rates ranging from 0.026 to 2.3 mm/yr, with maximum weighting of 60% on a value of 1.1 mm/yr. These reported slip rates are based on a combination of data from Anders and others (1990 #409), Piety and others (1986 #55; 1992 #538), and McCalpin (1993 #796). The late Quaternary characteristics of this fault (overall geomorphic expression, continuity of scarps, age of faulted deposits, etc.)
suggest the slip rate during this period is probably less than the 1.1 mm/yr that Wong and others (2000 #4484) favored. Because most of the reported slip rates are less than 1 mm/yr (especially the younger ones), we assign the 0.2-1 mm/yr slip-rate category to this section of the Grand Valley fault.

<table>
<thead>
<tr>
<th>Date and Compiler(s)</th>
<th>1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>James P. McCalpin, GEO-HAZ Consulting, Inc.</td>
<td></td>
</tr>
<tr>
<td>Michael N. Machette, U.S. Geological Survey</td>
<td></td>
</tr>
<tr>
<td>Kathleen M. Haller, U.S. Geological Survey</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>---</td>
</tr>
</tbody>
</table>
Earthquake Hazards Program

Database Search

Complete Report for North Bridger Creek fault (Class A) No. 737

Brief Report || Partial Report


| **Synopsis** | One of many short, west-dipping normal faults that parallel east-directed thrust faults in Mesozoic sedimentary rock in this part of the Overthrust Belt. Little is known about this short normal fault that displaces rock of the Tertiary Wasatch Formation and an overlying erosion surface of unknown age. |
| **Name comments** | Fault unnamed in compilation by Gibbons and Dickey (1983). The informal name North Bridger Creek has been informally applied to the fault by J.P. McCalpin. Fault only extends about 4 km north-northeast from North Bridger Creek and is located between Sillem Ridge and Elk Mountain. |
| **County(s) and State(s)** | LINCOLN COUNTY COUNTY, WYOMING |
| **AMS sheet(s)** | Ogden |
| **Physiographic province(s)** | MIDDLE ROCKY MOUNTAINS |
| **Reliability of location** | Good  
Compiled at 1:250,000 scale.  
Comments: Mapped in reconnaissance (1:100,000 scale) by Gibbons and Dickey (1983 #821). Fault traces recompiled at 1:250,000-scale on map with topographic base. |
| **Geologic setting** | One of many short, west-dipping normal faults that parallel east-directed thrust faults in Mesozoic sedimentary rock in this part of the Overthrust Belt. Fault is located between Sillem Ridge and Elk Mountain. |
| **Length (km)** | 4 km. |
| **Average strike** | N17°E |
| **Sense of movement** | Normal |
**Comments:** Shown as normal by Gibbons and Dickey (1983 #821).

<table>
<thead>
<tr>
<th>Dip</th>
</tr>
</thead>
<tbody>
<tr>
<td>No fault scarps are known to exist, but the fault lies at the base of somewhat linear west-facing escarpment on rock of the Tertiary Wasatch Formation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Paleoseismology studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>No fault scarps are known to exist, but the fault lies at the base of somewhat linear west-facing escarpment on rock of the Tertiary Wasatch Formation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Geomorphic expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tertiary Wasatch Formation and an overlying erosion surface of unknown age; deformation of Quaternary deposits not documented.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age of faulted surficial deposits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tertiary Wasatch Formation and an overlying erosion surface of unknown age; deformation of Quaternary deposits not documented.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Historic earthquake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary (&lt;1.6 Ma)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Most recent prehistoric deformation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary movement (probably on the basis of the faults proximity to the escarpment), but no specific justification was given.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Recurrence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 0.2 mm/yr</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Slip-rate category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comments: Low slip-rate category inferred based on absence of scarps and data to indicate otherwise.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date and Compiler (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>James P. McCalpin, GEO-HAZ Consulting, Inc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>References</th>
</tr>
</thead>
</table>

**U.S. Department of the Interior | U.S. Geological Survey**


Page Contact Information: EHP Web Team

Page Last Modified: July 16, 2008 20:11:08 UTC

008 20:11:08 UTC
Earthquake Hazards Program

Database Search

Complete Report for The Pinnacle fault (Class A) No. 739

**Brief Report || Partial Report**


<p>| <strong>Synopsis</strong> | One of many short, west-dipping normal faults along west side of Bear River Divide that parallel east-directed thrust faults in Mesozoic sedimentary rock in this part of the Overthrust Belt. This fault displaces rock of the Tertiary Wasatch Formation and an overlying erosion surface. |
| <strong>Name comments</strong> | Fault unnamed in compilation by Gibbons and Dickey (1983). The informal name &quot;The Pinnacle &quot; has been applied by J.P. McCalpin to this fault after a nearby geographic feature. Fault only extends about 2 km southwest from Alkali Creek. |
| <strong>County(s) and State(s)</strong> | UINTA COUNTY COUNTY, WYOMING |
| <strong>AMS sheet(s)</strong> | Ogden |
| <strong>Physiographic province(s)</strong> | MIDDLE ROCKY MOUNTAINS |
| <strong>Reliability of location</strong> | Good Compiled at 1:250,000 scale. Comments: Mapped in reconnaissance (1:100,000 scale) by Gibbons and Dickey (1983 #821). Fault traces recompiled at 1:250,000-scale on map with topographic base. |
| <strong>Geologic setting</strong> | One of many short, west-dipping normal faults along west side of Bear River Divide that parallel east-directed thrust faults in Mesozoic sedimentary rocks in this part of the Laramide Overthrust Belt. |
| <strong>Length (km)</strong> | 2 km. |
| <strong>Average strike</strong> | N25°W |
| <strong>Sense of movement</strong> | Normal |</p>
<table>
<thead>
<tr>
<th><strong>Paleoseismology studies</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geomorphic expression</strong></td>
<td>No fault scarps are known to exist, but the fault lies at the base of somewhat linear west-facing escarpment on rocks of the Tertiary Wasatch Formation.</td>
</tr>
<tr>
<td><strong>Age of faulted surficial deposits</strong></td>
<td>Tertiary Wasatch Formation and an overlying erosion surface of unknown age; deformation of Quaternary deposits not documented.</td>
</tr>
<tr>
<td><strong>Historic earthquake</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Most recent prehistoric deformation</strong></td>
<td>Quaternary (&lt;1.6 Ma)</td>
</tr>
<tr>
<td><strong>Comments:</strong> Gibbons and Dickey (1983 #821) suggested Quaternary movement (probably on the basis of the faults proximity to the escarpment), but no specific justification was given.</td>
<td></td>
</tr>
<tr>
<td><strong>Recurrence interval</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Slip-rate category</strong></td>
<td>Less than 0.2 mm/yr</td>
</tr>
<tr>
<td><strong>Comments:</strong> Low slip-rate category inferred based on absence of scarps and data to indicate otherwise.</td>
<td></td>
</tr>
<tr>
<td><strong>Date and Compiler(s)</strong></td>
<td>1994</td>
</tr>
<tr>
<td>James P. McCalpin, GEO-HAZ Consulting, Inc.</td>
<td></td>
</tr>
</tbody>
</table>
The Rock Creek fault is a high-angle, down-to-west normal fault within the Tunp Range; it may sole into the Laramide-age Tunp thrust fault. Scars are present along much of the length of this fault. Morphologic studies of the scarp have been conducted and one trench that was excavated constrains the timing of the most recent movement at about 3.3 ka.

Name originally appears on plate 1 of Rubey and others (1975 #816), but is not mentioned in the text. Also shown as the Beck Creek fault (Blackstone and DeBruin, 1987 #820). Fault extends from about 1.5 km west of headwaters of Mayfield Creek south to about 2 km west of headwaters of Bullpen Creek (5.3 km south of U.S. Highway 30N). According to Rubey and others (1980 #814), the fault extends 2 km farther north to West Branch Hams Fork.

Fault ID Comments:
Refers to number 16 (Rock Creek fault) in Witkind (1975 #819), shown but unnamed by Gibbons and Dickey (1983 #821).

Lincoln County County, Wyoming

Ogden
Preston

Middle Rocky Mountains

Good
Compiled at 1:250,000 scale.

Comments: Fault location from 1:62,500-scale mapping of Rubey and others (1975 #816, 1980 #814) as modified by unpublished 1:24,000-scale mapping of the compiler. Chambers (1988 #818) also mapped the extent of fault scarp at a scale of 1:63,360.
Fault traces were recompiled at 1:250,000 scale on a topographic base map.

<table>
<thead>
<tr>
<th><strong>Geologic setting</strong></th>
<th>High-angle, down-to-west normal fault within the Tunp Range bounding west side of Dempsey Ridge. The fault forms the eastern boundary of a graben that parallels the trend of decollement structures of the Overthrust Belt (Anders and LaForge, 1983 #836). The Rock Creek fault may sole into the Laramide-age Tunp thrust fault. Stratigraphic throw of Eocene and older units ranges from 300-500 m (Rubey and others, 1975 #816).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length (km)</strong></td>
<td>41 km.</td>
</tr>
<tr>
<td><strong>Average strike</strong></td>
<td>N5°E</td>
</tr>
<tr>
<td><strong>Sense of movement</strong></td>
<td>Normal</td>
</tr>
<tr>
<td><strong>Dip</strong></td>
<td><em>Comments:</em> Rubey and others (1975 #816) stated that data are insufficient to determine the fault's dip and geometry, but they showed the fault schematically in plate 2 as having a 60° W dip.</td>
</tr>
<tr>
<td><strong>Paleoseismology studies</strong></td>
<td>Site 729-1. McCalpin and students excavated a trench across a 6.4-m-high fault scarp at Cook Canyon (McCalpin, 1993 #796); total stratigraphic throw is more than 11 m at this site (McCalpin and Warren, 1992 #817). Nine radiocarbon ages were obtained, mainly from buried soils intercalated with alluvium on the downthrown block. These ages constrain the timing of a late Holocene event and define a minimum time for an earlier event because the older deformed colluvial wedge is greater than about 4,470 14C yr BP. However, the earlier history of faulting could not be reconstructed because the trench did not get through the thick Holocene alluvium that was deposited against the fault scarp on the downthrown block (McCalpin and Warren, 1992 #817). A charcoal sample from a buried soil under scarp-derived colluvium exposed in a stream cut bank in Cook Canyon (nearly the same location as site 729-1) in an earlier study (Chambers, 1988 #818) indicated the older event occurred since 4,780±260 14C yr BP; this age determination was taken to represent a maximum time for the earlier faulting event. Thus, the timing of the earlier event is inferred to be middle Holocene and constrained by these two radiocarbon ages (more than 4,470 14C yr BP and less than 4,780±260 14C yr BP). We consider the older (penultimate) event to be 4.6±0.2 ka for the purposes of this discussion.</td>
</tr>
<tr>
<td><strong>Geomorphic expression</strong></td>
<td>Most of fault length is characterized by scarps on steep colluvial slopes. Rubey and others (1975 #816) indicated that scarps are as much as 15 m high, Witkind (1975 #819) indicated they are less than 20 m high, but McCalpin (1993 #796) stated that some scarps are as much as 25 m high. Isolated scarps in alluviated drainages are 6-8 m high (McCalpin and Warren, 1992 #817; McCalpin, 1993 #796). Chambers (1988 #818) measured fault scarp profiles at seven locations, whereas Anders and LaForge</td>
</tr>
</tbody>
</table>
Age of faulted surficial deposits

| Holocene and Pleistocene landslide deposit and Tertiary bedrock (Rubey and others, 1975 | 816) are offset; however, most of the length of the fault is mapped at the alluvium-bedrock contact (Rubey and others, 1975 | 816; 1980 | 814). In contrast to the available geologic mapping, McCalpin (1993 | 796) stated that most of fault is in colluvium. |

Historic earthquake

| Most recent prehistoric deformation | Latest Quaternary (<15 ka) |
| Comments: The most recent event is bracketed by radiocarbon ages of 3,280±70 and 3,880±60 14C yr BP (McCalpin and Warren, 1992 | 817), or roughly 3.6±0.3 ka, whereas the penultimate (older) event is about 4.6±0.2 ka. Although Witkind (1975 | 819) inferred historic (<100 yr) movement of this fault; the basis for this inference is unclear and appears unfounded. |

Recurrence interval

| >3.3 k.y. (0 to 3.6±0.3 ka), 0.6-1.5 k.y. (3.3-4.8 ka), >10 k.y. (4.6±0.2 to 15 ka) |
| Comments: McCalpin (1993 | 796) provided these minimum and maximum recurrence intervals based on the occurrence of the two most recent paleoearthquakes at 3.6±0.3 ka (3,280-3,880 14C yr BP) and possibly 4.6±0.2 ka (4,470-4,780 14C yr BP). This equates to a permissible recurrence interval of about 0.6-1.5 k.y. However, the late Quaternary recurrence interval must be quite variable: it has been about 3.6±0.3 k.y. since the last event and it was at least 10 k.y. before the penultimate event at 4.6±0.2 ka (15 ka is the inferred time of deposition of older faulted deposit at trench site). |

Slip-rate category

| Between 0.2 and 1.0 mm/yr |
| Comments: On the basis of a colluvial-wedge thickness of 2.5 m, McCalpin and Warren (1992 | 817) calculated a displacement of 4-5 m for the most recent event at 3.6±0.3 ka; however, this amount may reflect both backtilting and displacement at the fault (i.e., a maximum amount of offset). This large slip is associated with a recurrence interval of only 0.6-1.5 k.y. This short recurrence interval suggests an earthquake cluster (two closely spaced events) that may not be characteristic of the longer late Quaternary history of the fault. Permissible slip rates derived from these data seem unreasonable for any significant geologic time interval (i.e., the Holocene), and are contrary to the 3.6±0.3 k.y. interval of non-rupturing since the most recent event. A slower slip rate is obtained from 11 m of stratigraphic separation of deposits with a preferred age of 15 ka as reported by McCalpin and Warren (1992 | 817). Considering the above discussion and the evidence for an earthquake cluster in the middle Holocene, we categorize the Rock Creek fault in the 0.2-1.0 mm/yr bracket and... |
recognize that it may have considerably faster slip rates over short intervals of geologic time (several thousand years). A similar treatment was afforded the nearby Greys River fault [728].

<table>
<thead>
<tr>
<th>Date and Compiler(s)</th>
<th>1994</th>
<th>James P. McCalpin, GEO-HAZ Consulting, Inc.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>#818</strong> Chambers, H.P., 1988, A regional ground motion model for historical seismicity along the Rock Creek fault, western Wyoming: Laramie, University of Wyoming, unpublished M.S. thesis, 102 p.**</td>
</tr>
</tbody>
</table>
**Earthquake Hazards Program**

**Database Search**

**Complete Report for Spring Creek fault (Class A) No. 738**

**Brief Report || Partial Report**


<table>
<thead>
<tr>
<th><strong>Synopsis</strong></th>
<th>One of many short, west-dipping normal faults along west side of Bear River Divide that parallel east-directed thrust faults in Mesozoic sedimentary rocks in this part of the Overthrust Belt. This short normal fault displaces rock of the Tertiary Wasatch Formation and an overlying erosion surface.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name comments</strong></td>
<td>Unnamed in compilation of Gibbons and Dickey (1983). The informal name Spring Creek fault has been applied by J.P. McCalpin to this structure. Fault only extends about 2 km southwest from Spring Creek.</td>
</tr>
<tr>
<td><strong>County(s) and State(s)</strong></td>
<td>LINCOLN COUNTY COUNTY, WYOMING</td>
</tr>
<tr>
<td><strong>AMS sheet(s)</strong></td>
<td>Ogden</td>
</tr>
<tr>
<td><strong>Physiographic province(s)</strong></td>
<td>MIDDLE ROCKY MOUNTAINS</td>
</tr>
</tbody>
</table>
| **Reliability of location** | Good Compiled at 1:250,000 scale.  
*Comments:* Mapped in reconnaissance (1:100,000 scale) by Gibbons and Dickey (1983 #821). Fault traces recompiled at 1:250,000-scale on map with topographic base. |
| **Geologic setting** | One of many short, west-dipping normal faults along west side of Bear River Divide that parallel east-directed thrust faults in Mesozoic sedimentary rock in this part of the Laramide Overthrust Belt. |
| **Length (km)** | 2 km. |
| **Average strike** | N25°E |
| **Sense of movement** | Normal |
| **Paleoseismology studies** |  |
| **Geomorphic expression** | No fault scarps are known to exist, but the fault lies at the base of somewhat linear west-facing escarpment on rock of the Tertiary Wasatch Formation. |
| **Age of faulted surficial deposits** | Tertiary Wasatch Formation and an overlying erosion surface of unknown age; deformation of Quaternary deposits not documented. |

| **Historic earthquake** |  |
| **Most recent prehistoric deformation** | Quaternary (<1.6 Ma) |
| **Comments:** Gibbons and Dickey (1983 #821) suggested Quaternary movement (probably on the basis of the faults proximity to the escarpment), but no specific justification was given. |

| **Recurrence interval** |  |
| **Slip-rate category** | Less than 0.2 mm/yr |
| **Comments:** Low slip-rate category inferred based on absence of scarps and data to indicate otherwise. |

| **Date and Compiler(s)** | 1994 |
| **James P. McCalpin, GEO-HAZ Consulting, Inc.** |


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**U.S. Department of the Interior | U.S. Geological Survey**
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Page Last Modified: July 16, 2008 20:11:08 UTC
**Earthquake Hazards Program**

**Database Search**

**Complete Report for Sublette Flat fault (Class A) No. 733**

**Brief Report || Partial Report**


<table>
<thead>
<tr>
<th><strong>Synopsis</strong></th>
<th>Little is known about this poorly expressed, west-dipping normal fault at the eastern margin of Sublette Flat, the narrow valley west of the north end of the fault.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name comments</strong></td>
<td>The informal name Sublette Flat fault has been applied by J.P. McCalpin to the fault along Sublette Flat, the narrow valley west of the north end of the fault. The fault, as shown here, extends from Grade Creek south to 1 km north of U.S. Highway 30N. The northern 6 km of the fault (between Grade Creek and Pine Creek) was not shown on the map of Rubey and others (1980 #814), but Rubey and others (1975 #816) showed a fault with similar strike extending south of U.S. Highway 30N for more than 30 km along the western flank of Sillem Ridge. Witkind (1975 #819) also shows the fault south of the highway, but only for about 10 km.</td>
</tr>
<tr>
<td><strong>Fault ID Comments:</strong></td>
<td>Refers to number 17 (en echelon series of faults) in Witkind (1975 #819).</td>
</tr>
<tr>
<td><strong>County(s) and State(s)</strong></td>
<td>LINCOLN COUNTY COUNTY, WYOMING</td>
</tr>
<tr>
<td><strong>AMS sheet(s)</strong></td>
<td>Preston</td>
</tr>
<tr>
<td></td>
<td>Ogden</td>
</tr>
<tr>
<td><strong>Physiographic province(s)</strong></td>
<td>MIDDLE ROCKY MOUNTAINS</td>
</tr>
<tr>
<td><strong>Reliability of location</strong></td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>Compiled at 1:250,000 scale.</td>
</tr>
</tbody>
</table>
| | Comments: Mapped at 1:62,500 scale by Rubey and others (1975 #816; 1980 #814). Location (dotted) of northern 6 km of fault is inferred from topography by compiler, although it was not
shown by Rubey (1980 #814). All fault traces recompiled at 1:250,000-scale on map with topographic base.

**Geologic setting**
This is one of many west-dipping normal faults that parallel east-directed thrust faults in Mesozoic sedimentary rocks in this part of the Overthrust Belt. The Sublette Flat fault bounds the western side of Rock Creek Ridge and southern part of the Tunp Range. Total stratigraphic offset is unknown, but cross sections by Rubey and others (1975 #816; 1980 #814) suggest less than 600 m of post-Mesozoic offset.

<table>
<thead>
<tr>
<th><strong>Length (km)</strong></th>
<th>36 km.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average strike</strong></td>
<td>N10°E</td>
</tr>
<tr>
<td><strong>Sense of movement</strong></td>
<td>Normal</td>
</tr>
<tr>
<td><strong>Comments:</strong> Shown as normal by Rubey and others (1975 #816; 1980 #814).</td>
<td></td>
</tr>
<tr>
<td><strong>Dip</strong></td>
<td>60°-80° W</td>
</tr>
<tr>
<td><strong>Comments:</strong> Shown in cross sections by Rubey and others (1975 #816) as dipping 60°-80° W; however, they indicate that data are insufficient to determine the dip of this fault. To the north, the fault is shown to dip 60° W (Rubey and others, 1980 #814).</td>
<td></td>
</tr>
<tr>
<td><strong>Paleoseismology studies</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Geomorphic expression</strong></td>
<td>No scarps are preserved at the alluvium-bedrock contact along the southern part of the fault, except for a locality 1.6 km (1 mile) south of latitude 42° N (Rubey and others, 1975 #816). However, south of 42° N (in the Cokeville 1:100,000-scale quadrangle), Rubey and others (1980 #814) showed poorly located fault scarps on Quaternary-Tertiary alluvium.</td>
</tr>
<tr>
<td><strong>Age of faulted surficial deposits</strong></td>
<td>Quaternary-Tertiary gravel (Rubey and others, 1975 #816; 1980 #814); Tertiary, Cretaceous, and Jurassic bedrock (Rubey and others, 1975 #816).</td>
</tr>
<tr>
<td><strong>Historic earthquake</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Most recent prehistoric deformation</strong></td>
<td>Quaternary (&lt;1.6 Ma)</td>
</tr>
<tr>
<td><strong>Comments:</strong> Timing of most recent event is poorly constrained and based on the presence of scarps on Quaternary-Tertiary gravel (Rubey and others, 1975 #816; 1980 #814). Witkind (1975 #819) indicated the fault is late Cenozoic (on the basis of only Miocene-Pliocene units being faulted), but showed it as late Quaternary on his map. Because there are scarps (albeit poorly expressed) and surficial geologic units of possible Quaternary age are faulted, we show the fault has having Quaternary movement.</td>
<td></td>
</tr>
<tr>
<td><strong>Recurrence interval</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Slip-rate category</strong></td>
<td>Less than 0.2 mm/yr</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td><strong>Comments:</strong> Low slip-rate category inferred by compiler based on general absence of data to suggest otherwise.</td>
<td></td>
</tr>
<tr>
<td><strong>Date and Compiler(s)</strong></td>
<td>1994&lt;br&gt;James P. McCalpin, GEO-HAZ Consulting, Inc.</td>
</tr>
</tbody>
</table>
Earthquake Hazards Program

Database Search

Complete Report for Western Bear Lake fault (Class A) No. 622

**Synopsis**

High-angle, predominantly down-to-the-east normal fault along the subdued escarpment of the northeast flank of the Wasatch Range in Idaho. The central 20 km of the western Bear Lake fault is characterized by low (3- to 8-m-high) fault scarps that formed in the middle Holocene. No evidence of earlier faulting is known to exist.

**Name comments**

The name "western Bear Lake fault" first came into use by McCalpin (1990 #4419) for the fault that is subparallel to the Eastern Bear Lake fault [2364]. Mansfield (1927 #4416) questioned the existence of faults along the west side of the valley, but several are shown of 1:250,000 scale map of Oriel and Platt (1980 #4396). Armstrong and Cressman (1963 #4417) referred to this as the "west Bear Lake fault". Robertson (1978 #4418) refers to the fault as the "Bloomington scarp" named for a particularly well expressed part of the fault near Bloomington, which extends from near Bern south to near Fish Haven, Idaho. The fault has been depicted in various ways. We show it here as McCalpin (1990 #4419) does, extending from Trail Creek (about 13 km southeast of Soda Springs, Idaho) south to about 1 km northeast of Fish Haven. However, McCalpin (1993 #796) suggests that the fault may only extend between Ovid and St. Charles, Idaho, where scarps are well expressed. Witkind (1975 #320) shows it extending more than 40 km further to the north, to the east side of Reservoir Mountain. Evans (1991 #4425) suggests that the fault only extends from the central western shore of Bear Lake to near Montpelier, or about half of the length shown here.

**Fault ID Comments:**

Compiled in cooperation with the Idaho Geological Survey

Refers to fault number 25 ("fault west side Bear Lake [west side of graben]") in compilation by Witkind (1975 #320).

<table>
<thead>
<tr>
<th><strong>County(s) and State(s)</strong></th>
<th>BEAR LAKE COUNTY COUNTY, IDAHO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AMS sheet(s)</strong></td>
<td>Preston</td>
</tr>
<tr>
<td><strong>Physiographic province(s)</strong></td>
<td>MIDDLE ROCKY MOUNTAINS</td>
</tr>
<tr>
<td><strong>Reliability of location</strong></td>
<td>Poor</td>
</tr>
<tr>
<td><strong>Compiled at 1:250,000 scale.</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Comments:* Location of fault from figure 2 of McCalpin (1990 #4419), which is a reduced version of the Preston 1:250,000 scale base map. Much of the length of the fault is approximately located on the original mapping.

**Geologic setting**
The Western Bear Lake fault extends along the northeastern flank of the Wasatch Range. It is subparallel to the northern part of the Eastern Bear Lake fault [2364], and thus the two faults bound the graben expressed as the Bear Lake Valley. McCalpin (1990 #4419) describes it as a complexly faulted hinge, related to formation of the Bear Lake graben. The fault may possibly extend into Utah, as it is on-trend with the Bear Lake (west side) fault [2531]. Evans (1991 #4425) suggests that the fault could sole into the an underlying thrust fault as "reflectors at depths greater than 4 km do not appear to be offset on the western margin of the basin".

**Length (km)** 59 km.

**Average strike** N9°W

**Sense of movement** Normal

*Comments:* Most agree that the predominant sense of movement is normal (Witkind, 1975 #320; McCalpin, 1990 #4419; 1993 #796).

**Dip**

**Paleoseismology studies**
McCalpin (1990 #4419) excavated two trenches approximately 400 m apart in September 1989. The southern trench is documented here; the northern one filled with water and little data resulted from the excavation.

Site 622-1. The trench and nearby auger holes suggest that 1.5-2.0 m, and possibly up to 3.5 m, of net throw occurred between 5.9 and 6.5 ka.

**Geomorphic expression**
The 20-km-long "Bloomington scarp" is expressed by low scarps generally "10 to 25 ft high" (3-8 m) (Robertson, 1978 #4418) on swamp deposits (McCalpin, 1993 #796). Armstrong and Cressman (1963 #4417) indicate that the "moderately straight lineaments, locally marked by scarps" roughly mark the topographic western edge of the Bear River Valley. Fault is located well to the east of...
the highly subdued mountain front escarpment along west side of Bear Lake Valley where the Wasatch Range eventually rises 1,000 m above valley floor. Local escarpment is 300 m.

<table>
<thead>
<tr>
<th><strong>Age of faulted surficial deposits</strong></th>
<th>Early Holocene alluvium and Quaternary loess are faulted, late Holocene alluvium is in fault contact with the older sediments (figure 7 in McCalpin, 1990 #4419)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Historic earthquake</strong></td>
<td>Latest Quaternary (&lt;15 ka)</td>
</tr>
<tr>
<td><strong>Most recent prehistoric deformation</strong></td>
<td>Comments: Trenching by McCalpin (1990 #4419) documents Holocene faulting (5.9-6.5 ka). Fault shown on map of Breckenridge and others (2003 #5878) in similar fashion as in this compilation.</td>
</tr>
<tr>
<td><strong>Recurrence interval</strong></td>
<td>Comments: McCalpin (1993 #796) states that during the interval of 11.2 ka to present only the Holocene event has occurred (5.9-6.5 ka) and thus can only provide an elapse time.</td>
</tr>
<tr>
<td><strong>Slip-rate category</strong></td>
<td>Less than 0.2 mm/yr</td>
</tr>
<tr>
<td><strong>Date and Compiler(s)</strong></td>
<td>2000 Kathleen M. Haller, U.S. Geological Survey Reed S. Lewis, Idaho Geological Survey</td>
</tr>
<tr>
<td>#</td>
<td>Reference</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
Earthquake Hazards Program

Database Search

Complete Report for Western Bear Valley faults (Class A) No. 735

**Brief Report || Partial Report**


| **Synopsis** | Two short faults were mapped by Gibbons and Dickey (1983 #821) along the western margin of the Bear River floodplain. Little is known about their timing, although they seem to have a low slip rate. |
| **Name comments** | Although unnamed by Gibbons and Dickey (1983 #821), the informal name Western Bear Valley faults has been applied by J.P. McCalpin to those faults that bound the western side of the Bear Valley. |
| **County(s) and State(s)** | LINCOLN COUNTY COUNTY, WYOMING |
| **AMS sheet(s)** | Ogden |
| **Physiographic province(s)** | MIDDLE ROCKY MOUNTAINS |
| **Reliability of location** | Good |
| **Length (km)** | 12 km. |
| **Average strike** | N21°E |
| **Sense of movement** | Normal |
| **Dip** | |

Comments: Mapped in reconnaissance (1:100,000 scale) by Gibbons and Dickey (1983 #821). Fault traces recompiled at 1:250,000-scale on map with topographic base.

These east-dipping normal faults coincide with the bedrock-alluvium contact; they are possibly antithetic to the larger west-dipping Eastern Bear Valley fault [734] on the opposite side of the Bear River.
<table>
<thead>
<tr>
<th><strong>Paleoseismology studies</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geomorphic expression</strong></td>
</tr>
<tr>
<td>Fault forms a somewhat linear bedrock-alluvium contact but no scarps are preserved, thus implying relatively old movement or young burial.</td>
</tr>
<tr>
<td><strong>Age of faulted surficial deposits</strong></td>
</tr>
<tr>
<td>The compiler considers the broad alluvial fans that lie along the bedrock-alluvial contact in the two fault locations to be of probable middle Pleistocene age. This antiquity explains the general absence of scarps on adjacent alluvial sites along the projection of the fault.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Historic earthquake</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Most recent prehistoric deformation</strong></td>
</tr>
<tr>
<td>Quaternary (&lt;1.6 Ma)</td>
</tr>
<tr>
<td><em>Comments</em>: Timing based on inference that middle Pleistocene age deposits rest against bedrock and are unfaulted.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Recurrence interval</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Slip-rate category</strong></td>
</tr>
<tr>
<td>Less than 0.2 mm/yr</td>
</tr>
<tr>
<td><em>Comments</em>: Low slip-rate category inferred from lack of fault scarps on deposits believed to middle Pleistocene or younger age.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Date and Compiler (s)</strong></th>
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<tr>
<td>1994</td>
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<tr>
<td>James P. McCalpin, GEO-HAZ Consulting, Inc.</td>
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<tr>
<th><strong>References</strong></th>
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Page Contact Information: EHP Web Team
Page Last Modified: July 16, 2008 20:11:08 UTC
Tabulation of Adjudicated Water Rights of the State of Wyoming - Water Division Number 4, Surface Water

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<th>APPROPRIATOR</th>
<th>PRIORITY</th>
<th>USE</th>
<th>C.F.S.</th>
<th>ACRES</th>
<th>HG LOC.</th>
<th>Notes</th>
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<tr>
<td>19572</td>
<td>POKER HOLLOW SPRING, Tributary Smith's Fork</td>
<td>Poker Hollow C.C. Camp, Water System</td>
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<td>J. H. Stoffers</td>
<td>-1882</td>
<td>I</td>
<td>0.71</td>
<td>50.00</td>
<td>T 49-24-119</td>
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<tr>
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<td></td>
<td>Abraham Stoner, original appropriator, April 19, 1928</td>
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<td></td>
<td>V. H. House</td>
<td>02-26-1882</td>
<td>1.8</td>
<td>0.94</td>
<td>626.00</td>
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<td>(Actually divers from North Fork Sublette Creek)</td>
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<tr>
<td>9249</td>
<td>LOST CREEK, Tributary Sublette Creek</td>
<td>Marks No. 1</td>
<td>08-02-1909</td>
<td>D.I.S.</td>
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<td>15.00</td>
<td>29-24-119</td>
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<td></td>
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<td>Marks No. 3</td>
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<td>102.00</td>
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<td>V. H. House</td>
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<td>(Adjudicated as from Sublette Creek)</td>
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<td>SOUTH FORK SUBLETTE OR RYAN CREEK, Tributary Sublette Creek</td>
<td>Ryan Irrigation</td>
<td>07-19-1886</td>
<td>D.I.S.</td>
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<td>60.00</td>
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<td>25.00</td>
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<td>10198</td>
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<td>0.21</td>
<td>15.00</td>
<td>18-24-119</td>
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<tr>
<td>10198</td>
<td></td>
<td>Alleman</td>
<td>12-17-1910</td>
<td>D.B.</td>
<td>1.09</td>
<td>76.72</td>
<td>24-24-119</td>
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<td>7677</td>
<td>UNDERWOOD CREEK OR TRAIL CREEK, Tributary Sublette Creek</td>
<td>Frederick No. 1</td>
<td>03-07-1907</td>
<td>I</td>
<td>20.00</td>
<td>140.00</td>
<td>1-23-119</td>
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<td>22136</td>
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<td>Frederick No. 1 Res.</td>
<td>06-03-1910</td>
<td>1.8</td>
<td>1.32</td>
<td>a.f.</td>
<td>6-23-119</td>
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<td>7678</td>
<td>WYMAN CREEK, Tributary Underwood Creek or Trail Creek</td>
<td>Frederick No. 2</td>
<td>05-27-1907</td>
<td>I</td>
<td>5.00</td>
<td>140.00</td>
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<tr>
<td>22148</td>
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<td>(Original supply is from Underwood Creek through the Frederick No. 1 Ditch, Permit No. 7677)</td>
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<tr>
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<td>Stoffers Res.</td>
<td>08-16-1910</td>
<td>I</td>
<td>3.74</td>
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April 8, 2005

Mr. John Teichert, Chairman
Cokeville Development Company
P.O. Box 190
Cokeville, WY 83114

Dear John:

As you know, my office has been reviewing the request from the Town of Bear River for an allocation of Original Bear River Compact storage. I will be copying you with my letter outlining how I plan to proceed with providing Bear River with the municipal water they need, without at this time impacting the 4,100 acre feet (AF) associated with a Smith's Fork project. But as demands for water continue to escalate in the Bear River Basin, it will become more and more difficult to retain in perpetuity the 4,100 AF for an unbuilt facility.

I understand that you are working diligently to create an appropriate taxing entity to meet Wyoming Water Development criteria and that you are also pursuing the flood control study through the Army Corps of Engineers. I also understand that constructing sizeable storage facilities can take considerable time.

Given these factors, this agency is willing to work with you to protect the 4,100 AF allocation from other demands for a 10 year period. However, I need to put you and the Development Company on notice that if a Smith's Fork project does not materialize by December 31, 2015, it is likely that the 4,100 AF of the Original Compact storage would become available for re-allocation to a more feasible project elsewhere in the Bear River basin in Wyoming.
If you’d like to discuss this issue further, don’t hesitate to contact me.

With best regards,

[Signature]
Patrick T. Tyrrell
State Engineer

Cc: Mayor Robin Rhodes, Town of Bear River
    Mayor Harris, City of Evanston
    Brian Honey, City Engineer
    Evan Simpson, Sunrise Engineering
    Jeff Fassett, Fassett Consulting
    Rep. Owen Peterson
    Sen. Ken Decaria
    Rep. Bruce Barnard
    Sen. Stan Cooper
    Rep. Kathy Davison
    Governor’s Office
    Phil Ogle, WWDC
    Chris Abernathy, WWDC
    Hugh McFadden, Attorney General’s Office
    Jade Henderson, Superintendent
    Kevin Wilde, Lead Hydrographer
    Don Shoemaker, Water Commissioner
    Kevin Payne, Water Commissioner
    Sue Lowry, Interstate Streams Administrator
    Sam Bennion, Cokeville Development Company
Appendix G

Easements and Rights of Way
LEGAL ASPECTS RELATING
to DITCH RIGHTS
and EASEMENTS

The law regarding ditch rights as a private property appurtenance separate from water rights is a confusing and often misunderstood concept in Wyoming water administration. The vast majority of water users in Wyoming have the misunderstanding that disagreements over the use of a ditch in all cases can be settled by decree of the water commissioner. While this may appear true under certain conditions (W.S. 41-6-301 through 41-6-308) the more common problems brought to the water commissioner are not settleable within his jurisdiction, and the most he can do is offer advice based on his knowledge of previous court decisions, always emphasizing that if his advice is not acceptable to all parties, those aggrieved should seek relief in civil court.

The Wyoming Supreme Court in 1912 noted the separation between water rights and ditch rights in the Collett vs Morgan case when it said:

"The Board of Control had no power or authority to determine as between the parties, the ownership or right to the use of the ditch. Its duties are confined to the distribution of the waters of the state between the several appropriators, the granting of permits to use the waters of the state for beneficial uses, to grant certificates therefor, and the general supervision of such waters.... The ditch ownership question cannot be settled by the Board but must be settled by agreement between the parties or by proceedings in court."

Keeping this in mind, and observing the fact that ditch easement and ownership questions continue to come before the water commissioners, who are perceived by the public to be the logically empowered public servants from whom free ditch advice can be attained, following are some of the most commonly asked questions, and responses which most properly address the problems.
1. Question: Where in the water statutes can I find out what the law is in regard to ditch easements and rights-of-way?

Answer: There is no water statute referencing ditch easements. These are matters of civil law and common law rather than water law and, as such, require agreement between the affected parties or litigation in court.

2. Question: How do I know if my ditch has an easement across my neighbor’s property?

Answer: Many times an easement for a ditch crossing neighboring properties will be recorded as such in the County Clerk’s office as an attachment to the deed to the property. If this is the case, the documented easement will normally contain specific lengths, widths and other conditions of the easement.

3. Question: If I check and find that no written easement has ever been recorded, does that mean my ditch has no easement?

Answer: No. In some cases, written easements may have been agreed to and signed by the affected landowners but not recorded. These are sometimes found in the possession of one or all of the affected landowners, and are usually binding, although their legality should always be verified by a neutral party (such as a County Attorney) if any of the parties questions the terms. In other cases, no written documentation of any kind exists, but an unwritten easement acquired by prescription may protect the right-of-way of the ditch to cross neighboring property.

4. Question: If I can find no written easement of any kind, how do I know if I have a prescriptive easement?

Answer: The accepted understanding of prescriptive acquisition of ditch easements was enunciated by the Wyoming Supreme Court in the 1956 case of Haines vs Galles, wherein it was said:

"Easements may be created by prescription or, more properly speaking under the modern doctrine, by presumption... In time, the fiction of a "lost grant" [has been] adopted by the courts—that is, the courts presumed, from the long possession and exercise of right by the defendant with the acquiescence of the owner, that there must have been originally a grant by the owner to the claimant which has [since] become lost... Today...in most of the states in the United States..., the rule is that the period for acquiring an easement...corresponds...to the local statute of limitations [which, in Wyoming, is ten (10) years]. It has been emphasized that a prescriptive right is founded upon the presumption of a grant."

In short, the fact that a ditch is found to exist in its present location suggests that, at some time in the past, the landowners agreed that it could be constructed there. If it has existed there for a period of ten years or longer, it has probably established its easement and cannot be removed, except by agreement of all affected parties.

5. Question: What if the ditch has been in place for a period of time less than the period prescribed by the statute of limitations; i.e. less than 10 years?

Answer: Then it may not have established a prescriptive easement, and its existence may be challenged in a civil court by any affected party.

6. Question: If I am buying, or selling, a parcel of land with appurtenant water rights, and there is no documented easement for my ditch(es) which cross neighboring properties, what assurance do I have that the easements are secure, assuming I feel sure that they have been successfully acquired by prescription by having been in place ten years or longer?

Answer: This question was addressed by the Wyoming Supreme Court in 1893 and the answer is still in use today. In the Frank vs Hicks case, the courts stated:
"A water right acquired for irrigation of lands and the ditch or other conduit for the water passes by a conveyance of the realty without being specifically mentioned." (emphasis added).

7. Question: Suppose I have acquired a ditch right by prescription across neighboring properties. What do the statutes say about the width of my easement; that is, how many feet am I allowed alongside my ditch to come and go on my neighbor's property?

Answer: There is nothing in the statutes which specifies a required width for ditch easements. By definition, an easement is an interest held by one owner in the property of another which entitles the holder to a specific limited use. In the case of ditch easements, the ditchowner has the right only to the specific limited access which is attendant to the purpose and function of the ditch. In Wyoming, the accepted view has been that the holder of a ditch easement has only the right to expect his ditch to remain in its historic physical location, and the right to conduct reasonable maintenance on the ditch. Thus, the easement accompanying a small ditch would allow only small equipment for maintenance of the ditch, while a larger ditch would have a correspondingly larger area allowed for maintenance equipment.

There is no provision for the ditchowner to expect to be able to construct a road along his ditch through the other owner's property, or to expect to be able to use any other roads, driveways, etc., which are not immediately in contact with the ditch easement. He must enter the property on the line of the ditch, confine all work to the line of the ditch, and leave the property on the line of the ditch, whenever possible to do so. In discussing entry on the lands of another for the purpose of waterway repair, the Wyoming Attorney General in 1965 quoted Kinney on Irrigation and Water Rights in stating:

8. Question: If the ditch which brings water across a neighboring property from the stream source to my irrigated land, or takes my wastewater across another's property, falls into disrepair, whose responsibility is it to have it repaired?

Answer: Wyoming Statute 41-5-101 clearly states that "The owner or owners of any ditch for irrigation, or other purposes, shall carefully maintain the embankments thereof so that the water of such ditch may not flood or damage the premises of others." In addition to this statutory direction, the Wyoming Supreme Court, in the 1905 case of Howell vs Big Horn Basin Colonization Company observed that:

"The well settled rule is that the owner of an irrigating ditch is bound to exercise reasonable care and skill to prevent injury to other persons from such ditch, and he will be liable for such damages occurring to others as a result of his negligence or unskillfulness in constructing, maintaining or operating the ditch."

It is generally agreed that the "owner" or "owners" of a ditch consist of anyone who uses the ditch or water therefrom for any purpose whatever. The proportionate ownership of the ditch among several owners is determined by the "ratio between the water right of each water user to the total water rights adjudicated under such irrigation works" (Wyoming Statute 41-6-303).

9. Question: If my neighbor fails to properly maintain his ditch across my property, can I ask the Water Commissioner, State Engineer's Office, or Board of Control to institute damage or liability proceedings against him?
11. Question: It

Answer: No. Since a ditch is, in essence, an object of private property, anyone who feels his private property rights have been violated must institute his own damage proceedings in a court of civil law. However, the water commissioner, upon inspection of an "undermaintained" ditch which cannot handle its properly adjudicated amount of water, may restrict the headgate of the ditch to where it only diverts what the ditch can safely carry. If one of the landowners' crops suffer because of this restriction, he will probably have no recourse due to his own failure to provide adequate capacity by proper maintenance.

10. Question: What if I try to destroy my ditch or to put the headgate of my ditch across his property? Am I liable for him to remove it? And can he sue me?

Answer: Technically, Wyoming Statute 41-5-101 (cited above in answer #8) is the only guidance which speaks to maintenance obligations. However, it is generally agreed that in an instance of this type, reasonable maintenance is all that is required. It is also generally agreed that one who causes his own problems, is not entitled to relief from another party. The Wyoming Supreme Court, in the 1976 Bard Ranch vs Weber case, has said:

"The owner of an easement and the owner of the land encumbered by the easement each possess rights, and each must, as far as possible, respect the other's use."

11. Question: What if I try to stop him?

Answer: The Wyoming Attorney General addressed this question in 1965 in quoting from Weil in "Water Rights in the Western States" when he said:

"As in the case of any easement, the ditchowner as the dominant, has the duty of keeping the ditch in repair, and not the landowner. Correspondingly, he has the right of entry upon the servient estate to make repairs and to clean out the ditches, and if the landowner interferes, injunction lies."

However, it is often the case that a landowner who wishes to be in total control of his own property will persuade the ditchowner to allow him to maintain the ditch across his own property for the ditchowner. As long as he maintains it in a condition adequate for the passage of the proper amount of water, and in a condition acceptable to the ditchowner, there may be no reason for the ditchowner to enter the easement, although the right to do so continues to exist. If a conflict arises as to the adequacy of such maintenance, the matter may require litigation in the courts. Again, the Water Commissioner, State Engineer's Office, or Board of Control, are not empowered to pass judgment on such a conflict.

12. Question: Suppose a neighbor's ditch crossing my land is in a location which is cumbersome or a hindrance to the efficiency of my operation. Can I destroy the ditch?

Answer: No. Sutherland on Damages (4th ed. Vol. 4, pg. 3760) says:

"One who destroys a private irrigating ditch is liable for the difference in the value of the land belonging to the owner without the ditch and with it."

13. Question: Suppose a neighbor's ditch crossing my land is in a location which is cumbersome or a hindrance to the efficiency of my operation. Can I require him to move the ditch or to put it in a buried pipeline in a location that allows me the full enjoyment of my property?
Answer: There is no statutory support for such forced requirement. In most cases, since such a change may be a benefit to both parties, both may agree to a shared project which may create advantages for each of them. However, if the ditchowner feels there will be no advantage to him, he may refuse to enter such an agreement, particularly if the ditch has historically been and continues to be adequate for his purposes and is well-maintained. In that case, the landowner whose property is encumbered by the ditch may seek permission from the ditchowner to make the changes himself and at his own expense. If the ditchowner agrees to allow such a change, he is entitled to expect that his historic amount of water and patterns of use are not affected in any way. If the change is carried out and the ditchowner's use is affected, the landowner responsible for making the change is obligated to correct whatever problems he may have created. He may also have to accept responsibility for any additional long-term maintenance above what was originally required before the work was done.

14. Question: Suppose my ditch crossing a neighbor's land has historically caused a seeped or boggy spot in his property. Am I required to repair the ditch to stop the seepage if he so demands?

Answer: Technically, yes (see question #8). However, numerous factors enter into a question of ditch seepage. If the problem has existed for many many years and not gotten any worse, there may be a defense. If the complaining landowner bought the land with knowledge that the boggy area was present and it had existed prior to his acquisition of the land, he may not be granted relief. In any case, this again is a matter to be litigated in civil court if the landowners cannot reach agreement. A competent court would be the only entity able to evaluate the opposing claims in terms of property damage, etc.

15. Question: Suppose I am the owner of a historic ditch crossing another owner's property and he builds a new house or other structure in the vicinity of the ditch which creates and/or is later damaged by seepage from my ditch. Am I liable for damages?

Answer: Probably not. Wyoming Statute 17-12-103 provides for a "priority of right by location" which essentially says that if the ditch was there first, the owners of any property introduced at a later time are compelled to protect themselves from any damages caused by the ditch. On the other hand, the same statute requires that if structures or other property were there before the ditch was built, the ditchowner is obligated to care for the ditch in such a manner as will prevent damage to any property located prior to ditch construction. If he fails to do so, he may be found liable for damages through civil proceedings.

16. Question: If I own irrigated land within the boundaries of an irrigation district or company, and a neighbor all of a sudden begins using a delivery lateral or waste ditch in which I have always been the only user, can I have the water commissioner, State Engineer's office, or Board of Control throw him out of "my" ditch?

Answer: No. Since there is no requirement that a permit map accompanying a filing to the State Engineer for a multi-owner ditch or canal has to show individual laterals for delivery of water to each individual farm or tract, there is seldom any record for water administrator use delineating who all is entitled to use a specific delivery lateral or waste ditch. In the absence of any documentation to the effect of who has a right to take water out of any given ditch, the only way to establish ownership is, again, by agreement of the parties or through litigation. It sometimes happens that the district or company will have its own map and/or listing of users entitled to take water from a certain headgate or lateral and in those cases, the findings of the directors would rule. Since state water administrators normally have no records to determine such matters, they have no authority deciding who can and can't use a certain internal lateral or waste ditch.
17. Question: Has there been any pronouncement as to legalities of someone placing unauthorized obstructions, or undersized culverts, in an irrigation or wastewater ditch?

Answer: Aside from the knowledge that basic common sense dictates that one just can't obstruct a ditch or channel where water is accustomed to flowing, Wyoming Statutes regarding miscellaneous offenses to public health and safety provide the following penalty:

"If any person, company, or corporation shall obstruct or injure...or shall in anywise pollute or obstruct any watercourse, lake, pond, marsh...or continue such obstruction...so as to render the same unwholesome or offensive...[he/they] so offending...shall be fined not exceeding $100, and such nuisance...may be removed...by the sheriff of the proper county." (W.S. 35-10-401).

Similarly, under the general regulatory provisions of the game and fish statutes, section 23-3-204(b) (ii) reads:

"No person shall allow any refuse or substance to pass into any public water...which obstructs the natural flow, channels, or condition of any stream or body of water."

"Violation of this section constitutes a first degree misdemeanor." (W.S. 23-3-204 (c)).

Another direct reference in the statutes to ditch obstruction is found in the general provisions regarding highways, and outlines the procedures to be followed when such an obstruction causes flooding of public roads.

"No person or persons...shall be permitted or allowed to dam the water or waters of any stream or...ditch...so that the water thus dammed...shall overflow any public road or highway...nor shall any person...owning or controlling any ditch or irrigated lands, allow any wastewater from the same to flow across or upon any public road or highway. Any person finding a public road or highway or bridge flooded or damaged by such wastewater may report the same to the road supervisor of the county in which the road, highway, or bridge may be located, who shall make an inspection and report to the prosecuting attorney of the said county. If the report to the...supervisor shows that such damage has occurred, it shall then be the duty of the said prosecuting attorney to institute proceedings against the party or parties whose negligence has caused such damage." (W.S. 24-1-116).

While these references are somewhat specific as to their intent, it is again clear that water administrators are not intended to be involved in their resolution. These statutes are not found under Title 41, the water statutes, but rather are constructed under Title 23 (Game and Fish), Title 24 (Highway) and Title 35 (Public Health and Safety), and require the complaining party to file a civil complaint with the proper civil authorities.

The only possible reference to ditch obstruction in the Title 41 statutes would have to be inferred from the "Prohibited acts" found under W.S. 41-5-110, which water administrators often refer to as the penalty reference for water stealing. That statute reads as follows:

"Any person or persons who shall knowingly and willfully cut, dig or break down, or open any gate, bank, embankment or side of any ditch, canal or reservoir, flume, tunnel or feeder in which such person or persons may be joint owners, or on the property of another, or in the lawful possession of another or others, and used for the purpose of irrigation, milling, manufacturing, mining or domestic purposes, with intent maliciously to injure any person, association or corporation, or for his or her own gain, unlawfully, with the intention of stealing, taking or causing to run or pour out of such canal or reservoir, feeder or flume,
any water for his or her own profit, benefit or advantage, to the injury of any other person, persons, association or corporation lawfully in the use of such water, or of such ditch, canal, tunnel, feeder or flume, he, she, it or they, so offending shall be deemed guilty of a misdemeanor, and on conviction thereof shall be fined in any sum not exceeding one hundred dollars ($100.00), and may be imprisoned in the county jail not exceeding six (6) months, or both, in the discretion of the court."

While ditch obstruction is not specifically mentioned in this statute as an action a person may carry out "with intent maliciously to injure any person...or for his or her own gain," there exists a possibility that an offender attempting to steal someone else's water by diverting it out of its proper ditch may place a dam or other obstruction in the ditch to facilitate such diversion. It appears that this is the only circumstance in which a water administrator would have jurisdiction to become involved, and even then, the duties would only extend to denying the stolen water or, under extreme circumstances, arrest for the act of stealing water. The obliteration of a ditch, or obstruction of a dry ditch in anticipation of stealing water later would still be considered civil differences between parties, and be countered by the filing of a complaint with civil authorities.

It sometimes happens that someone will install a culvert crossing or other pipe, which is deemed too small by the owner or owners of the ditch, in a ditch used to supply appropriated water, or carry wastewater. The water administrator is often contacted and asked to require the offender(s) to either remove or install a larger pipe to restore the original capacity of the ditch at that point. Because there is no statutory or case law guidance for the water administrator to take such an action, it is again proper to identify such a disagreement as a civil matter between the parties. While most water administrators have some degree of engineering expertise, they are not, for the most part, qualified to determine whether or not a pipe or culvert is of adequate or proper size to deliver or carry a specified amount of water. If the ditch overflows because the newly installed culvert can't handle the water, it will be necessary to determine whether it was because the culvert was too small, or whether the ditchowner was attempting to carry more water than he should have been. Such a determination would have to be made by a competent engineer retained by the parties, unless the water administrator has extreme confidence in his engineering abilities, and is willing to stand behind them in court.

18. Question: What if a landowner builds a fence right up next to the ditch or across any ditchbank which has been clearly established as being within the historic maintenance easement of that ditch?

Answer: The answer to this question is the same as the answer to Question Number 11. If a landowner interferes with a ditchowner’s ability to maintain his ditch, the ditchowner may seek an injunction from the court ordering the landowner to refrain from interfering.

19. Question: Suppose a ditchowner or company, after cleaning its ditch through my property, leaves the silt or other dredged material in unsightly piles, or deposits it on my fence, road or other property. Am I obligated to accept such treatment?

Answer: Not necessarily. As discussed in the answer to Question number 7, the ditch easement cannot be continuously expanded or exercised without consideration for the servient landowner. The ideal method of disposing of dredged material would often be to load it into dump trucks and haul it away. However, economics often dictate that this approach may not be feasible or desirable, or that the material is needed to rebuild the banks of the ditch in the same area. In these cases, the ditchowner should take care in depositing the dredged material so as not to cover any more property than has historically been covered and,
upon completion of the cleaning, smooth the piles out into a level and slightly berm if requested by the landowner. As described in the answer to Question number 7, any injury done to the landowner raises the possibility of liability against the ditchowner.

20. Question: Who determines the necessity and extent of ditch maintenance? Suppose my neighbor, with whom I share ownership of a ditch, decides that our ditch needs extensive work and, without talking to me, hires a contractor, or himself carries out work which I feel is far in excess of what was necessary to maintain the ditch in operating condition and then sends me a bill for my share. Am I obligated under W.S. 41-5-102 to pay my proportionate share of the cost of the job, if I feel sure the work could have been done for much less cost?

Answer: A co-owner in a ditch should never undertake to work on the co-owned ditch without discussing the necessity and extent of the proposed work with his co-owners and securing their agreement as to what work needs to be done and how it will be paid for. The statute that obligates a co-owner to pay "...his, her or their proportionate share of the work..." uses the phrase "...necessary for the proper maintenance and operation of such ditch..." as the guide. Work done over and above what is "necessary," is done at the expense of the one who does, or contracts, the excess work and costs. Clearly, the only ones who can determine the necessity of maintenance work are the co-owners of the facility. In some cases, depending on his knowledge of the system, the local water commissioner may be asked to give his opinion as to the necessity and extent of work needed, based on the ditch capacity necessary to carry water to water rights on down the ditch, etc. If the work has already been done at the time the water administrator is contacted, unless he has personal knowledge of the condition of the ditch before the work, he should once again inform the complainants that their lawyers should be contacted to settle the matter. In the case of a company ditch, it sometimes happens that the company as a whole will vote to conduct maintenance or improvements on the ditch over the objection of one or more of its members, who, once the work is done, will refuse to pay for their proportionate share. Provided the benefits are deemed to be a value to the purpose of the whole company, it will generally be found that the enforcement provisions of W.S. 41-5-102, 103 and 105 are applicable.

21. Question: Does my ditch maintenance easement through neighboring properties include the right to cut down trees that have grown up along the ditchbanks?

Answer: Historically in Wyoming the understanding has been that the ditchowner has the right to cut all trees and brush along the ditch as part of his obligation to "maintain the embankments thereof so that the water of such ditch may not flood or damage the premises of others" (W.S. 41-5-101). Mature tree roots seeking water which grow out into the line of a ditch have the effect of catching trash and debris which can plug the ditch and cause it to overflow, creating a damage liability for the ditchowner. Stands of trees along any watercourse often attract beaver which create obstruction problems by cutting trees so that they fall into the water with the same result. Tree root pathways in ditchbanks, the same as in reservoir dams, create conduits for seepage which can result in washouts and other injurious situations. Additionally, USDA SCS information shows that one mature cottonwood or willow tree will consume up to 250 gallons of water per day, revealing that the cumulative consumption effects of ditchbank phreatophytes can be negatively significant on appropriated water which is being conveyed through a ditch on its way to its designated land.

With the proliferation of subdivisions in irrigated land, the problem has taken on an additional dimension. Subdivision lot buyers who find an irrigation ditch traversing their property often see a landscaping opportunity in that the ditch
provides sort of an automatic watering system. They will then plant expensive trees or shrubs in the ditch easement with the intent that the roots from their plants will grow directly to the ditch for water. When the ditchowner comes through to clean the ditch in the spring, his dual-tired tractor mashes, breaks or destroys the landscape trees and the fight is on. To date in Wyoming there has not been found a successful civil case wherein the tree owners have overcome the right and obligation of the ditchowner to maintain his ditch embankments under W.S. 41-5-101. While under certain circumstances the landowner and ditchowner might sign some sort of written agreement that the trees can stay as long as the landowner will accept a transfer of liability to himself in case an injurious situation occurs, any vegetation encroachment on the easement which negates the ability of the ditchowner to get his ditch cleaning equipment through as he historically has should be rejected.

22. Question: Suppose a spring flood or beaver work has changed the stream channel on my neighbor's land so that water to satisfy my appropriation no longer comes to my headgate. Can I enter my neighbor's land to restore the channel to protect my ability to divert?

Answer: The Wyoming Supreme Court and Wyoming Attorney General have answered this question in the affirmative (see Attorneys General Opinions, July 27, 1965, Opinion 34). In the 1903 case of Willey v. Decker, the Wyoming Supreme Court noted:

"That a valid appropriation of water from a natural stream constitutes an easement in the stream, and that such easement is an incorporeal hereditament, the appropriation being in perpetuity, cannot be disputed. He is an appropriator from the natural stream, through the intermediate agency of the ditch, and has the right to have the quantity of water so appropriated flow in the natural stream, and through the ditch for his use."
In summary, it is emphasized that this memorandum is not intended to provide conclusive legal answers to the questions posed. It is also emphasized that water administrators are not empowered to adjudge as between parties involved in ditch disputes. This memorandum is intended to provide the water administrator with a general background of historic practice the courts have used to resolve conflicts over the use of ditches, in order that the administrator may have documented references to support any advice he may be called upon to offer to persons involved in conflicts over ditch matters. It is also intended to provide water administrators with the ability to be consistent with their counterparts across the state, in the positions they may take when confronted with the situations noted. It is possible in some cases that litigation may be avoided by the water administrator’s ability to offer advice as a disinterested or neutral arbitrator, but he should not represent his advice as being a final decree. Upon receipt of the administrator’s advice, the parties must be allowed to make their own decision as to whether or not they wish to seek additional legal advice or pursue litigation.
Appendix H

Canal Inventory Maps
Covey / Mau Canals
Covey / Mau Canals

Legend

Wetlands CLASS

- Aquatic Bed
- Emergent
- Sands Shrub
- Unconsolidated Bottoms
- Unconsolidated Shale

Covey / Mau Canals

Legend

Wetlands CLASS

- Aquatic Bed
- Emergent
- Sands Shrub
- Unconsolidated Bottoms
- Unconsolidated Shale
Covey / Mau Canals
Covey / Mau Canals
Appendix I

Environmental Permitting
United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
5353 Yellowstone Road, Suite 308A
Cheyenne, Wyoming 82009

In Reply Refer To:
ES-61411/W.22/WY08SL0040

Doug Yadon
Chris Wichmann
Short Elliott Hendrickson, Inc.
2637 Midpoint Drive, Suite E
Fort Collins, Colorado 80525-4432

Gentlemen:

Thank you for your letter of November 14, 2007, received in our office on November 15, regarding the proposed Sublette Creek Reservoir and Covey/Mau Canal Rehabilitation Project, Level II Study. Based on information provided in your letter, Short Elliott Hendrickson, Inc. is under contract to the Wyoming Water Development Commission (WWDC) to evaluate alternatives for new multipurpose reservoir storage within the Sublette Creek drainage basin and to assess the condition and need for rehabilitation or upgrade (if any) of the existing Covey Canal and Mau Ditch. Five alternatives have been identified with target reservoir capacities ranging from 1,500 acre-feet (af) to 5,000 af with potential additional capacity ranging from 0 to 10,000 af. All alternatives are located within Lincoln County, Wyoming.

As stated in your letter, the overall objective of the dam and reservoir component of the project is assess the technical feasibility and permitability of storing as much as practicable of Wyoming's share of legally available water in this portion of the Bear River basin as is currently allocated to the Cokeville Development Association for the benefit of local irrigation and other potential uses in Wyoming. Sublette Creek is tributary to the Bear River approximately 3 miles south of Cokeville, Wyoming. Bureau of Land Management, state and private lands are present within the Sublette Creek drainage basin.

In response to your request, the U.S. Fish and Wildlife Service (Service) is providing you with information on threatened and endangered species and migratory birds. The Service provides recommendations for protective measures for threatened and endangered species in accordance with the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.). Protective measures for migratory birds are provided in accordance with the Migratory Bird Treaty Act (MBTA), 16 U.S.C. 703 and the Bald and Golden Eagle Protection Act (BGEPA), 16 U.S.C. 668.
If you determine that the proposed project may affect any of the following listed species, please contact our office to discuss consultation requirements under the Act:

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>STATUS</th>
<th>HABITAT</th>
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<tbody>
<tr>
<td>Black-footed ferret <em>(Mustela nigripes)</em></td>
<td>Endangered</td>
<td>Prairie dog towns</td>
</tr>
<tr>
<td>Canada lynx <em>(Lynx canadensis)</em></td>
<td>Threatened</td>
<td>Montane forests</td>
</tr>
<tr>
<td>Gray wolf <em>(Canis lupus)</em></td>
<td>Experimental</td>
<td>Greater Yellowstone ecosystem</td>
</tr>
<tr>
<td>Ute ladies'-tresses <em>(Spiranthes spilvialis)</em></td>
<td>Threatened</td>
<td>Seasonally moist soils and wet meadows of drainages below 7000 feet</td>
</tr>
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</table>

**Black-footed ferret**: Black-footed ferrets may be affected if prairie dog towns are impacted. Please be aware that black-footed ferret surveys are no longer recommended in black-tailed prairie dog towns statewide. However, we encourage you to protect all prairie dog towns for their value to the prairie ecosystem and the myriad of species that rely on them. We further encourage you to analyze potentially disturbed prairie dog towns for their value to future black-footed ferret reintroduction.

**Canada lynx**: The Service published a Final Rule in the Federal Register on March 24, 2000 (65 FR 16052) listing the Canada lynx *(Lynx canadensis)* in the contiguous United States as threatened. Historically, lynx were observed in every mountain range in the state. Concentrations of observations occur in western Wyoming in the Wyoming and Salt River ranges and continuing north through the Teton and Absaroka ranges in and around Yellowstone National Park. Numerous records have also come from the west slope of the Wind River Range, with fewer observations in the Bighorn and Uinta mountains (Reeve et al. 1986). In Wyoming, the lynx lives in subalpine/coniferous forests of mixed age and structural classes. Mature forests with downed logs and windfalls provide cover for denning sites, escape, and protection from severe weather. Early to mid-successional forest with high stem densities of conifer saplings provide optimal habitat for the lynx's primary prey, the snowshoe hare. Snowshoe hare-reach their highest densities in regenerating forests that provide visual cover from predators and thermal cover (Wolff 1980, Litvaitis et al. 1985). It is likely that winter, when food is less abundant and less nutritious and energy demands are higher, is the limiting season for snowshoe hares (Pietz and Tester 1983). To most benefit lynx, habitats should retain an overstory for concealment and forested connectivity between feeding, security, and denning habitats. On federal lands, federal agencies have agreed to apply the Lynx Conservation Assessment and Strategy (LCAS, Ruediger et al., 2000) to project evaluations in order to analyze effects of planned and on-going projects on the lynx and lynx habitat. The LCAS contains the best available information regarding management actions and their effects on lynx and provides standards and guidelines which, when implemented, will provide consistent and effective
conservation of lynx on federal lands. However, please be advised that the USDA Forest Service has amended Forest Plans to include updated lynx management guidance that supersedes the LCAS. In the future, BLM guidance for lynx management may be revised accordingly. Please contact your local BLM Field Office for further guidance.

The Service has identified significant threats to the lynx including (1) loss and/or modification of habitat; (2) past commercial harvest (trapping), which is partially responsible for the extremely small lynx population; (3) inadequate regulatory mechanisms to protect lynx and their habitat; and (4) other factors such as increased human access into suitable habitat and human-induced changes in habitat allowing other species (e.g., bobcats and coyotes) to move into lynx habitat and compete with them. Examples of human alteration of forests include loss of and conversion of forested habitats through urbanization, ski areas and other developments; fragmentation that leads to isolation of forested habitats by highways or other major construction; and certain timber harvesting practices and fire suppression measures.

Gray wolf: All wolves within Wyoming are now considered part of the nonessential experimental population. Although such wolves remain listed and protected under the Endangered Species Act of 1973, as amended (Act), additional flexibility is provided for their management under the provisions of the final rule and special regulations promulgated for the nonessential experimental population on November 22, 1994 (59 FR 60252). Requirements for interagency consultation under section 7 of the Act differ based on the land ownership and/or management responsibility where the animals occur. On any unit of National Park System or National Wildlife Refuge System lands, wolves that are part of the experimental population are considered a threatened species and the full provisions of section 7 apply. Thus, the Service and any other action agency is prohibited from authorizing, funding or carrying out an action within a National Park or National Wildlife Refuge that is likely to jeopardize the continued existence of the gray wolf. Formal section 7 consultation is required if a Federal action within these areas "may affect" the gray wolf.

Additional management flexibility is provided for managing wolves existing outside of the National Park or National Wildlife Refuge System (e.g., Forest Service lands). Wolves designated as nonessential experimental in these areas are treated as proposed rather than listed. Two provisions of section 7 apply to Federal actions outside National Parks or National Wildlife Refuges: (1) section 7 (a)(1), which states all Federal agencies shall utilize their authorities to carry out programs for the conservation of listed species; and, (2) section 7 (a)(4), which requires Federal agencies to confer with the Service on actions that are likely to jeopardize the continued existence of the species.

Wolves are dependant on movements of big game populations and may occur in large ungulate migration, wintering, or parturition areas. During project activities wolves may change their use of the project areas based upon changes to big game population numbers and changes in movement of herds. Project planning should consider impacts to big game populations, including wintering grounds and migration corridors.
Ute ladies'-tresses: Ute ladies'-tresses is a perennial, terrestrial orchid, 8 to 20 inches tall, with white or ivory flowers clustered into a spike arrangement at the top of the stem. *S. diluvialis* typically blooms from late July through August; however, depending on location and climatic conditions, it may bloom in early July or still be in flower as late as early October. *S. diluvialis* is endemic to moist soils near wetland meadows, springs, lakes, and perennial streams where it colonizes early successional point bars or sandy edges. The elevation range of known occurrences is 4,200 to 7,000 feet (although no known populations in Wyoming occur above 5,500 feet) in alluvial substrates along riparian edges, gravel bars, old oxbows, and moist to wet meadows. Soils where *S. diluvialis* have been found typically range from fine silt/sand, to gravels and cobbles, as well as to highly organic and peaty soil types. *S. diluvialis* is not found in heavy or tight clay soils or in extremely saline or alkaline soils. *S. diluvialis* seems intolerant of shade and small scattered groups are found primarily in areas where vegetation is relatively open. Surveys should be conducted by knowledgeable botanists trained in conducting rare plant surveys. *S. diluvialis* is difficult to survey for primarily due to its unpredictability of emergence of flowering parts and subsequent rapid desiccation of specimens. The Service does not maintain a list of “qualified” surveyors but can refer those wishing to become familiar with the orchid to experts who can provide training or services.

Migratory Birds: The MBTA, enacted in 1918, prohibits the taking of any migratory birds, their parts, nests, or eggs except as permitted by regulations, and does not require intent to be proven. Section 703 of the MBTA states, “Unless and except as permitted by regulations ... it shall be unlawful at any time, by any means or in any manner, to ... take, capture, kill, attempt to take, capture, or kill, or possess ... any migratory bird, any part, nest, or eggs of any such bird...” The BGEPA prohibits knowingly taking, or taking with wanton disregard for the consequences of an activity, any bald or golden eagles or their body parts, nests, or eggs, which includes collection, molestation, disturbance, or killing.

Work that could lead to the take of a migratory bird or eagle, their young, eggs, or nests (for example, if you are going to erect new roads, or power lines in the vicinity of a nest), should be coordinated with our office before any actions are taken. Removal or destruction of such nests, or causing abandonment of a nest could constitute violation of one or both of the above statutes. Removal of any active migratory bird nest or nest tree is prohibited. For golden eagles, inactive nest permits are limited to activities involving resource extraction or human health and safety. Mitigation, as determined by the local Service field office, may be required for loss of these nests. No permits will be issued for an active nest of any migratory bird species, unless removal of an active nest is necessary for reasons of human health and safety. Therefore, if nesting migratory birds are present on, or near the project area, timing is a significant consideration and needs to be addressed in project planning.

If nest manipulation is proposed for this project, the project proponent should contact the Service's Migratory Bird Office in Denver at 303-236-8171 to see if a permit can be issued for this project. No nest manipulation is allowed without a permit. If a permit cannot be issued, the project may need to be modified to ensure take of a migratory bird or eagle, their young, eggs or nest will not occur.
Bald Eagle: On July 9, 2007, the Service published a Federal Register notice (72 FR 37346) announcing that the bald eagle (Haliaeetus leucocephalus) would be removed from the list of threatened and endangered species under Endangered Species Act of 1973, as amended (16 U.S.C 1531 et seq.) on August 8, 2007. However, the protections provided to the bald eagle under the Bald and Golden Eagle Protection Act, 16 U.S.C. 668 (BGEPA) and the Migratory Bird Treaty Act 16 U.S.C. 703 (MBTA) will remain in place. The term “disturb” under the BGEPA has recently been defined as: “to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior (72 FR 31332).

To assist with the de-listing transition, the Service has developed National Bald Eagle Management Guidelines to advise land managers when and under what circumstances the protective provisions of the MBTA and BGEPA may apply to their activities. These guidelines are available on our web page at http://www.fws.gov/migratorybirds/baldeagle.htm. The Service intends to update these guidelines as more information becomes available through adaptive management. Please be advised that the Service’s Wyoming Ecological Services Office, in collaboration with the Wyoming Game and Fish Department will be modifying these guidelines in the near future to ensure they adequately address the unique conditions of our state. We will notify you of these “Wyoming” guidelines as soon as they become available. Additionally, the Service has proposed a permit structure under the BGEPA that is similar to the permit structure that exists under the Endangered Species Act for when impacts are unavoidable. However, this structure is currently undergoing public comment and is not yet in place. Please contact the Wyoming Ecological Services Office if you have any questions regarding this permit structure, the de-listing decision, or require technical assistance regarding any planned or ongoing activities that cannot be conducted in compliance with the MBTA, BGEPA, or the National Bald Eagle Management Guidelines.

We appreciate your efforts to ensure the conservation of Wyoming’s fish and wildlife resources. If you have questions regarding this letter or your responsibilities under the Act and/or the MBTA in particular, please contact Jan McKee of my office at the letterhead address or phone (307) 772-2374, extension 242.

Sincerely,

[Signature]
Brian T. Kelly
Field Supervisor
Wyoming Field Office

cc: BLM, Kemmerer Field Office, Kemmerer, WY (MaryJo Rugwell)
WGFD, Non-game Coordinator, Lander, WY (B. Oakleaf)
WGFD, Statewide Habitat Protection Coordinator, Cheyenne, WY (V. Stelzer)
Literature Cited


### Sublett Creek Reservoir and Covey/Mau Canal

**Kemmerer Field Office Meeting**  
December 12, 2007

<table>
<thead>
<tr>
<th>Name</th>
<th>Office/Address</th>
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<th>E-Mail Address</th>
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<tbody>
<tr>
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<tr>
<td>Lara Oles (Wildlife)</td>
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<tr>
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<td>Realty Specialist BLM-KFO</td>
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<td>Chris Wichmann</td>
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<tr>
<td>Lance Porter</td>
<td>KFO</td>
<td>307-828-4503</td>
<td><a href="mailto:lance_porter@blm.gov">lance_porter@blm.gov</a></td>
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<tr>
<td>Steve Muth</td>
<td>WY Water Dev. Comm</td>
<td>307-777-5417</td>
<td><a href="mailto:smuth@state.wy.us">smuth@state.wy.us</a></td>
</tr>
<tr>
<td>Doug Yaden</td>
<td>2637 Midnight Dr,</td>
<td>470.484.3611</td>
<td><a href="mailto:duyaden@sehinc.com">duyaden@sehinc.com</a></td>
</tr>
<tr>
<td></td>
<td>Cheyenne</td>
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</table>
December 14, 2007

WER 11715
Short Elliott Hendrickson Inc.
Sublette Creek Reservoir and Covey/Mau Canal Rehabilitation Project
Level II Study

Chris Wichmann
Short Elliott Hendrickson Inc.
7000 Yellowtail Road, Suite 230
Cheyenne, WY 82009

Dear Mr. Wichmann:

The staff of the Wyoming Game and Fish Department has reviewed the Sublette Creek Reservoir and Covey/Mau Canal Rehabilitation Project Level II Study. We offer the following comments for your consideration.

Terrestrial Considerations:

We have significant terrestrial concerns regarding this proposal.

These proposed reservoirs will have significant impacts on both terrestrial wildlife populations and public access. Crucial winter range and migration corridors will be impacted for the Wyoming Range Mule Deer, West Green River Elk, and Lincoln Moose herd units. All of these herd units are high profile, extremely popular herds that yield substantial consumptive and non-consumptive recreational contributions to Wyoming. The Wyoming Range Mule Deer herd is one of the premiere mule deer populations in the world. A large percentage of the deer in this herd unit move directly through the proposed reservoir areas from summer to winter ranges. Given existing impacts to this and other ungulate populations in this area, additional impacts will greatly hamper these herds' ability to meet publicly acceptable management objectives.

In addition to impacts to big game species, this proposal will negatively impact multiple greater sage-grouse leks, and adjacent nesting and brood rearing habitat. Given the current status of this species and proposals from the Department and other entities to protect critical greater sage-grouse habitats (including this area), these impacts are unacceptable.

A significant amount of riparian habitats will be inundated due to this proposal. Particularly in the west, including this area, riparian habitats support the highest wildlife species
diversity, and disproportionately contribute to populations of mule deer (parturition habitats), songbirds, raptors, and other species. These are particularly important habitats for moose.

Construction of these reservoirs will also negatively impact seasonal public access to large blocks of public lands under federal jurisdiction. The access road through Underwood Canyon will be inundated, removing a main access route to these lands. In addition, lands that have undergone significant cooperative (BLM, RMEF, WGFD) habitat improvement efforts will be inundated during reservoir completion, including the Lost Creek unit, which was purchased by the BLM and the Rocky Mountain elk Foundation for wintering elk, deer, and moose. Alternatively, public access during critical winter months in this area following reservoir construction will be increased, resulting in increased stress and winter losses of wintering wildlife.

**Aquatic Considerations:**

We have significant aquatic concerns regarding this proposal.

These proposed reservoirs will have significant impacts on Wyoming’s aquatic resources. The northern leopard frog, northern leatherside chub, and Bonneville cutthroat trout are three species of greatest conservation needs in the Bear River drainage. The Sublette watershed was sampled in 2005 and found native nongame fish populations of sculpins (mottled or pauite; species not determined), redside shiners, longnose dace, speckled dace and most importantly northern leatherside chubs. Leatherside chub is a species of concern throughout its range in Wyoming, Utah, and Idaho, and is the subject of a Conservation Agreement that is currently being drafted by all three states. Though Bonneville cutthroat trout were not collected in 2005 it is suspected that the species is present.

It should be noted that Bonneville cutthroat trout have been petitioned as an endangered species. The District Court of Colorado dismissed the civil action initiated by the Center for Biological Diversity challenging the USFWS decision relating to the listing of Bonneville cutthroat trout as “Not Warranted” in early 2007. However, a court order in October will make USFWS again consider this cutthroat trout species for protection as an endangered species. Not only have Bonneville cutthroat trout populations been scrutinized by nonprofit organizations, but the leatherside chub populations are also being reviewed.

In addition to the direct effects of a dam on the species in the stream, other indirect effects such as changes in water temperature, volume, and chemistry, and altered habitat that will be conducive to exotic species will also be of concern. A significant portion of wetlands and riparian habitats will also be inundated. Even though this proposal probably won't be as big an issue to Bonneville cutthroat trout as a dam on the Smiths Fork, it will have negative aspects that far outweigh any positives to the aquatic community that may occur as a result of this project. This project will have more negative impact to the Northern leatherside chub than Bonneville cutthroat trout.
Thank you for the opportunity to comment.

Sincerely,

JOHN EMMERICH
DEPUTY DIRECTOR

cc: USFWS
In Reply Refer To:
ES-614111/W.39/WY08FA0203

Mr. Doug Yadon
Short Elliott Hendrickson, Inc.
2637 Midpoint Drive, Suite E
Fort Collins, Colorado 80525-4432

Dear Mr. Yadon:

Thank you for your letter of September 3, 2008, received in our office on September 4, regarding the Draft Report for the Sublette Creek Reservoir and Covey/Mau Canal Rehabilitation Project, Level II Study. This project is tentatively planned for Lincoln County, Wyoming, southeast of the Town of Cokeville. You have requested that we review and provide comments on the draft report, particularly sections 7.0, 8.0, and 9.0.

We understand that one of the objectives of your current study is to identifying any significant known or potential environmental resource issues (but not to evaluate them at this stage). The U.S. Fish and Wildlife Service (Service) is providing you with general comments based on our review of the draft report and pursuant to the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.), and the Fish and Wildlife Coordination Act (48 Stat. 401, as amended, 16 U.S.C. 661 et seq.).

7.0 Water Storage Site Evaluation

In our correspondence dated December 5, 2007, we identified the black-footed ferret, Canada lynx, gray wolf, and Ute Ladies'-tresses as potentially occurring in the project’s vicinity. We recommend you provide adequate documentation that the necessary habitats for each of these species occur or do not occur within the project area, and the project would or would not impact that species or its habitat. For example, early to mid-successional forest with high stem densities of conifer saplings provide optimal habitat for the lynx’s primary prey, the snowshoe hare. Since this habitat type is not likely to be present on this site, one would not expect to find Canada lynx. White-tailed prairie dogs could occur on the site, supporting potential habitat for the black-footed ferret; however, the document does not indicate the prairie dog’s presence or absence. The “Sublette Creek watershed contains portions of crucial winter habitat for mule deer and elk” (Page 52), and consequently, the gray wolf could potentially be found in this area. Finally, any potential habitat for Ute Ladies'-tresses should be identified prior to finalizing the decision among the potential dam sites.
Fish passage remains a concern with dam construction projects. Although there are no known threatened or endangered aquatic species in the Sublette Creek drainage, there are two species that the Wyoming Game and Fish Department (WGFD) defines as species of greatest conservation need and are also on the Bureau of Land Management’s sensitive species list: the Northern leatherside chub (Lepidomeda copei) and the Bonneville or Bear River cutthroat trout (Oncorhynchus clarkii utah). The Northern leatherside chub was recently petitioned for listing, but the Service has not completed a finding on the petition. The Bonneville cutthroat trout was also petitioned, but the Service determined that the subspecies did not warrant listing at this time. However, we continue to encourage actions that will further the conservation of the Bonneville cutthroat trout.

In addition to these two fish species, the western distinct population segment of the northern leopard frog (Rana pipiens) was also petitioned for listing under the Act, but the Service has not completed a finding on the petition. We suggest working closely with the WGFD to discuss the potential for impacts to this species and possible mitigation strategies if appropriate.

9.0 Permitting and Mitigation

If this project proceeds, there are several mitigation tools that should be investigated to reduce impacts to the sensitive fish species:

- Construct the dam site as high in the drainage as possible, to reduce the amount of stream habitat obstructed by the dam,
- Install fish screens on the diversion dam (especially if bringing water off the Smiths Fork) that shunts water into the Covey Canal (and eventually into the reservoir),
- Install fish ladders or other alternative method (e.g., engineered side channel) to bring fish around the dam, and
- It appears that there is a low-head dam (possibly a diversion dam) on Sublette Creek at its confluence with the Bear River. If this dam/diversion could be re-designed to allow fish passage upstream where it is blocked, several miles of stream habitat would be available to these sensitive fish species from the Bear River mainstem into Sublette Creek.

We appreciate your efforts to ensure the conservation of Wyoming’s natural resources. If you have questions regarding this letter or your responsibilities under the Act and/or other authorities or resources described above, please contact Scott Covington of my office at the letterhead address or phone (307) 772-2374, extension 246.

Sincerely,

[Signature]

Brian T. Kelly
Field Supervisor
Wyoming Field Office

cc: WGFD, Fisheries Supervisor, Pinedale, WY (H. Sexauer)
WGFD, Statewide Habitat Protection Coordinator, Cheyenne, WY (V. Stelter)
October 6, 2008

WER 11715
Short Elliott Hendrickson Inc.
Sublette Creek Reservoir and
Covey/Mau Canal Rehabilitation Project
Level II Study - Draft Report

Doug Yadon
Short Elliott Hendrickson Inc.
2637 Midpoint Drive, Suite E
Fort Collins, CO 80525-4432

Dear Mr. Yadon:

The staff of the Wyoming Game and Fish Department has reviewed the Sublette Creek Reservoir and Covey/Mau Canal Rehabilitation Project Level II Study - Draft Report. We offer the following comments for your consideration.

**Terrestrial Considerations:**

We have no additional comments regarding terrestrial wildlife relevant to this project, beyond those presented in our letter dated December 14, 2007, many of which were addressed in the Draft Report. We would like to reiterate our concern that development of these proposed reservoirs will have significant impacts on crucial winter range and migration corridors for the Wyoming Range mule deer, West Green River elk, and Lincoln moose herd units.

**Aquatic Considerations:**

Based on what we presently know of the project and its potential operation, this dam and reservoir is not a high priority to the Wyoming Game and Fish Department (WGFD) in terms of additional reservoir fishing opportunities to Wyoming. At this time we have not conducted any detailed analyses or quantified the project’s overall effects to the aquatic resources in the affected area of the project. As a consequence all of the comments provided here should be viewed as preliminary assessments and may change as additional project information becomes available. Note also that these comments may not represent a complete listing of potential project effects.

**BACKGROUND INFORMATION**

The native amphibians, reptiles, and fish present within the Sublette Creek Reservoir project area include northern leopard frog, tiger salamander, northern leatherside chub,
Bonneville cutthroat trout (BRC), sculpins, longnose dace, Utah chub, speckled dace, Utah suckers, and garter snakes. In 2008, we electrofished and conducted amphibian surveys and found three species of concern within the project area. These include northern leatherside chubs, Bonneville cutthroat trout and northern leopard frogs.

Northern leatherside chub (Native Species, Status 1, or NSS1 for short) populations are physically isolated and/or extremely low density and extirpation seems possible. Habitat for leatherside chubs is declining or vulnerable to habitat alterations. The draft range-wide conservation agreement for leatherside chub in the states of Wyoming, Utah and Idaho was completed in July 2008 and is currently being reviewed by specialists within the states. Leatherside chubs evolved and reside in river systems with diverse physical habitat features. The species typically lives in cool to cold flowing waters with water temperatures less than 68 degrees Fahrenheit. Adults use pools and riffles but the juvenile fish require low velocity or non-flowing backwater pools that are connected to the main stream to complete this stage of their life history. The disruption of access to diverse stream habitats by the creation of in-channel barriers of any kind (physical, chemical or thermal) and replacement of flowing water habitat with standing water habitat such as a reservoir will likely have negative consequences for this species.

Bonneville cutthroat trout (NSS2 species) populations are also physically isolated in much of their historic range but overall habitat in Wyoming is considered stable. The Bonneville cutthroat trout range-wide agreement and a strategy was completed in 2000 with the goal being to “ensure the long-term existence of Bonneville cutthroat trout within its historic range by coordinating conservation efforts among states, tribal governments, federal management agencies, and other involved parties”. It should be noted that Bonneville cutthroat trout have been petitioned for listing as an endangered species under the U. S. Fish and Wildlife Service (USFWS) Endangered Species Act. The District Court of Colorado dismissed the civil action that was initiated by the Center for Biological Diversity challenging the USFWS decision relating to the listing of Bonneville cutthroat trout as “Not Warranted” in early 2007. However, a court order in October of 2007 made the USFWS again consider this cutthroat trout species for protection as an endangered species. Once again listing was considered “Not Warranted”. Bonneville cutthroat trout populations will likely continue to been scrutinized by nonprofit organizations in the future.

Bonneville cutthroat trout evolved in a riverine (flowing water) system though populations do persist in some reservoir environments where there is adequate habitat for them to complete their entire life history. Cutthroat trout require cold water (preferably less than 65 F) for all life stages. Spawning and rearing streams tend to be cold and nutrient poor. Bonneville cutthroat trout seek out gravel substrate in riffles and pool crests for spawning and they require substrate relatively clean of fine sediment.

Northern leopard frogs are found throughout the project area, including the proposed inundated area (Site 1). Though it appears that their population and habitats are stable there is little known about their distribution throughout their historic range.
POTENTIAL PROJECT-RELATED EFFECTS:

All reservoirs cause significant changes in the natural characteristics of flowing streams. Specifically, dams and the water released from reservoirs is known to affect hydrologic patterns (intra- and inter-annual flow variability patterns that many aquatic organisms are adapted to), stream connectivity (up and downstream passage for aquatic organisms, nutrients, and bedload materials), geomorphology (the physical form and function of stream channels including erosion processes and stream bank stability), biology (the number and kinds of organisms that occur within the reservoir footprint and downstream channel – including fish, terrestrial wildlife, and riparian vegetation), and water quality (temperature, chemistry, and suspended sediments). A good source of information about these effects and supporting documentation can be found in Annear et al. (2004). Should this project be built we anticipate all of these kinds of effects, though some may be of more significance than others. Likewise, some effects may be more easily mitigated than others. Detailed, site-specific studies that may take several years to complete will be required to quantify project-related effects and develop appropriate mitigation strategies. Some but not all of the specific effects that might occur are noted below.

Water temperature in the reservoir may reach unsuitable temperatures for trout and could limit or preclude angling opportunities for cold-water species. Maximum summer water temperature in the Smiths Fork River is also of concern as summer fish kills have occurred in past years due to increased water temperature for prolonged periods. An increase in water taken from the Smiths Fork River (and resultant decreased flow in the river) could magnify this condition. The temperature of releases during the winter could also be a concern. The water in reservoirs typically stratifies according to thermal properties during the winter (and summer). In the winter, relatively warm water is found at the bottom of reservoirs, but the release of this water disrupts natural ice forming processes in the stream below the dam. Such changes can affect habitat and survival of aquatic species below the dam (Annear et al. 2002). To avoid or minimize these undesirable consequences, releases should be made from the surface of the reservoir where water temperatures are closer to the temperature of water flowing into the reservoir. Detailed stream temperature simulation studies should be done to address all of these concerns.

Nonnative trout species are present in the project area and are a concern to the persistence of the native fish species (especially Bonneville cutthroat trout). Removal of all nonnative trout from all tributaries within the project area (the entire Sublette Creek watershed) would be a benefit to the status of Bonneville cutthroat trout and help preclude the likelihood of this species being listed as threatened or endangered in the future. We encourage the project sponsor to include this feature in the project and coordinate closely with us on the details of conducting this work.

Existing information suggests that the timing, duration and magnitude of flows associated with reservoir releases into Sublette Creek may change significantly. Should this occur it is highly likely that such change in the hydrologic regime will alter geomorphological processes (erosion and deposition) and change the channel shape as well as water quality. More specifically, accelerated stream bank and streambed erosion is possible and the channel would either widen or deepen depending on what sediments are mobilized (bank or bed) and where they are deposited. As a consequence, we encourage the project sponsor to conduct a thorough geomorphological analysis of how future flow releases will affect the stream channel below the dam.
The quantity and quality (including species diversity) of riparian vegetation and habitats has a direct effect on the form and function of in-channel stream features as well as the terrestrial wildlife that reside in riparian areas. We anticipate potential riparian effects caused not only by inundation of existing habitats by a new reservoir but also as a consequence of the altered hydrologic regime of reservoir releases. We do not anticipate riparian vegetation to develop along the reservoir shoreline that will offset existing stream riparian habitats because the annual fluctuation patterns of the new reservoir will not support such growth. Likewise, the loss of overbank flooding along the stream below the dam will preclude the maintenance and development of riparian habitats over an extended length of stream. Wetland habitats associated with the existing riparian corridor will also be lost with the inundation of the project area and potential loss of overbank flooding below the dam. Wetland communities do not typically develop in the shoreline around irrigation reservoirs. As a consequence, riparian and wetland habitats within the project area (including up and downstream stream segments) should be quantified and a mitigation plan developed to offset those losses.

SPECIFIC COMMENTS ON THE REPORT

1) Sect. 3.1.2 states, "The significance of the Lost Creek Cooperative Management Unit (LCCMU) to potential water storage projects in the Sublette Creek watershed is discussed in Section 7.0." We suggest the wording be changed as follows: "Potential effects of water storage projects in the Sublette Creek watershed on the Lost Creek Cooperative Management Unit (LCCMU) are discussed in Section 7.0.". There is nothing about LCCMU in section 7.0. This is a Department concern, primarily related to terrestrial habitat issues.

2) There is no mention in the report of issues associated with riverine connectivity (passage or entrainment) for fish or other aquatic organisms. This is a concern on Sublette Creek and the Covey and Mau diversions on the Smiths Fork. The loss of Bonneville cutthroat trout into the Covey and Mau Canal diversion on the Smiths Fork River has been well documented and considering the timing of increased water diversions associated with this project this loss would likely increase. In addition, the existing diversion structure on the Smiths Fork River likely inhibits upstream movement of all fish, particularly native non-game species. Reduced flows in the river resulting from increased water diversion would further reduce opportunities for upstream movement during critical periods. We recommend that consideration of this issue be included in the project.

3) Sect. 9.1.3 - Animal and Plant Resources: There is no mention of the range-wide Bonneville cutthroat trout conservation agreement, range-wide leatherside chub conservation agreement and the WGFD Comprehensive Wildlife Conservation Strategy plan. Several species mentioned, as well as Bonneville cutthroat trout, fall under this Department management strategy. The report does not list Bonneville cutthroat trout as a species of concern. We recommend that the documents listed here be recognized as well as the recommendations they contain. The final report should also recognize that Bonneville cutthroat trout is a species of concern.

4) Sect. 6.1 (paragraph 5): "A probable instream flow requirement of 65 cfs for the Smiths Fork mainstem was identified in the previous Level 1 Study (Sunrise Engineering, Inc. 2004) assuming a reservoir was constructed on Smiths Fork. We note that this
recommendation is a preliminary one and caution against institutionalizing it. Given the present state of the project, we encourage the sponsor to remove this quantitative reference and note that a project-specific instream flow requirement will developed. It is unlikely that a single instream flow, or minimum flow, will suffice for this project. Rather, a seasonally appropriate instream flow regime is needed (Annear et al. 2004). Our agency has considerable expertise in this field and we encourage the project sponsor to work closely with our staff on this project feature.

5) Sect 8.3.2. The report states that the maximum depth of the reservoir will be 45 feet with the average depth of the reservoir will be about 17 feet. For this project to achieve one of its expressed purposes as a recreational fishery, a minimum fishery pool will be needed to ensure protection of this public value. We encourage the project sponsor to note that a guaranteed minimum fishery pool will be provided. Our agency has considerable expertise in quantifying minimum fishery pool trade-offs and we encourage the project sponsor to work closely with our staff on this project feature.

6) Sect 8.3.5. Outlet structure: To address downstream temperature concerns as described above, the outlet should include multiple penstocks to allow maximum flexibility to manage temperature of releases at all times of year. Target temperatures for summer will probably depend on a variety of factors and fishery management goals. The temperature of releases in the winter, if any, should approximate natural winter stream temperatures as closely as possible.

7) Sect 8.3.5. Return irrigation flows (quantity and quality) may have significant effects on fishery resources in the Sublette Creek drainage and the Bear River. We encourage the project sponsor to conduct a detailed study to address the potential effects of return flows on fishery resources in receiving water bodies.

PRELIMINARY MITIGATION AND FISHERY ENHANCEMENT RECOMMENDATIONS

Fish screens should be installed and maintained on the Covey and Mau canals to prevent fish loss from the Smiths Fork. Fish passage issues on the Smiths Fork also need to be addressed. If the proposed project proceeds, mitigation of these concerns (e.g. fish screen, fish ladders, and minimum flows at critical times) should be part of the plan.

Chemical treatments of the Sublette Creek drainage to remove non-native trout and restore a genetically pure population of native trout and other native fish species would be a project benefit. If included, this effort should occur prior to construction of the proposed reservoir and may take up to 3 years or more to plan and complete. Our agency has considerable expertise in this area and we recommend the project sponsor work closely with our staff to plan and conduct this work. This work should be a project expense.

As part of the above fishery renovation effort, planning and funding should also be included to salvage native fish species from renovated stream segments or collect them in other streams and reintroduce them into these restored stream habitats once non-native fish have been removed.

The project should include a minimum fishery pool to maximize public benefits. The precise size of the pool cannot be determined at this time but for planning purposes, the project sponsor may use a figure of 30% of the storage at the maximum pool elevation.
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Provide fish passage from the Bear River to the reservoir. Fish ladder at the reservoir and minimum flow in Sublette Creek at critical times needs to be part of the plan.

An instream flow requirement in the Smiths Fork should be a part of the overall mitigation plan but the present number being used by the project planners should be re-evaluated. In similar situations, it takes 12 to 18 months to plan a project, conduct field studies, analyze data, and generate recommendations for instream flow regimes. We encourage project planners to work closely with our staff to develop this project feature.

To ensure Bonneville cutthroat trout and leatherside chub have adequate habitat for spawning and rearing, mitigation measures for the tributaries entering the reservoir are necessary. Instream channel habitat improvements upstream of the proposed reservoir would improve spawning and rearing habitat for all native species. Upland habitat improvements may also be appropriate to restore, maintain or enhance riverine habitat conditions for native fish species.

An appropriate quantity and quality of wetland and riparian habitats should be created and maintained for the life of the project. Among other species, this project feature is important for all life stages of Northern leopard frogs.

Thank you for the opportunity to comment.

Sincerely,

[Signature]

JOHN EMMERICH  
DEPUTY DIRECTOR

JE:VS:gb

cc: USFWS

REFERENCES
