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3.0 AFFECTED ENVIRONMENT

This chapter describes the current conditions of the resources that might be affected by the Project. The Permit Area is located in the Great Divide Basin of Wyoming and is in the northeastern corner of Sweetwater County, Wyoming, near Carbon County, Wyoming. The Permit Area is about 15 miles southwest of Bairoil, Wyoming, about 38 miles northwest of Rawlins, and about 90 miles southwest of Casper. The Permit Area consists of 201 unpatented federal lode claims and one state mineral lease totaling approximately 4,254 acres.

The regional landscape consists of rolling plains with some draws, rock outcroppings, ridges, bluffs and some isolated mountainous areas. Vegetation is primarily sagebrush and rabbitbrush. The area is sparsely populated, and the closest residence is approximately 15 miles from the Permit Area boundary. The weather is dry and windy, with short, hot summers and cold winters. There is no perennial surface water, although there are a few ephemeral drainages that can convey surface water during spring snowmelt and following intense rainstorms.

The resources described in this section include:

- Land Use;
- Transportation;
- Geology, Ore Mineralogy and Seismology;
- Soils;
- Surface Water, Wetlands and Aquatic Ecology;
- Groundwater;
- Vegetation;
- Wildlife;
- Wild Horses;
- Meteorology, Climatology and Air Quality;
- Noise;
- Historic and Cultural Resources;
- Visual and Scenic Resources;
- Socioeconomic Conditions; and
- Background Radiology.

The description of the affected environment is based on available information from sources, such as the United States Geological Survey, and on data collected by LCI and provided in the Technical Report in support of the NRC license (LCI, 2010) and in the WDEQ-LQD Permit to Mine and associated Mine Unit 1 documents (LCI, 2011b). The information in this chapter forms the basis for assessing the potential impacts of the proposed action and viable alternatives and for developing effective monitoring and mitigation measures.

3.1 Land Use

The land within the Permit Area is entirely publicly owned. Eighty-five percent is public land, managed by the BLM through the Rawlins and Lander Field Offices, and fifteen percent is owned by the State of Wyoming (**Figure 3.1-1**). The surrounding area is also largely publicly owned, with the majority being public land and a smaller percentage being state land and scattered private holdings, including mineral claims.

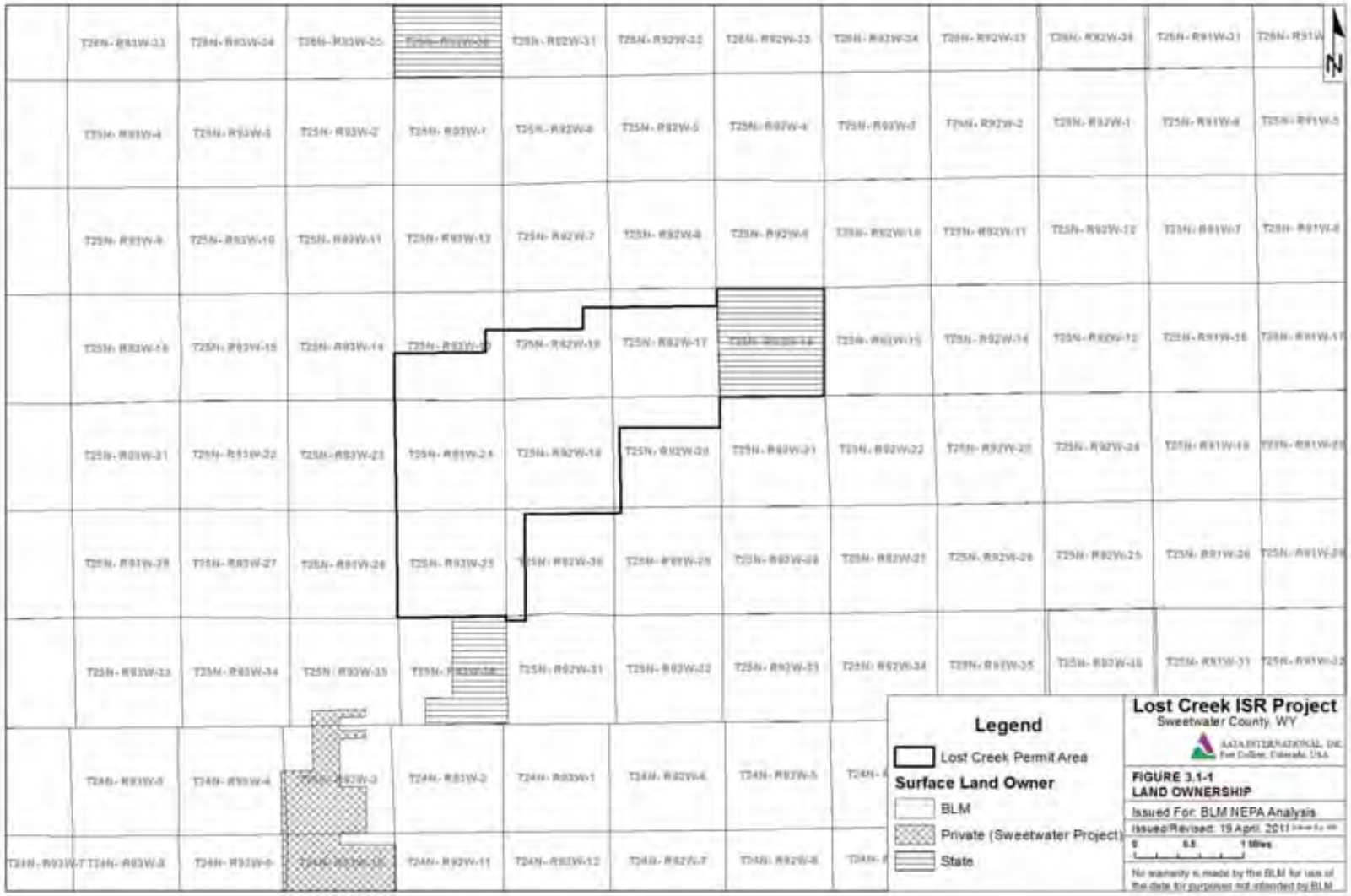
3.1.1 Historic and Existing Land Use

The historic land uses of the Permit Area and vicinity over the last century include livestock grazing, wildlife habitat, dispersed recreation, minerals and energy development, and infrastructure, and are comparable to the existing land uses. Each land use is discussed below. In addition, the wilderness characteristics of the area, originally evaluated in 1979, were reviewed in accordance with Section 603 of FLPMA.

3.1.1.1 Livestock Grazing

The primary land use in the Permit Area is rangeland for cattle; no farms, residences, or population centers are present. The only agricultural production within the Permit Area and vicinity is related to livestock grazing, which is managed in accordance with BLM grazing regulations (43 CFR 4100).

The Permit Area lies at the intersection of three BLM grazing allotments: Stewart Creek, Cyclone Rim, and Green Mountain (**Figure 3.1-2**). The Stewart Creek grazing allotment occupies 182,800 acres (170,209 public acres); Cyclone Rim occupies 308,608 acres (291,954 public acres); Green Mountain occupies 522,290 acres (468,407 public acres). The Stewart Creek grazing allotment has 1,214 acres within the Permit Area (0.7 percent of the total grazing allotment). The Cyclone Rim grazing allotment has 2,170 acres within the Permit Area (0.7 percent of the total grazing allotment), and the Green Mountain grazing allotment has 870 acres within the Permit Area (0.2 percent of the total grazing allotment).


Legend
Lost Creek Permit Area
Surface Land Owner
BLM
Private (Sweetwater Project)
State
Lost Creek ISR Project
Sweetwater County, WY
FIGURE 3.1-1
LAND OWNERSHIP
Issued For: BLM NEPA Analysis
Issued/Revised: 19 April, 2011
1 Miles
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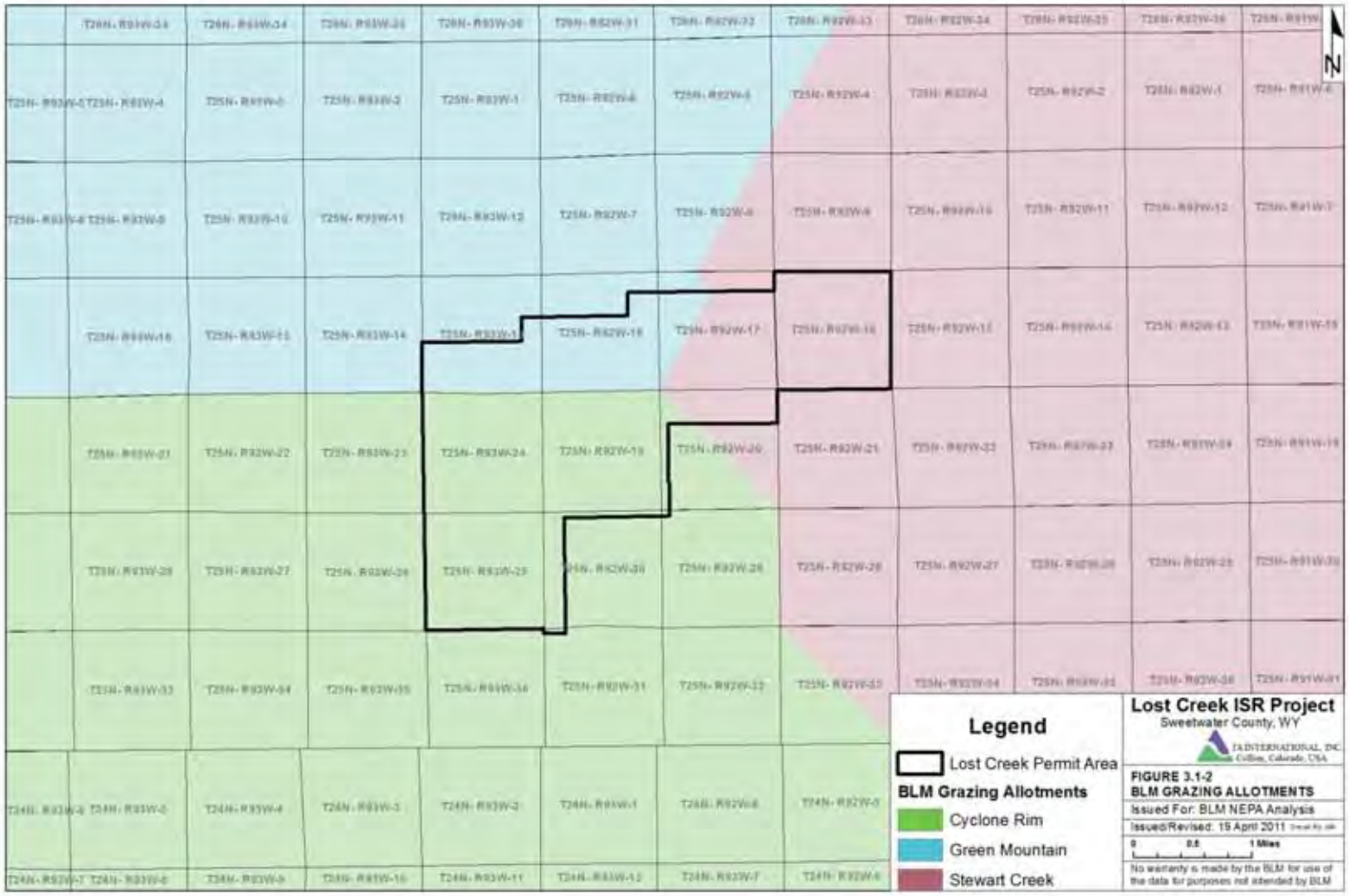
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Lost Creek Permit Area
BLM Grazing Allotments
Cyclone Rim
Green Mountain
Stewart Creek
Lost Creek ISR Project
Sweetwater County, WY
FIGURE 3.1-2
BLM GRAZING ALLOTMENTS
Issued For: BLM NEPA Analysis
Issued/Revised: 15 April 2011
0
0.5
1 Miles
No warranty is made by the BLM for use of the data for purposes not intended by BLM

The Stewart Creek and Cyclone Rim grazing allotments are managed by the BLM Rawlins Field Office. Animal Unit Months (AUMs) of summer and winter grazing are associated with each allotment. An AUM is a common unit of measure defined as the amount of forage to sustain one mature cow and calf (or the equivalent) for one month. The total AUMs of these two allotments are:

- Stewart Creek
  - Summer Cattle: 8,894 AUMs (8,418 AUMs for public land)
  - Winter Cattle: 11,034 AUMs (10,472 AUMs for public land)
- Cyclone Rim
  - Summer Cattle: 22,304 AUMs (21,060 AUMs for public land)
  - Winter Cattle: 27,504 AUMs (26,012 AUMs for public land)

The portion of the Stewart Creek allotment within the Permit Area provides as much as 80 AUMs of cattle grazing, and the portion of the Cyclone Rim allotment within the Permit Area provides as much as 205 AUMs of cattle grazing.

The Green Mountain allotment is managed by the BLM Lander Field Office, The total AUMs for the Green Mountain allotment is 66,657 AUMs (57,638 AUMs for public land). Within the Permit Area, the Green Mountain allotment provides as much as 125 AUMs of grazing.

Water sources that support this grazing are discussed in **Sections 3.5** and **3.6**.

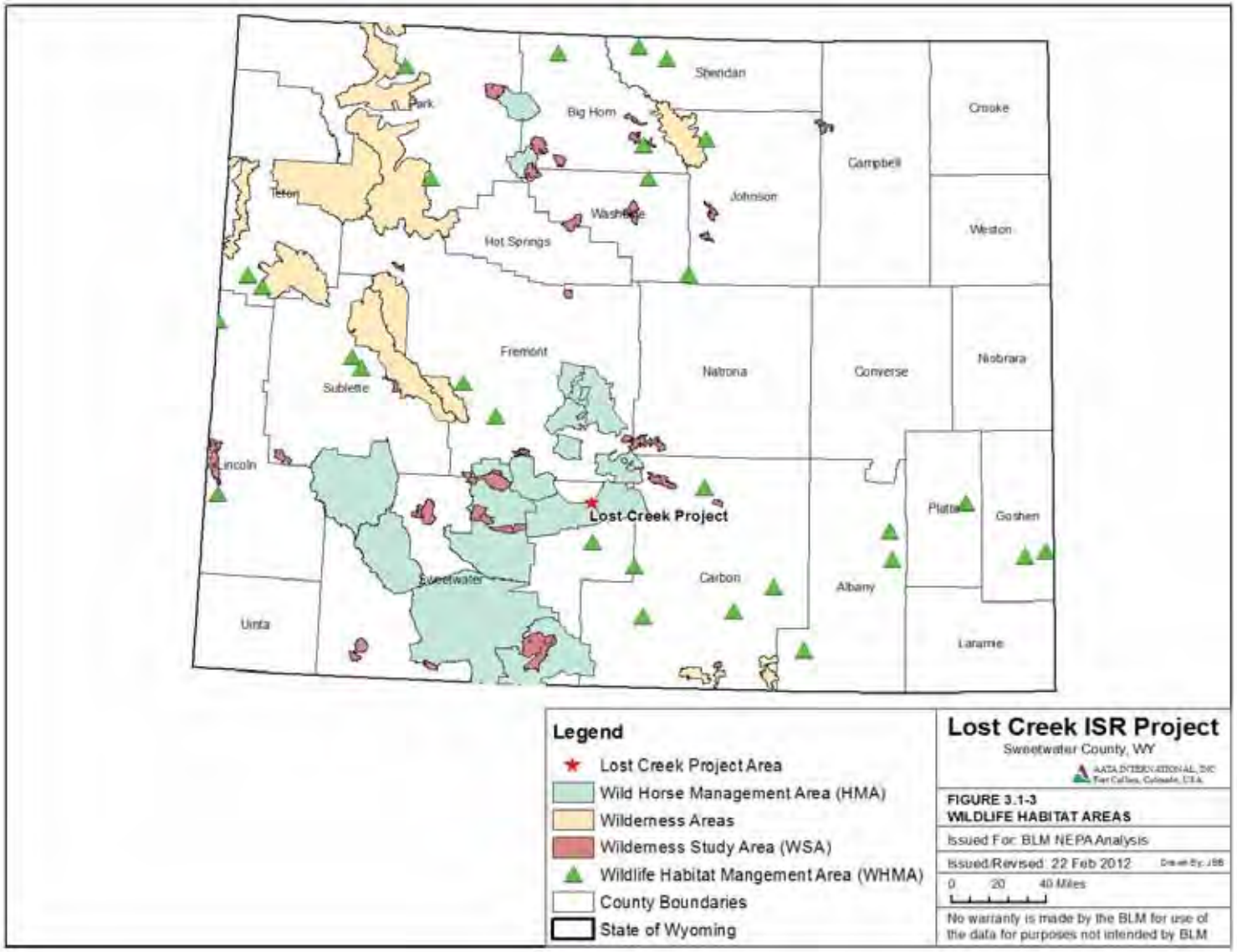
3.1.1.2 Wildlife Habitat

Of the land management regimes and priorities affecting wildlife habitat in Wyoming (WGFD, 2005b and 2012), five are discussed due to proximity to the Permit Area and per regulatory requirement:

- Wild Horse Management Areas or Herd Management Areas (HMAs);
- Wilderness Areas;
- Wilderness Study Areas (WSAs);
- Wildlife Habitat Management Areas (WHMAs); and
- Greater Sage-grouse Core Areas.

Herd Management Areas (HMAs)

The BLM manages wild horses in HMAs, establishing appropriate management levels (AMLs) for each HMA. An AML is the ideal population of wild horses for a specific area, ensuring a thriving ecological balance among all the users and resources of the HMA (wildlife, livestock, wild horses, vegetation, water, and soil). In Wyoming about 5,000 wild horses are managed within 16 different HMAs (**Figure 3.1-3**).


Sheridan
Big Horn
Crooke
Park
Campbell
Johnson
Teton
Washakie
Weston
Hot Springs
Fremont
Natrona
Converse
Niobrara
Sublette
Lincoln
Lost Creek Project
Platte
Goshen
Sweetwater
Carbon
Albany
Uinta
Laramie
Legend
Lost Creek Project Area
Wild Horse Management Area (HMA)
Wilderness Areas
Wilderness Study Area (WSA)
Wildlife Habitat Mangement Area (WHMA)
County Boundaries
State of Wyoming
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC
Fort Collins, Colorado, USA
FIGURE 3.1-3
WILDLIFE HABITAT AREAS
Issued For: BLM NEPA Analysis
Issued/Revised: 22 Feb 2012
Drawn By: JBB
0 20 40 Miles
No warranty is made by the BLM for use of the data for purposes not intended by BLM

There are 11 HMAs in the Project region: two in Carbon County and nine in Sweetwater County. These 11 HMAs account for 62 percent of the area used for wild horse management in Wyoming. The Permit Area overlaps two HMAs: the Lost Creek HMA and the Stewart Creek HMA; less than one percent of the two HMAs are within the Permit Area. While there are specified AMLs for the Lost Creek HMA and the Stewart Creek HMA, the horses are free to roam and are not confined to HMAs. **Section 3.9** provides more detailed discussion of the region's wild horses.

Wilderness Areas

Wyoming has 13 Wilderness Areas. As defined by the Wilderness Act of 1964, Wilderness Areas are generally in natural condition, provide outstanding opportunity for solitude and primitive recreation, are at least 5,000 acres, and are of ecological, geological or other nature-of-history value. There are no Wilderness Areas in Sweetwater County; however, there are three Wilderness Areas in Carbon County: Hudson Park, Encampment River and Savage Run Wildernesses. As shown on **Figure 3.1-3**, the closest Wilderness Areas are about 60 miles away from the Permit Area.

Wilderness Study Areas (WSAs)

Wyoming has several WSAs, which are lands under wilderness review. WSAs are managed in a manner so as to not impair their suitability for preservation as wilderness until they are designated by Congress as wilderness or until they are released from further wilderness consideration in accordance with FLPMA and the Wilderness Act (BLM, 1995). Six WSAs are within 50 miles of the Permit Area. These WSAs are Split Rock, Ferris Mountain, Bennett Mountain, Alkali Basin/Sand Dunes, Honeycomb Buttes, and Sweetwater Canyon (**Figure 3.1-3**).

Wildlife Habitat Management Areas (WHMAs)

WGFD has 36 designated WHMAs (**Figure 3.1-3)**, which are areas that are designed to protect and enhance crucial habitats, such as migration corridors, wintering habitat and foraging grounds. The WHMAs in Carbon County include: Red Rim-Grizzly, Red Rim-Daley, Pennock Mountain, Wick/Beumee and Morgan Creek. The only WHMA in Sweetwater County, and the closest WHMA to the Permit Area, is Chain Lakes, which is about six miles south of the Permit Area and is designated for antelope habitat.

Greater Sage-grouse Core Areas

Greater Sage-grouse Core Areas have been designated throughout Wyoming for the protection of Greater sage-grouse. **Section 3.8.3.2** discusses the core areas, including the area in which the Project is located.

3.1.1.3 Dispersed Recreation

The BLM uses the Recreation Opportunity Spectrum (ROS) to identify and characterize recreational opportunities on public lands in terms of setting, activity, and experience. The ROS has six classes: Primitive, Semi-Primitive Non-Motorized, Semi-Primitive Motorized, Roaded Natural, Rural and Urban. Each class is based on physical (remoteness, naturalness, facilities), social (social encounters, evidence of use), and managerial (visitor services, management controls, user fees) conditions. The physical conditions of the Permit Area appear natural, except for primitive roads, nearby improved roads that may be visible, and other evidence of activity related to development of oil, gas, and uranium and to livestock grazing. In other words, modifications to and management of the natural setting are noticeable but may blend with the natural environment. Public access is managed by the BLM as Front Country, Middle Country, or Back Country. The Permit Area is designated as Middle Country, which is located more than 0.5 miles from improved roads. Middle Country access does not restrict natural resource development and allows motorized and mechanized uses in most areas with some restrictions. At the Permit Area, the frequency of contact with other parties, and the likelihood of hearing engine noise and observing motorized vehicle tracks is moderate. In addition, managerial controls and services are limited in the Permit Area. Therefore, due to its physical, social, and managerial conditions, the Permit Area is considered Roaded Natural to Rural.

Dispersed recreation activities of the region include sightseeing, wild horse viewing, hunting, hiking, picnicking, rock hounding, horseback riding, mountain biking, and camping. The Permit Area is within the Western Extensive Recreation Management Area (ERMA) of the BLM Rawlins Field Office. The Western ERMA extends to the Continental Divide National Scenic Trail (CDNST) Special Recreation Management Area. The closest section of the CDNST is about eight miles northeast of the Permit Area (**Section 3.13.2**). Recreational uses of the CDNST include hiking, mountain biking, horseback riding, and limited motor vehicle use.

About 14 miles north of the Permit Area lies Green Mountain, which provides the only developed recreation facilities in an alpine setting in a several hundred square-mile area. Green Mountain has one developed campground with 18 campsites, water, toilets, and other amenities. The campground is under-used and is closed during elk calving season. Common recreational activities at and near Green Mountain include sightseeing, hunting, rock hounding, wild horse viewing, fishing, mountain biking, and picnicking. There are additional primitive camping areas available for campers with recreational vehicles and tents.

The closest portion of the Rawlins-Fort Washakie Stage Road is located approximately four miles northeast of the Permit Area (BLM, 2009e), and portions of the road parallel Highway 287 from Rawlins to Lander. The road was developed in the latter half of the 1800s to serve the headquarters of the Wind

River Indian Reservation; however, the road is not well marked, mapped or used currently.

There are no designated recreation areas or facilities within two miles of the Permit Area, although there is some dispersed recreational use, such as hunting. Hunting is a major past-time for Wyoming residents and non-residents alike. The hunting season is typically from September through December, with the highest activity in October and November. In Wyoming, hunting can occur on both public and private land. Both state and federal agencies provide access to lands and include: State Trust Land Office, US Forest Service (USFS), and BLM. WGFD manages popular large game, including mule deer, white-tailed deer, elk, moose, pronghorn, big horn sheep, and mountain goats as well as game birds, such as: spotted, blue and ruffled grouse; wild turkey; and pheasant.

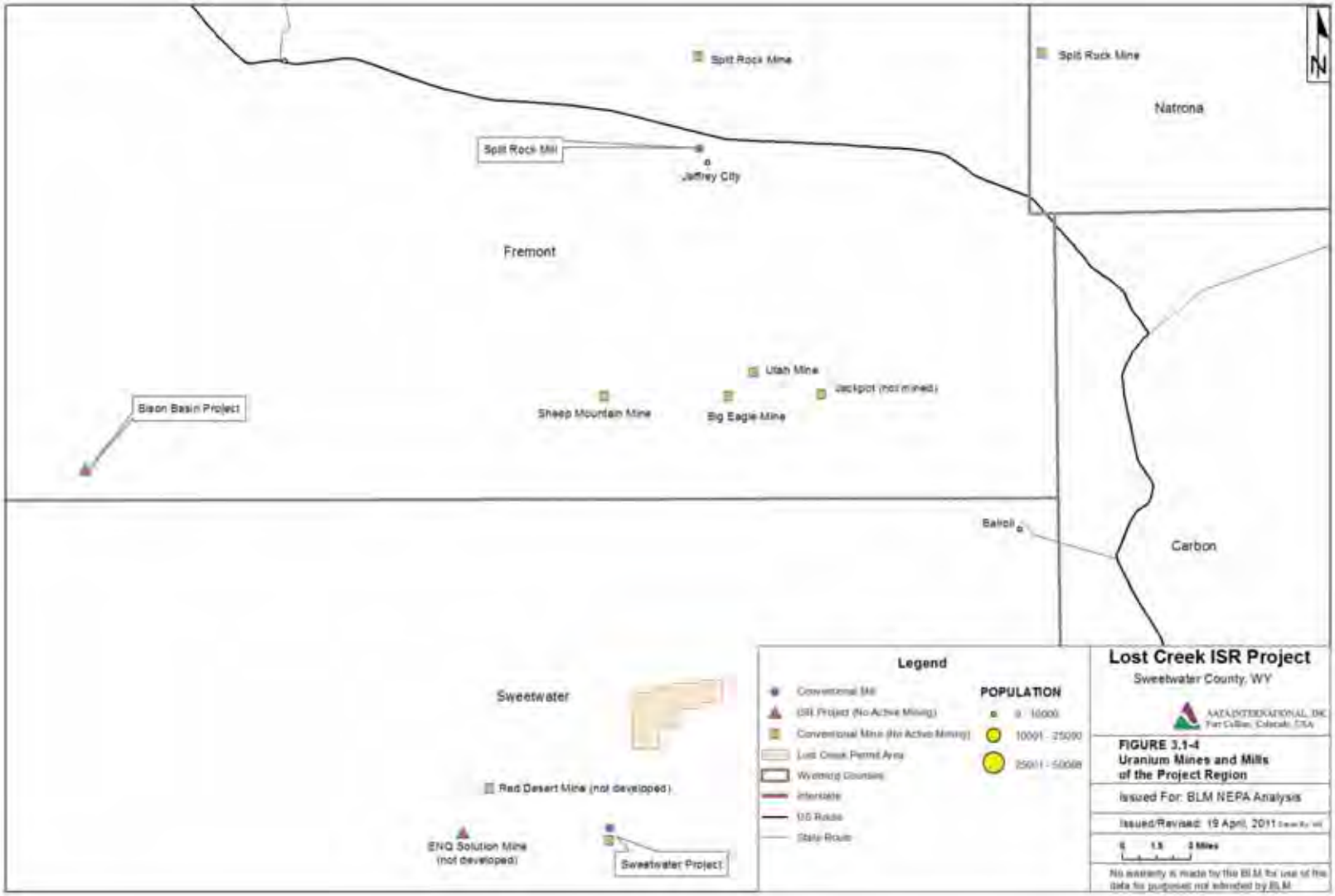
The Permit Area is located in Antelope Hunt Area 61 (Chain Lakes) and Deer Hunt Area 98 (Chain Lakes). In 2008, antelope and mule deer were the only two species reported as harvested within these Hunt Areas. Antelope were harvested more successfully than mule deer. In 210 hunter days, 70 antelope were harvested with an 80-percent success rate. In 558 hunter days, only 46 mule deer were harvested with a 33-percent success rate (WGFD, 2008a). The harvest totals reported include buck, doe, and fawn antelope and deer.

3.1.1.4 Minerals and Energy Development

Uranium

Wyoming has been the nation's leading producer of uranium ore since 1995, and hosts the nation's largest uranium reserves (Wyoming State Geological Survey, 2010). While conventional uranium mining, i.e., open pit and underground mining, has primarily been used in Wyoming, ISR has also been used. **Figure 3.1-4** shows the uranium mines in the northern portion of the Great Divide Basin and adjacent areas; some of which were not developed and most of which are in reclamation or have been reclaimed by the operator or WDEQ.

The closest uranium project to the Permit Area is Kennecott Uranium Company's Sweetwater Project. The northern boundary of the Sweetwater Project is one mile south-southwest of the southern Permit Area boundary (**Figures 3.1-1** and **3.1-4**). The Sweetwater Project once included an open pit mine and a mill; the mine was reclaimed by the operator and the mill is on standby. Plans to redevelop a previous ISR project, the Bison Basin Project, about 25 miles northwest of the Permit Area, were deferred indefinitely (Wildhorse Energy, 2010).

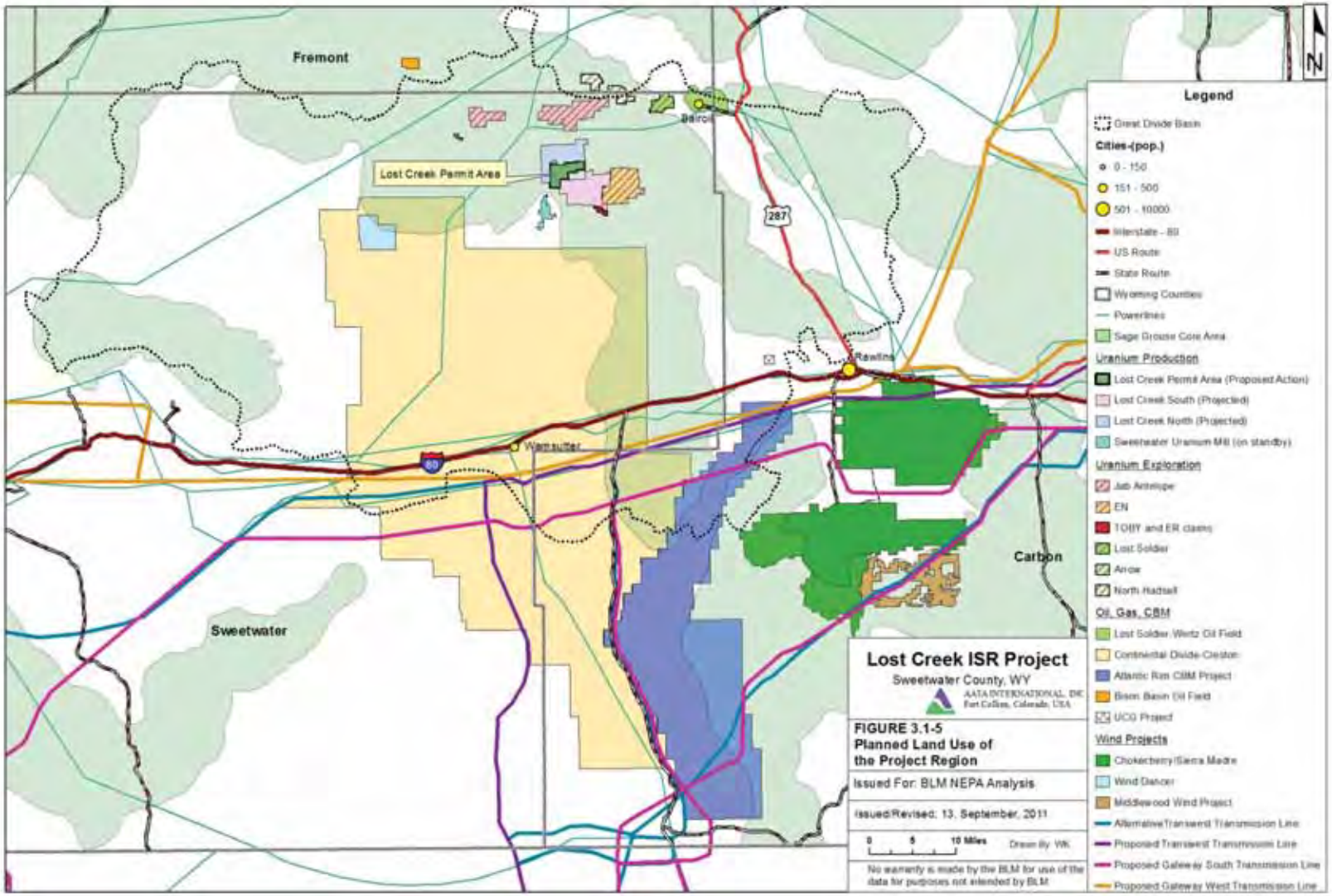

Split Rock Mine
Split Rock Mill
Jeffrey City
Fremont
Natrona
Utah Mine
Jackpot (not mined)
Sheep Mountain Mine
Big Eagle Mine
Bison Basin Project
Baiol
Carbon
Sweetwater
Red Desert Mine (not developed)
ENQ Solution Mine
(not developed)
Sweetwater Project
Legend
Conventional Mill
ISR Project (No Active Mining)
Conventional Mine (No Active Mining)
Lost Creek Permit Area
Wyoming Counties
Interstate
US Route
State Route
POPULATION
0 - 10000
10001 - 25000
25001 - 50000
Lost Creek ISR Project
Sweetwater County, WY
SAIC INTERNATIONAL, INC
Fort Collins, Colorado, USA
FIGURE 3.1-4
Uranium Mines and Mills
of the Project Region
Issued For: BLM NEPA Analysis
Issued/Revised: 19 April, 2011
0 1.5 3 Miles
No warranty is made by the BLM for use of this data for purposes not intended by BLM

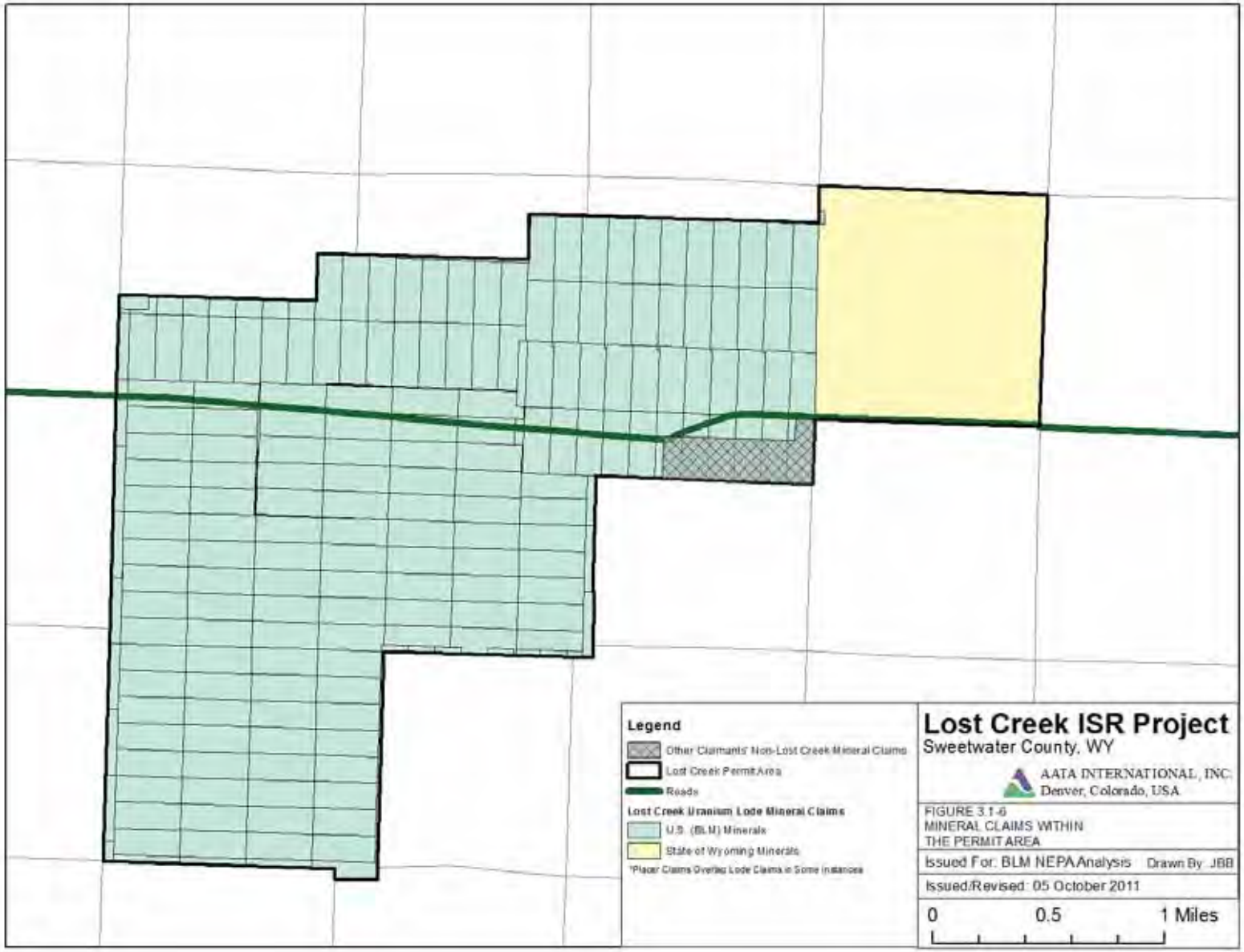
To the northwest, in the Gas Hills of the Wind River Basin, there was considerable historic uranium mining. Most of the sites are in reclamation or have been reclaimed by the operator or WDEQ. There is some continued mining interest, including exploration work, one ISR project in permitting, and potential restart of surface mining. These projects are on the order of 50 miles from the Permit Area, in a different geologic and ecological setting.

Existing uranium-related activities in the north-central portion of the Great Divide Basin are primarily exploration drilling and, in a few locations, more testing to better define ore distribution, subsurface characteristics, and baseline conditions. Exploration for other resources, such as oil and gas, often involve seismic testing or other procedures that provide relatively detailed subsurface information before drilling begins. However, to delineate uranium deposits, few tools are available other than drilling to obtain cores and geophysical data. Therefore, exploration begins with widely spaced drill holes and the spacing is reduced to focus efforts on areas of greater potential. Most of the locations identified as specific uranium exploration areas on **Figure 3.1-5** have had some drilling on them over time, and scattered exploration drilling has also occurred outside these areas. The discovery of uranium deposits in the Permit Area and consequential exploratory drilling and studies and property transfers have occurred over the course of four decades:

- Pre-1976: Numerous companies held the property; uranium mineralization was discovered by Climax Uranium and Conoco.
- 1976: Texasgulf optioned property from Valley Development Inc.
- 1977 through 1979: Texasgulf optioned property from Valley Development Inc., delineated the main trend of the mineralization, obtained a 50-percent interest in the Conoco claims on the trend to the east, and exercised its option with Valley Development Inc.
- 1986: Power Nuclear Corporation acquired the properties.
- 2000: Power Nuclear Corporation sold its Lost Creek properties to New Frontiers Uranium, LLC.
- 2005: New Frontiers Uranium, LLC transferred its Wyoming properties and data, including its Lost Creek property, to NFU Wyoming, LLC (NFU).
- 2005: Ur-Energy USA Inc. purchased NFU from New Frontiers Uranium, LLC on terms.
- 2007: Ur-Energy USA Inc. completed the acquisition of NFU from New Frontiers Uranium, LLC and maintained NFU as a wholly owned subsidiary. Ur-Energy USA Inc. formed LCI to develop the Lost Creek property and transferred the Lost Creek property from NFU to LCI.

At least 560 uranium exploration holes were drilled in the Permit Area prior to 2000. Information on the well identification, location, total depth, and completion date of these historic exploration holes is discussed in **Sections 3.3** and **3.6**. The LCI claims are shown on **Figure 3.1-6**.


Fremont
Sweetwater
Carbon
Lost Creek Permit Area
Baird
Rawlins
Wamsutter
287
80
Legend
Great Divide Basin
Cities-(pop.)
0 - 150
151 - 500
501 - 10000
Interstate - 80
US Route
State Route
Wyoming Counties
Powerlines
Sage Grouse Core Area
Uranium Production
Lost Creek Permit Area (Proposed Action)
Lost Creek South (Projected)
Lost Creek North (Projected)
Sweetwater Uranium Mill (on standby)
Uranium Exploration
Jab Antelope
EN
TOBY and ER claims
Lost Soldier
Arrow
North Hadsell
Oil, Gas, CBM
Lost Soldier Wertz Oil Field
Continental Divide-Creston
Atlantic Rim CBM Project
Bison Basin Oil Field
UCG Project
Wind Projects
Chokecherry/Sierra Madre
Wind Dancer
Middlewood Wind Project
Alternative Transwest Transmission Line
Proposed Transwest Transmission Line
Proposed Gateway South Transmission Line
Proposed Gateway West Transmission Line
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC
Fort Collins, Colorado, USA
FIGURE 3.1-5
Planned Land Use of
the Project Region
Issued For: BLM NEPA Analysis
Issued/Revised: 13, September, 2011
0 5 10 Miles
Drawn By: WK
No warranty is made by the BLM for use of the data for purposes not intended by BLM


Legend
Other Claimants' Non-Lost Creek Mineral Claims
Lost Creek Permit Area
Roads
Lost Creek Uranium Lode Mineral Claims
U.S. (BLM) Minerals
State of Wyoming Minerals
*Placer Claims Overlay Lode Claims in Some Instances
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC.
Denver, Colorado, USA
FIGURE 3.1-6
MINERAL CLAIMS WITHIN
THE PERMIT AREA
Issued For: BLM NEPA Analysis
Drawn By: JBB
Issued/Revised: 05 October 2011
0
0.5
1 Miles

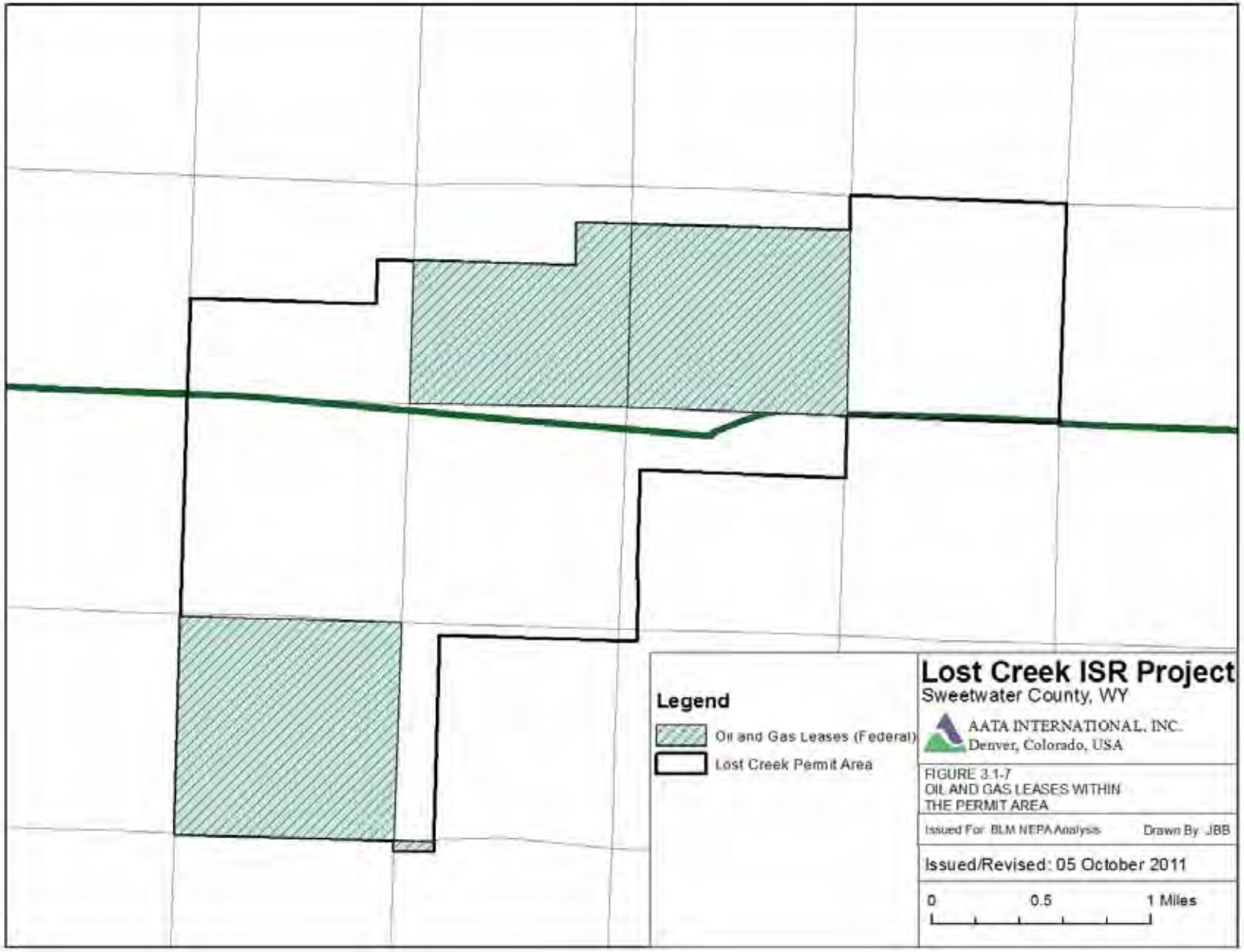
Oil and Natural Gas

There has been scattered oil and gas exploration drilling in the northern portion of the Great Divide Basin. These drilling locations are identified in the Class I Underground Injection Control Permit, which was prepared for LCI by Petrotek in 2010 and is included as Attachment ADJ-2 in the WDEQ-LQD Permit to Mine (LCI, 2011b). The closest producing well is about eight miles southwest of the Permit Area. Leases also exist in the northern portion of the Basin, including leases within the Permit Area (**Figure 3.1-7**); however, there are no known plans for development of these leases.

The Lost Soldier-Wertz Oil Fields near Bairoil were discovered in the early 1900s and continue to be produced. The closest portion of these fields is 16 miles northeast of the Permit Area. The oil fields are in their final stage of production, under carbon dioxide injection (enhanced oil recovery) since 1989. The Bison Basin Oil Field is another old field and is about 25 miles to the west-northwest of the Permit Area (**Figure 3.1-5**).

The most extensive development in the region relates to the Continental Divide and Creston Blue Gap gas fields and subsequent infill projects (**Figure 3.1-5**). The development is on the checkerboard pattern of private and federal surface and mineral ownership that resulted from historic land grants from the federal government for railroad development. One infill project is the Wind Dancer Natural Gas Development Project (WDNGDP), which encompasses about 6,400 acres 18 miles southwest of the Permit Area. The WDNGDP consists of the drilling, completion, and operation of up to 12 natural gas wells and associated facilities (access roads, pipelines, utility corridors). The WDNGDP started in 2004 with an anticipated life of 30 years. Another infill project, the Continental Divide-Creston Project, is in planning, as discussed in the next section.

The Atlantic Rim coal bed methane and natural gas development project covers 270,080 acres, located approximately 31 miles south of the Permit Area (**Figure 3.1-5**). The northern portion of this project is in the checkerboard ownership pattern. In March 2007, the BLM published a Record of Decision regarding the Final Environmental Impact Statement for this project (BLM, 2007a). Work began that year on the 1,800 coal bed methane wells and 200 natural gas wells to be drilled over a 20-year period and to be in production for 30 to 50 years.


Legend
Oil and Gas Leases (Federal)
Lost Creek Permit Area
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC.
Denver, Colorado, USA
FIGURE 3.1-7
OIL AND GAS LEASES WITHIN
THE PERMIT AREA
Issued For: BLM NEPA Analysis
Drawn By: JBB
Issued/Revised: 05 October 2011
0
0.5
1 Miles

Coal and Coal Bed Methane

There are no surface or underground coal mines in the eastern portion of the Great Divide Basin. There are two coal mines (the Bridger and Black Butte Mines) in the western portion of the Great Divide Basin. The Bridger Mine is located approximately 51 miles southwest of the Permit Area within Sweetwater County. It occupies approximately 10,054 acres of disturbed land. The Bridger Mine produced approximately 6.1 million tons of coal in 2009 (Wyoming Mining Association, 2010). The Bridger Coal Company submitted a coal "lease by application" to convert surface mining operations to underground mining in order to extend the life of the mine. The Black Butte Mine, located approximately 52 miles southwest of the Permit Area and also in Sweetwater County, encompasses approximately 11,483 acres of disturbed land. It produced 3.8 million tons of coal in 2009 (Wyoming Mining Association, 2010).

Historically, there was interest in mining coal in the northern portion of the Basin for the railroad, but the difficulty of mining, due in part to steeply dipping beds along the Basin margins, discouraged development (Smith, 1909). Subsequent development of more readily accessible coal in the Hanna Basin to the east and in the mines in the western portion of the State further discouraged development. Several surface mines and one underground mine are in reclamation in the Hanna Basin, which is about 75 miles east of the Permit Area. The Elk Mountain Mine, which is producing, is located in the Carbon Basin approximately 85 miles east of the proposed Project. This mine produced 262,065 tons of coal in 2009 (Wyoming Mining Association, 2010). A surface coal gasification facility was also considered in the Carbon Basin, but there are no definitive plans at present.

One underground coal gasification project, currently in reclamation, is located about 20 miles south-southwest of the Permit Area on the eastern margin of the Great Divide Basin. It was permitted by WDEQ-LQD as a Research and Development Project, and minimal gasification activities were conducted.

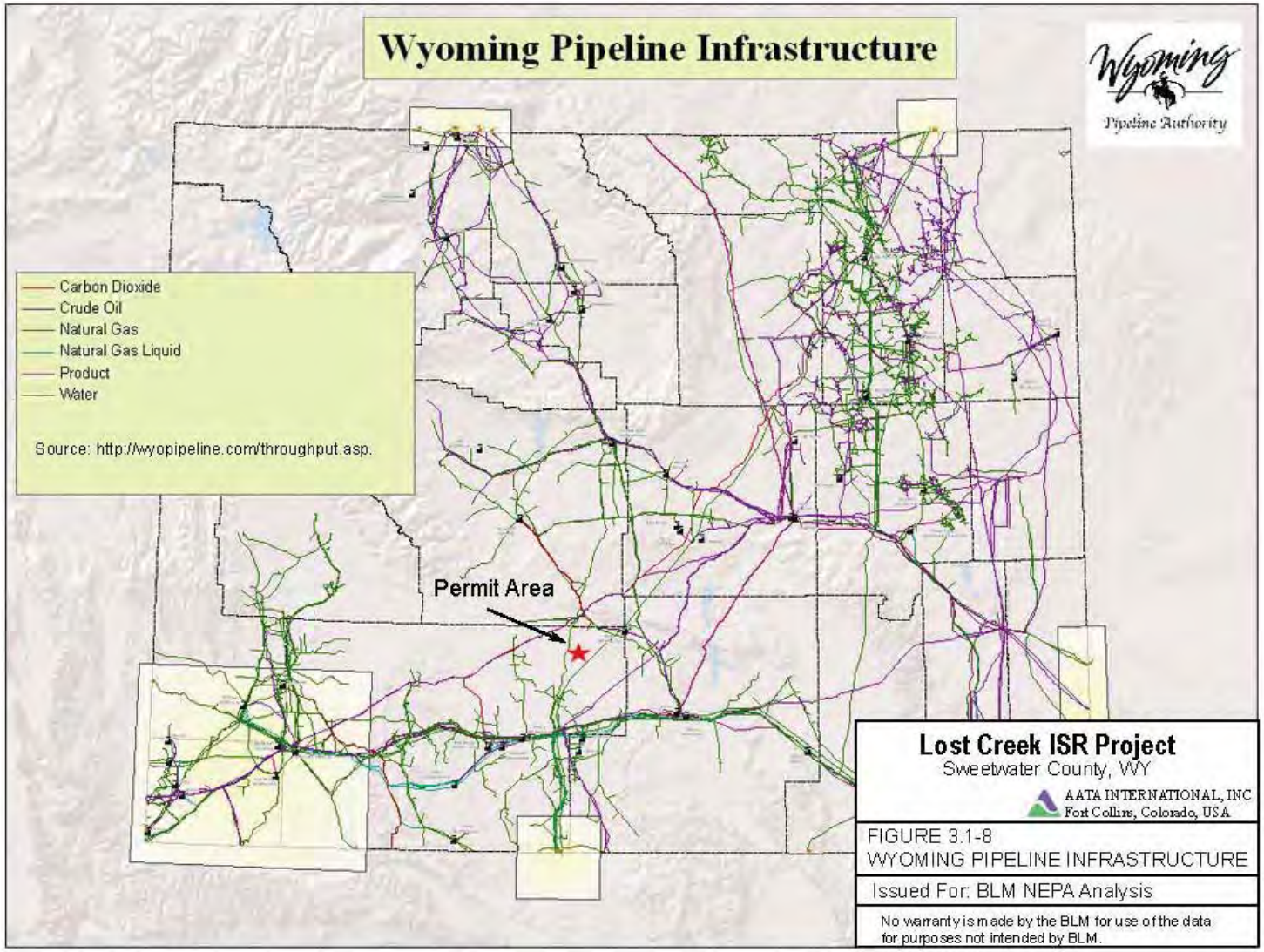
The nearest coal bed methane project is the Atlantic Rim Project, which includes both coal bed methane and natural gas development, as noted above in the Oil and Natural Gas subsection. A pilot coal bed methane project, the Pappy Draw Exploratory Project, was approved by BLM in 2008 (BLM, 2008b). The proposed location was in the vicinity of the proposed JAB and Antelope uranium claims about five miles north of the Permit Area (**Figure 3.1-5**). However, the pilot project was terminated and new approvals would be needed for any additional efforts (BLM, 2009a).

3.1.1.5 Infrastructure

The Permit Area is served by an Interstate Highway (I-80), a US Highway (US 287), Wyoming State routes (SR 220 and 73 to Bairoil), local County roads, and BLM roads. There are no maintained roads within the Permit Area. Transportation is discussed in **Section 3.2**.

Wyoming has a network of pipelines that deliver carbon dioxide, oil, natural gas, and water throughout the State. The Permit Area is between two natural gas pipelines (**Figure 3.1-8**). The pipeline 2.6 miles to the west of the Permit Area boundary is the Entrega section of the Rocky Mountain Express LLC Pipeline. The pipeline 3.6 miles to the east of the Permit Area boundary is the True Oil Company/Maverick Pipeline that runs northeast through the State.

There is a power line that extends north-south along the western boundary of the Permit Area. The right-of-way easement for this power line is 25 feet wide.


Wyoming Pipeline Infrastructure
Wyoming
Pipeline Authority
Carbon Dioxide
Crude Oil
Natural Gas
Natural Gas Liquid
Product
Water
Source: http://wyopipeline.com/throughput.asp.
Permit Area
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC
Fort Collins, Colorado, USA
FIGURE 3.1-8
WYOMING PIPELINE INFRASTRUCTURE
Issued For: BLM NEPA Analysis
No warranty is made by the BLM for use of the data for purposes not intended by BLM.

3.1.1.6 Wilderness Characteristics

FLPMA requires the BLM to maintain an inventory of public lands and the resources contained within that land, including the wilderness characteristics of the land. An Instruction Memorandum developed in July of 2011 outlines the steps to perform a wilderness characteristics inventory on BLM land (BLM, 2011f). Wilderness is defined as "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain" (BLM, 2001). Land is considered to have wilderness characteristics if it meets these criteria:

- 5,000 acres or more of roadless land;
- Affected primarily by the forces of nature; and
- Outstanding opportunities for solitude or primitive and unconfined recreation.

While wilderness characteristic inventories have been done in the past, the FLPMA requires that these inventories be maintained and updated to reflect any changes (BLM, 2001). As changes may have occurred since the last inventory was conducted, a wilderness characteristic inventory was performed to update a past inventory with respect to the Permit Area and adjacent lands (**Appendix A**).

The wilderness characteristics of the Seven Lakes Area (Inventory Unit No. WY-030-049), which includes the Permit Area, were evaluated in 1979. The evaluation concluded that the Seven Lakes Area "does not have potential for wilderness" primarily because "[m]an's activities are noticeable most everywhere", including the crisscross of roads and other evidence of activity related to development of oil, gas, and uranium and to livestock grazing.

The conditions have changed little since the 1979 evaluation. Various features related to human activities within and near the Permit Area include a transmission line, fences, well improvements, and roads, and photographs of these features are included in **Appendix A**. Some of the roads are currently maintained, such as the Wamsutter-Crooks Gap Road and the Sooner Road at the west and east ends, respectively, of the Access Roads to the Permit Area. Other observations of human disturbance along roads are residual impacts of exploration activities conducted prior to current requirements for road reclamation. Many of the residual roads are evident on the USGS maps for the area. Existing surface disturbances in the Permit Area are discussed in more detail in **Section 3.4.6**.

While most of the human influence would be substantially unnoticeable when examined alone, the cumulative effect of the dirt roads, fences, wells, and power lines creates a landscape that has been significantly impacted by man. As such, the region was determined to not meet the naturalness criteria, and is not considered as land with wilderness characteristics.

3.1.2 Planned Land Use

The existing land uses of livestock grazing, wildlife habitat, dispersed recreation, minerals and energy development, and infrastructure are expected to continue. No new land uses are expected; however, some changes to existing uses are expected. Potential changes to livestock grazing, such as the changes to the Green Mountain Grazing Allotment (if implemented), are not anticipated to affect the Project (BLM, 2011d; Dayton, 2011). No changes in the existing land uses for wildlife habitat and dispersed recreation are anticipated. Changes in minerals and energy development and infrastructure are described below.

3.1.2.1 Minerals and Energy Development

Both Carbon and Sweetwater Counties are experiencing considerable natural resource development, much of which is related to oil and gas exploration and production. Based on publicly available information, no projects are currently planned in the Permit Area; however, several projects are proposed in the Project region (**Figure 3.1-5**).

Uranium

The closest proposed ISR project to the Permit Area is Uranium One, Inc.'s JAB-Antelope Project, which encompasses two areas located about three miles north and seven miles northwest of the Permit Area. In August 2009, the NRC issued a Notice of Intent to Prepare a Supplemental Environmental Impact Statement for that project (74 FR 41174, 14 August 2009). However, in October 2009, Uranium One, Inc. requested deferral of the NRC review (Uranium One, Inc., 2010), and the projected submittal date is NRC's 2013 fiscal year (NRC, 2012).

In August 2011, BLM started public scoping for the Sheep Mountain Project, a conventional mine and heap leach recovery operation about 18 miles north of the Permit Area (BLM, 2011h).

Ur-Energy has the following claim blocks that may be developed after additional exploration and after permitting with federal, state, and county agencies:

- Lost Creek North, immediately north;
- Lost Creek South, immediately south-southwest;
- EN, about three miles southeast;
- Toby and ER, about four miles southeast;
- North Hadsell, about eight miles north and northeast;
- Lost Soldier, about nine miles northeast;
- Arrow, about ten miles west-northwest; and
- RS, about 12 miles north.

Oil and Natural Gas

Although there is research on further enhanced oil recovery from the Lost Soldier – Wertz Fields (Yin et al., 2012), no specific projects are planned. In February 2012, the BLM Lander Field Office published a Scoping Notice for work to improve production from the existing Bison Basin Oil Field (BLM, 2012). The improvements include ten new wells and facility improvements with an anticipated life of 20 years.

The approximately 1.1-million-acre Continental Divide – Creston Project involves drilling and development of about 9,000 wells with associated facilities (roads, pipelines, compressor stations, power system) by numerous companies to further develop natural gas resources within the existing Continental Divide and Creston Blue Gap natural gas fields. The anticipated duration of the project is 15 years for construction and 30 to 40 years of project development and operation. The northern boundary of the proposed project is about seven miles south of the Permit Area. The BLM published a Scoping Notice in April 2006 (BLM, 2006), and work on the Draft EIS is on-going.

Wind

The closest proposed wind power project is the Chokecherry and Sierra Madre Wind Energy Project. This Project has two areas located 40 and 44 miles southeast of the Permit Area in Carbon County, south of Rawlins. This 1,000-turbine wind farm is proposed by the Power Company of Wyoming; construction of the project is anticipated to begin in 2012 (Power Company of Wyoming, 2011). The BLM published a Draft Environmental Impact Statement in July 2011 (BLM, 2011a).

3.1.2.2 Infrastructure

Two large proposed transmission projects of the Project region are the TransWest Express Transmission Project and the Gateway West Transmission Project (**Figure 3.1-5**). The TransWest Express Transmission Project includes a 600-kilovolt direct-current transmission system that will extend about 725 miles from south-central Wyoming, through northwestern Colorado and central Utah, to southern Nevada. The Western Area Power Administration and TransWest Express LLC would be joint owners of the extra-high-voltage line designed to carry renewable power generated in Wyoming to the Desert Southwest. This project is anticipated to begin construction in 2013 (TransWest Express LLC, 2011). The transmission line would be as close as about 30 miles directly south of the Permit Area, although an alternate route could be closer.

The Gateway West Transmission Project is a collaborative effort between Idaho Power Company and Rocky Mountain Power to construct and operate 230- and 500-kilovolt transmission lines from Glenrock, Wyoming to Melba, Idaho. This project is composed of 11 transmission line segments with a total length of

approximately 1,000 miles across southern Wyoming and southern Idaho. This proposed project crosses approximately 500 miles of public land managed by the BLM, including 200 miles in Wyoming. This project is scheduled for line segments to be completed in phases between 2014 and 2018 (Idaho Power Company and Rocky Mountain Power, 2011). The transmission line would be as close as 30 miles south of the Permit Area.

3.2 Transportation

This section provides a description of the regional and on-site transportation network that is relevant to the Project. Most transportation would use the road network, but goods may be transported by rail to and from Wamsutter. The road network would be used for:

- shipments of construction materials, process chemicals, office supplies, and related materials from suppliers to the Plant;
- shipment of yellowcake slurry to an off-site drying facility;
- shipments of waste material to be disposed of off-site; and
- movement of personnel to and from the site and within the Permit Area.

3.2.1 Regional Transportation Corridors

The transportation system serving the Project relies almost exclusively on existing public roads and highways (**Figure 3.2-1**). Automobiles and trucks are the primary mode of transportation. The local and regional transportation network relevant to the Project consists of primary, secondary, local, and unimproved roads. The Permit Area is served by an Interstate Highway (I-80); a US Highway (US 287); Wyoming State routes (SR 220 and 73 to Bairoil); local Carbon, Sweetwater, and Fremont County roads; and BLM roads. The roads are paved with the exception of the County and BLM roads, which are generally gravel surface, although some short stretches may be paved. In addition to the designated routes, there are a number of four-wheel-drive routes that traverse the area for recreation and grazing access, as well as various other uses, including oil, gas, and mineral exploration.

The primary interstate and US highways are well maintained. The other county and BLM roads providing access to the Permit Area are generally maintained biannually and in fair condition, depending on the season and how recently maintenance occurred. These roads are infrequently plowed in the winter. Ranchers, government agency personnel, and some hunters, fishermen, and other recreationists use these roads, along with personnel involved in oil, gas, and mineral exploration and development.

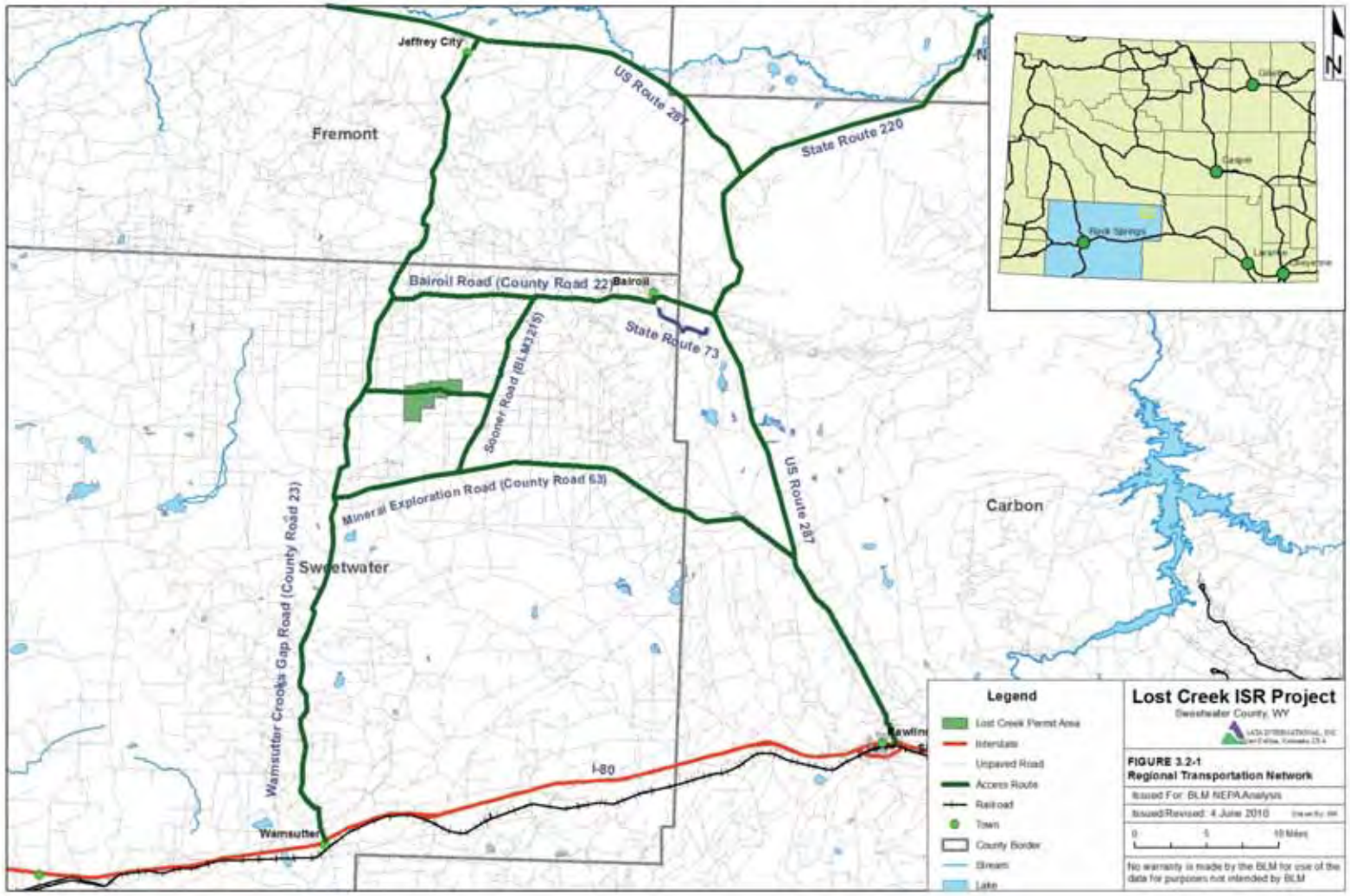

Jeffrey City
US Route 287
Fremont
State Route 220
Bairoil Road (County Road 22)
Bairoil
State Route 73
Sooner Road (BLM3215)
Mineral Exploration Road (County Road 63)
US Route 287
Carbon
Sweetwater
Wamsutter Crooks Gap Road (County Road 23)
I-80
Wamsutter
Legend
Lost Creek Permit Area
Interstate
Unpaved Road
Access Route
Railroad
Town
County Border
Stream
Lake
Lost Creek ISR Project
Sweetwater County, WY
FIGURE 3.2-1
Regional Transportation Network
Issued For: BLM NEPA Analysis
Issued/Revised: 4 June 2010
0
5
10 Miles
No warranty is made by the BLM for use of the data for purposes not intended by BLM

Table 3.2-1 describes these roads, with daily and peak traffic counts for the roads that are regularly monitored. Traffic counts are not available for the county roads. These roads receive little traffic for most of the year, but road use peaks in the summer and fall, when hunting and dispersed recreation is greatest.

Table 3.2-1 Local and Regional Roads

Road/Counties	Road Surface	Lanes	Speed Limit	Average Daily Traffic	Peak Hourly Traffic	Peak Time
I-80 Carbon Sweetwater	Paved	4	75	12,430 13,840	549 644	4-5pm-Aug. 4-5pm-Aug.
US-287 Carbon Fremont	Paved	2	65	1,820 1,870	460 259 North 308 South	2-3pm-Aug. 3-4pm-July 3-4pm-July
WY-73 Carbon	Paved	2	65	230	ND[1]	ND
County Rd 22 (Bairoil Rd)	Gravel	2	Not posted	ND	ND	ND
County Rd 23N (Wamsutter-Crooks Gap Rd)	Gravel	2	Not posted	ND	ND	ND
County Rd 63/BLM 3206 (Mineral Exploration Rd)	Paved/ gravel	2	Not posted	ND	ND	ND
BLM Rd 2315 (Sooner Rd)	Gravel	2	Not posted	ND	ND	ND

* Sandidge. M. Transportation Technician 3, WYDOT Planning Traffic Surveys. Personal communication. March, 2007
[1] ND = No Data

Traffic safety data are summarized in **Table 3.2-1**. An Operator's or Owner's Traffic Accident Report is required by the Wyoming Department of Transportation (WYDOT) if any party is injured or if there is property damage of $1,000 or more (Carpenter, T. Senior Data Analyst, WYDOT. Personal communication, March 2007). The accident rate was calculated by dividing the mean number of truck accidents per year (2002 to 2006) by the product of the road segment length, the average number of trucks per day, and the number of days per year (365). From 2002 to 2006, no accidents involving large trucks occurred on the segment of interest of WY-73, so the accident rate was calculated using all traffic. During this period, there were an average of 230 cars per day, and a total of three accidents. Traffic counts were not available for the county and BLM roads listed in **Table 3.2-2**, so the accident rate for these segments could not be calculated directly. Where no data were available, the truck accident rate was estimated as 2.2×10^{-6} accidents per mile (Harwood and Russell, 1990), a widely

cited value for two-lane rural roads. Most traffic accidents do not cause injuries or fatalities. From 2002 to 2005, an annual average of 15,867 accidents occurred in Wyoming. Of these accidents, 0.9 percent were fatal, 25 percent caused injuries, and 74 percent caused property damage only (WYDOT, 2007).

Table 3.2-2 Traffic Safety Data

Road	Length (mile)	Trucks/ Day	Annual Truck Accidents	Period of Record	Accident Rate (Accidents/mile)
I-80 (Carbon and SW County) milepost 57.04 to 270.9	223.9	6,627	408.8	2002-2006	7.5E-07
US-287 Rawlins to Muddy Gap	43.1	490	6	2002-2006	7.8E-07
WY-73 (287 to Bairoil) Milepost 0 to 4.65[1]	4.7	30	0	2002-2006	1.5E-06
County Road 22 (Bairoil Rd)[2]	ND[3]	ND	0.6	2002-2006	2.2E-06
County Road 23 (Wamsutter-Crooks Gap Rd)[2]	ND	ND	0.8	2002-2006	2.2E-06
County Road 63/BLM 3206 (Mineral Exploration Rd)[2]	ND	ND	0.6	2002-2006	2.2E-06
BLM Road 3215 (Sooner Rd)[2]	ND	ND	ND	2002-2006	2.2E-06

* (WYDOT, 2007)
[1] No Truck Accidents; Accident rate calculated from all vehicles
[2] Generic Accident Rate (Harwood and Russell, 1990)
[3] ND = No Data

3.2.2 On-site Transportation Corridors

Currently, the only on-site transportation corridors are two-track roads that are accessible year-round by four-wheel-drive vehicles. Most are indistinct, difficult to delineate, or do not have obvious end points. These tracks are not maintained, have no drainage, and are sometimes impassable during the winter months. Access to the site from west of the Project is via the West Access Road from the Wamsutter Crooks Gap Road (County Road 23N), and the site is accessed from the east via the East Access Road from Sooner Road (BLM 3215). Pictures of the East and West Access Roads are included as **Figures 2.2-1** and **2.2-2**, respectively.

3.3 Geology, Ore Mineralogy, and Seismology

The following is a description of the geology, ore mineralogy, and seismology of the Project. Data were obtained from the WDEQ-LQD Permit to Mine and associated Mine Unit 1 (MU1) documents (LCI, 2011b).

3.3.1 Regional Geology

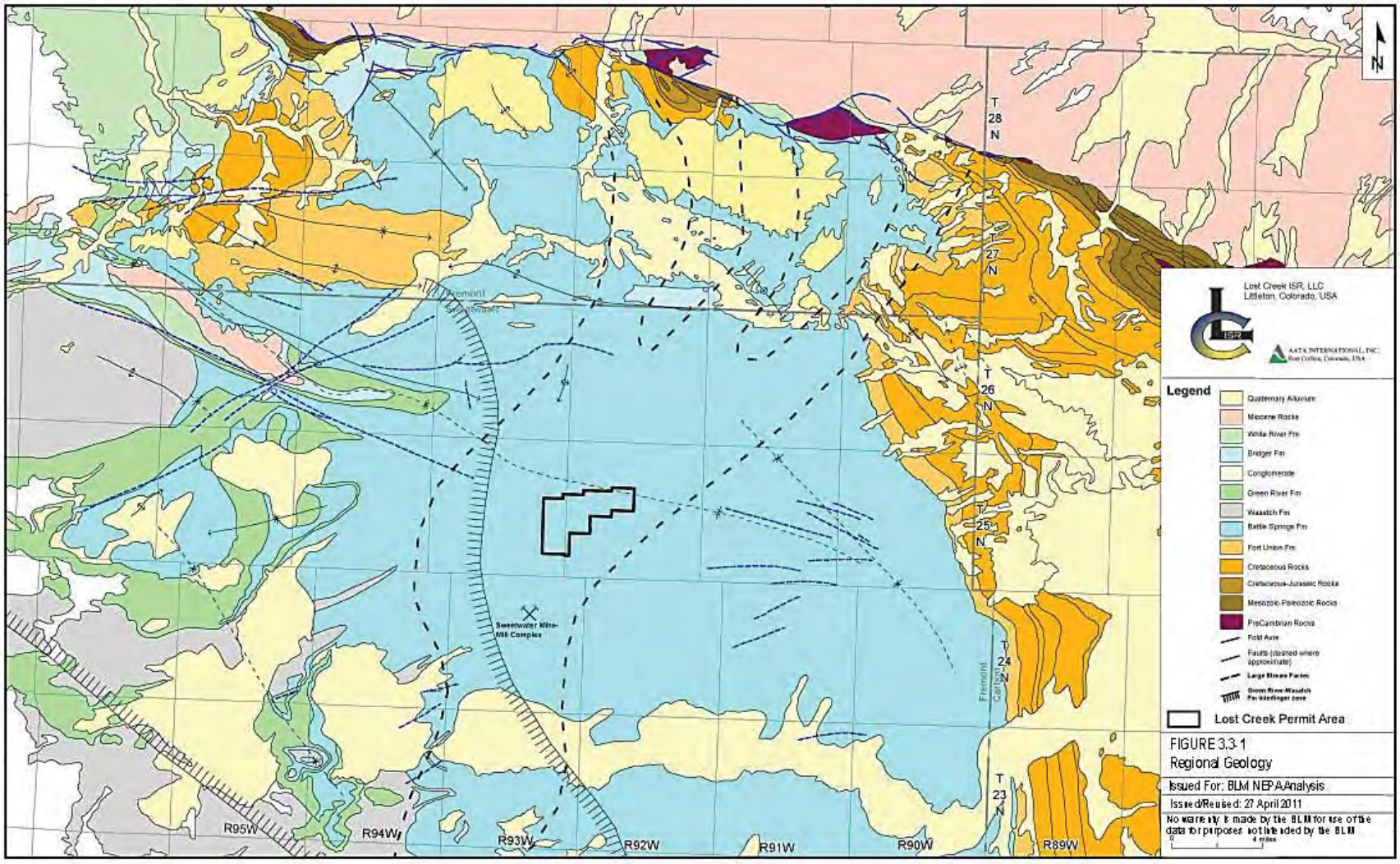
The Great Divide Basin (Basin) is an oval-shaped structural depression, encompassing some 3,500 square miles in south-central Wyoming. The Basin is bounded on the north by the Wind River Range and Granite Mountains, on the east by the Rawlins Uplift, on the south by the Wamsutter Arch and on the west by the Rock Springs Uplift. The formations underlying the region consist of several thousand feet of sedimentary materials, ranging in age from Cambrian to Quaternary, overlying PreCambrian granite. Structural development of the Basin began in the Late Cretaceous and continued through much of the Early Eocene. The regional geologic map is shown in **Figure 3.3-1**.

3.3.1.1 Stratigraphy

The earliest sedimentation in the Basin was the Paleocene (Early Tertiary) Fort Union Formation, which was unconformably deposited on the Lance Formation of Late Cretaceous age. The Fort Union Formation consists mostly of lacustrine shales, siltstones, and thin sandstones, which locally contain lignite beds. The Fort Union Formation varies in thickness from place to place in the Basin, and is approximately 4,650 feet thick beneath the Permit Area.

The Fort Union Formation is unconformably overlain by sediments of Eocene age, making up about 6,200 feet of basin fill. The western and southern portions of the Basin are covered by the Wasatch Formation, which consists of sandstone, siltstone, limestone, conglomerate and lignite beds. The rocks in the Wasatch Formation are believed to be of fluvial-lacustrine origin. Towards the north and northeast, the Wasatch Formation rapidly grades into and inter-tongues with the equally thick, fine- to coarse-grained arkosic sandstones and conglomerates of the Battle Spring Formation, a typical alluvial fan complex. The source of the Battle Spring sediments is believed to be the ancestral Granite Mountains to the north. Pliocene pediment deposits and recent alluvium cover large areas of the Basin surface. **Table 3.3-1** and **Figure 3.3-2** show the general stratigraphy of the Basin.

The upper portion of the Battle Spring Formation is the host to the uranium mineralization in the Permit Area. In the Permit Area, the top 700 feet of the Battle Spring Formation is divided into at least five uranium-bearing horizons marked from top to bottom as BC, DE, FG, HJ, and KM. These horizons are separated from one another by various thicknesses of shale, mudstone and siltstone (**Figure 3.3-3**).


N
T 28 N
T 27 N
T 26 N
T 25 N
T 24 N
T 23 N
R95W
R94W
R93W
R92W
R91W
R90W
R89W
Fremont
Carbon
Sweetwater Mine-Mill Complex
Lost Creek ISR, LLC
Littleton, Colorado, USA
AATA INTERNATIONAL, INC.
Legend
Quaternary Alluvium
Miocene Rocks
White River Fm
Bridger Fm
Conglomerate
Green River Fm
Wasatch Fm
Battle Springs Fm
Fort Union Fm
Cretaceous Rocks
Cretaceous-Jurassic Rocks
Mesozoic-Paleozoic Rocks
PreCambrian Rocks
Fold Axis
Faults (dashed where approximate)
Large Stream Facies
Green River-Wasatch Fm Interfinger zone
Lost Creek Permit Area
FIGURE 3.3-1
Regional Geology
Issued For: BLM NEPA Analysis
Issued/Revised: 27 April 2011
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0
4 miles

Table 3.3-1 Permit Area Stratigraphy (Page 1 of 3)

Age	Formation	Thickness [1] (feet)	Aquifer [2]	Lithology
Quaternary	Alluvium (Qa)	0 to 20	Yes	Sands and clays derived chiefly from the Tertiary formations in the area.
Early Eocene	Battle Spring/ Wasatch Formation	6,200	Yes	Battle Spring Formation is a major fluvial system, consisting of alternating fine to coarse-grained sandstones, minor conglomerates, siltstones and mudstones. Host to mineralization. Minor carbonaceous matter. Color buff to tan in the oxidized areas and gray to dark-gray in unoxidized zones. Dips average of 3 degrees to the west. Mineralization in top portion in at least five sand units separated by various shales, siltstones and mudstones. Wasatch Formation interfingers with the Battle Spring Formation and consists of fine sandstones, mudstones, siltstones and lignites.
Unconformity [3]				
Paleocene	Fort Union Formation	4,650	Yes	Consists of alternating fine to coarse-grained sandstone siltstone and mudstone. Contains various layers of lignitic coal beds.

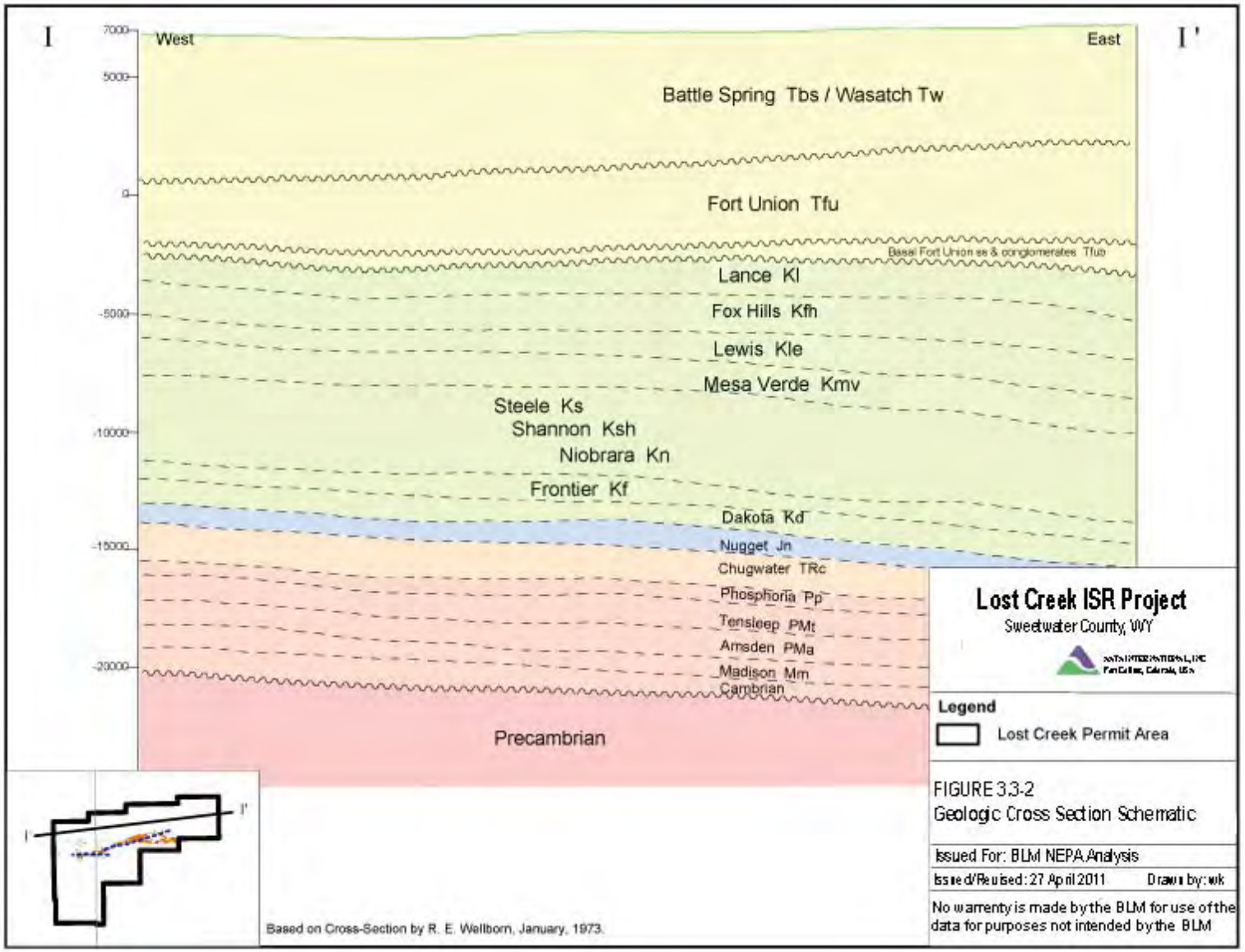
Table 3.3-1 Permit Area Stratigraphy (Page 2 of 3)

Age	Formation	Thickness [1] (feet)	Aquifer [2]	Lithology
Unconformity [3]				
Cretaceous	Lance Formation	2,950	Yes	Interbedded sandstone, siltstone and mudstone. Gray to brownish gray. Locally carbonaceous. Sandstone is white to grayish orange.
	Fox Hills Formation	550	No	Consists of coarsening upward shale and fine-grained sand with thin coal beds near the top. Represents a transition from marine to non-marine environment. Grades into Lewis Shale at the base.
	Lewis Shale	1,200	No	Interbedded dark-gray and olive-gray shale and olive-gray sandstone.
Unconformity [3]				
Cretaceous	Mesa Verde Group	800	No	Gray to dark gray shales with interbedded buff to tan fine to medium grained sandstones.
	Steele and Niobrara Shales	2,000 to 2,500	No	Steele shale is soft gray marine. Niobrara shale is dark gray and contains calcareous zones.
	Frontier Formation	500 to 1,000	Yes	Gray sandstone and sandy shale.
	Dakota Formation	300 to 400	Yes	Marine sandstone, tan to buff, fine to medium grained may contain carbonaceous shale layer.
Jurassic	Nugget Sandstone	500	Yes	Grayish to dull red coarse-grained cross-bedded quartz sandstone.
Triassic	Chugwater	1,500	No	Red shale and siltstone contains gypsum partings near the base.
Permian	Phosphoria	300	No	Black to dark gray shale, chert and phosphorite.

Table 3.3-1 Permit Area Stratigraphy (Page 3 of 3)

Age	Formation	Thickness [1] (feet)	Aquifer [2]	Lithology
Permian-Pennsylvanian	Tensleep	500	No	White to gray sandstone containing thin limestone and dolomite partings.
Pennsylvanian-Mississippian	Amsden and Madison	250	No	Red and green shale and dolomite, sandstone near base.
Cambrian	Undifferentiated	1,000	No	Siltstone and quartzite, including Flathead sandstone.
Unconformity [3]				
Precambrian	Basement		No	Granites and associated metamorphic and igneous rocks.

* (Love and Christiansen,1985; Wellborn and Wold, 1993)
[1] Thicknesses shown are approximate and apply only to the Permit Area and vicinity.
[2] Aquifer designation only applicable to the vicinity of the Permit Area.
[3] Only major unconformities are shown.


I
I'
West
East
7000
5000
0
-5000
-10000
-15000
-20000
Battle Spring Tbs / Wasatch Tw
Fort Union Tfu
Basal Fort Union ss & conglomerates Tfub
Lance Kl
Fox Hills Kfh
Lewis Kle
Mesa Verde Kmv
Steele Ks
Shannon Ksh
Niobrara Kn
Frontier Kf
Dakota Kd
Nugget Jn
Chugwater TRc
Phosphoria Pp
Tensleep PMt
Amsden PMa
Madison Mm
Cambrian
Precambrian
Based on Cross-Section by R. E. Wellborn, January, 1973.
Lost Creek ISR Project
Sweetwater County, WY
Legend
Lost Creek Permit Area
FIGURE 3.3-2
Geologic Cross Section Schematic
Issued For: BLM NEPA Analysis
Issued/Revised: 27 April 2011
Drawn by: wk
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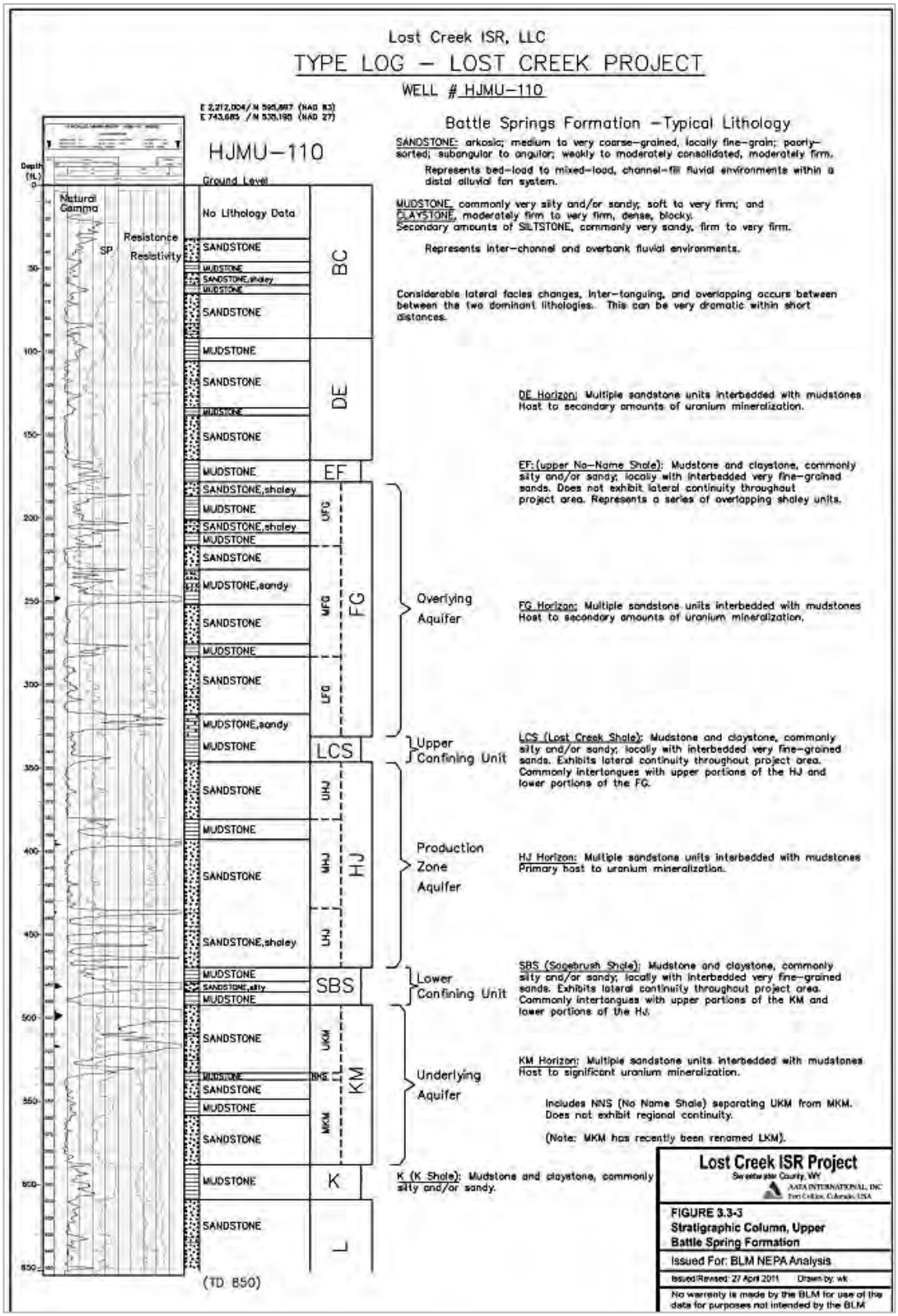
Lost Creek ISR, LLC
TYPE LOG – LOST CREEK PROJECT
WELL # HJMU–110
E 2,212,004/N 595,897 (NAD 83)
E 743,685 /N 535,193 (NAD 27)
HJMU–110
Ground Level
Depth (ft.)
Natural Gamma
SP
Resistance
Resistivity
No Lithology Data
SANDSTONE
MUDSTONE
SANDSTONE,shaley
SANDSTONE,sandy
SANDSTONE,silty
BC
DE
EF
UFG
MFG
LFG
FG
LCS
UHJ
MHJ
LHJ
HJ
SBS
UKM
NNS
MKM
KM
K
L
(TD 850)
Battle Springs Formation –Typical Lithology
SANDSTONE- arkosic; medium to very coarse-grained, locally fine-grain; poorly-sorted; subangular to angular; weakly to moderately consolidated, moderately firm.
Represents bed-load to mixed-load, channel-fill fluvial environments within a distal alluvial fan system.
MUDSTONE, commonly very silty and/or sandy; soft to very firm; and CLAYSTONE, moderately firm to very firm, dense, blocky.
Secondary amounts of SILTSTONE, commonly very sandy, firm to very firm.
Represents inter-channel and overbank fluvial environments.
Considerable lateral facies changes, inter-tonguing, and overlapping occurs between between the two dominant lithologies. This can be very dramatic within short distances.
DE Horizon: Multiple sandstone units interbedded with mudstones Host to secondary amounts of uranium mineralization.
EF: (upper No-Name Shale): Mudstone and claystone, commonly silty and/or sandy; locally with interbedded very fine-grained sands. Does not exhibit lateral continuity throughout project area. Represents a series of overlapping shaley units.
Overlying Aquifer
FG Horizon: Multiple sandstone units interbedded with mudstones Host to secondary amounts of uranium mineralization.
Upper Confining Unit
LCS (Lost Creek Shale): Mudstone and claystone, commonly silty and/or sandy; locally with interbedded very fine-grained sands. Exhibits lateral continuity throughout project area. Commonly intertongues with upper portions of the HJ and lower portions of the FG.
Production Zone Aquifer
HJ Horizon: Multiple sandstone units interbedded with mudstones Primary host to uranium mineralization.
Lower Confining Unit
SBS (Sagebrush Shale): Mudstone and claystone, commonly silty and/or sandy; locally with interbedded very fine-grained sands. Exhibits lateral continuity throughout project area. Commonly intertongues with upper portions of the KM and lower portions of the HJ.
Underlying Aquifer
KM Horizon: Multiple sandstone units interbedded with mudstones Host to significant uranium mineralization.
Includes NNS (No Name Shale) separating UKM from MKM. Does not exhibit regional continuity.
(Note: MKM has recently been renamed LKM).
K (K Shale): Mudstone and claystone, commonly silty and/or sandy.
Lost Creek ISR Project
Sweetwater County, WY
NATA INTERNATIONAL, INC
Fort Collins, Colorado, USA
FIGURE 3.3-3
Stratigraphic Column, Upper Battle Spring Formation
Issued For: BLM NEPA Analysis
Issued/Revised: 27 April 2011 Drawn by: wk
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3.3.1.2 Structure

The present physiographic feature of the Basin was generated by the Laramide Orogeny. During the Late Cretaceous and Early Tertiary, the structures surrounding the Basin were either rejuvenated or were formed, transforming the area into a bowl-shaped geological structure, the Basin. During this upheaval, the Wind River Mountains and Granite Mountains were uplifted on the north side of the Basin. The Rawlins Uplift formed to the east; the Wamsutter Arch formed to the south; and the Rock Spring Uplift formed to the west. All of these highs formed a ring around the Basin, turning the Basin into a bowl-like structure with drainage inward. The Continental Divide, extending from the south, splits into two and forms half circles on the east and west sides of the Basin, joining again as one topographic high on the north side of the Basin.

The Basin is asymmetrical with its major axis trending west-northwest. Several anticlines and synclines have been mapped within the Basin, and some of these features are oil-bearing (at much deeper levels than the uranium-bearing formations). Noteworthy among these structures is the Lost Soldier anticline in the northeastern part of the Basin, approximately 15 miles northeast of the Permit Area. The Battle Spring and Fort Union Formations, as well as older rocks crop out in the anticline; and the formations on the southwestern flank of the anticline dip 20 to 25 degrees to the southwest. The dip gradually becomes gentler away from the anticline, and, at the Permit Area, it is merely three degrees to the west.

Contemporaneous with the uplift of the mountains surrounding the Basin, there were episodes of normal and thrust faulting within and around the Basin. Most of the major faults are located in the northern part of the Basin, with displacement ranging from a few feet to over 3,000 feet. However, toward the center of the Basin near the Permit Area, faulting seems to be only on a minor scale. For example, the displacement at the Lost Creek Fault that traverses the mineralized area from west-southwest to east-northeast is from zero to about 80 feet.

3.3.2 Permit Area and Mine Unit Geology

The Project is located in the north-central portion of the Great Divide Basin. Detailed information on the geology of the Permit Area is available in Appendix D5 of the WDEQ-LQD Permit to Mine (LCI, 2011b), which primarily addresses the ore-bearing and associated formations of interest for the Project. More specific geologic information on the ore-bearing and associated formations in Mine Unit 1 (MU1) is available in the WDEQ-LQD MU1 documents (LCI, 2011b). Prior to development of additional mine units, more specific information on each unit would be submitted to WDEQ-LQD and NRC as part of the required Hydrologic Test Plan for each unit. Information on the deeper formations of interest for the UIC Class I wells is included in the WDEQ-WQD application of those wells (Petrotek Engineering Corporation, 2009), which is included as

Attachment ADJ-2 to the WDEQ-LQD Permit to Mine (LCI, 2011b) and primarily addresses deeper formations.

3.3.2.1 Ore-Bearing and Associated Formations in the Main Permit Area

Geological cross-sections throughout the Permit Area are presented in Plates D5-1a, b, c, d, e, f and g in Appendix D5 of the WDEQ-LQD Permit to Mine (LCI, 2011b). Thickness (isopach) maps of the major sands and shales are also presented in Appendix D5 of the WDEQ-LQD Permit to Mine Plates D5-2a, b, c, and d. The locations of the cross-sections are illustrated on Plate D5-3 in Appendix D5 of the WDEQ-LQD Permit to Mine, (General Location Map-Geology) and also on insets within each cross section. These cross sections display stratigraphic and structural relationships interpreted from drill hole log data and projected onto true north-south or east-west planes. The true distance between drill holes are annotated near the top of each section. Endpoints of each cross-section are projected to the Permit Area boundaries. Extrapolation of the stratigraphy to the Permit Area boundary is based on data from historic exploration drill holes located just outside of the Permit Area boundary. These hole locations have not been identified on drill hole maps or cross-sections as they are outside of the Permit Area boundary. The following information presents the historic drill holes used for the extrapolations:

- Cross-Section F-F' (Plate D5-1e in Appendix D5 of the WDEQ-LQD Permit to Mine): The northern extrapolation of the stratigraphy is based on exploration Drill Hole #85-1, which is about 180 feet north of the property boundary. This drill hole is located at the following coordinates: Easting 2,204,464; Northing 598,174 (NAD 83, State Plane).
- Cross-Section G-G' (Plate D5-1f in Appendix D5 of the WDEQ-LQD Permit to Mine): The northern extrapolation is based on exploration Drill Hole #TT-10, about 120 feet north of the property boundary. This drill hole is located at: Easting 2,209,068; Northing 599,245 (NAD 83, State Plane).
- Cross-Section H-H' (Plate D5-1g in Appendix D5 of the WDEQ-LQD Permit to Mine): The northern extrapolation is based on exploration Drill Hole #A-530, about 940 feet north of the property boundary. This drill hole is located at: Easting 2,213,017; Northing 601,164 (NAD 83, State Plane). The southern extrapolation is based on exploration Drill Hole #RD-187, about 174 feet south of the property boundary. This drill hole is located at: Easting 2,213,202; Northing 594,142 (NAD 83, State Plane).

The cross-sections also illustrate the piezometric surfaces for the DE, LFG, HJ and UKM Horizons. Depiction of these surfaces on the cross-sections were generated by tracking the intersection of the plane of the cross-section profile with potentiometric contours plotted for the given horizons, which are presented in Appendix D5 of the WDEQ-LQD Permit to Mine (Plates D6-11a through

D6-11d). In the WDEQ-LQD Permit to Mine, Attachment D5-1 contains copies of typical geophysical logs from the Permit Area, and Attachment D6-3 contains copies of the geophysical logs from the baseline monitor wells.

Section 16 of Township 25 North, Range 92 West (Plate D5-3 in the WDEQ-LQD Permit to Mine) was not included on the cross-sections because of the limited subsurface data in this section and because no mining of this section is planned. Twenty holes have been drilled in Section 16, five of which are regional baseline monitor wells installed by LCI. Two of the exploration holes, OH1 and RD393, were shallow and did not penetrate to a depth sufficient to fully measure any of the stratigraphic units. Similarly, two of the existing monitor wells, MB-07 and MB-08, were only drilled to monitor shallow units. The stratigraphy and structure in Section 16 are discussed in the following sections. If LCI's plans change for Section 16, additional subsurface information will be collected and the WDEQ-LQD Permit to Mine revised to include that information.

3.3.2.2 Ore-Bearing and Associated Formations in MU1

Locations of the geological cross-sections through MU1 are shown on Figure 2-6 in Attachment MU1 2-1 of the WDEQ-LQD MU1 documents (LCI, 2011b). The cross-sections are presented in Figures 2-7 through 2-11, and thickness (isopach) maps of the major sands and shales are presented in Figures 2-2 through 2-4 of Attachment MU1 2-1. To detail offsets across the Lost Creek Fault through MU1, a series of 'cross-stitch' sections are also included in the MU1 documents. All of the locations are shown on each of Figures MU1 5-1 through 5-5, and the geologic logs are included on Plates MU1 5-2 and 5-3.

3.3.2.3 Deeper Formations Evaluated for UIC Class I Wells

Information on the deeper formations of interest for the UIC Class I wells, in particular, the Fort Union Formation, is included in the WDEQ-WQD permit application for those wells (Petrotek Engineering Corporation, 2009), which is included as Attachment ADJ-2 to the WDEQ-LQD Permit to Mine (LCI, 2011b) and primarily addresses deeper formations. Figures 19, 20, and 21 in the WDEQ-WQD permit application are regional cross-sections, with the cross-section locations shown on the same figure. Figure 25 shows the Permit Area cross-section locations, and the cross-sections are included as Figures 26 and 27. A structural contour map of the Fort Union Formation in the Basin is also included as Figure 22.

3.3.2.4 Stratigraphy

The entire Permit Area is covered by the upper part of the Battle Spring Formation, which is the host to uranium mineralization. Generally, in the Basin, the Battle Spring and Wasatch Formations, which are time equivalent, interfinger with one another. In the Permit Area, the upper half of the lithologic units

consists of the Battle Spring Formation and the lower half is made up of the Wasatch Formation. Geologic development of the Basin began in the Late Cretaceous and continued through much of the Early Eocene. During the early Basin subsidence, the Fort Union Formation, consisting of approximately 4,650 feet of Paleocene age sediment, was unconformably deposited on the late Cretaceous age Lance Formation. During the Eocene, an additional 6,200 feet of sediments, consisting of the Wasatch and the Battle Springs Formations, were uncomformably deposited on the Fort Union Formation. In the western and southern portions of the Basin, the Wasatch Formation, consisting of sandstone, siltstone, limestone, conglomerate and lignite beds, was deposited. Towards the north and northeast, the Wasatch Formation rapidly grades into and inter-tongues with the equally thick, fine- to coarse-grained arkosic sandstones and conglomerates of the Battle Spring Formation, a typical alluvial fan complex. The source of the Battle Spring and Wasatch sediments is believed to be the ancestral Granite Mountains to the north. Deeper in the Basin and lying unconformably are various Cretaceous, Jurassic, Triassic, Paleozoic, and Precambrian basement lithologic units (**Table 3.3-1**). A schematic geologic cross section across the Permit Area is shown in **Figure 3.3-2**, depicting all lithologic units present under the Permit Area.

3.3.2.5 Ore-Bearing and Associated Formations - Main Permit Area

The upper portion of the Battle Spring Formation is the host to the uranium mineralization in the Permit Area, where the uranium mineralization is associated with finer-grained sandstones and siltstones. In the Permit Area, the upper portion of the Battle Spring Formation is divided into at least five horizons marked from top to bottom as BC, DE, FG, HJ, and KM, each with various amounts of mineralization. These horizons are separated from one another by various thicknesses of shale, mudstone and siltstone (**Figure 3.3-4**).

The two horizons with the most mineralization are HJ and KM, which have been further divided into upper, middle, and lower sub-units of sandstones (i.e., UHJ Sand, MHJ Sand, and LHJ Sand; and UKM Sand, MKM Sand, and LKM Sand). The HJ Horizon, on average, is about 120 feet thick. The thinner part of HJ Horizon is generally south of the Lost Creek Fault. A thicker part of the HJ Horizon runs parallel to the Lost Creek Fault, trending in a west-southwest to east-northeasterly direction. The mineralization is mostly concentrated in the middle part of the HJ Horizon and occurs as both roll front and tabular deposits. Although the shales bounding the HJ Horizon (i.e., the Lost Creek Shale [LCS] and the Sage Brush Shale [SBS]) are continuous in the Permit Area, the subdivided Sand units within the HJ Horizon are separated by discontinuous shale, siltstone and mudstones. The UKM Sand lies under the Sage Brush Shale and has an average thickness of about 40 feet. In the eastern part of the Permit Area, the unit is 20 to 50 feet thick; whereas the sand unit in the western portion of the Permit Area is 40 to more than 60 feet thick, indicating the development of

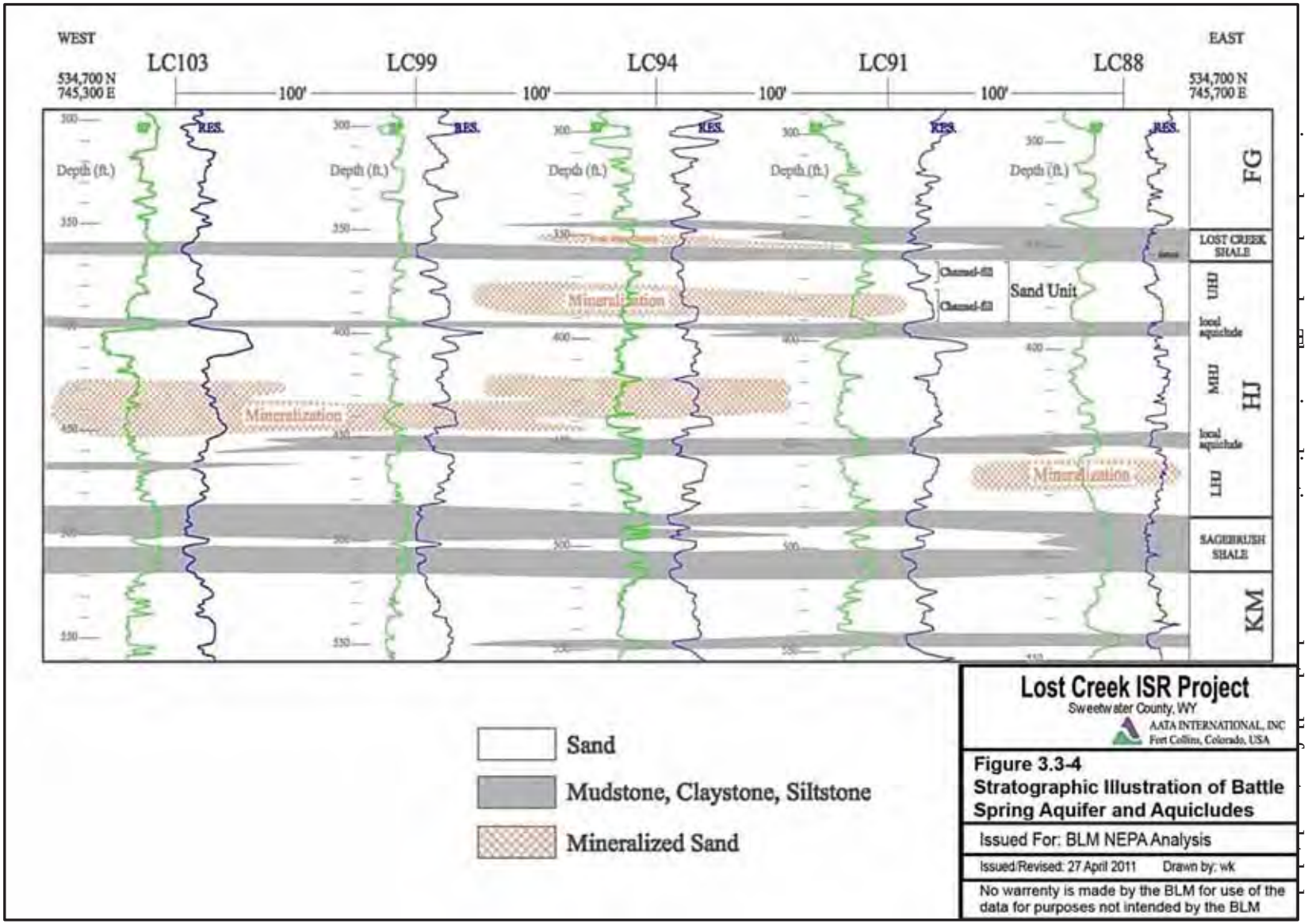


Figure 3.3-4
Stratographic Illustration of Battle Spring Aquifer and Aquicludes

The stratigraphic layering extends east into Section 16. The layers of interest (DE, EF, FG, LCS, HJ, SBS, KM and KSH) have very similar thicknesses to MU1, although the uppermost BC layer is absent and the underlying layers are slightly shallower in Section 16 because of dip. (The strike at Lost Creek is approximately NE/SW with a dip of roughly two degrees northwest.) Gamma log signatures for holes drilled in the southeastern portion of Section 16 indicate the existence of mineralized roll front trends. Based on the trends in the HJ and KM Horizons in the rest of the Permit Area, LCI expects these fronts to extend into this portion of Section 16.

The Battle Spring Formation in the Permit Area is part of a major alluvial system, consisting of thick beds of very fine- to coarse-grained arkosic sandstones separated by various layers of mudstones and siltstones. Conglomerate beds may exist locally.

Aquifers in the Battle Spring Formation typically consist of thick sequences of multiple, medium- to coarse-grained, fluvial channel-fill sands. Mapable sand units (e.g., the UHJ Sand) may range from five to 50 feet in composite thickness, and typically consist of multiple stacked channel-fill sands. Aquifers, in turn, typically consist of multiple stacked sand units. Sand units are commonly separated vertically by locally thick beds of mudstone, claystone, siltstone or fine-grained sands. These interbeds represent local aquitards and aquicludes, which can be considered internal to the regional aquifer. Total composite thickness of an aquifer (e.g., the HJ Horizon) is commonly in excess of 100 feet.

Aquicludes and aquitards (e.g., the Lost Creek Shale or Sage Brush Shale) represent quiescent floodplain and overbank sedimentary environments between channel fill sequences. Generally referred to as ‘shales’ they are, in essence, sedimentary sequences dominated by mudstone and claystone lithology; but also may include substantial amounts of siltstone and fine-grained sands. These lithologies can exhibit considerable lateral facies changes and interfingering, and are often transitional to the aquifers above or below. As a result, dramatic thickening and thinning of the aquicludes can occur locally. Thicknesses of the Lost Creek and Sagebrush Shales are commonly in excess of 25 feet. The thinnest observed occurrences of these units are five feet thick, within the accuracy of the interpretation of down-hole geophysical logs, which is plus or minus six inches.

Aquicludes may locally include occurrences of mineralization in the vicinity of lithologic interfingering and facies changes with mineralized sands. Mineralization in this setting would not be targeted for mining and thus would experience minimal, if any, contact with production lixiviant. Given the very low concentrations of uranium within the shales (0.05 percent or less), the structural integrity and confinement characteristics of the shales would remain unchanged, even if uranium in the shales were incidentally contacted and removed through mining.

3.3.2.6 Deeper Formations Evaluated for UIC Class I Wells

The following information is summarized from the WDEQ-WQD application (Petrotek Engineering Corporation, 2009), included as Attachment ADJ-2 to the WDEQ-LQD Permit to Mine (LCI, 2011b). The base of the Wasatch/Battle Spring Formation is about 6,100 feet below ground surface (ft bgs) in the vicinity of the Permit Area. The lower 300 feet is a low-permeability shale sequence that, combined with lower permeability intervals in the Fort Union Formation, is the confinement interval for the deep wells. The depth to the Fort Union Formation is about 5,000 feet in the vicinity of the Permit Area. The Formation is divided into Upper, Middle, and Lower Units, based on general lithology (which consists of sequences of sandstones, siltstones, and shales) and the presence or absence of coal-bearing intervals. The Lance Formation is also composed of siltstone, fine sandstone, and shale sequences with some coal-bearing intervals. Sediments underlying the Lance Formation include the Fox Hills Sandstone, Lewis Shale, and Mesaverde Group. The deepest sediments in the vicinity of the Permit Area, for which drilling data are available, are in the Mesaverde Group, which is about 16,000 ft bgs. Although there are hydrocarbon 'shows' in the Mesaverde Group, there are no producing or plugged wells in any of the strata within a mile of the Permit Area, outside the Area of Review for the UIC Class I wells, whether the area is defined technically or as the regulatory minimum.

3.3.2.7 Structure

Geologic structural features in the Permit Area are illustrated on the cross-sections (Plates D5-1a through D5-1g), the isopach maps (Plates D5-2a through D5-2d), and the general location map (Plate D5-3) in Appendix D5 of the WDEQ-LQD Permit to Mine (LCI, 2011b). In the Permit Area, the Battle Spring Formation is nearly flat-lying, dipping gently to the northwest at roughly three degrees. Several anticlines and synclines have been mapped within the Basin. Noteworthy among these structures is the Lost Soldier anticline in the northeastern part of the Basin, approximately 15 miles northeast of the Permit Area. The Battle Spring and Fort Union Formations, as well as older rocks crop out in the anticline; and the formations on the southwestern flank of the anticline dip 20 to 25 degrees to the southwest. The dip gradually becomes gentler, and, at the Permit Area, it is merely three degrees to the west.

Contemporaneous with the uplift of the mountains surrounding the Basin, there were episodes of normal and thrust faulting within and around the Basin. Most of the major faults are located in the northern part of the Basin, with displacement ranging from a few feet to over 3,000 feet. Toward the center of the Basin near the Permit Area, faulting is only on a minor scale. For example, the displacement at the Lost Creek Fault (Fault), which traverses the mineralized area from west-southwest to east-northeast is from zero to about 80 feet. The Fault has been recently interpreted as a sequence of sub-parallel faults with opposite displacement occurring in an en echelon configuration.

Recent drilling activity has identified the presence of additional faulting. A second fault (the North Fault) occurs in the northwestern portion of the Permit Area. Limited data indicate that the maximum displacement is approximately 70 feet, with the downthrown block to the north. Likewise, a third fault (the South Fault) is found in the south-central portion of the Permit Area. Maximum displacement is roughly 40 feet, with the downthrown block to the north. Both of these faults are oriented sub-parallel to the Lost Creek Fault sequence. Also, both are located outside of anticipated production areas.

No faulting has been identified in Section 16. The Fault, however, is known to extend east-northeast out of the central portion of the Permit Area and is suspected to extend into the southeastern portion of Section 16. The current drill hole spacing is insufficient to confidently identify faulting because topographic relief could mask the occurrence of any fault with an offset on the order of 20 to 40 feet. However, it is possible that further drilling would identify normal faulting in the southern part of Section 16.

As previously noted, detail on offsets across the Fault through MU1 is presented in a series of 'cross-stitch' sections in the MU1 documents (LCI, 2011b). All of the locations are shown on each of Figures MU1 5-1 through 5-5, and the geologic logs are included on Plates MU1 5-2 and 5-3.

3.3.3 Ore Mineralogy and Geochemistry

The upper portion of the Battle Spring Formation is the host to the uranium mineralization in the Permit Area. The age of uranium mineralization in the Battle Spring Formation is believed to be between 35 and 26 million years before present. Uranium mineralization in the Basin generally occurs either as tabular or C-shaped roll-front deposits. Oxygen-rich surface water, carrying dissolved uranium, entered various sandstones in the Basin. The water percolated down dip, oxidizing the sandstones on its way down dip. Upon reaching locations rich in organic matter, the water lost its oxidizing potential and deposited the uranium, forming the two types of mineralization mentioned above.

The main uranium minerals are uraninite, a uranium oxide, and coffinite, a uranium silicate. The uranium mineralization is of sub-microscopic size and can be seen only in scanning electron microscope (SEM) magnification. They are associated and, at times, intergrown with round pyrite particles. The uranium, besides occurring with pyrite, also occurs as coating around sand grains, filling of voids between grains, and minute particles within larger clay particles.

Known mineralized intervals are found at depths ranging from near surface down to 1,150 ft bgs in the Permit Area. It is possible that deeper mineralization may also exist. The main mineralization horizons trend in an east-northeast direction for at least three miles, and are up to 2,000 feet wide. The thickness of individual

mineralized beds at the Permit Area ranges from five to 28 feet and averages about 16 feet. The mineralization grade ranges from 0.03 percent to more than 0.20 percent equivalent uranium oxide (eU_3O_8). Four main mineralized horizons, from depths of 350 to 600 feet, have been identified. The richest mineralized zone occurs in the middle part of the HJ Horizon (MHJ Sand) and it is about 30 feet thick, 400 to 450 feet deep, and is believed to contain more than 50 percent of the total resource under the Permit Area.

Leach amenability studies, using the 'bottle roll' method, were performed on core samples collected from the Permit Area in 2007. The analytical results of the bottle roll tests indicate leach efficiencies of 84 percent to 93 percent where bicarbonate was added to the leach solution (a standard ISR practice). The testing demonstrated leach amenability to varying levels of bicarbonate and oxidant addition and accomplished the goal of defining the chemical factors for leaching the ore body and determining the maximum economic leach efficiencies.

The bottle roll tests were conducted using standard industry practice and rigorous modern laboratory controls. The tests were performed on seven uniform splits of a composite core recovered from hole LC66C. Oxidation of uranium in core that has been exposed to the atmosphere can increase the leachability of the uranium, yielding results that are not representative of the in situ deposit. Therefore, the drill core was vacuum-sealed in airtight plastic sleeves immediately after recovery to protect the uranium-bearing minerals from exposure to the air.

Upon completion of the coring program, the sealed core was characterized by geologists and transferred to the laboratory. A single core composite of eight feet of core was selected for leach amenability, bicarbonate and oxidant studies. The selected core composite was chosen to represent a typical production zone for the Project. The composite splits were then subjected to bottle roll amenability testing, in which each individual sample was placed in a plastic container with a hydrogen peroxide lixiviant in a measured volume estimated to be five pore volumes (PVs) of the tested interval, and then rolled mechanically for 16 hours. The lixiviant was extracted and tested for uranium content in the solution and new lixiviant was added and the process was repeated. Each sample was subjected to five additional periods of leaching, to represent the total volume of fluid that would leach uranium from the host over the life of an ISR operation. These six roll sets, each being leached with five PVs of lixiviant, replicate a total of 30 PVs of lixiviant passing through the deposit, thus closely simulating an actual ISR operation. Once the six sets of rotation were completed, the core was analyzed to determine the amount of uranium remaining, in order to establish the efficiency of the leaching system. This allows a determination of the potential in situ leachability of the uranium-bearing sandstone and the potential rate of recovery.

A total of seven tests were conducted. The first test, LC-2001-01, showed low recovery without a bicarbonate addition, which demonstrated the requirement for bicarbonate addition to the lixiviant and the effectiveness of the sample

preparation for the test. The other six samples (LC-2001-02 through -07) successfully demonstrated the ore's wide range of amenability to varying chemical conditions. The results of these tests demonstrate that uranium is easily mobilized for production and that the chemical conditions used in the tests would be equally effective under both low and high oxidant injection rates. The results of this testing are summarized in **Table 3.3-2**.

Table 3.3-2 Leach Amenability

Sample ID	Solution Base	Bicarbonate (g/L)	H_2O_2 (g/L)	Uranium Recovery (percent)
LC-2001-01	Ground Water	Natural Bicarb	0.25	20.0
LC-2001-02	Ground Water	1.0	0.25	84.1
LC-2001-03	Ground Water	1.5	0.25	86.4
LC-2001-04	Ground Water	2.0	0.25	93.3
LC-2001-05	Ground Water	2.0	0.50	87.1
LC-2001-06	Synthetic	2.0	0.25	92.6
LC-2001-07	Synthetic	2.0	0.50	88.1

Hole ID: LC-66C
Core Composition Depth Interval: 412 to 420.4 feet
Pre-Test Feed Grade: 0.0513% $_cU$

3.3.4 Seismology

The discussion of the seismology of the Permit Area and surrounding areas includes: an analysis of historic seismicity; an analysis of the Uniform Building Code (UBC); a deterministic analysis of nearby faults; an analysis of the maximum credible "floating earthquake;" and a discussion of the existing short- and long-term probabilistic seismic hazard analysis. The materials presented here are mainly based on the seismologic characterization of Sweetwater, Carbon, Fremont, and Natrona Counties by personnel from the Wyoming State Geological Survey (Case et al., 2002a, 2002b, 2002c and 2003).

3.3.4.1 Historic Seismicity

The Permit Area is located in the northeastern portion of the Basin, in south-central Wyoming. Historically, south-central Wyoming has had a low to moderate level of seismicity compared to the rest of the State of Wyoming. As shown in **Figure 3.3-5**, most of the historical earthquakes occurred in the west-northwest portion of Wyoming. Significant historical earthquakes adjacent to the Permit Area are described below, and are organized by areas in which they occurred.

Town of Bairoil Area

Bairoil is located about 15 miles northeast of the Permit Area. Historically, there have been only a few earthquakes that have occurred within 20 miles of Bairoil. On August 11, 1916, a non-damaging intensity III earthquake occurred approximately 17 miles northwest of Bairoil. On June 1, 1993, a non-damaging magnitude 3.8, intensity III earthquake occurred four miles north of Bairoil, and was felt by some residents. On December 10, 1996, a non-damaging magnitude 2.6 earthquake occurred approximately ten miles northwest of Bairoil. A few residents also felt that event.

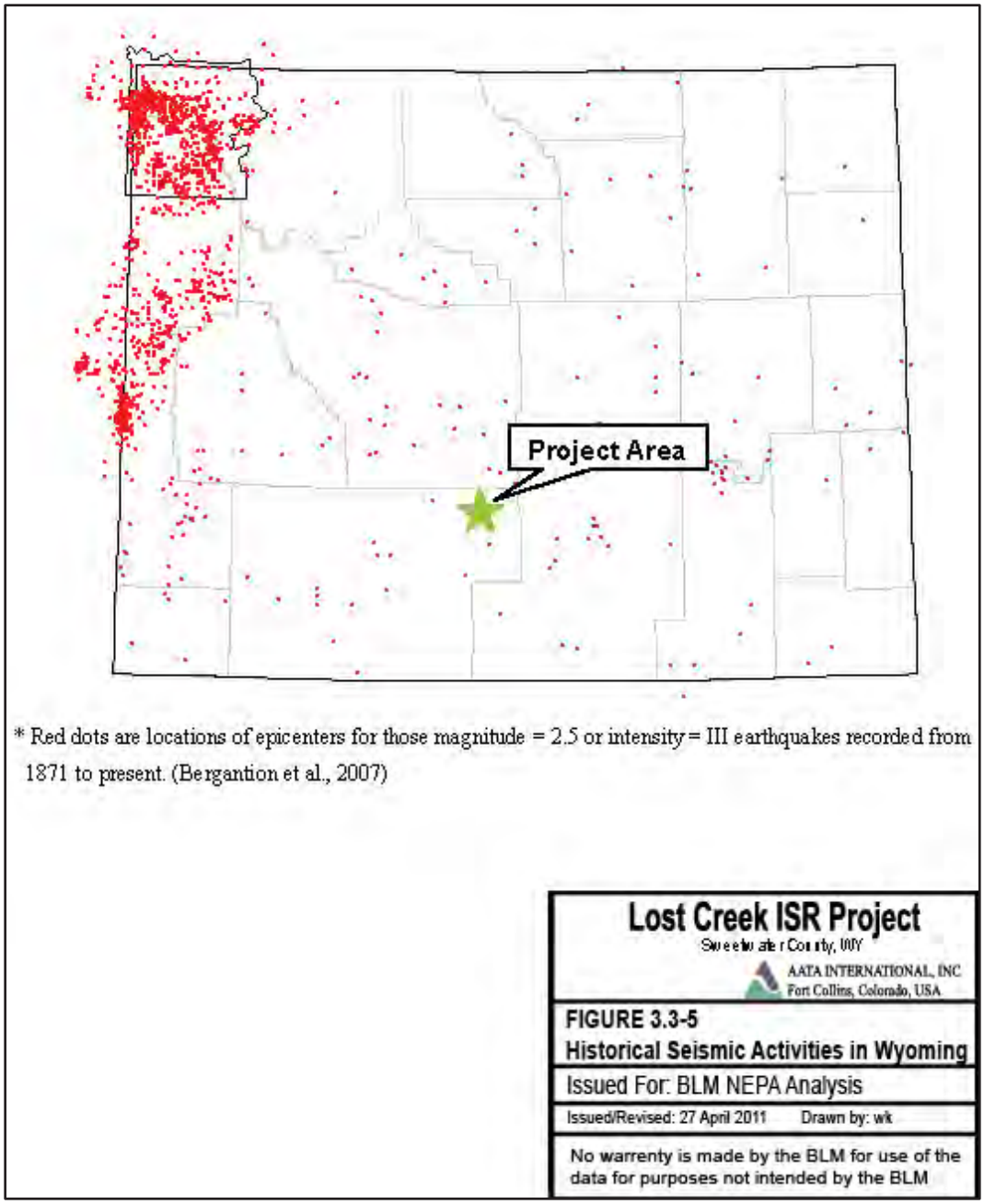
Two recent earthquakes were recorded near Bairoil in 2000. On May 26, 2000, a magnitude 4.0 earthquake occurred, followed by another (magnitude 2.8) four days later, on May 30, 2000. Both earthquakes were located about 3.5 miles southwest of Bairoil. Most residents in Bairoil felt the first earthquake. No significant damage was associated with either seismic event (Cook, 2000).

City of Rawlins Area

Rawlins is approximately 38 miles southeast of the Permit Area. The first recorded earthquake that was felt and reported immediately southwest of Rawlins occurred on March 28, 1896. The intensity IV earthquake shook for about two seconds. On March 10, 1917, an earthquake (intensity IV) was recorded approximately one mile northeast of Rawlins. The earthquake was felt as a distinct shock that caused wooden buildings to noticeably vibrate. Stone buildings were not affected by the event (*Rawlins Republican, 1917* as referenced in Case et al., 2002a).

On September 10, 1964, a magnitude 4.1 earthquake occurred approximately 30 miles west of Rawlins. One Rawlins resident reported that the earthquake caused a crack in the basement of his home. No other damage was reported (*Daily Times, 1964* as referenced in Case et al., 2002a).

Small earthquakes were detected, on April 13, 1973, May 30, 1973, and June 1, 1973, approximately thirty-four miles east of Rawlins. No one reported feeling these events. On July 11, 1975, Rawlins residents felt an earthquake (intensity II) event. On January 27, 1976, an earthquake (magnitude 2.3, intensity V) occurred approximately 12 miles north of Rawlins. Several people reported that they were thrown out of bed (*Daily Times, 1976* as referenced in Case et al., 2002a). On March 3, 1977, an earthquake (intensity V) was reported approximately 40 miles south-southeast of Rawlins. Doors and dishes were rattled in southern Carbon County homes; but no significant damage was reported (*Laramie Daily Boomerang, 1977* as referenced in Case et al., 2002a).



On April 13, 1991 and April 19, 1991, magnitude 3.2 and magnitude 2.9 earthquakes, respectively, occurred near the center of the Seminoe Reservoir. A magnitude 3.1 earthquake occurred on December 18, 1991, southwest of the Seminoe Reservoir, approximately 20 miles east-northeast of Rawlins. No one reported feeling these Seminoe-Reservoir-area earthquakes. On August 6, 1998, a magnitude 3.6 earthquake occurred approximately 13 miles north of Rawlins. Residents in Rawlins reported hearing a sound and then feeling a jolt. On April, 1999, a magnitude 4.3 earthquake occurred approximately 50 miles southwest of Rawlins. It was felt in Rawlins; and residents reported that pictures fell off the walls.

City of Rock Springs Area

Rock Springs is located approximately 80 miles southwest of the Permit Area. The first recorded earthquake that was felt in Sweetwater County occurred on April 28, 1888. This intensity IV earthquake, which originated near Rock Springs, did not cause any appreciable damage. On July 25, 1910, an intensity V earthquake occurred at the same time that the Union Pacific Number One Mine in Rock Springs partially collapsed. On July 28, 1930, an intensity IV earthquake, with an epicenter near Rock Springs, was felt in Rock Springs (*Casper Daily Tribune, 1930* as referenced in Case et al., 2002c). The earthquake awakened many residents; and some merchandise fell off of store shelves.

On March 21, 1942, a non-damaging, intensity III earthquake was felt in the Rock Springs area. This event was followed, on September 14, 1946, by an intensity IV earthquake. On October 25, 1947, a small earthquake with no assigned intensity or magnitude occurred southeast of Rock Springs. Two intensity IV earthquakes occurred in the Rock Springs area on September 24, 1948. The events rattled dishes in parts of Rock Springs.

A magnitude 3.9 event was recorded on January 5, 1964, approximately 23 miles south of Rock Springs. The University of Utah Seismograph Stations detected a non-damaging, magnitude 2.4 earthquake on March 19, 1968. This event was centered approximately 17 miles southeast of Rock Springs. A magnitude 3.2 event occurred on May 29, 1975, approximately 33 miles northeast of Rock Springs. A week later, on June 6, 1975, a magnitude 3.7 earthquake was recorded in the same area. No damage was associated with any of the 1975 events.

The University of Utah Seismograph Stations recorded a non-damaging magnitude 2.7 earthquake on June 5, 1986. This event was located approximately 30 miles southwest of Rawlins, Wyoming.

On February 1, 1992, the University of Utah Seismograph Stations recorded a non-damaging magnitude 2.3 earthquake, approximately seven miles north of Rock Springs.

City of Lander Area

Lander is about 70 miles northwest of the Permit Area. A number of earthquakes have occurred in the Lander area. The first reported earthquake occurred on January 22, 1889, and had an intensity of III to IV. This was followed by an intensity IV event on November 21, 1895, during which houses were jarred and dishes rattled. On November 23, 1934, an intensity V earthquake was centered approximately 20 miles northwest of Lander. For a radius of ten miles around Lander, residents reported that dishes were thrown from cupboards, and that pictures fell down from the walls. Cracks were found in buildings along two business blocks; and the brick chimney of the Fremont County Courthouse in Lander was separated by two inches from the building. The earthquake was felt

at Rock Springs and Green River, Wyoming (*Casper Tribune-Herald, 1934* as referenced in Case et al., 2002b).

There were a series of earthquakes in the Lander area in the 1950s that caused little damage. On August 17, 1950, there was an intensity IV earthquake that caused loose objects to rattle and buildings to creak. On January 12, 1954, there was an intensity II event; and on December 13, 1955, there was an intensity IV event near Lander, with no damage reported.

On June 14, 1973, a small earthquake was reported about eight miles east-northeast of Lander. The earthquake has been recently interpreted as a probable explosion. On January 31, 1992, a non-damaging magnitude 2.8 earthquake occurred approximately 20 miles northwest of Lander. This event was followed, on October 10, 1992, by a magnitude 4.0, intensity III earthquake centered approximately 22 miles east of Lander.

City of Casper Area

Casper is located about 90 miles northeast of the Permit Area. Two of the earliest recorded earthquakes in Wyoming occurred near Casper. The first was on June 25, 1894, and had an estimated intensity of V. In residences on Casper Mountain, dishes rattled and fell on the floor and people were thrown from their beds. Water in the Platte River changed from fairly clear to reddish, and became thick with mud, due to the river banks slumping into the river during the earthquake. On November 14, 1897, an even larger event was felt. An intensity VI to VII earthquake, one of the largest recorded in central and eastern Wyoming, caused considerable damage to a few buildings. As a result of the earthquake, a portion of the Grand Central Hotel in Casper was cracked from the first to the third story. Some of the ceilings in the Grand Central Hotel were also severely damaged.

On October 25, 1922, an intensity IV earthquake was reported in the Casper area. The event was felt in Casper; at Salt Creek, 50 miles north of Casper; and at Bucknum, 22 miles west of Casper. Dishes were rattled and hanging pictures were tilted near Salt Creek. No significant damage was reported in Casper (*Casper Daily Tribune, 1922* as referenced in Case et al., 2003). On December 11, 1942, an intensity IV earthquake was recorded north of Casper. Although no damage was reported, the event was felt in Casper, Salt Creek, and Glenrock, 25 miles east of Casper (*Casper Tribune-Herald, 1942* as referenced in Case et al., 2003). On August 2, 1948, another intensity IV earthquake was reported in the Casper area. No damage was reported (*Casper Tribune-Herald, 1948* as referenced in Case et al., 2002c). In the 1950s, two earthquakes caused some concern among Casper residents. On January 24, 1954, an intensity IV earthquake near Alcova, 30 miles southwest of Casper, did not result in any reported damage (*Casper Tribune-Herald, 1954* as referenced in Case et al., 2002b). On August 19, 1959, an intensity IV earthquake was felt in Casper.

Most recently, on October 19, 1996, a magnitude 4.2 earthquake was recorded approximately 15 miles north-northeast of Casper. No damage was reported.

3.3.4.2 UBC and International Building Code

With safety in mind, the UBC provides Seismic Zone Maps to help identify which building design factors are critical to specific areas of the country. Five UBC seismic zones are recognized, ranging from Zone 0 to Zone 4. These 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 (1986). The criteria they developed are as follows:

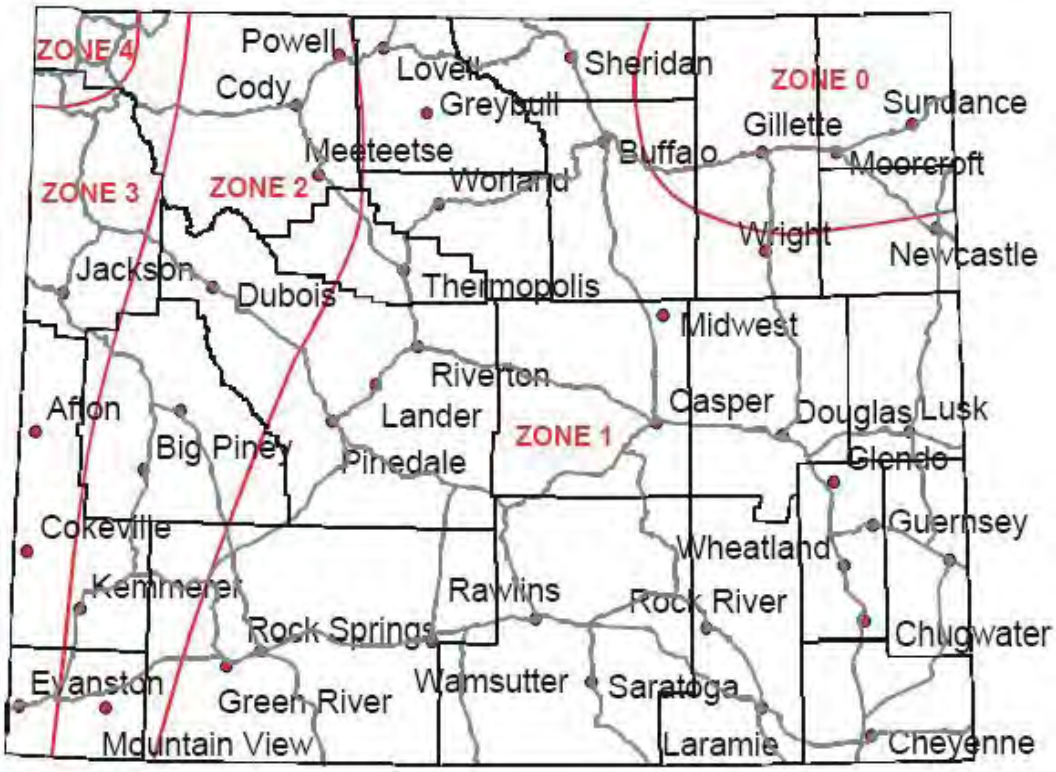
- Zone 4: ≥ 30 percent gravity effective peak acceleration;
- Zone 3: 20 to ≤ 30 percent gravity effective peak acceleration;
- Zone 2: 10 to ≤ 20 percent gravity effective peak acceleration;
- Zone 1: 5 to ≤ 10 percent gravity effective peak acceleration; and
- Zone 0: ≤ 5 percent gravity effective peak acceleration.

The Seismology Committee of the Structural Engineers Association of California assumed that there was a 90 percent probability that the above values would not be exceeded in 50 years, or a 100 percent probability that the values would be exceeded in 475 years.

Figure 3.3-6 shows the delineation of UBC seismic zones in Wyoming. The Permit Area is located in Seismic Zone 1. Since effective peak accelerations (90 percent chance of non-exceedance in 50 years) can range from five to ten percent gravity in Zone 1, it may be reasonable to assume that an average peak acceleration of 7.5 percent gravity could be applied to the design of a non-critical facility located near the center of Zone 1.

UBC has been used in Wyoming for many years. Recently, the UBC has been replaced by the International Building Code (IBC). Wyoming also adopted this in lieu of the UBC to its regulations in late 2008. While the UBC has always been based on seismic zones; the IBC is based on probabilistic analysis (involving a full evaluation of the potential earthquake generating fault system of the region), and uses ground motion parameters for seismic design. The following sections discuss the fault system of the Project region, probabilistic seismic hazard analysis of the Permit Area and nearby region, and present a 2,500-year probabilistic ground acceleration map used by IBC.

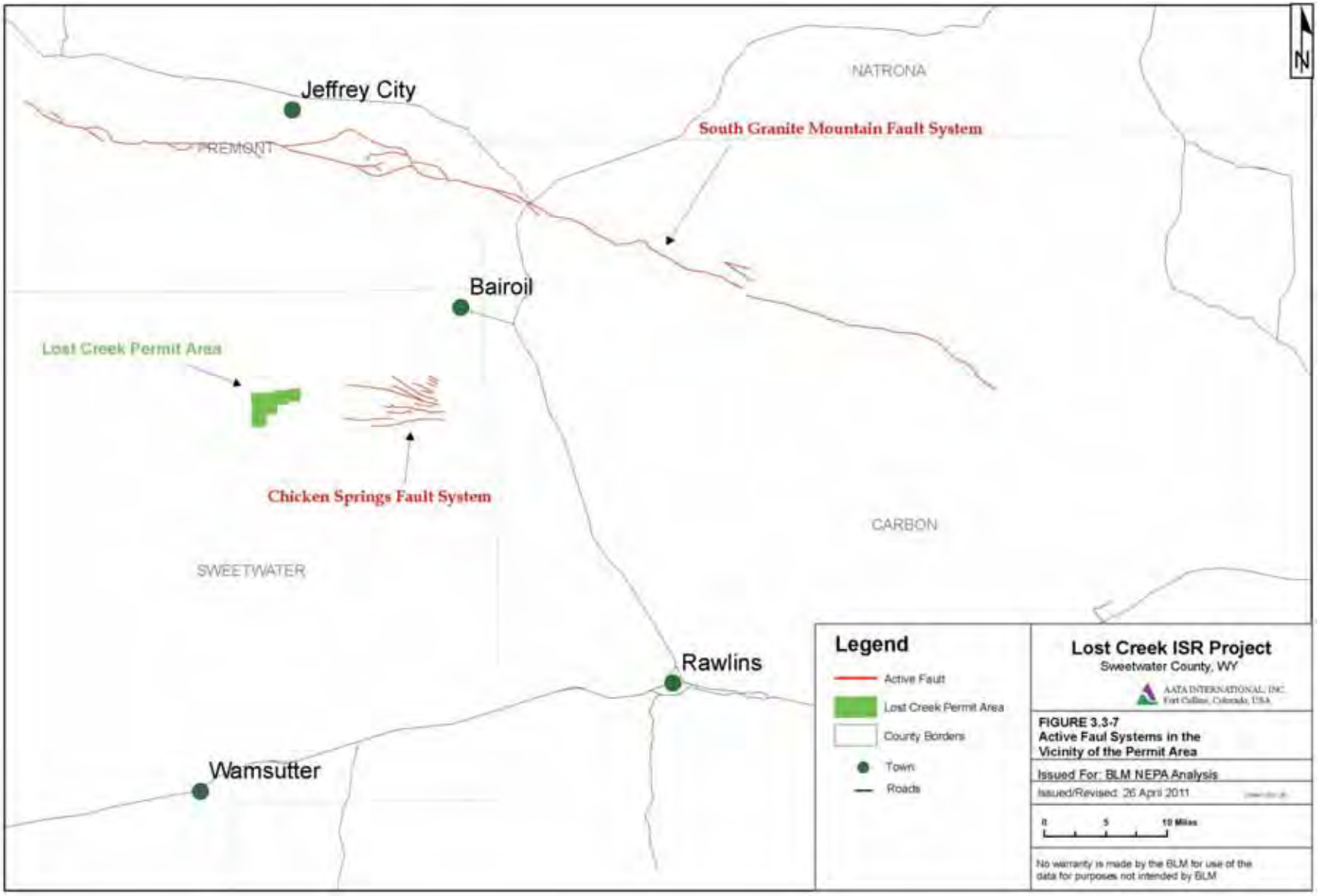
Figure 3.3-6 Seismic Zones in Wyoming



3.3.4.3 Deterministic Analysis of Active Fault Systems

There are two active fault systems in the vicinity of the Permit Area, the Chicken Springs Fault System and the South Granite Mountain Fault System (**Figure 3.3-7**).

The Chicken Springs Fault System, located six miles east of the Permit Area, is composed of a series of east-west trending segments. In 1996, the Wyoming State Geological Survey investigated this fault system, and determined that the most recent activity on the system appears to be Holocene in age. Reconnaissance-level studies indicated that the fault system is capable of generating a magnitude 6.5 earthquake (Case et al., 2002c). A magnitude 6.5 earthquake on the Chicken Springs Fault System would generate peak horizontal accelerations of approximately 4.8 percent gravity at Rawlins (Case et al., 2002c). These accelerations would be roughly equivalent to an intensity V earthquake, which may cause some light damage. Bairoil, however, would be subjected to a peak horizontal acceleration of approximately 23 percent g, or an intensity VII earthquake (Case et al., 2002c). Intensity VII events have the potential to cause moderate damage.


N
NATRONA
Jeffrey City
South Granite Mountain Fault System
FREMONT
Bairoil
Lost Creek Permit Area
Chicken Springs Fault System
CARBON
SWEETWATER
Rawlins
Wamsutter
Legend
Active Fault
Lost Creek Permit Area
County Borders
Town
Roads
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC.
Fort Collins, Colorado, USA
FIGURE 3.3-7
Active Faul Systems in the
Vicinity of the Permit Area
Issued For: BLM NEPA Analysis
Issued/Revised: 26 April 2011
0
5
10 Miles
No warranty is made by the BLM for use of the
data for purposes not intended by BLM

The South Granite Mountain Fault System is located about 14 miles northeast of the Permit Area. This fault system is composed of several northwest-southeast trending normal and thrust faults in southeastern Fremont County and northwestern Carbon County. The active segments of the system have been assigned a maximum magnitude of 6.75, which could generate peak horizontal accelerations of approximately 20 percent gravity at Bairoil and 6.1 percent gravity at the Rawlins (Case et al., 2002c). These accelerations would be roughly equivalent to an intensity VII earthquake at Bairoil and an intensity V earthquake at Rawlins. Bairoil could sustain moderate damage; whereas minor or no damage could occur at Rawlins.

3.3.4.4 Maximum Tectonic Province Earthquake "Floating Earthquake" Seismogenic Source

Tectonic provinces are regions with a uniform potential for the occurrence of earthquakes that are tied to buried faults with no surface expression. 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 most 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.

The US Geological Survey (USGS) identified tectonic provinces in a report titled "Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States" (Algermissen et al., 1982). In that report, Sweetwater County was classified as being in a tectonic province with a "floating earthquake" maximum magnitude of 6.1. Geomatrix (1988) 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 degrees West longitude on the east, 40 degrees North latitude on the south, and 45 degrees North latitude on the north. Geomatrix (1988) estimated that the largest "floating earthquake" in the "Wyoming Foreland Structural Province" would have a magnitude in the 6.0 to 6.5 range, with an average value of magnitude 6.25.

3.3.4.5 Probabilistic Seismic Hazard Analysis and IBC

The USGS publishes probabilistic acceleration maps for 500-, 1,000-, 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 would be met or exceeded in a shorter time frame. For example, a ten percent probability that acceleration may be met or exceeded in 50 years is roughly equivalent to a 100 percent probability of exceedance in 500 years.

The 500-year map provides accelerations that are comparable to those derived from the UBC and from the deterministic analysis on the Green Mountain Segment of the South Granite Mountain Fault System. It was often used for planning purposes for average structures. Based on the 500-year map (ten percent probability of exceedance in 50 years), the estimated peak horizontal acceleration in the Permit Area is approximately 6.5 percent g, which is comparable to the acceleration expected in Seismic Zone 1 of the UBC (**Figure 3.3-8**). These accelerations (3.9 to 9.2 percent g) are roughly comparable to intensity V earthquakes, which can result in cracked plaster and broken dishes, but minor or no construction damages (Case et al., 2002c).

While the UBC intended that structures be designed for "life-safety" in the event of an earthquake with a ten percent probability of being exceeded in 50 years (commonly referred to as the 475-year, or 500-year earthquake), the IBC intends design for "collapse prevention" in a much larger earthquake, i.e., the 2,500-year earthquake. **Figure 3.3-9** presents the probabilistic peak ground acceleration during a 2,500-year earthquake. The estimated acceleration in the Permit Area is 20 percent gravity on the 2,500-year map, which would be roughly equivalent to an intensity VII earthquake. As previously discussed, the Chicken Springs and South Granite Mountain fault system could potentially generate a 6.5 and 6.75 earthquake, with peak ground acceleration of 20 and 23 percent (intensity VII) at the Town of Bairoil.

Figure 3.3-8 500-Year Probabilistic Acceleration Map of Wyoming

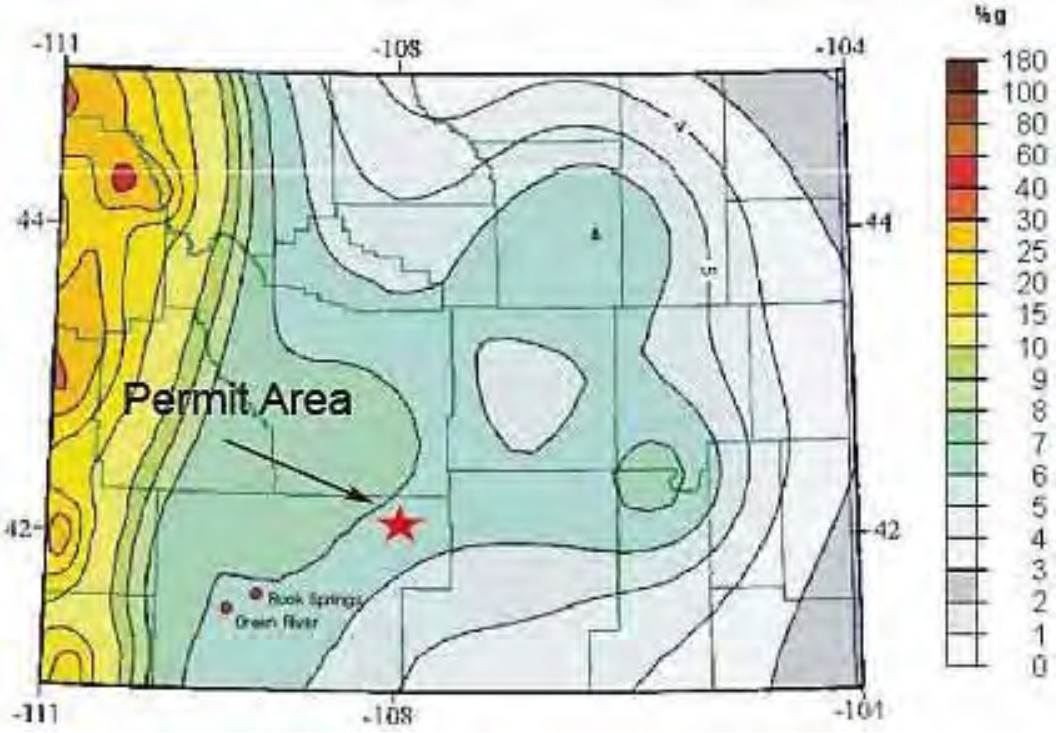
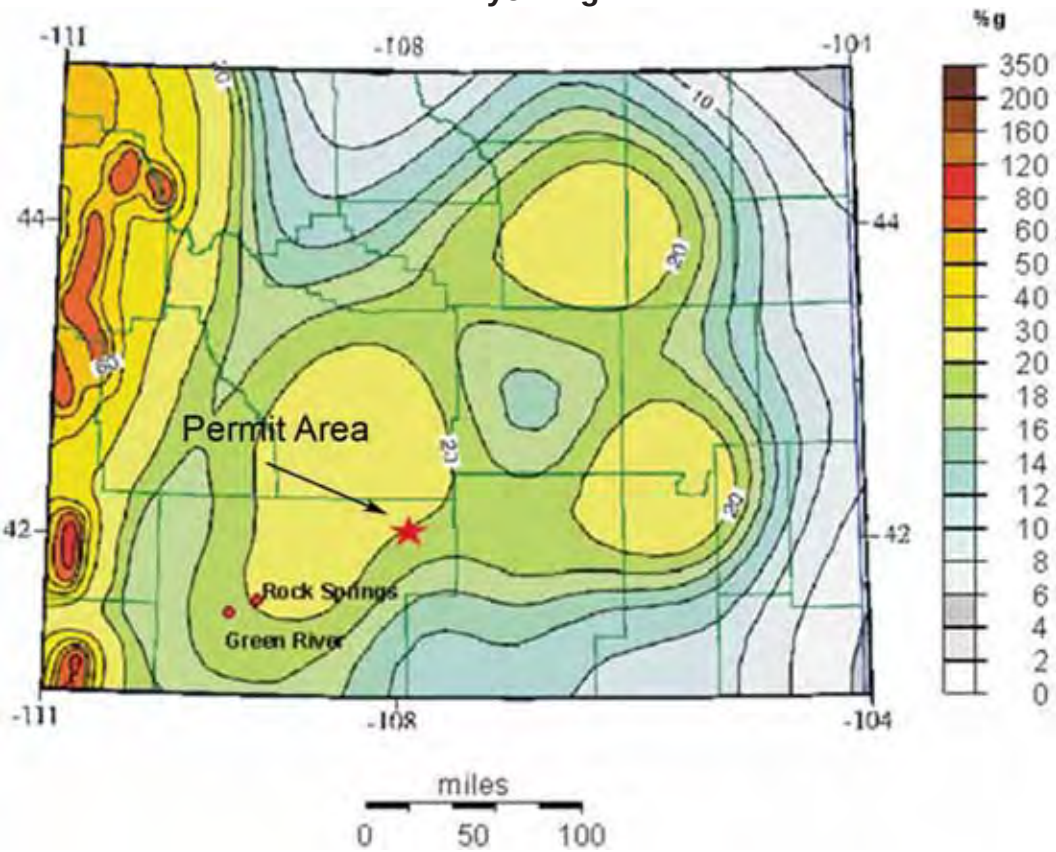


Figure 3.3-9 2,500-Year Probabilistic Acceleration Map of Wyoming



3.4 Soils

The Permit Area is located in the Basin at an approximate elevation of 7,000 feet. The region has limited precipitation and high potential evaporation (**Section 3.10**). This results in little soil moisture available for the growth of most plants. Limited soil moisture, when coupled with cold temperatures that persist for much of the year, result in plant communities dominated by shrubs, cushion plants or cacti rather than by herbaceous species (**Section 3.7**). The terrain of the Permit Area slopes gently to the south. Perennial streams are not present. The bedrock is interbedded shales and sandstones, which serve as the parent material for the soils. The resulting soils are typical of semi-arid areas in Wyoming.

No previous soil studies by the Natural Resources Conservation Service (NRCS) or Soil Conservation Service (SCS) exist for the Permit Area. Two empirical soils studies were completed by Munn and Arneson (1998) at 1:500,000 and the 1:100,000 scales, but both were based on a simplified five-factor soil formation model.

Several soil surveys and studies have been performed in the Permit Area for various regulatory requirements:

- An Order 3 soil survey of the Permit Area in 2006 for overall baseline conditions;
- An Order 1 soil survey of the Plant site and MU1 in 2008 for more site-specific information to determine stripping depths and topsoil stockpile requirements;
- A geotechnical survey of the Plant site in 2008 to determine construction suitability; and
- In September 2009, an Order 3 soil survey of the East and West Access Roads and an Order 1 soil survey of the deep injection well sites and access corridors within the main Permit Area.

All of the surveys were designed and performed according to protocols in the National Soil Survey Handbook (Soil Survey Division Staff, 1993). The above studies are discussed in more detail below in chronological order. In addition, areas of historic disturbance were delineated as the soils in these areas may have been impacted.

3.4.1 2006 Order 3 Soil Survey

In April 2006, a reconnaissance soil survey of the entire Permit Area was completed to determine soil profile locations based on vegetation, landform type, and position on the landform. From this survey, 19 soil profiles were located and excavated in June 2006 (**Figure 3.4-1**). Soil profiles were excavated with a backhoe to a minimum depth of four feet. Profiles were examined and data were recorded on field sheets. Composite samples were collected from each soil horizon. Samples from ten locations were selected for laboratory analysis. Parameters to be analyzed were selected by consulting WDEQ Guideline No. 1 (1994a). Analyses were performed by Energy Laboratories of Casper, Wyoming, and the results are available in **Table 3.4-1**.

Based on these reconnaissance survey results, the soils of the Permit Area were classified as Typic Torriorthent with three different textures: loamy, mixed, mesic; fine loamy, mixed, mesic; and fine loamy over sandy, mixed, mesic (**Figures 3.4-1** and **3.4-2**). All three textures support the same vegetation types and densities; Lowland Big Sagebrush Shrubland is found in the ephemeral channels and Upland Big Sagebrush Shrubland is found everywhere else. Lab results indicated that the soils are all either suitable or marginally suitable for topsoil according to WDEQ Guideline No. 1 Topsoil Suitability, Table I-2 (1994a). No groundwater was encountered at any of the sampling sites. The complete report is included in Appendix D7 of the WDEQ-LQD Permit to Mine (LCI, 2011b).

3.4.2 2008 Geotechnical Study

A geotechnical engineering report was conducted on the Plant site in September 2008 (Inberg-Miller Engineering, 2008). Twelve borings, completed from 20 to 45 feet in depth, revealed various layers of sand and clay over sedimentary bedrock. Observations showed that the topsoil was composed of 0.5 to 2 feet of stiff to hard sandy clay and contained very little organic material. Subsoil was encountered from about two to four feet below surface and was composed of dense to hard clayey sand and sandy clay. Sedimentary bedrock was encountered below the subsoil. No groundwater was encountered in any of the borings. The full engineering report, which indicated the site suitable for construction of the proposed facilities subject to appropriate site preparation, is presented in Attachment OP-7 of the WDEQ-LQD Permit to Mine (LCI, 2011b).

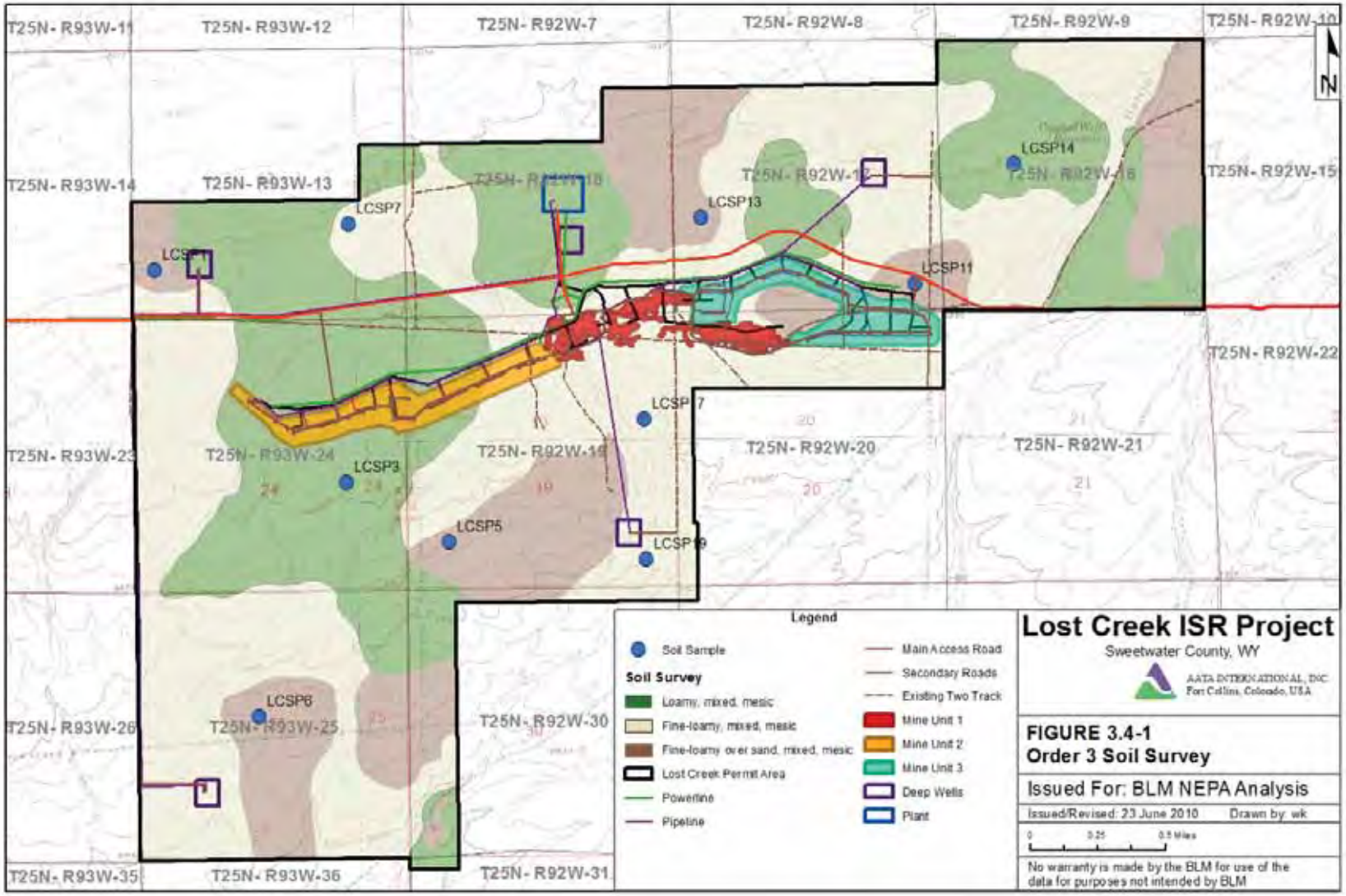

T25N- R93W-11
T25N- R93W-12
T25N- R92W-7
T25N- R92W-8
T25N- R92W-9
T25N- R92W-10
T25N- R93W-14
T25N- R93W-13
T25N- R92W-15
T25N- R92W-22
T25N- R93W-23
T25N- R93W-24
T25N- R92W-20
T25N- R92W-21
T25N- R93W-26
T25N- R93W-25
T25N- R92W-30
T25N- R93W-35
T25N- R93W-36
T25N- R92W-31
LCSP7
LCSP13
LCSP14
LCSP11
LCSP3
LCSP5
LCSP6
N
Legend
Soil Sample
Soil Survey
Loamy, mixed, mesic
Fine-loamy, mixed, mesic
Fine-loamy over sand, mixed, mesic
Lost Creek Permit Area
Powerline
Pipeline
Main Access Road
Secondary Roads
Existing Two Track
Mine Unit 1
Mine Unit 2
Mine Unit 3
Deep Wells
Plant
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC
Fort Collins, Colorado, USA
FIGURE 3.4-1
Order 3 Soil Survey
Issued For: BLM NEPA Analysis
Issued/Revised: 23 June 2010
Drawn by: wk
0
0.25
0.5 Miles
No warranty is made by the BLM for use of the data for purposes not intended by BLM

Table 3.4-1 Soil Sampling Results, 2006 Order 3 Soil Survey (Page 1 of 4)

Analyte	PQL	Units	LCSP 1A	LCSP 1B1	LCSP 3A	LCSP 3B	LCSP 5AB	LCSP 5B1	LCSP 5B2
Acid Potential	1	t/kt	0	0	0	0	0	0	0
Acid/Base Potential	1000	t/kt	5	5	6	28	5	17	17
Lime as $CaCO_3$	0.1	%	0.5	0.5	0.6	2.8	0.5	1.7	1.7
Neutralization Potential	1	t/kt	5	5	6	28	5	17	17
Calcium, saturated paste	0.05	meq/L	2.8	1.7	2.1	2.6	3.2	7	21
Conductivity, paste extract	0.01	mmhos/cm	0.40	0.27	0.39	0.84	0.51	1.24	4.89
Magnesium, saturated paste	0.08	meq/L	1.3	0.31	0.85	0.76	1.4	2.4	8.9
pH, saturated paste	0.1	s.u.	6.7	6.7	7.1	8.1	7.7	8.2	7.9
Saturation %	0.1	%	25.6	24.8	24.1	37.5	20	21.9	25.8
Sodium Adsorption Ratio (SAR)	0.01	unitless	0.23	0.51	0.80	4.72	0.55	0.81	6.1
Sodium, saturated paste	0.04	meq/L	0.33	0.51	0.97	6.1	0.83	1.8	24
Nitrate as N, KCL Extract	1.0	mg/kg	1.7	1.3	<1.0	1.1	<1.0	<1.0	<1.0
Boron	0.20	mg/kg-dry	0.27	0.30	0.25	0.43	0.27	0.28	1.4
Arsenic	0.002	mg/kg-dry	0.037	0.038	0.036	0.085	0.079	0.085	0.138
Molybdenum	0.1	mg/kg-dry	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium	0.007	mg/kg-dry	0.021	0.035	0.022	0.009	0.026	0.022	0.066
Clay	1.0	%	17	20	15	15	15	20	19
Coarse Fragments	1.0	%	4.0	3.9	4.6	24	2.6	4.9	24
Sand	1.0	%	33	56	74	45	82	62	72
Silt	1.0	%	50	24	11	40	3	18	9
Texture	1.0	%	SiL-L	SL-SCL	SL	L	SL	SL-SCL	SL
Total Organic Matter	0.10	%	1.5	0.81	0.69	0.47	0.84	0.57	0.58

Table 3.4-1 Soil Sampling Results, 2006 Order 3 Soil Survey (Page 2 of 4)

Analyte	PQL	Units	LCSP 6AB	LCSP 6B1	LCSP 6B2	LCSP 7AB	LCSP 7B1	LCSP 7B2
Acid Potential	1	t/kt	0	0	0	0	0	0
Acid/Base Potential	1000	t/kt	6	7	7	5	4	3
Lime as $CaCO_3$	0.1	%	0.6	0.7	0.7	0.5	0.4	0.3
Neutralization Potential	1	t/kt	6	7	7	5	4	3
Calcium, saturated paste	0.05	meq/L	2.5	1.5	2	5.6	4.3	1.9
Conductivity, paste extract	0.01	mmhos/cm	0.42	0.31	0.9	0.83	0.92	0.36
Magnesium, saturated paste	0.08	meq/L	1.3	0.77	0.98	2.7	2	0.85
pH, saturated paste	0.1	s.u.	7.5	7.9	8.3	6.6	8.3	8.1
Saturation %	0.1	%	25.9	24.9	31.4	17.6	22.8	34.3
SAR	0.01	unitless	0.32	1.23	5.7	0.48	0.42	0.42
Sodium, saturated paste	0.04	meq/L	0.44	1.3	6.9	0.98	0.74	0.49
Nitrate as N, KCL Extract	1.0	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Boron	0.20	mg/kg-dry	0.27	0.33	0.53	0.4	<0.20	0.35
Arsenic	0.002	mg/kg-dry	0.05	0.047	0.02	0.056	0.03	0.027
Molybdenum	0.1	mg/kg-dry	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium	0.007	mg/kg-dry	0.016	<0.007	0.011	0.023	0.011	<0.007
Clay	1.0	%	16	17	14	22	22	21
Coarse Fragments	1.0	%	5.8	7.8	5.5		1.8	
Sand	1.0	%	66	63	81	58	51	62
Silt	1.0	%	18	20	5	20	27	17
Texture	1.0	%	SL	SL	SL	SCL	SCL	SCL
Total Organic Matter	0.10	%	0.84	0.51	0.35	1.1	0.27	0.41

Table 3.4-1 Soil Sampling Results, 2006 Order 3 Soil Survey (Page 3 of 4)

Analyte	PQL	Units	LCSP 11A	LCSP 11B1	LCSP 11B2	LCSP 13AB	LCSP 13B	LCSP 13BD	LCSP 14A	LCSP 14AB	LCSP 14B	LCSP 14B
Acid Potential	1	t/kt	0	0	0	0	0	0	0	0	0	0
Acid/Base Potential	1000	t/kt	8	11	8	2	8	8	3	13	7	3
Lime as $CaCO_3$	0.1	%	0.8	1.1	0.8	0.2	0.8	0.8	0.3	1.3	0.7	0.3
Neutralization Potential	1	t/kt	8	11	8	2	8	8	3	13	7	3
Calcium, saturated paste	0.05	meq/L	4.4	4.6	0.99	4	0.61	8.8	2.8	0.88	3.9	1.8
Conductivity, paste extract	0.01	mmhos/cm	0.94	0.92	0.4	0.51	0.54	1.67	0.36	0.59	0.92	0.35
Magnesium, saturated paste	0.08	meq/L	2.1	2	0.3	1.7	0.3	3.6	1.1	0.79	2.5	0.99
pH, saturated paste	0.1	s.u.	7.3	8.2	8.7	6.9	7.8	7.8	7.2	8	8.2	8.4
Saturation %	0.1	%	24.5	27.6	31	18	15.7	17.3	20.8	27.4	22	26.6
SAR	0.01	unitless	0.42	0.95	4.76	0.28	0.3	0.32	0.32	5.47	1.05	0.98
Sodium, saturated paste	0.04	meq/L	0.76	1.7	3.8	0.47	0.2	0.79	0.44	5	1.9	1.1
Nitrate as N, KCL Extract	1.0	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Boron	0.20	mg/kg-dry	0.25	<0.20	<0.20	0.26	0.27	0.32	0.4	<0.20	0.36	<0.20
Arsenic	0.002	mg/kg-dry	0.061	0.079	0.09	0.044	0.044	0.046	0.037	0.041	0.037	0.021
Molybdenum	0.1	mg/kg-dry	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium	0.007	mg/kg-dry	0.021	0.013	<0.007	<0.007	0.013	0.024	0.015	0.01	<0.007	<0.007
Clay	1.0	%	18	28	9	15	20	17	23	13	17	20
Coarse Fragments	1.0	%	10	39	5.6		3.1	3		8.3	1.8	
Sand	1.0	%	82	48	87	67	47	61	56	77	76	71
Silt	1.0	%	<1.0	24	4	18	33	22	21	10	7	9
Texture	1.0	%	SL	SCL	LS	SL	L	SL	SCL	SL	SL	SL-SCL
Total Organic Matter	0.10	%	0.93	0.51	0.11	1.1	0.53	0.68	1.1	0.22	0.23	0.41

Table 3.4-1 Soil Sampling Results, 2006 Order 3 Soil Survey (Page 4 of 4)

Analyte	PQL	Units	LCSP 17A	LCSP 17B	LCSP 19A	LCSP 19B	LCSP 19BL
Acid Potential	1	t/kt	0	0	0	0	0
Acid/Base Potential	1000	t/kt	11	17	8	6	8
Lime as CaCO3	0.1	%					
Neutralization Potential	1	t/kt	11	17	8	6	8
Calcium, saturated paste	0.05	meq/L	3.0	4.2	2.2	1.2	0.50
Conductivity, paste extract	0.01	mmhos/ cm	0.38	0.82	0.31	0.18	0.13
Magnesium,saturated paste	0.08	meq/L	1.2	0.84	0.99	0.46	0.16
pH, sat. paste	0.1	s.u.	6.6	8.0	6.4	7.0	7.7
Saturation %	0.1	%	27.6	30.2	32.1	24.2	32.6
Sodium Adsortpion Ratio (SAR)	0.01	unitless	0.39	3.99	0.27	0.41	0.60
Sodium, saturated paste	0.04	meq/L	0.56	6.3	0.34	0.37	0.34
Nitrate as N, KCL Extract	1.0	mg/kg	1.3	<1.0	1.5	1.2	1.1
Boron	0.20	mg/kg-dry	<0.20	0.25	<0.20	<0.20	0.32
Arsenic	0.002	mg/kg-dry	0.038	0.069	0.026	0.017	<0.002
Molybdenum	0.1	mg/kg-dry	<0.1	<0.1	<0.1	<0.1	<0.1
Selenium	0.007	mg/kg-dry	0.011	0.008	<0.007	<0.007	<0.007
Clay	1.0	%	15	11	11	6.0	<1.0
Coarse Fragments	1.0	%	6.2	6.6	5.3	11	<1.0
Sand	1.0	%	72	83	71	88	100
Silt	1.0	%	13	6.0	18	6.0	<1.0
Texture	1.0	%	SL	LS	SL	LS	S
Total Organic Matter	0.10	%	1.0	<0.2	0.9	<0.2	<0.2

Figure 3.4-2 Photographs of 2006 Soil Survey Sampling Points

Sample point LCSP14
Typic Torriorthent,
loamy, mixed, mesic

Sample point LCSP7
Typic Torriorthent,
fine loamy, mixed, mesic

Sample point LCSP6
Typic Torriorthent,
fine loamy, mixed, mesic

3.4.3 2008 Order 1 Soil Survey

The 2008 Order 1 soil survey was completed at the Plant site and MU1. A three-inch diameter hand-held soil auger was used to excavate soil pits up to a depth of 60 inches or the C horizon (whichever was less). Thirty-two soil pits were excavated and described. The pit data and interpretations were then used to select ten larger soil profile excavations. Each profile excavation was approximately 15 feet long, five feet deep, and four to five feet wide.

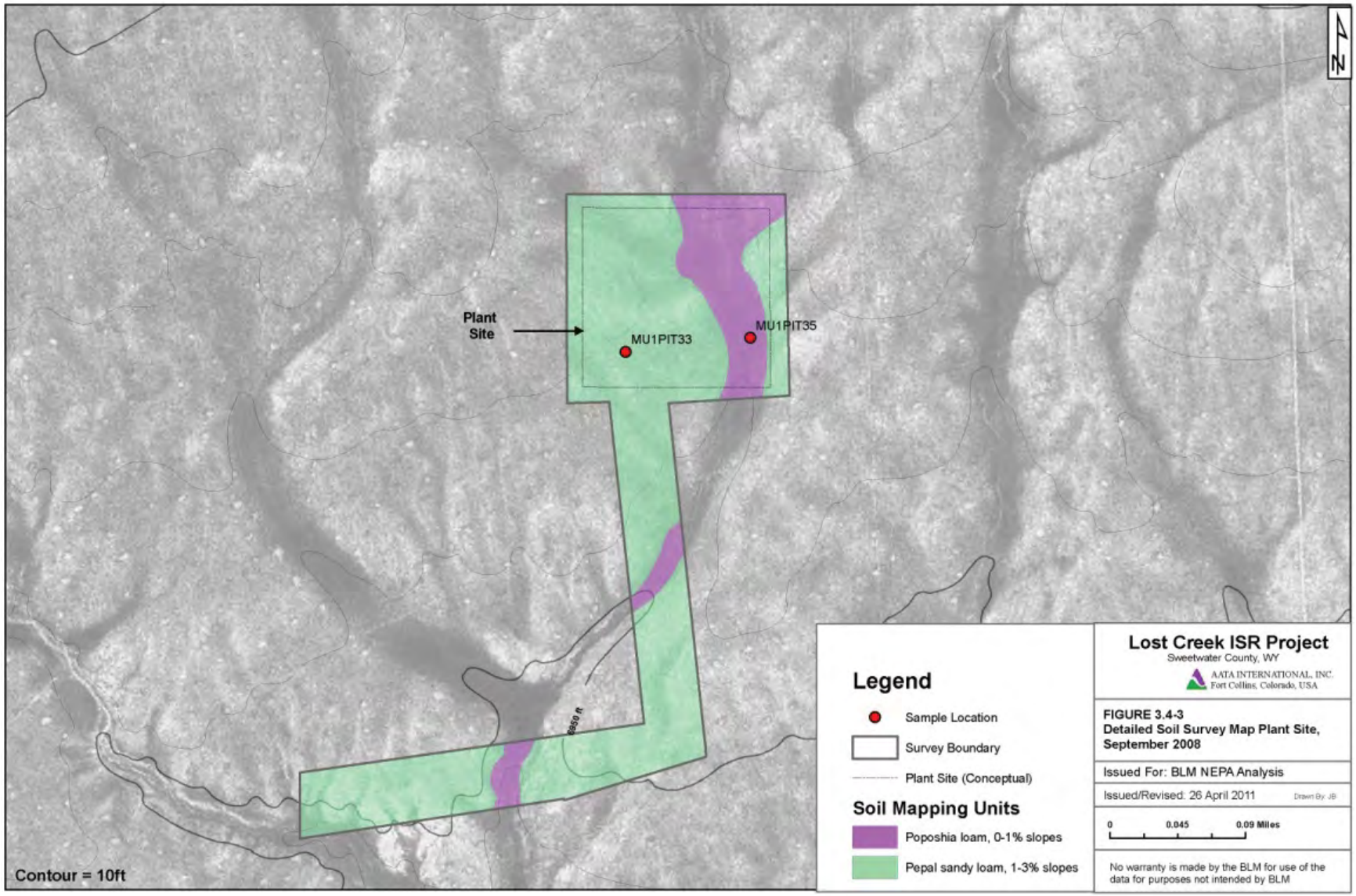
Based on these more detailed survey results, three soil series were identified at the Plant Site and MU1: Pepal Sandy Loam, Poposhia Loam, and Teagulf Sandy Loam. Detailed soils maps were created for the Plant Site and MU1 (**Figures 3.4-3** and **3.4-4**, respectively). Soil samples were analyzed for six of the soil profiles. Laboratory samples were analyzed for WDEQ Guideline No. 1 (1994a) soil texture and soil fertility parameters by Energy Laboratories in Casper, Wyoming. Results of this analysis are presented in **Table 3.4-2**.

All of the soil types are favorable media for plant growth. Based on the survey results, the Pepal Sandy Loam provides 14 to 18 inches of suitable topsoil; the Poposhia Loam provides about 19 to 24 inches of suitable topsoil; and the Teagulf Sandy Loam provides about six to 12 inches of suitable topsoil (**Figure 3.4-5**). No groundwater was encountered at any of the sampling sites. The complete report for the Plant site is included in Attachment OP-5a in the main portion of the WDEQ-LQD Permit to Mine, and the complete report for MU1 is included in Attachment MU1 3-1 of the MU1 documents in the WDEQ-LQD Permit to Mine (LCI, 2011b).

3.4.4 2009 Order 1 Soil Survey

The 2009 Order 1 soil survey was completed for the deep injection well sites and access corridors within the main Permit Area. A sharpshooter spade and a bucket auger were used to excavate soil pits and characterize the soils. Fifteen locations were selected for backhoe profile excavations (**Figures 3.4-6** through **3.4-10**). These fifteen profiles were described, documented, and sampled. Samples from fourteen of the soil profiles were analyzed, and the results are presented in **Table 3.4-3**.

The three soil series identified were the same as in the 2008 Order 1 soil survey: Pepal Sandy Loam, Teagulf Sandy Loam, and Poposhia Loam (**Figure 3.4-11**). Based on the survey results, the average recommended topsoil salvage depth is 16 inches for the Pepal Sandy Loam, 22 inches for the Poposhia Loam, and ten inches for the Teagulf Sandy Loam. These depths are similar to those of the 2008 Order 1 soil survey. No groundwater was encountered at any of the sampling sites. The complete report for the 2009 survey is included in Attachment OP-5b of the WDEQ-LQD Permit to Mine (LCI, 2011b).


N
Plant Site
MU1PIT33
MU1PIT35
8850 ft
Contour = 10ft
Legend
Sample Location
Survey Boundary
Plant Site (Conceptual)
Soil Mapping Units
Poposhia loam, 0-1% slopes
Pepal sandy loam, 1-3% slopes
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC.
Fort Collins, Colorado, USA
FIGURE 3.4-3
Detailed Soil Survey Map Plant Site, September 2008
Issued For: BLM NEPA Analysis
Issued/Revised: 26 April 2011
Drawn By: JB
0
0.045
0.09 Miles
No warranty is made by the BLM for use of the data for purposes not intended by BLM

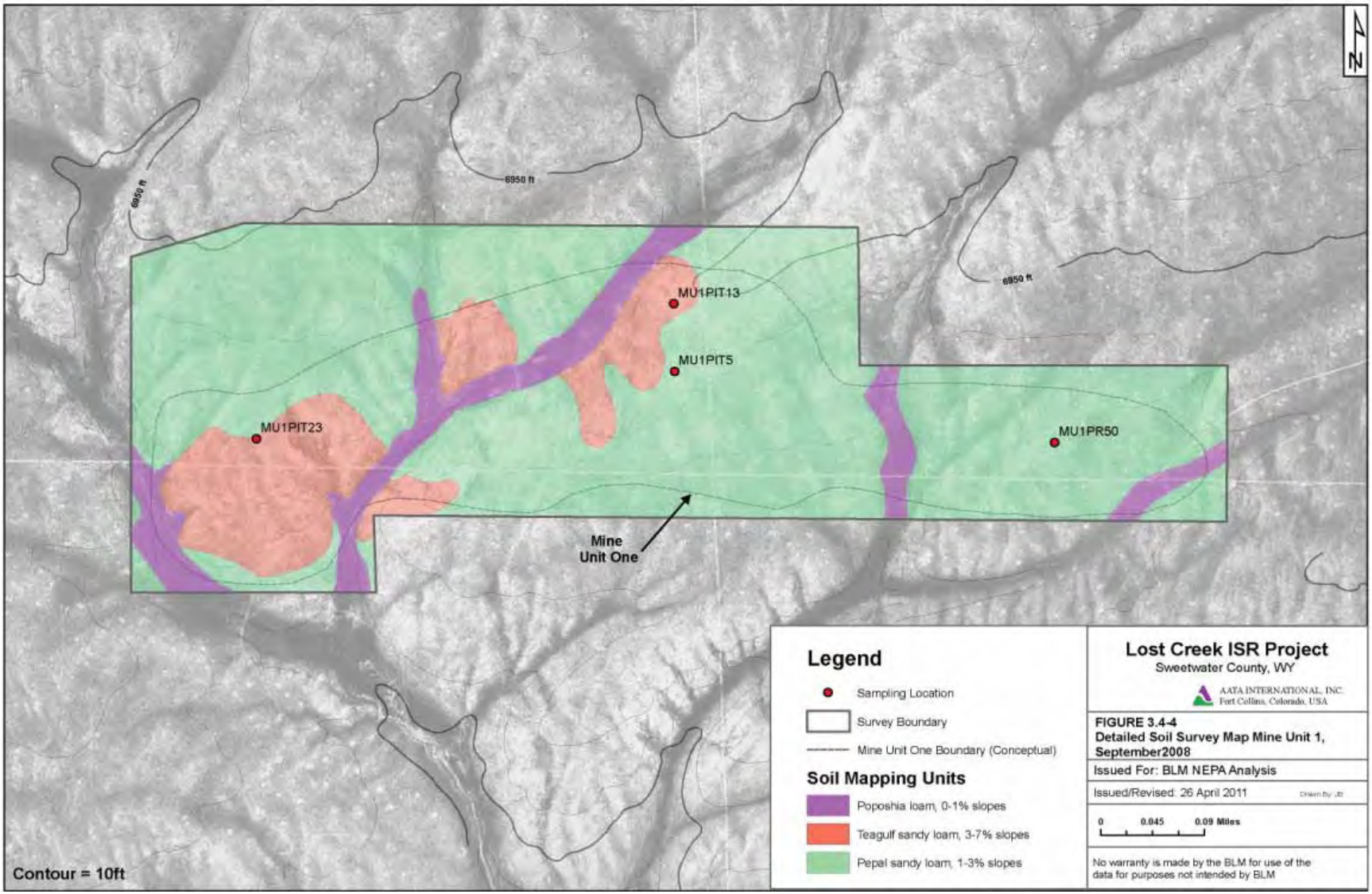

N
6950 ft
6950 ft
6950 ft
MU1PIT13
MU1PIT5
MU1PIT23
MU1PR50
Mine
Unit One
Contour = 10ft
Legend
Sampling Location
Survey Boundary
Mine Unit One Boundary (Conceptual)
Soil Mapping Units
Poposhia loam, 0-1% slopes
Teagulf sandy loam, 3-7% slopes
Pepal sandy loam, 1-3% slopes
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC.
Fort Collins, Colorado, USA
FIGURE 3.4-4
Detailed Soil Survey Map Mine Unit 1,
September2008
Issued For: BLM NEPA Analysis
Issued/Revised: 26 April 2011
Drawn by: JB
0
0.045
0.09 Miles
No warranty is made by the BLM for use of the
data for purposes not intended by BLM

Table 3.4-2 Soil Sampling Results, 2008 Order 1 Soil Survey

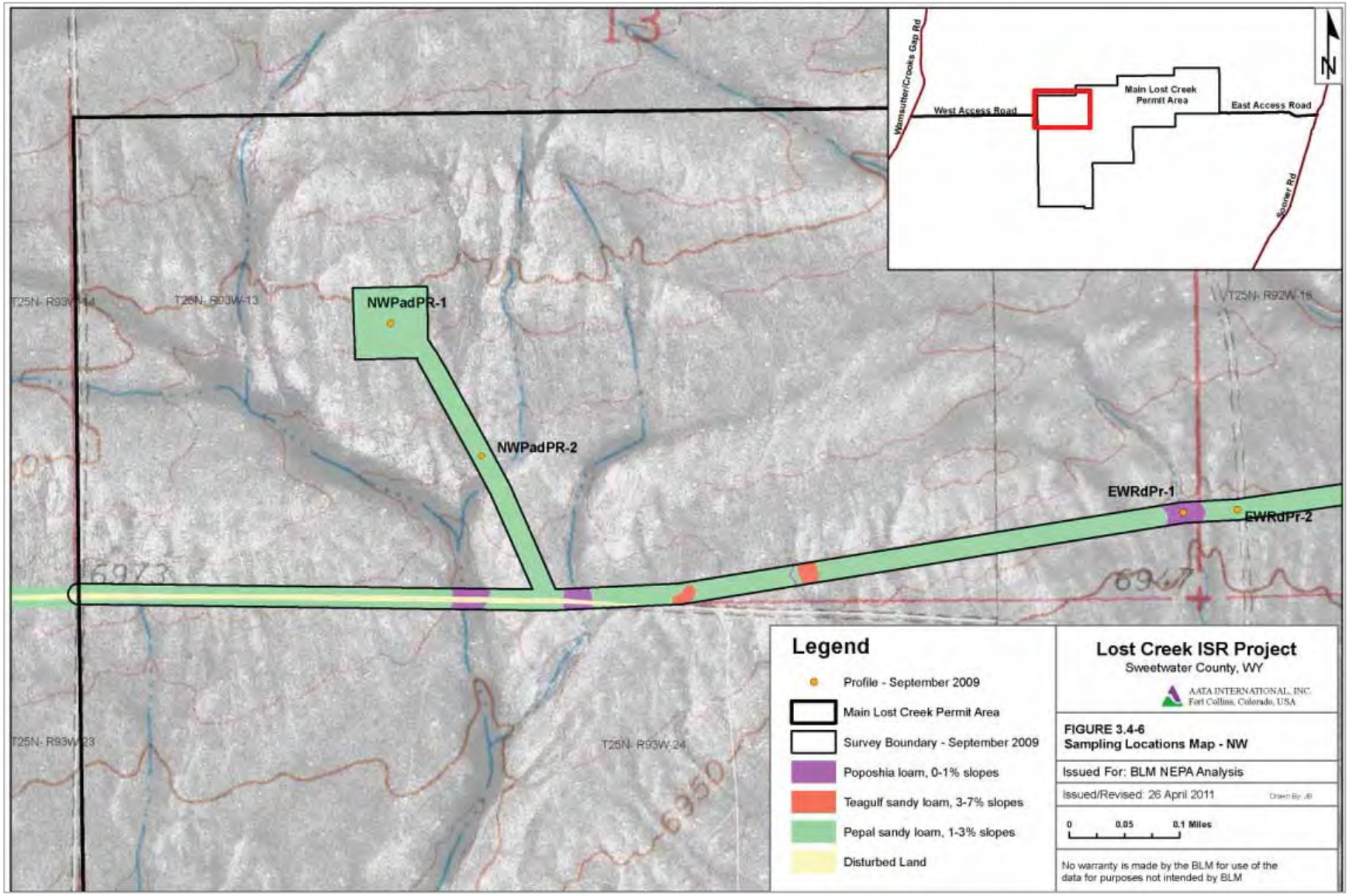
Soil Series		Pepal Sandy Loam				Poposhia Loam						Teagulf Sandy Loam		
Profile Number & Location		MU1PR33		MU1PR50		MU1PR15		MU1PR35				MU1 PR13	MU1PR23	
Sample Depth (inches)		0-12	12-33	0-6	6-60	0-24	24-	0-8	8-18	18-	34-	0-10	0-10	10-60
Parameter	Units / Horizon	A, B	B	A, B	C	A, B	C	A	B	B	C	A, B	A, B	C
pH	standard units	7	7	7.8	7.7	7.6	6.9	6.1	6.5	6.3	6.6	7.8	7.3	8
Electrical Conductivity	mmhos/ cm	0.39	0.51	0.47	0.47	0.52	0.57	0.78	0.31	2.77	0.53	0.48	0.55	1.82
Saturation	%	27.1	34.4	41.5	35.1	37	31.6	53.8	34.1	43.2	40.7	27.1	31.7	30.6
SAR	unitless	0.39	0.68	0.84	0.48	0.26	0.34	0.1	0.17	0.25	0.27	0.83	0.52	4.34
Selenium	ppm	<0.00	<0.00	0.01	0.01	0	0	0.01	0.01	0.01	0	<0.002	0.01	0.01
Boron	ppm	<0.20	<0.20	<0.20	<0.20	0.63	0.29	0.78	0.21	0.27	0.22	0.23	<0.20	0.31
Lime as $CaCO_3$	%	1.1	0.9	1	0.7	1	0.7	2	1.1	1.3	1.2	0.8	1.1	0.9
Calcium	meq/L	2.77	3.26	2.54	2.94	4.02	4.14	3.84	1.86	1.96	3.21	3.22	3.56	7.8
Magnesium	meq/L	1.16	1.42	1.13	1.3	1.85	1.69	1.7	0.86	0.8	1.38	1.03	1.83	3.33
Sodium	meq/L	0.55	1.03	1.13	0.7	0.44	0.58	0.17	0.2	0.3	0.41	1.2	0.85	10.2
Organic Matter	%	0.8	0.5	1.5	0.5	2.4	0.9	5.6	1.2	0.9	0.7	1	0.9	0.3
Sand (%)	%	58	84	72	80	42	52	31	38	28	44	66	68	82
Silt (%)	%	24	4	10	6	38	28	44	40	44	33	16	16	6
Clay (%)	%	18	12	18	14	20	20	25	22	28	23	18	16	12
Texture		SL	LS	SL	SL	L	L	L	L	CL	L	SL	SL	SL

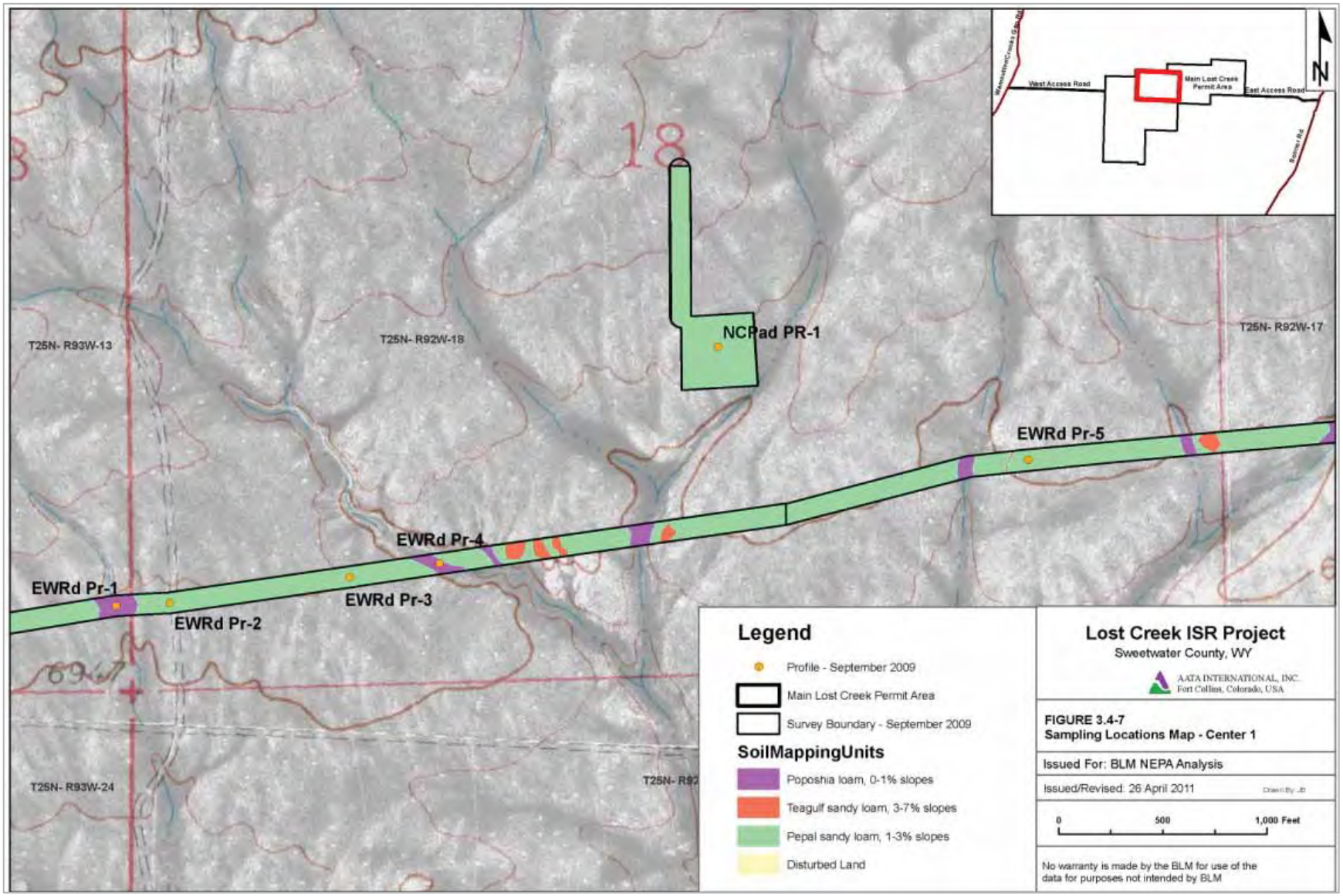
Figure 3.4-5 Photographs of 2008 Soil Survey Sampling Points

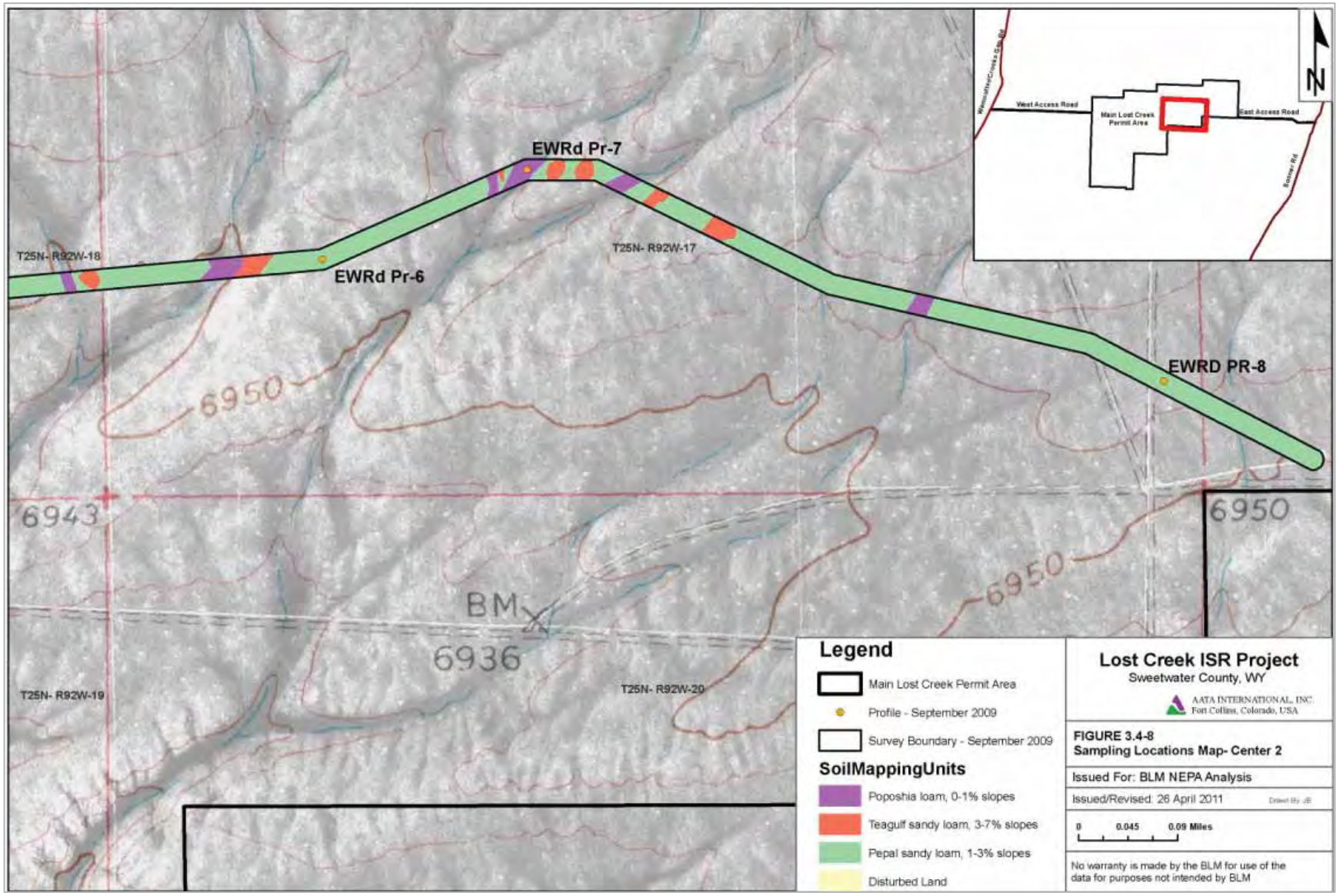
Sample point MU1PR50
Pepal Sandy Loam

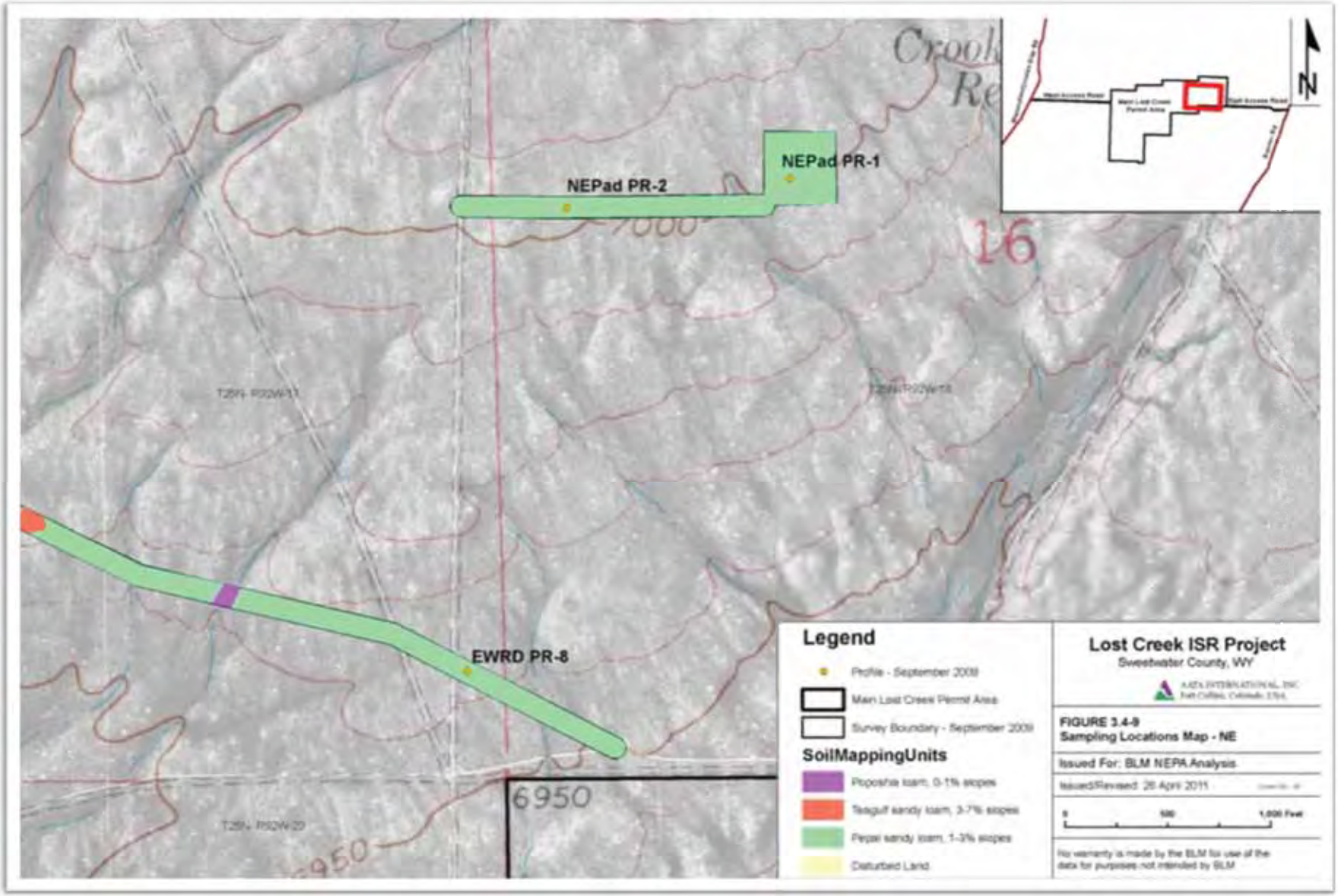
Sample point MU1PR15
Poposhia Loam

Sample point MU1PR13
Teagulf Sandy Loam


Wamsutter/Crooks Gap Rd
West Access Road
Main Lost Creek Permit Area
East Access Road
Sooner Rd
N
T25N- R93W-14
T25N- R93W-13
T25N- R92W-18
T25N- R93W-23
T25N- R93W-24
NWPadPR-1
NWPadPR-2
EWRdPr-1
EWRdPr-2
6973
6947
6950
Legend
Profile - September 2009
Main Lost Creek Permit Area
Survey Boundary - September 2009
Poposhia loam, 0-1% slopes
Teagulf sandy loam, 3-7% slopes
Pepal sandy loam, 1-3% slopes
Disturbed Land
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC.
Fort Collins, Colorado, USA
FIGURE 3.4-6
Sampling Locations Map - NW
Issued For: BLM NEPA Analysis
Issued/Revised: 26 April 2011
Drawn By: JB
0 0.05 0.1 Miles
No warranty is made by the BLM for use of the data for purposes not intended by BLM


T25N- R93W-13
T25N- R92W-18
T25N- R92W-17
T25N- R93W-24
NCPad PR-1
EWRd Pr-1
EWRd Pr-2
EWRd Pr-3
EWRd Pr-4
EWRd Pr-5
West Access Road
Main Lost Creek Permit Area
East Access Road
N
Legend
Profile - September 2009
Main Lost Creek Permit Area
Survey Boundary - September 2009
SoilMappingUnits
Poposhia loam, 0-1% slopes
Teagulf sandy loam, 3-7% slopes
Pepal sandy loam, 1-3% slopes
Disturbed Land
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC.
Fort Collins, Colorado, USA
FIGURE 3.4-7
Sampling Locations Map - Center 1
Issued For: BLM NEPA Analysis
Issued/Revised: 26 April 2011
0
500
1,000 Feet
No warranty is made by the BLM for use of the data for purposes not intended by BLM


EWRd Pr-7
EWRd Pr-6
EWRD PR-8
T25N- R92W-18
T25N- R92W-17
T25N- R92W-19
T25N- R92W-20
6950
6943
6936
BM
West Access Road
East Access Road
Main Lost Creek Permit Area
N
Legend
Main Lost Creek Permit Area
Profile - September 2009
Survey Boundary - September 2009
SoilMappingUnits
Poposhia loam, 0-1% slopes
Teagulf sandy loam, 3-7% slopes
Pepal sandy loam, 1-3% slopes
Disturbed Land
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC.
Fort Collins, Colorado, USA
FIGURE 3.4-8
Sampling Locations Map- Center 2
Issued For: BLM NEPA Analysis
Issued/Revised: 26 April 2011
0 0.045 0.09 Miles
No warranty is made by the BLM for use of the data for purposes not intended by BLM


NEPad PR-1
NEPad PR-2
EWRD PR-8
16
6950
Legend
Profile - September 2009
Main Lost Creek Permit Area
Survey Boundary - September 2009
SoilMappingUnits
Poposhia loam, 0-1% slopes
Teagulf sandy loam, 3-7% slopes
Pepal sandy loam, 1-3% slopes
Disturbed Land
Lost Creek ISR Project
Sweetwater County, WY
FIGURE 3.4-9
Sampling Locations Map - NE
Issued For: BLM NEPA Analysis
Issued/Revised: 28 April 2011
No warranty is made by the BLM for use of the data for purposes not intended by BLM

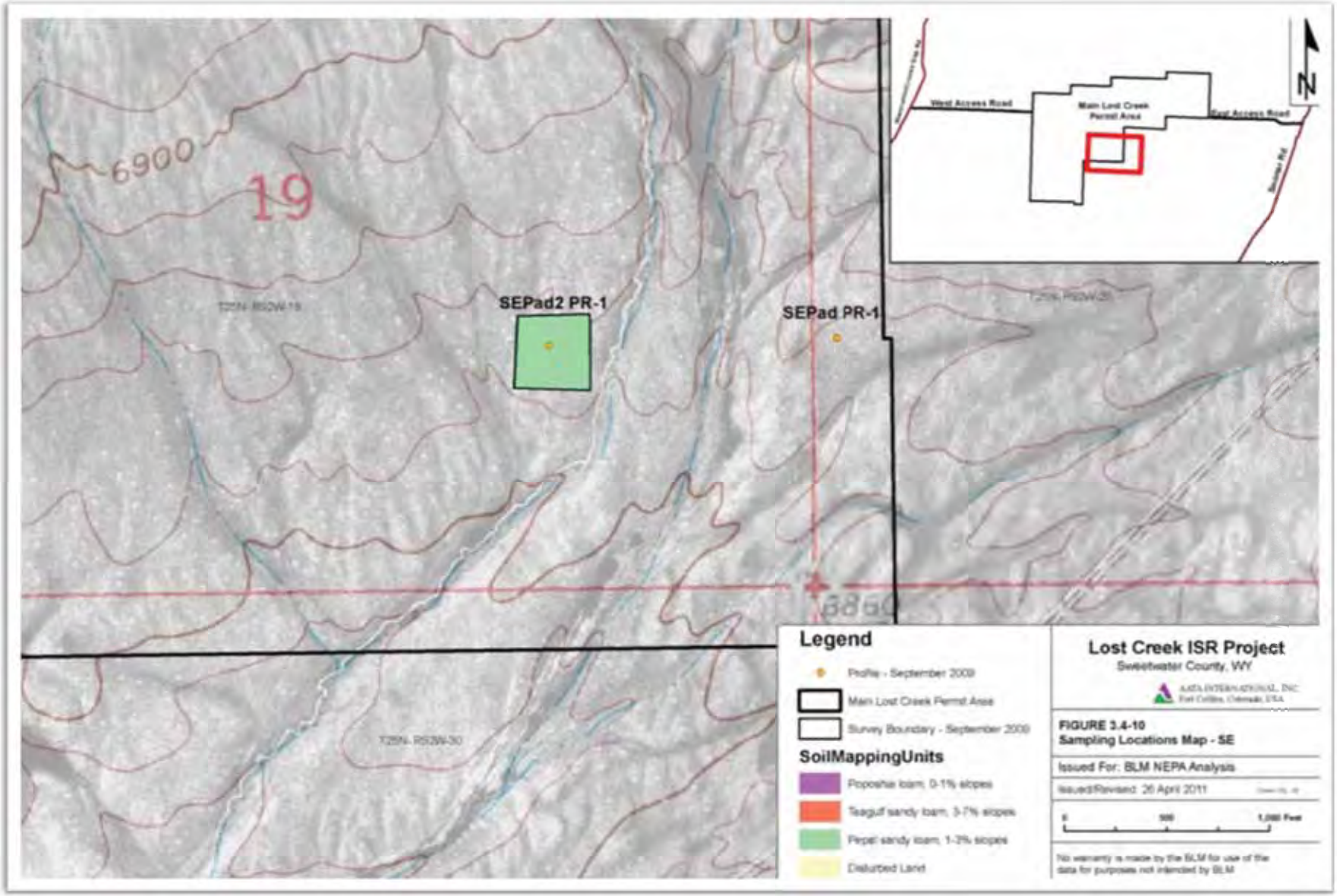

6900
19
SEPad2 PR-1
SEPad PR-1
6850
West Access Road
Main Lost Creek Permit Area
East Access Road
N
Legend
Profile - September 2009
Main Lost Creek Permit Area
Survey Boundary - September 2009
SoilMappingUnits
Poposhia loam, 0-1% slopes
Teagulf sandy loam, 3-7% slopes
Pepal sandy loam, 1-3% slopes
Disturbed Land
Lost Creek ISR Project
Sweetwater County, WY
FIGURE 3.4-10
Sampling Locations Map - SE
Issued For: BLM NEPA Analysis
Issued/Revised: 26 April 2011
0
500
1,000 Feet
No warranty is made by the BLM for use of the data for purposes not intended by BLM

Table 3.4-3 Soil Sampling Results, 2009 Order 1 Soil Survey (Page 1 of 6)

	Soil Type	Pepal Sandy Loam								
	Sampling Location	NW Pad PR-1				NW Pad PR-2				
	Sample Depth (inches)	0-3	3-12	12-16	16-48	0-3	3-10	10-18	18-38	18-38
Parameter	Horizon / Units	A	Bw	Bw	Cr	A	Bw	Bk	C/Cr	C/Cr
pH	standard units	6.3	7.1	7.4	8.8	7.2	7.3	7.8	8.3	8.3
Electrical Conductivity	mmhos/cm	0.1	0.2	0.2	0.7	0.2	0.2	1.9	5.2	5.4
Saturation	%	26.1	30.4	33.8	32.9	24.0	31.2	31.6	38.4	35.3
SAR	unitless	1.2	1.1	0.7	5.0	1.8	3.4	8.6	12.0	12.1
Selenium	ppm	0.049	0.045	0.015	0.040	0.041	0.019	0.032	0.034	0.035
Boron	ppm	0.01	0.03	0.02	0.02	0.03	0.03	0.02	0.11	0.13
Lime Estimate		Low	Low	Low	Very High	Low	Low	Medium	Very High	Very High
Calcium	meq/L	0.4	0.8	1.4	3.0	0.7	0.5	5.7	31.0	31.6
Magnesium	meq/L	0.1	0.2	0.4	0.6	0.2	0.1	1.9	9.2	9.5
Sodium	meq/L	0.6	0.8	0.7	6.7	1.2	1.9	16.7	53.7	54.8
Potassium	meq/L	0.2	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	0.1	0.1
Organic Matter	%	1.0	1.3	0.6	0.9	1.1	0.9	0.7	0.5	0.5
Sand	%	69	51	62	69	59	43	51	50	50
Silt	%	16	26	20	9	27	29	29	37	36
Clay	%	15	23	18	22	14	28	20	13	14
Texture		SL	SCL	SL	SCL	SL	CL	L	L	L
Nitrate NO_3-N	ppm	10.7	4.6	6.6	7.7	5.3	2.2	5.7	8.7	8.9
Phosphorus	ppm	6.2	1.8	0.3	0.6	2.8	0.3	0.3	3.1	3.1
Potassium	ppm	99.2	51.6	24.9	24.4	110	53.3	27.2	17.0	16.9
Zinc	ppm	0.28	0.06	0.06	0.03	0.22	0.11	0.10	0.08	0.08
Iron	ppm	9.43	2.53	0.89	0.45	4.44	2.32	0.90	0.73	0.79
Manganese	ppm	1.93	0.47	0.37	0.21	0.95	0.54	0.29	0.22	0.20
Copper	ppm	0.83	0.75	0.54	0.50	1.19	0.95	0.93	0.67	0.65

Table 3.4-3 Soil Sampling Results, 2009 Order 1 Soil Survey (Page 2 of 6)

	Soil Type	Pepal Sandy Loam								
	Sampling Location	NC Pad PR-1					SE Pad PR-1			
	Sample Depth (inches)	0-3	3-11	11-18	18-40	40-62	0-3	3-16	16-30	30-52
Parameter	Horizon / Units	A	B	Bk	C/Cr	Cr	A	Bw	Bc	C/Cr
pH	standard units	6.9	7.3	8.1	8.5	8.0	6.5	7.1	8.7	8.3
Electrical Conductivity	mmhos/cm	0.2	0.2	0.2	1.1	4.8	0.2	0.1	1.3	0.3
Saturation	%	29.1	29.9	26.4	28.3	29.0	20.6	26.1	29.0	26.5
SAR	unitless	0.9	0.6	3.3	6.1	8.2	1.3	1.6	10.5	1.2
Selenium	ppm	0.019	0.025	0.04	0.022	0.05	0.032	0.028	0.045	0.057
Boron	ppm	0.02	0.03	0.02	0.03	0.16	0.01	0.01	0.03	0.02
Lime Estimate		Low	Low	Low	High	High	Low	Low	Medium	Low
Calcium	meq/L	0.7	1.5	0.4	3.2	44.1	0.7	0.3	3.1	1.3
Magnesium	meq/L	0.2	0.6	0.1	1.4	14.4	0.2	0.0	1.0	0.4
Sodium	meq/L	0.6	0.7	1.7	9.2	44.4	0.8	0.7	14.9	1.1
Potassium	meq/L	0.2	<0.1	<0.1	0.1	0.8	0.2	<0.1	0.1	<0.1
Organic Matter	%	1.1	0.8	0.7	0.5	0.4	0.9	0.5	0.5	0.4
Sand	%	70	61	52	65	65	71	65	70	79
Silt	%	15	15	27	19	19	16	19	15	7
Clay	%	15	24	21	16	16	13	16	15	14
Texture		SL	SCL	SCL	SL	SL	SL	SL	SL	SL
Nitrate NO_3-N	ppm	3.0	3.3	5.9	4.8	8.8	3.9	4.9	2.3	3.5
Phosphorus	ppm	2.5	0.6	0.6	0.6	1.2	3.7	0.9	6.2	2.5
Potassium	ppm	119	50.3	34.1	29.8	76.4	83.9	43.7	54.0	19.3
Zinc	ppm	<0.01	<0.01	0.03	<0.01	0.48	0.17	0.11	0.04	0.03
Iron	ppm	4.85	2.96	2.05	1.61	3.11	7.03	3.47	1.12	1.03
Manganese	ppm	0.83	0.28	0.39	<0.01	0.66	1.27	0.53	0.32	0.20
Copper	ppm	0.88	0.69	0.55	0.41	0.30	0.87	1.18	0.42	0.55

Table 3.4-3 Soil Sampling Results, 2009 Order 1 Soil Survey (Page 3 of 6)

	Soil Type	Pepal Sandy Loam								
	Sampling Location	NE Pad PR-1					NE Pad PR-2			
	Sample Depth (inches)	0-3	3-8	8-16	16-34	34-68	0-3	3-16	16-30	30-62
Parameter	Horizon / Units	A	Bw	BC	C/Cr	Cr	A	Bw	Bk	C/Cr
pH	standard units	7.0	7.4	7.7	8.5	8.8	5.5	7.0	8.2	8.2
Electrical Conductivity	mmhos/cm	0.3	0.1	0.2	0.2	0.3	0.2	0.1	0.3	3.7
Saturation	%	22.1	28.1	28.1	27.8	23.7	28.1	27.2	26.9	27.7
SAR	unitless	1.2	0.9	0.8	0.9	2.0	0.8	1.3	1.3	5.5
Selenium	ppm	0.04	0.04	0.04	0.035	0.036	0.04	0.05	0.05	0.05
Boron	ppm	0.02	0.03	0.02	0.01	0.00	0.03	0.03	0.02	0.11
Lime Estimate		Low	Low	Low	Medium	Medium	Low	Low	High	High
Calcium	meq/L	0.8	0.7	0.8	1.1	1.5	0.6	0.5	1.6	26.7
Magnesium	meq/L	0.3	0.1	0.1	0.1	0.2	0.2	<0.1	0.8	16.6
Sodium	meq/L	0.9	0.5	0.6	0.7	1.9	0.5	0.6	1.4	25.6
Potassium	meq/L	0.2	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	0.3
Organic Matter	%	1.2	0.9	0.4	0.3	0.2	1.1	0.5	0.7	0.5
Sand	%	67	58	78	84	80	65	58	55	79
Silt	%	21	20	7	4	8	19	25	27	8
Clay	%	12	22	15	12	12	16	17	18	13
Texture		SL	SCL	SL	LS	SL	SL	SL	SL	SL
Nitrate NO_3-N	ppm	5.5	9.2	5.5	6.2	6.7	5.9	10.3	10.3	8.3
Phosphorus	ppm	3.7	0.9	1.2	6.5	7.4	8.1	0.6	0.9	11.2
Potassium	ppm	153	77.4	25.3	19.5	17.3	180	63.8	54.9	51.7
Zinc	ppm	0.27	0.08	0.03	<0.01	0.03	0.76	0.11	0.05	0.10
Iron	ppm	6.17	3.3	1.38	0.88	1.25	20.9	4.75	2.62	2.32
Manganese	ppm	1.13	0.52	0.24	0.15	0.35	5.09	1.04	0.68	0.50
Copper	ppm	1.40	1.10	0.65	0.47	0.57	1.86	1.07	0.75	0.85

Table 3.4-3 Soil Sampling Results, 2009 Order 1 Soil Survey (Page 4 of 6)

	Soil Type	Pepal Sandy Loam												
	Sampling Location	EW Rd PR-3				EW Rd PR-5					EW Rd PR-6			
	Sample Depth (inches)	0-3	3-16	16-30	30-55	0-3	3-10	10-16	16-25	25-53	0-3	3-14	14-28	28-56
Parameter	Horizon / Units	A	Bw	Bck	C/Cr	A	Bw1	Bw2	Bck	C/Cr	A	Bw	Bck	C/Cr
pH	standard units	7.1	7.7	8.3	8.3	7.1	7.6	8.1	8.3	8.3	7.0	7.3	8.6	8.3
Electrical Conductivity	mmhos/cm	0.2	0.2	0.9	5.7	0.2	0.1	0.2	0.2	2.2	0.2	0.1	0.2	2.1
Saturation	%	27.7	26.4	29.8	31.6	23.6	32.2	28.2	22.4	40.7	25.4	27.9	30.4	29.6
SAR	unitless	0.6	1.5	4.9	7.1	1.1	1.4	<0.1	2.5	6.5	0.6	1.1	1.0	8.9
Selenium	ppm	0.028	0.033	0.024	0.030	0.033	0.044	0.036	0.040	0.046	0.015	0.051	0.045	0.030
Boron	ppm	0.03	0.04	0.02	0.11	0.02	0.03	0.02	0.02	0.05	0.03	0.02	0.01	0.05
Lime Estimate		Low	Low	High	High	Low	Low	Low	Very High	Medium	Low	Low	Very High	High
Calcium	meq/L	1.0	0.9	3.0	43.3	0.7	0.4	<0.1	0.8	8.8	0.7	0.3	1.5	6.3
Magnesium	meq/L	0.4	0.3	1.3	21.2	0.3	0.1	<0.1	<0.1	2.7	0.3	0.1	0.3	3.3
Sodium	meq/L	0.5	1.1	7.2	40.3	0.8	0.7	0.0	1.7	15.7	0.5	0.5	0.9	19.5
Potassium	meq/L	1.1	0.1	0.1	0.5	0.2	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	0.2
Organic Matter	%	1.0	0.7	0.6	0.5	1.0	0.8	0.4	0.8	0.4	1.0	0.6	0.5	0.9
Sand	%	77	54	66	80	72	49	50	61	69	65	59	79	80
Silt	%	13	27	15	6	13	26	30	26	17	18	17	7	8
Clay	%	10	19	19	14	15	25	20	13	14	17	24	14	12
Texture		SL	SL	SL	SL	SL	SCL	L	SL	SL	SL	SCL	SL	SL
Nitrate NO_3-N	ppm	3.8	4.5	5.3	8.0	12.0	3.1	1.2	4.2	7.5	2.8	1.3	4.9	8.3
Phosphorus	ppm	4.3	<0.1	0.9	11.2	2.8	<0.1	<0.1	<0.1	0.6	3.7	0.3	0.3	1.2
Potassium	ppm	235	70.4	29.2	40.9	117	28.0	15.2	11.7	14.0	129	29.1	10.1	47.6
Zinc	ppm	<0.01	<0.01	<0.01	<0.01	0.21	0.09	0.04	0.01	0.01	0.24	0.05	0.04	0.04
Iron	ppm	5.6	3.97	1.62	0.93	3.86	1.44	0.96	1.02	0.77	4.54	1.49	0.48	0.66
Manganese	ppm	1.63	0.28	0.18	0.06	1.19	0.28	0.20	0.18	0.15	1.34	0.28	0.19	0.19
Copper	ppm	1.10	0.91	0.70	0.52	0.97	1.49	1.21	0.60	0.42	0.79	0.61	0.33	1.02

Table 3.4-3 Soil Sampling Results, 2009 Order 1 Soil Survey (Page 5 of 6)

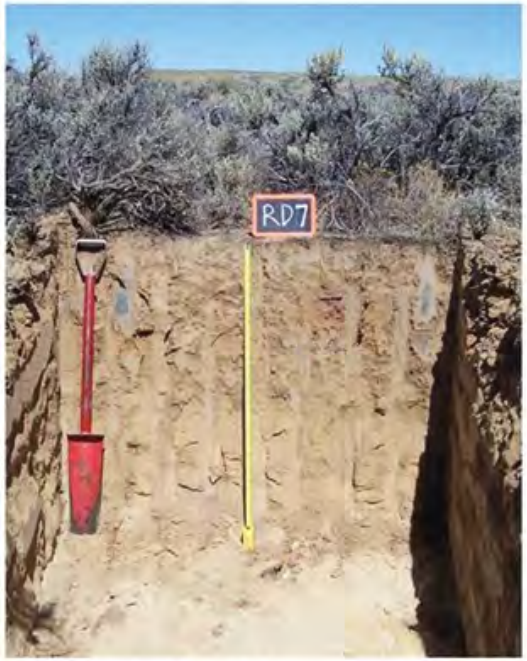
	Soil Type	Poposhia Loam												
	Sampling Location	EW Rd PR-1				EW Rd PR-4					EW Rd PR-7			
	Sample Depth (inches)	0-3.5	3.5-14	14-24	24-35	0-4	4-19	19-34	34-58	34-58	0-4	4-12	12-22	22-47
Parameter	Horizon / Units	A	Bw	Bc	C/Cr	A	Bw	Bc	C/Cr	C/Cr	A	Bw1	Bw2	C
pH	standard units	6.4	6.4	6.9	6.9	6.1	6.7	6.2	6.5	6.3	6.2	5.9	6.4	7.6
Electrical Conductivity	mmhos/cm	0.2	0.2	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.3	0.1	0.1	0.2
Saturation	%	31.1	26.8	22.7	34.5	34.6	29.0	25.7	22.4	22.6	47.5	53.1	29.1	28.2
SAR	unitless	1.1	1.5	1.6	1.2	1.1	1.4	2.6	2.7	3.2	1.0	0.9	1.3	0.5
Selenium	ppm	0.03	0.022	0.029	0.019	0.03	0.013	0.016	0.031	0.032	0.038	0.040	0.033	0.027
Boron	ppm	0.03	0.02	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.04	0.04	0.02	0.01
Lime Estimate		Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Calcium	meq/L	0.6	0.4	0.2	0.2	1.1	0.3	<0.1	<0.1	<0.1	1.2	0.6	0.2	0.9
Magnesium	meq/L	0.1	0.1	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	0.4	0.2	<0.1	0.2
Sodium	meq/L	0.7	0.7	0.5	0.4	0.9	0.6	0.4	0.4	0.4	0.9	0.6	0.5	0.3
Potassium	meq/L	0.3	0.4	<0.1	<0.1	0.5	0.1	0.1	0.1	<0.1	0.3	0.1	<0.1	0.1
Organic Matter	%	2.4	1.0	0.4	0.8	1.7	0.9	0.3	0.5	0.5	4.0	1.6	0.8	0.3
Sand	%	61	63	73	82	49	54	75	79	79	33	38	49	80
Silt	%	27	22	13	4	37	30	8	8	7	52	43	26	6
Clay	%	12	15	14	14	14	16	17	13	14	15	19	25	14
Texture		SL	SL	SL	SL	L	SL	SL	SL	SL	SiL	L	SCL	SL
Nitrate NO_3-N	ppm	6.5	6.0	9.2	4.8	7.7	4.2	8.2	4.3	3.8	11.4	4.7	4.9	8.9
Phosphorus	ppm	7.4	2.5	2.5	1.8	10.6	10.6	3.1	3.1	3.1	14.9	3.1	0.6	0.6
Potassium	ppm	252	190	54.8	32.0	246	122	49.8	42.7	47.0	320	158	92.1	23.5
Zinc	ppm	0.68	0.21	0.06	0.04	0.57	<0.01	<0.01	<0.01	<0.01	1.85	0.24	0.07	0.06
Iron	ppm	22.9	19.1	9.42	3.20	27.7	21.5	5.53	9.32	9.02	39.5	14.6	5.50	1.21
Manganese	ppm	3.85	0.96	0.53	0.25	3.88	0.64	0.18	0.08	0.09	5.83	0.74	0.34	0.16
Copper	ppm	1.67	1.25	0.65	0.98	1.51	0.92	0.87	0.44	0.46	3.04	1.13	0.71	0.48

Table 3.4-3 Soil Sampling Results, 2009 Order 1 Soil Survey (Page 6 of 6)

	Soil Type	Teagulf Sandy Loam									
	Sampling Location	EW Rd PR-2				EW Rd PR-8					
	Sample Depth (inches)	0-2	2-7	7-14	14-27	0-2	2-6	6-15	15-27	27-53	27-53
Parameter	Horizon / Units	A	Bw	Ck	C/Cr	A	B	BC	C/Cr	Cr	Cr
pH	standard units	7.0	7.2	7.4	8.2	7.0	7.4	7.7	8.4	8.5	8.6
Electrical Conductivity	mmhos/cm	0.1	0.1	0.2	0.2	0.2	0.1	0.8	0.2	0.3	0.3
Saturation	%	22.9	31.2	29.3	31.8	21.1	31.1	29.1	27.8	28.2	28.2
SAR	unitless	0.8	0.9	0.7	1.0	1.3	0.4	<0.1	0.6	1.7	1.5
Selenium	ppm	0.01	0.026	0.024	0.023	0.038	0.041	0.040	0.044	0.015	0.016
Boron	ppm	0.02	0.02	0.02	0.01	0.02	0.01	<0.01	0.01	0.01	0.01
Lime Estimate		Low	Low	Low	Medium	Low	Low	Low	High	Medium	Medium
Calcium	meq/L	0.7	0.6	1.1	1.0	0.7	0.1	<0.1	1.8	1.9	1.8
Magnesium	meq/L	0.1	0.1	0.3	0.1	0.2	<0.1	<0.1	0.4	0.3	0.2
Sodium	meq/L	0.5	0.5	0.5	0.8	0.9	0.1	0.0	0.6	1.8	1.6
Potassium	meq/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Organic Matter	%	0.7	0.9	0.4	0.2	0.8	0.7	0.4	0.3	0.2	0.3
Sand	%	73	74	82	86	67	67	80	81	81	80
Silt	%	14	12	5	2	19	15	4	2	4	6
Clay	%	13	14	13	12	14	18	16	17	15	14
Texture		SL	SL	SL	LS	SL	SL	SL	SL	SL	SL
Nitrate NO_3-N	ppm	5.7	4.3	4.3	3.9	7.6	11.2	3.5	6.2	9.2	9.7
Phosphorus	ppm	3.1	1.2	1.2	0.9	2.5	0.6	<0.1	0.3	2.5	2.1
Potassium	ppm	114	42.8	27.6	24.6	84.2	34.0	14.8	8.89	7.06	7.96
Zinc	ppm	0.23	<0.01	<0.01	<0.01	0.23	0.08	0.33	0.08	0.07	0.07
Iron	ppm	6.34	2.67	1.31	0.97	4.46	2.03	1.05	0.52	0.43	0.46
Manganese	ppm	1.11	0.36	0.01	<0.01	0.86	0.38	0.45	0.21	0.17	0.18
Copper	ppm	0.92	1.03	0.89	0.23	0.77	0.70	0.61	0.33	0.54	0.49

Figure 3.4-11 Photographs of 2009 Soil Survey Sampling Points

Sample point NC-1 Pad
Pepal Sandy Loam



Sample point EWRd1
Poposhia Loam

Sample point EWRd8
Teagulf Sandy Loam

3.4.5 2009 Order 3 Soil Survey

The 2009 Order 3 soil survey was conducted along the East and West Access Roads. Because the study area for the Order 3 survey of the East and West Roads was narrow, the survey was conducted by driving and walking along the existing two-track that bisects the study area. All soils within five feet of each side of the centerline of the two-track were classified as disturbed. Survey results indicated the remainder of the 100-foot-wide corridor Pepal Sandy Loam, Poposhia Loam, or Teagulf Sandy Loam, the three soil types that had previously been identified within the main Permit Area. A soil map was created and is presented on **Figures 3.4-12** and **3.4-13**. Detailed descriptions of the three soil types are presented with the Order 1 survey results.

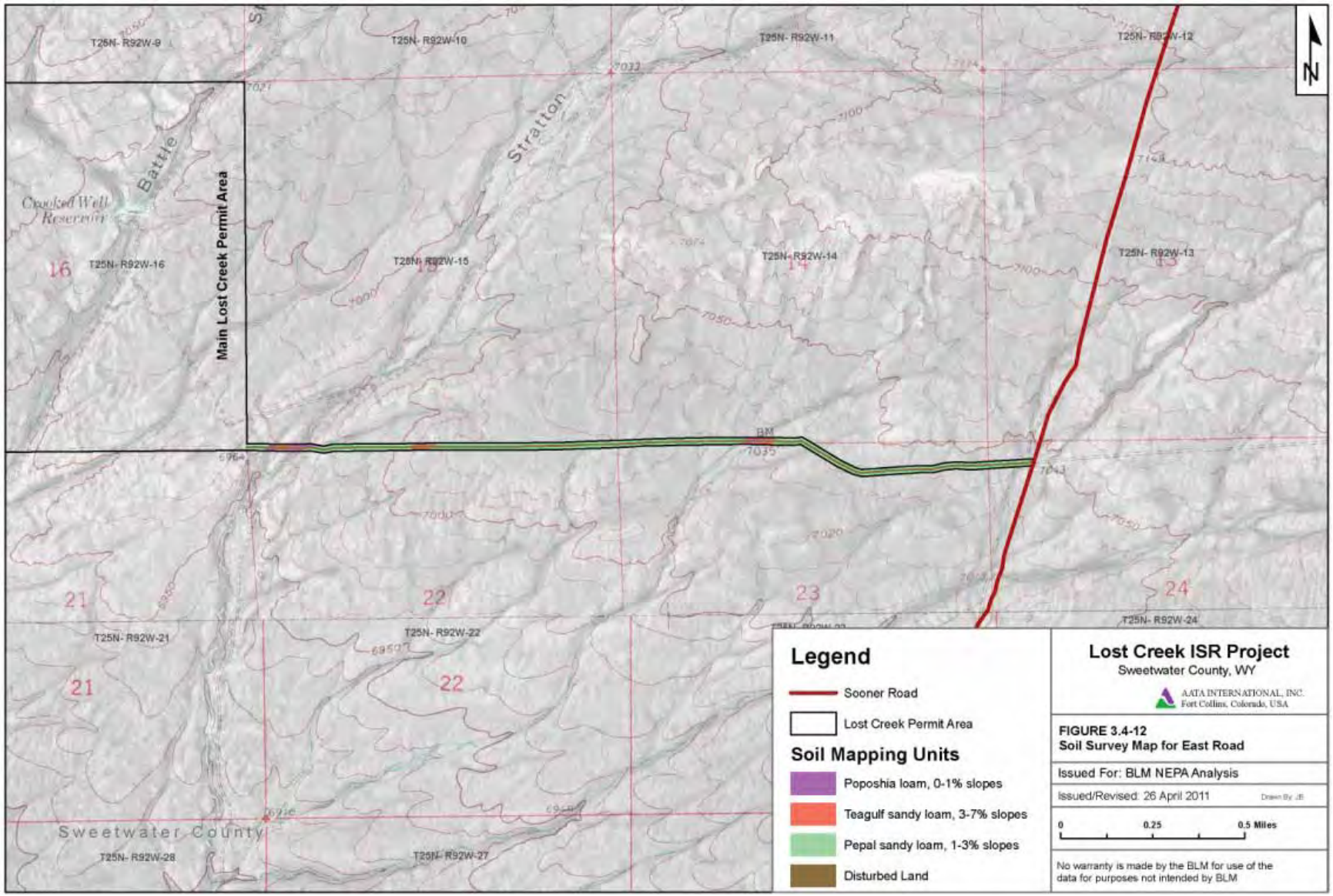
3.4.6 Areas of Limited Reclamation Potential and Prior Surface Disturbance

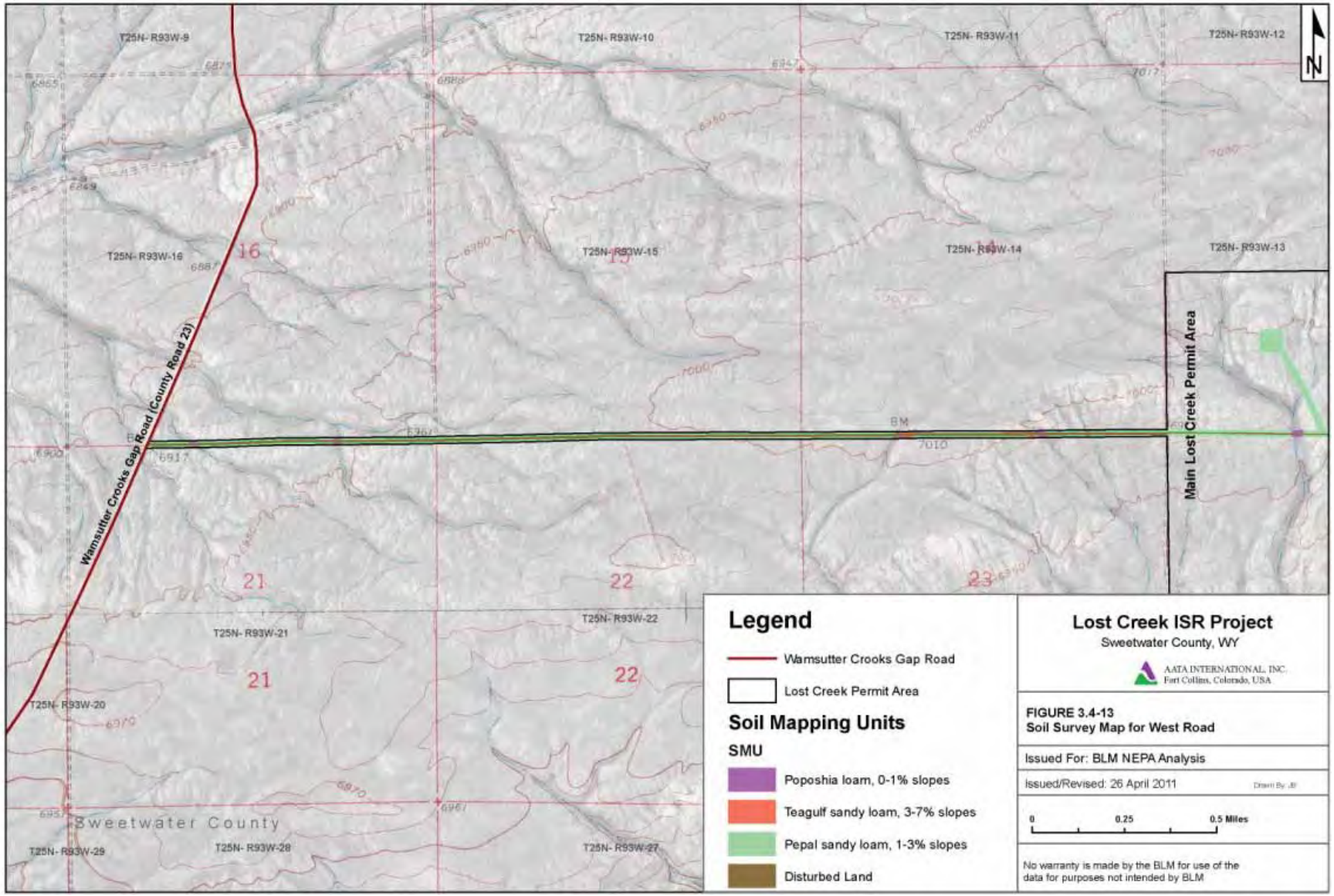
No areas of Limited Reclamation Potential, as defined in the Wyoming Reclamation Policy (BLM, 2009b), have been identified in the areas to be disturbed. As discussed in **Section 3.7**, slopes are gentle, and no cliffs or rock outcrops are present. The geological substrates do not change abruptly across the site (**Section 3.3**), and topsoil and subsoil depths are sufficient to support vegetation. The weather conditions, with the potential for wind scour and freezing and thawing cycles, require careful soil protection and reclamation practices.

The soil sample results were within the WDEQ-LQD topsoil suitability guidelines (WDEQ-LQD, 1994a), with a few exceptions that were close to the criteria. No areas of seleniferous soils were found, as evidenced by the lack of selenium indicator vegetation species (**Section 3.7.6**) and low selenium concentrations in the soil samples (**Tables 3.4-1** through **3.4-3**), which were all below the WDEQ-LQD topsoil suitability limit (0.1 ppm). Boron concentrations were also all below the suitability limit (5 ppm). None of the pH results for the topsoil samples were outside the suitability range (5.5 - 8.5). Of the subsoil samples, six were above the pH range with the highest value at 8.8, but these were at disperse locations. None of the electrical conductivity results for the topsoil or subsoil samples were outside the suitability range (0 - 8 mmhos/cm). Six topsoil and seven subsoil samples were below the suitability range for saturation (25 to 85 percent), with the lowest value at 20%. No topsoil samples were outside the Sodium Adsorption Ratio (SAR) suitability range (0 - 10), and three subsoil samples had SAR values up to 12.1.

There was surface disturbance prior to LCI exploration within the Permit Area. Most of this disturbance was due to historical exploration activities for oil and gas, as well as for uranium, and to livestock and wildlife grazing. The primary historic surface disturbance activities included vehicle traffic and drilling-related actions. These activities compacted the soils along two-track roads and at drilling

sites, resulting in limited infiltration rates and decreased the vegetation regrowth in those areas. The road surfaces have little to no organic matter, and most of the topsoil has been eroded from them. Approximately 26 miles of existing roads were delineated from the 2002 aerial photo of the Permit Area (**Figures 3.4-14** and **3.4-15**). Field measurements in 2007 indicate that the roads range from 6.9 to 9.4 feet wide. Using a default width of ten feet, the disturbance associated with the existing two-track roads is on the order of 31 acres. A few of these roads may still be used by grazing lessees, hunters, and for on-going exploration activities. Evidence of abandoned drill sites is more difficult to delineate, but numerous small areas are evident on the aerial photograph. The extent of the historic disturbance in areas to be redisturbed and then reclaimed as part of the proposed action is limited and is not anticipated to interfere with the reclamation.


T25N- R92W-9
T25N- R92W-10
T25N- R92W-11
T25N- R92W-12
T25N- R92W-13
T25N- R92W-14
T25N- R92W-15
T25N- R92W-16
T25N- R92W-21
T25N- R92W-22
T25N- R92W-24
T25N- R92W-27
T25N- R92W-28
Main Lost Creek Permit Area
Stratton
Battle
Crooked Well Reservoir
Sweetwater County
N
Legend
Sooner Road
Lost Creek Permit Area
Soil Mapping Units
Poposhia loam, 0-1% slopes
Teagulf sandy loam, 3-7% slopes
Pepal sandy loam, 1-3% slopes
Disturbed Land
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC.
Fort Collins, Colorado, USA
FIGURE 3.4-12
Soil Survey Map for East Road
Issued For: BLM NEPA Analysis
Issued/Revised: 26 April 2011
0
0.25
0.5 Miles
No warranty is made by the BLM for use of the data for purposes not intended by BLM


T25N- R93W-9
T25N- R93W-10
T25N- R93W-11
T25N- R93W-12
T25N- R93W-13
T25N- R93W-14
T25N- R93W-15
T25N- R93W-16
T25N- R93W-20
T25N- R93W-21
T25N- R93W-22
T25N- R93W-27
T25N- R93W-28
T25N- R93W-29
Wamsutter Crooks Gap Road (County Road 23)
Main Lost Creek Permit Area
Sweetwater County
N
Legend
Wamsutter Crooks Gap Road
Lost Creek Permit Area
Soil Mapping Units
SMU
Poposhia loam, 0-1% slopes
Teagulf sandy loam, 3-7% slopes
Pepal sandy loam, 1-3% slopes
Disturbed Land
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC.
Fort Collins, Colorado, USA
FIGURE 3.4-13
Soil Survey Map for West Road
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Issued/Revised: 26 April 2011
0
0.25
0.5 Miles
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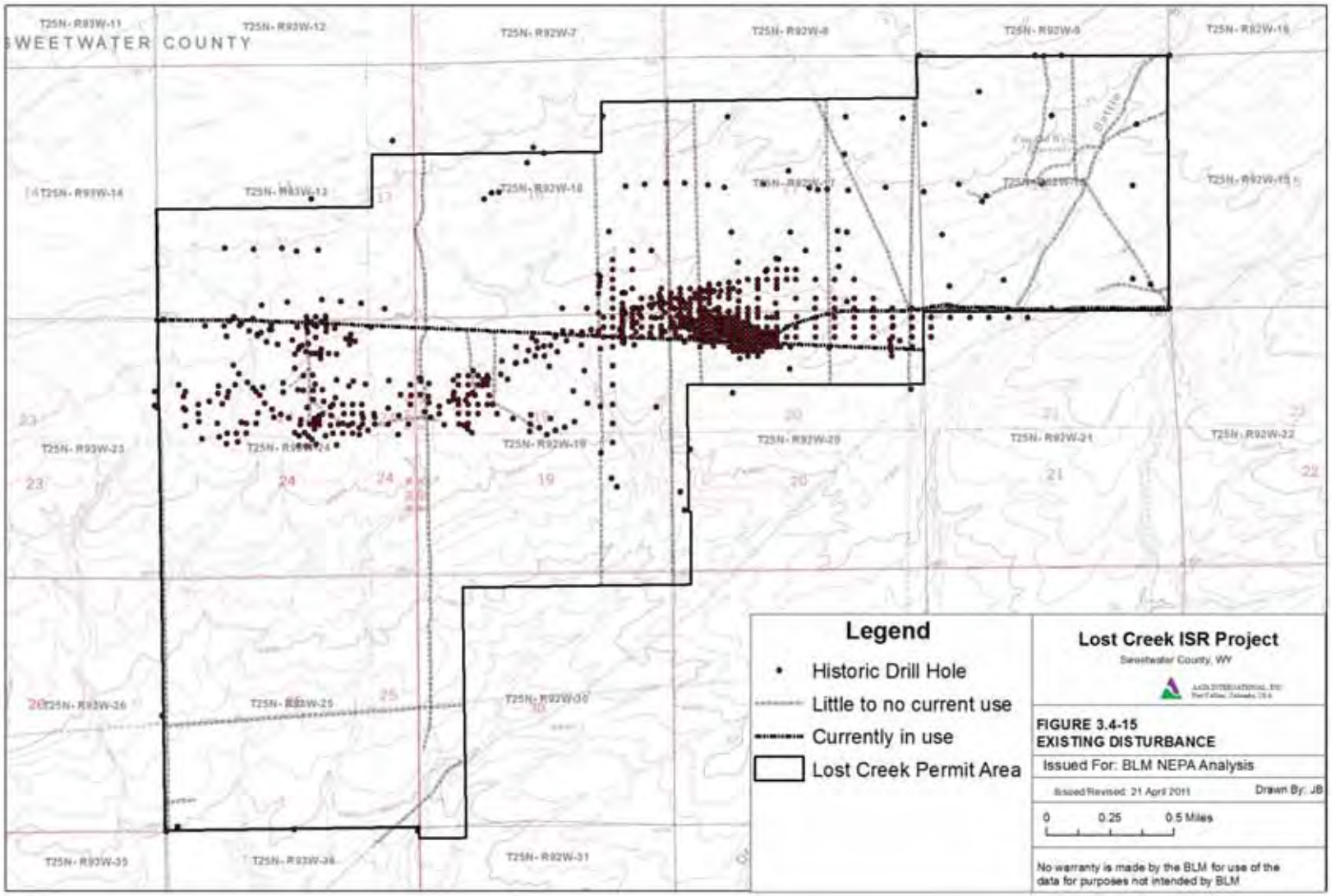
Figure 3.4-14 Typical Two-Track Road within the Permit Area

* prior to LCI activities


SWEETWATER COUNTY
T25N-R93W-11
T25N-R93W-12
T25N-R92W-7
T25N-R92W-8
T25N-R92W-9
T25N-R92W-10
T25N-R93W-14
T25N-R93W-13
T25N-R92W-18
T25N-R92W-15
T25N-R93W-23
T25N-R93W-24
T25N-R92W-19
T25N-R92W-20
T25N-R92W-21
T25N-R92W-22
T25N-R93W-26
T25N-R93W-25
T25N-R92W-30
T25N-R93W-35
T25N-R93W-36
T25N-R92W-31
Legend
Historic Drill Hole
Little to no current use
Currently in use
Lost Creek Permit Area
Lost Creek ISR Project
Sweetwater County, WY
FIGURE 3.4-15
EXISTING DISTURBANCE
Issued For: BLM NEPA Analysis
Issued/Revised: 21 April 2011
Drawn By: JB
0 0.25 0.5 Miles
No warranty is made by the BLM for use of the data for purposes not intended by BLM

3.5 Surface Waters, Wetlands and Aquatic Ecology

3.5.1 Surface Waters

The Permit Area is located in the Great Divide Basin (Basin), a topographically closed system that drains internally due to a divergence in the Continental Divide. **Figure 1.2-1** shows the location of the Permit Area within the Basin. Runoff from precipitation or snowmelt within the Basin infiltrates into the soils, is evaporated or transpired, or drains to low areas within the Basin, forming seasonal playa lakes. Due to the fact that all of the channels are ephemeral and that the Permit Area lies within a closed, isolated basin, no surface water features on the property connect to a tributary of a navigable water body. As such, no surface waters within the Permit Area are considered waters of the US under the jurisdictional authority of the US Army Corps of Engineers (USACE). However, surface waters within the Permit Area are considered 'waters of the state' (WS 35-11-103(c)(vi)), and are afforded protection under State and BLM regulations (RMP Page 3-127)(BLM, 2008c)

Section 3.10 describes the meteorological and climatic conditions of the Basin and the Permit Area in detail. Due to the arid climate and high infiltration capacity of the soils, all of the streams in the Permit Area are ephemeral; there are no perennial or intermittent drainages in the Permit Area, according to the conventional definition by Meinzer (1923) and as applied by BLM (1998):

> **Perennial** - A stream that flows continuously. Perennial streams are generally associated with a water table in the localities through which they flow.
> **Intermittent** - Intermittent streams receive their base flow from groundwater and flow is augmented by seasonal events such as precipitation or snowmelt runoff.
> **Ephemeral** – Ephemeral streams are seasonal and have no contribution from groundwater; they only flow in direct response to seasonal events such as precipitation or snowmelt runoff.

Based on the loam and sandy-loam soils found at the site, the steady-state saturated infiltration rate under laboratory conditions is estimated at 0.2 to 0.8 inches per hour (Hillel, 1980). However, the practical infiltration rate is likely much higher because saturated conditions are rare, and more macropores are present under field conditions and at large scales. Infiltration-excess (Hortonian) overland flow has not been observed at the site, except on the compacted soils found in existing two-track roads. When present, runoff is conveyed by numerous ephemeral channels that are vegetated by sagebrush and do not support aquatic life. Alluvial deposits, if any, along drainages are not extensive, and the shallow

groundwater table is typically 150 to 200 feet below ground surface (**Section 3.6.2.1**).

3.5.1.1 Surface Water Features

Figure 3.5-1 shows the surface water features in the main Permit Area; and **Figure 3.5-2** shows the features along the East and West Roads to the Permit Area. The main Permit Area consists of three principle watersheds that, together, drain greater than 99 percent of the main Permit Area. Only one drainage in the main Permit Area is named on the USGS 1:24,000 scale topography maps: Battle Spring Draw. For the purposes of the WDEQ-LQD Permit to Mine (LCI, 2011b), the principle drainages were named Western Draw, West Battle Spring Draw, and East Battle Spring Draw by LCI.

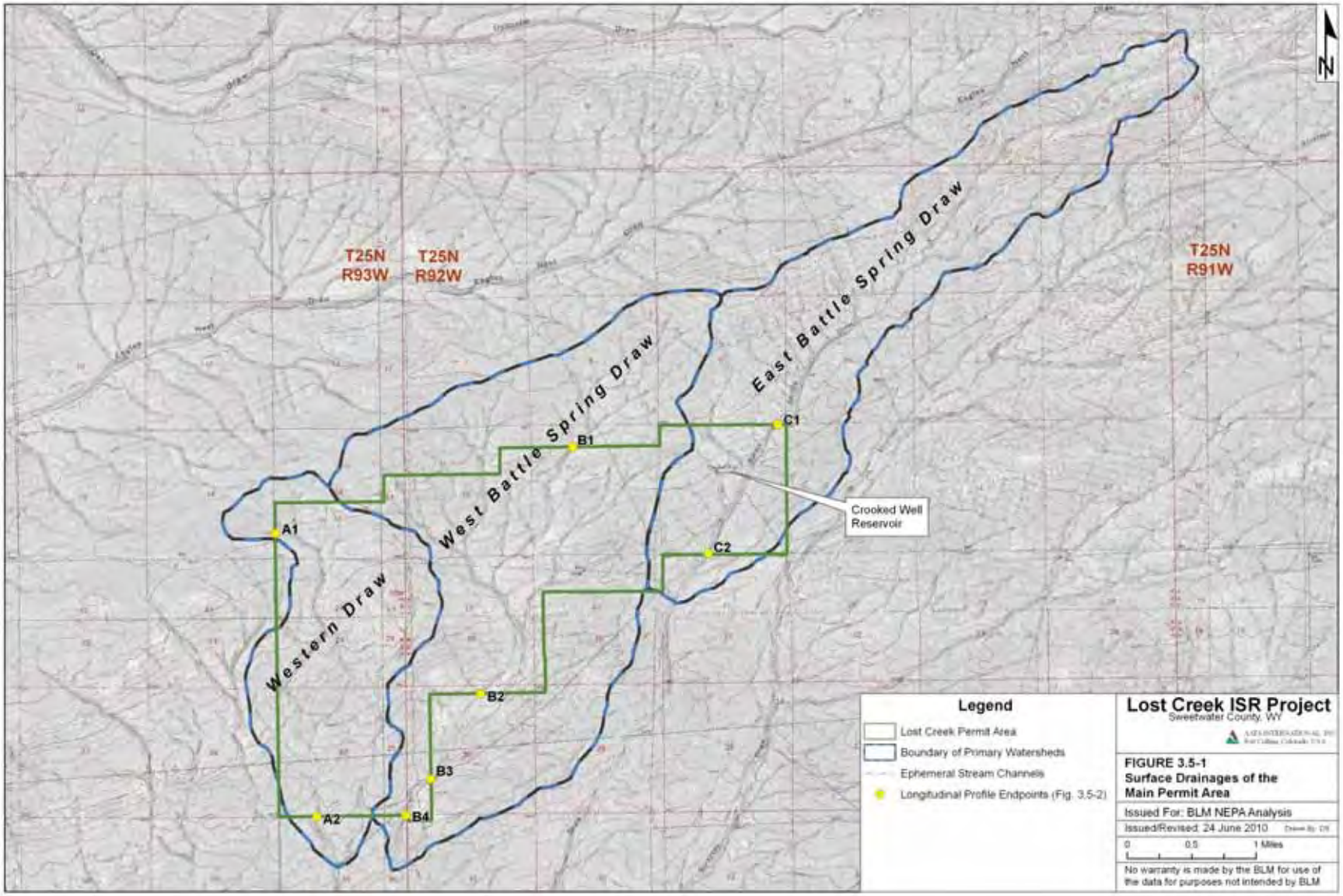
The Western Draw watershed covers 2.9 square miles, of which 2.4 square miles are within the Permit Area; the West Battle Spring Draw watershed covers 7.0 square miles, of which 3.1 square miles are within the Permit Area; the East Battle Spring Draw watershed covers 5.1 square miles, of which 1.0 square mile is within the Permit Area. The entire main Permit Area drains into the Battle Spring Flat, approximately nine miles southwest of the Permit Area.

The East Road to the Permit Area is in the Stratton Draw and East Fork Stratton Draw watersheds, both of which are shown on USGS 1:24,000 scale topography maps. The Stratton Draw Watershed is 13.8 square miles, of which 0.02 square miles are in the Permit Area. The East Fork Stratton Draw is 5.6 square miles, of which 0.03 square miles are in the Permit area. No substantial drainages cross the East Access Road in the East Fork Stratton Draw watershed.

The West Road is within the Eagles Nest Draw and Far Western Draw watersheds, both of which are shown on USGS 1:24,000 scale topography maps. The Eagles Nest Draw watershed is 16,021 acres, of which 16.6 acres are within the Permit area, and the Far Western Draw is 2,618 acres, of which 68.5 acres are within the Permit Area. The road traverses the ridgeline that divides these watersheds, and does not cross any significant drainages.

Figure 3.5-3 shows a longitudinal profile of the main channel in each of the primary watersheds within the main Permit Area, and the endpoints are shown in **Figure 3.5-2**. Within the Permit Area, the average slope of the main channel in the Western Draw, West Battle Spring Draw, and East Battle Spring Draw watersheds is 1.4, 1.2, and 1.1 percent, respectively. The sinuosity (channel length divided by valley length) of the main channels are 1.24, 1.10, and 1.03, respectively, and the drainage density is 3.0, 4.2, and 5.0 miles per square mile, respectively.

The ephemeral channels are typically trapezoidal and U-shaped in cross-section; they are approximately ten to 15 feet wide, and incised three to six feet near the


N
T25N
R93W
T25N
R92W
T25N
R91W
East Battle Spring Draw
West Battle Spring Draw
Western Draw
A1
A2
B1
B2
B3
B4
C1
C2
Crooked Well
Reservoir
Legend
Lost Creek Permit Area
Boundary of Primary Watersheds
Ephemeral Stream Channels
Longitudinal Profile Endpoints (Fig. 3.5-2)
Lost Creek ISR Project
Sweetwater County, WY
FIGURE 3.5-1
Surface Drainages of the
Main Permit Area
Issued For: BLM NEPA Analysis
Issued/Revised: 24 June 2010
0
0.5
1 Miles
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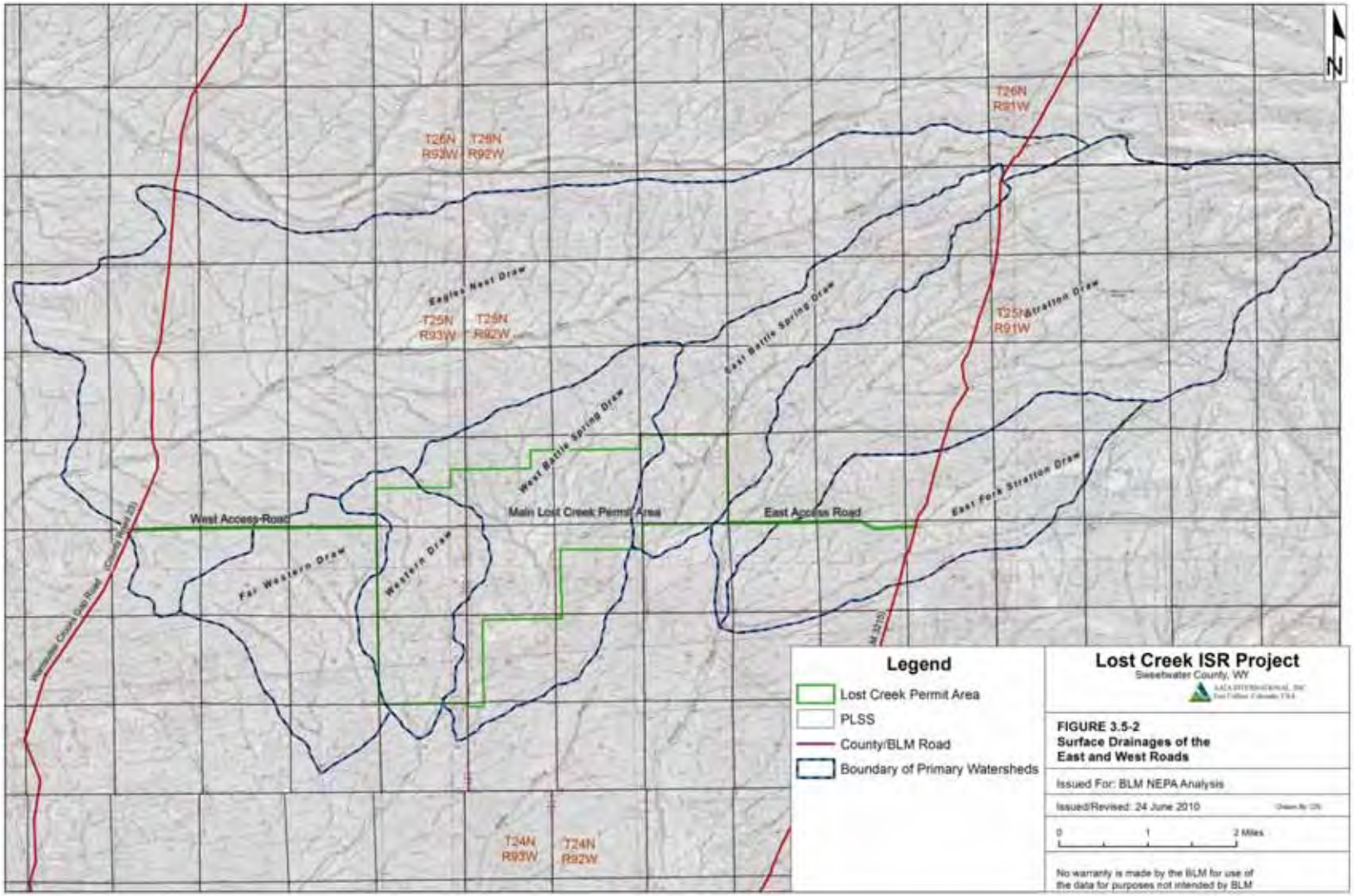
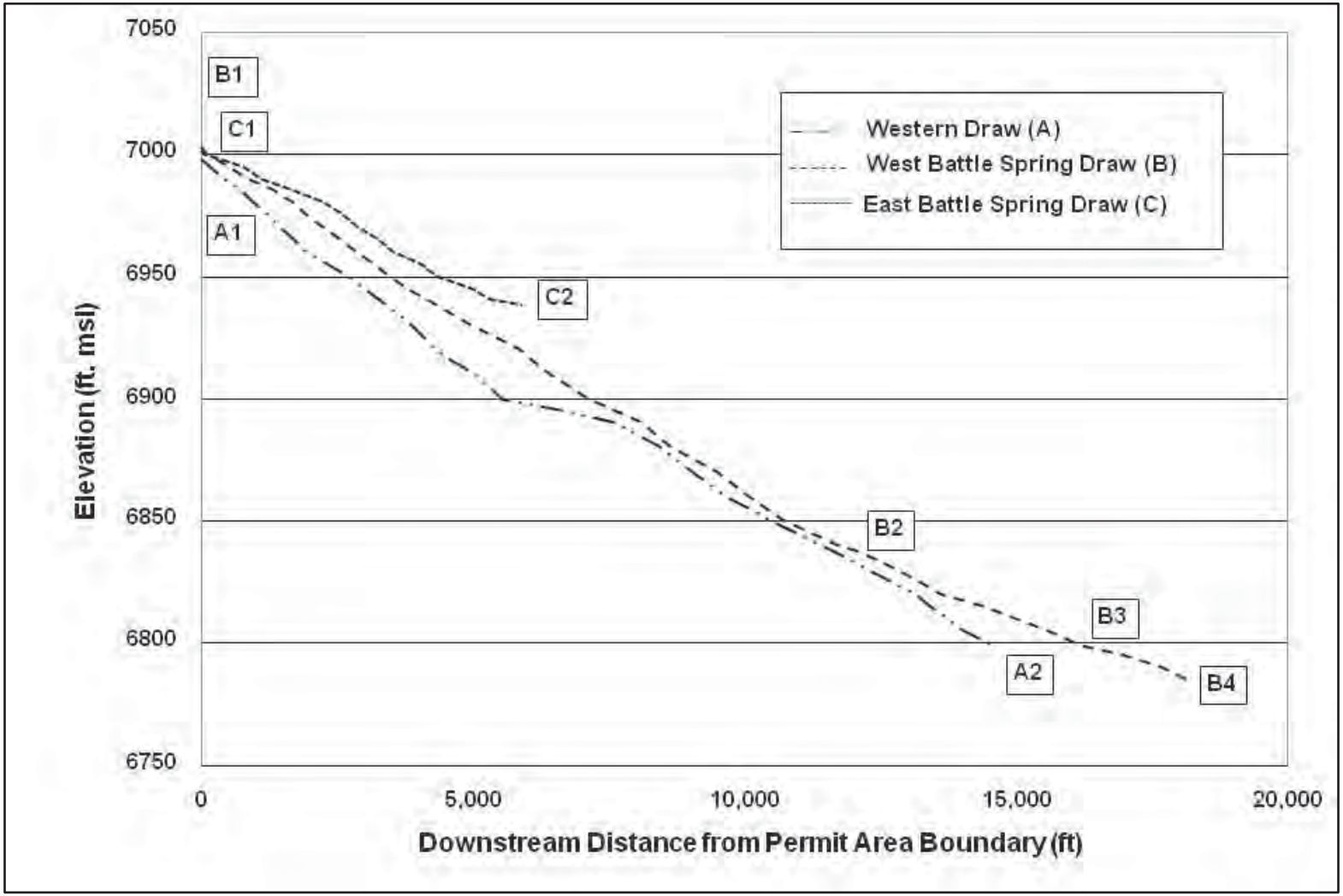

N
T26N R93W
T26N R92W
T26N R91W
Eagles Nest Draw
T25N R93W
T25N R92W
T25N R91W
Stratton Draw
East Battle Spring Draw
West Battle Spring Draw
East Fork Stratton Draw
West Access Road
Main Lost Creek Permit Area
East Access Road
Far Western Draw
Western Draw
Wamsutter Creek Gas Road
County Rd 23
M 23100
T24N R93W
T24N R92W
Legend
Lost Creek Permit Area
PLSS
County/BLM Road
Boundary of Primary Watersheds
Lost Creek ISR Project
Sweetwater County, WY
FIGURE 3.5-2
Surface Drainages of the
East and West Roads
Issued For: BLM NEPA Analysis
Issued/Revised: 24 June 2010
0
1
2 Miles
No warranty is made by the BLM for use of
the data for purposes not intended by BLM

Figure 3.5-3 Longitudinal Profiles of the Main Permit Area's Principle Drainages



One small (less than one-quarter acre) seasonal stock pond, Crooked Well Reservoir, is located in the northeast portion of the Permit Area (**Figure 3.5-1**). The reservoir detains seasonal flow behind a dirt berm across East Battle Springs Draw (**Figure 3.5-4**) and is used by cattle, wild horses, and wildlife as a water source. Crooked Well Reservoir fills in March or April, when there is sufficient snowmelt runoff in East Battle Springs Draw, and is dry for most of the year.

Figure 3.5-4 Crooked Well Reservoir

Looking southwest.
April 2006.

Looking north.
April 2007.

Looking west.
April 2009.

3.5.1.2 Streamflow

The long-term mean annual precipitation is approximately ten inches per year in the Project region. April, May, and June are the wettest months, as discussed in **Section 3.9**. Annual runoff is very low due to the dry climate and high infiltration capacity of the soils. Runoff generally occurs as a result of spring snowmelt (**Figure 3.5-5**) or, less frequently, in response to large summer thunderstorms. The quantity of spring runoff is variable, depending on the amount of winter snowfall accumulation. Peak flows are driven by high intensity rain events, but surface flow from rainfall is generally short-lived.

Figure 3.5-5 Typical Snowmelt Runoff

Approximately 15 miles northeast of the Permit Area in April 2007

Field personnel (with formal training in hydrology), working on-site from 2006 through 2009, visually and conservatively estimated the flow of an on-site streamflow event at 0.5 cubic feet per second (cfs). This streamflow event was in response to snowmelt in the springtime. Due to the lack of disturbance of bed sediment and litter in the ephemeral channels, the low slope of the area, and the paucity of overland flow in response to observed rainfall events, it is believed that no flows greater than 1.0 cfs occurred during that period. Low flows, while

present, were dispersed across the channels and too shallow to measure using standard velocity-area methods (**Figure 3.5-5**).

Peak flows were estimated using a statistical regression model developed for Wyoming by Miller (2003). Peak flows for the smallest of the three watersheds in the main Permit Area, Western Draw, were estimated as 17 cfs for the two-year event and 227 cfs for the 100-year event; peak flows in the largest watershed in the main Permit Area, West Battle Springs Draw, were estimated as 29 cfs for the two-year event and 344 cfs for the 100-year event. Stratton Draw is the only significant channel that would generate substantial peak flows in the East and West Road portions of the Permit Area. The calculated two-year and 100-year peak discharges for this watershed are 43 and 477 cfs, respectively. Actual peak runoff rates may be lower because of the high infiltration capacity of the soils. The deeply incised channels are expected to convey and contain peak flows within their banks.

3.5.1.3 Surface Water Quality

Under the WDEQ-WQD Classification, Battle Spring Draw is listed as a Class 3B water body. Beneficial uses for Class 3B waters can include recreation, wildlife, "other aquatic life", agriculture, industry, and scenic value, but do not include drinking water, game fish, non-game fish, and fish consumption. Water quality data of samples collected in 1975 and 1976 from Battle Spring Draw for the Sweetwater Uranium Mill and Mine near the Permit Area are presented in **Table 3.5-1** (Sheperd Miller, 1994). The pH was highly alkaline at 9.5 standard units (SU). Uranium concentrations ranged from 0.006 to 0.95 mg/L.

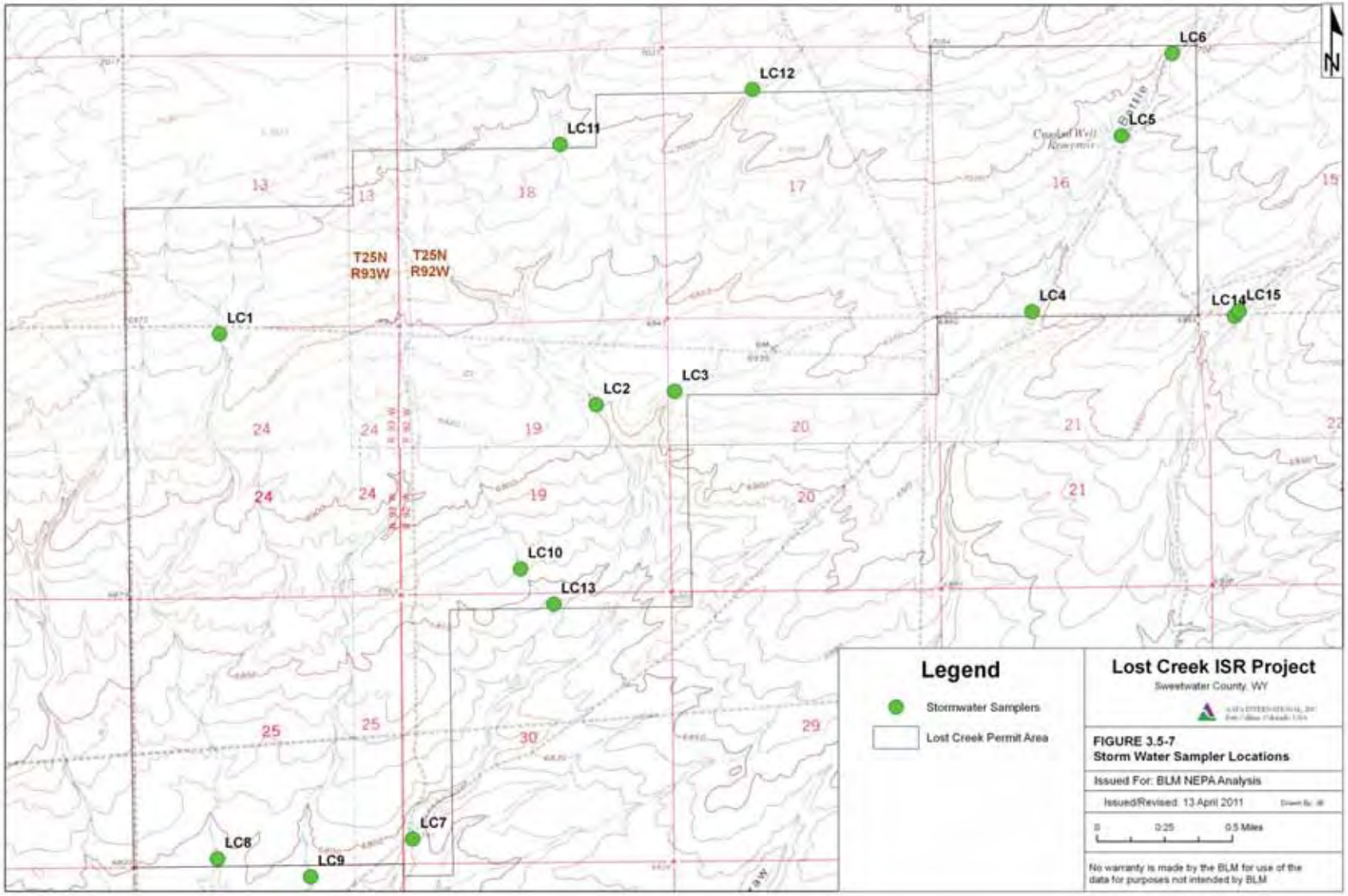
Storm Water Samplers, fitted with Nalgene bottles, were installed to collect one-liter grab samples of first flush streamflow during runoff events (**Figure 3.5-6**). The sampling locations were selected based on their topographic potential to concentrate the ephemeral surface flows. In April 2006, samplers were installed at 12 locations in the main Permit Area (LC1 through LC12 on **Figure 3.5-7**). In April 2007, an additional sampler (LC13) was added to represent an area in the southeastern corner that was added to the Permit Area in the summer of 2006. Three of these locations were selected to capture runoff as it enters the main Permit Area from the upstream side (LC6, LC11 and LC12), and the others capture runoff within the main Permit Area (LC1, LC2, LC3, LC5 and LC10) or at the downstream boundary (LC4, LC7, LC8, LC9 and LC13). In September 2009, two samplers (LC14 and LC15) were added along Stratton Draw, upstream and downstream of the East Access Road (**Figure 3.5-7**).

Table 3.5-1 Historic Surface Water Data – Battle Spring Draw

Sample Date	1975					1976
	July	April	June	August	October	July
Sodium (mg/L)	116	--	--	--	--	--
Potassium (mg/L)	8	--	--	--	--	--
Calcium (mg/L)	23	--	--	--	--	--
Magnesium (mg/L)	5	--	--	--	--	--
Sulfate (mg/L)	130	--	--	--	--	--
Chloride (mg/L)	18	--	--	--	--	--
Carbonate (mg/L)	0	--	--	--	--	--
Bicarbonate (mg/L)	220	--	--	--	--	--
TDS (mg/L)	276	--	--	--	--	--
pH (SU)	9.5	--	--	--	--	--
Gross Alpha (pCi/L)	--	--	--	156 ± 34	--	--
Gross Beta (pCi/L)	--	--	--	90.3 ± 8.8	--	--
Thorium-230 (pCi/L)	--	--	--	3.34 ± 0.43	--	--
Radium-226 (pCi/L)	--	--	--	33.5 ± 1.1	--	--
Strontium-90 (pCi/L)	--	--	--	1.5 ± 0.6	--	--
Uranium (mg/L)	0.006	0.153	0.153	0.289	0.95	0.5

pCi/L = picoCuries per liter
-- = No data

Figure 3.5-6 Storm Water Sampler


LC1
LC2
LC3
LC4
LC5
LC6
LC7
LC8
LC9
LC10
LC11
LC12
LC13
LC14
LC15
T25N R93W
T25N R92W
Legend
Stormwater Samplers
Lost Creek Permit Area
Lost Creek ISR Project
Sweetwater County, WY
FIGURE 3.5-7
Storm Water Sampler Locations
Issued For: BLM NEPA Analysis
Issued/Revised: 13 April 2011
0 0.25 0.5 Miles
No warranty is made by the BLM for use of the data for purposes not intended by BLM

Seven of the samplers in the main Permit Area collected full, one-liter samples from snowmelt runoff in March and April 2007. These samples were retrieved on April 17, 2007. No water (or insufficient water for analysis) was collected in the other samplers. The water quality data for the seven surface water samples are summarized in **Table 3.5-2**. Ionic strength was low in all samples, which is probably due to the majority of the sample being snowmelt. For all samples, the dissolved and total concentrations of trace metals were near or below the detection limit. Radiometric parameters, including uranium, lead-210, polonium-210, and thorium-230, were generally below detection with the exception of dissolved uranium, which was detected at very low concentrations (0.0003 to 0.0004 mg/L) in two samples, suspended uranium (0.0003 to 0.0009 mg/L) in two samples, and total uranium (0.0003 to 0.0009 mg/L) in four samples. Total radium-226 was detected at a low concentration (0.5 pCi/L) in one sample. This was the LC2 location in one of the larger channels in the center of the Permit Area. Gross alpha was also detected in small amounts (1.1 to 3.6 pCi/L) in six samples. The highest concentration was 3.6 pCi/L and was again from the LC2 location. The pH of the samples was slightly acidic to neutral, ranging from 6.39 to 7.12 SU. Conductivity was low with no more than 100 micromhos per centimeter (μmhos/cm) for all samples.

In general, the quality of water was very good for all samples. The radiometric parameters detected in the LC2 sample correlate well with the radiological scans of the Permit Area. This central area has the highest radioactive activity, as indicated by the results from the radiological surveys. Still, the levels are well below all Wyoming agricultural and drinking water standards. Differences between the 2007 and historical data could be attributed to either a difference in streamflow during the sampling period or differences in the sampling locations.

3.5.1.4 Surface Water Uses

Surface-water permits with legal descriptions inside and within three miles of the main Permit Area were queried using the WSEO Water Rights Database (WSEO, 2010). **Table 3.5-3** lists the twelve surface water permits within three miles of the Permit Area. None of these locations are within one mile of the Permit Area, and all are related to mining operations to the southwest of the Permit Area.

There are four BLM wells within one mile of the main Permit Area. These wells have stock ponds associated with them. Stock ponds are typically used for overflow water whenever wells are pumped to provide water to wildlife, livestock, or wild horses. The water-use permits for these ponds are associated with the wells that supply the ponds, i.e., they are not associated with any surface-water-use permits. These wells are described in more detail in **Section 3.6.3.1**.

As noted in the previous section, the Crooked Well Reservoir (**Figure 3.5-1**) is in the Permit Area. However, it is a small off-channel detention pond, less than one-quarter acre in size, and there is no water-use permit associated with it.

Table 3.5-2 Surface Water Quality Data (Page 1 of 5)

Parameter	Units	Detection Limit	Sampling Location						
			LC1	LC2	LC4	LC5	LC10	LC11	LC12
Major Ions-Dissolved									
Calcium	mg/L	1.0	2.8	5.6	3.3	5.5	3.3	5.2	7.4
Magnesium	mg/L	1.0	0.9	1.5	0.9	1.6	0.6	1.3	1
Sodium	mg/L	1.0	1.1	1.1	0.8	1.2	1.4	1	1
Potassium	mg/L	1.0	4.1	6.2	5	7.8	8.4	9.4	3.4
Carbonate	mg/L	1.0	<1	<1	<1	<1	<1	<1	<1
Bicarbonate	mg/L	1.0	12	27	17	30	29	15	24
Sulfate	mg/L	1.0	3	3	3	5	13	6	6
Chloride	mg/L	1.0	2	1	1	2	1	2	<1
Ammonia as N	mg/L	0.05	0.46	0.6	0.55	1.11	8.7	0.86	0.41
Nitrite as N	mg/L	0.10	<0.1	<0.1	<0.1	<0.1	0.3	0.2	<0.1
Nitrite + Nitrate as N	mg/L	0.10	0.3	0.3	0.3	<0.1	0.7	0.6	0.9
Fluoride	mg/L	0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Silica	mg/L	1.0	6.9	9.9	7.1	14.5	0.9	1.1	3.9
Trace Metals-Dissolved									
Aluminum	mg/L	0.10	0.3	0.7	0.6	0.6	<0.1	0.2	0.7
Arsenic	mg/L	0.001	0.002	0.003	0.002	0.006	0.002	0.002	0.001
Barium	mg/L	0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Table 3.5-2 Surface Water Quality Data (Page 2 of 5)

Parameter	Units	Detection Limit	Sampling Location						
			LC1	LC2	LC4	LC5	LC10	LC11	LC12
Boron	mg/L	0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	mg/L	0.005	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Copper	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	mg/L	0.05	0.66	0.76	0.66	1.26	0.04	0.17	0.35
Lead	mg/L	0.001	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese	mg/L	0.01	0.03	0.01	0.07	0.4	0.07	0.13	0.04
Mercury	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum	mg/L	0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Selenium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.004	<0.001
Silver	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	mg/L	0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	mg/L	0.01	0.07	0.04	0.05	0.03	0.22	0.13	0.08
Trace Metals-Total									
Aluminum	mg/L	0.10	0.5	1.4	1.6	2.7	0.1	0.3	0.8
Arsenic	mg/L	0.001	0.001	0.002	<0.001	0.004	<0.001	<0.001	<0.001
Barium	mg/L	0.10	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1

Table 3.5-2 Surface Water Quality Data (Page 3 of 5)

Parameter	Units	Detection Limit	Sampling Location						
			LC1	LC2	LC4	LC5	LC10	LC11	LC12
Boron	mg/L	0.10	0.6	1	0.8	0.4	0.7	0.8	1.2
Cadmium	mg/L	0.005	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Copper	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	mg/L	0.05	0.24	0.54	0.29	1.83	0.06	0.21	0.17
Lead	mg/L	0.001	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese	mg/L	0.01	0.04	0.13	0.08	1.45	0.06	0.13	0.03
Mercury	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum	mg/L	0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Selenium	mg/L	0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
Silver	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	mg/L	0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	mg/L	0.01	0.06	0.03	0.05	0.08	0.22	0.13	0.09
Radiometric-Dissolved									
Uranium	mg/L	0.0003	<0.0003	0.0004	<0.0003	0.0003	<0.0003	<0.0004	<0.0003
Lead 210	pCi/L	2.2	<2.4	<2.2	<2.2	<2.5	<2.2	<2.3	<2.2
Polonium 210	pCi/L	2.2	<2.4	<2.2	<2.2	<2.5	<2.2	<2.3	<2.2

Table 3.5-2 Surface Water Quality Data (Page 4 of 5)

Parameter	Units	Detection Limit	Sampling Location						
			LC1	LC2	LC4	LC5	LC10	LC11	LC12
Thorium 230	pCi/L	0.4	<0.5	<0.4	<0.4	<0.5	<0.4	<0.5	<0.4
Radiometric-Suspended									
Uranium	mg/L	0.0003	<0.0003	0.0005	<0.0003	0.0006	<0.0003	<0.0003	<0.0003
Lead 210	pCi/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Polonium 210	pCi/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Thorium 230	pCi/L	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Radium 226	pCi/L	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Radiometric-Total									
Uranium	mg/L	0.0003	0.0003	0.0008	0.0003	0.0009	<0.0003	<0.0003	<0.0003
Radium 226	pCi/L	0.2	<0.2	0.5	<0.2	<0.2	<0.2	<0.2	<0.2
Radium 228	pCi/L	1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Gross Alpha minus Rn & U	pCi/L	1	1.3	3.6	1.4	2.6	1.2	<1.0	1.1
Gross Beta	pCi/L	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Non-Metals									
pH	SU	0.01	7.1	6.86	6.66	6.83	7.12	6.41	6.39
Conductivity	µmhos/cm	1.0	36.4	57.3	40.5	64.5	100	66.4	62.6
Total Suspended Solids @ 105°C	mg/L	1.0	36	422	24	5280	4	14	9
Alkalinity as $CaCO_3$	mg/L	1.0	10	22	14	25	24	12	20

Table 3.5-2 Surface Water Quality Data (Page 5 of 5)

Parameter	Units	Detection Limit	Sampling Location						
			LC1	LC2	LC4	LC5	LC10	LC11	LC12
Quality Assurance Data		Target Range							
Anion	meq/L		0.355	0.571	0.377	0.655	0.823	0.486	0.609
Cation	meq/L		0.462	0.766	0.537	0.881	1.12	0.748	0.698
WDEQ A/C Balance	percent	-5 to +5	13	14.6	17.4	14.7	15.2	21.3	6.82
Calculate TDS	mg/L		29	43	30	52	46	37	40

Table 3.5-3 Surface Water Rights within Three Miles of the Main Permit Area

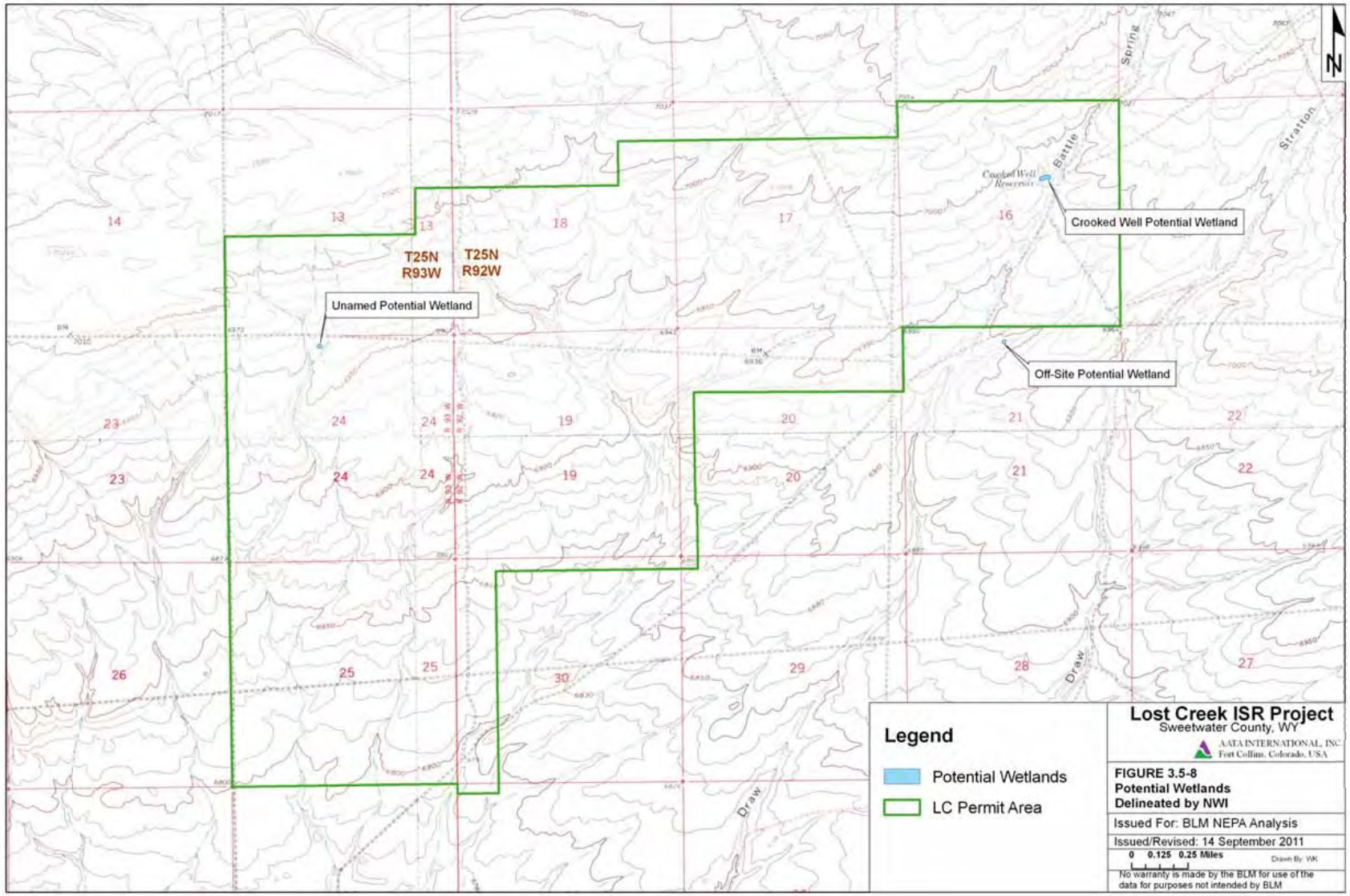
Map ID	Permit Number	Applicant	Township, Range, Section, ¼¼	Uses	Priority	Status	Permit Facility Name	Source	Amount (ac-ft)
1	P7871R	Green Mountain Mining Venture	24N, 93W, 3, SESW	Wildlife, Stock	7/28/1977	Unadjudicated	Blue No. 5 Reservoir	Minerals Draw	4106.4
2	P7871R	Green Mountain Mining Venture	24N, 93W, 3, SWSW	Wildlife, Stock	7/28/1977	Unadjudicated	Blue No. 5 Reservoir	Minerals Draw	4106.4
3	P7871R	Green Mountain Mining Venture	24N, 93W, 9, NENE	Wildlife, Stock	7/28/1977	Unadjudicated	Blue No. 5 Reservoir	Minerals Draw	4106.4
4	P10088R	Kennecott Uranium Co.	24N, 93W, 9, NESE	Industrial, Temporary Use	7/27/1994	Unadjudicated	Sweetwater Pit Reservoir	Road Draw	3809.32
5	P10088R	Kennecott Uranium Co.	24N, 93W, 9, SESE	Industrial, Temporary Use	7/27/1994	Unadjudicated	Sweetwater Pit Reservoir	Road Draw	3809.32
6	P7871R	Green Mountain Mining Venture	24N, 93W, 10, NENW	Wildlife, Stock	7/28/1977	Unadjudicated	Blue No. 5 Reservoir	Minerals Draw	4106.4
7	P7871R	Green Mountain Mining Venture	24N, 93W, 10, NWNW	Wildlife, Stock	7/28/1977	Unadjudicated	Blue No. 5 Reservoir	Minerals Draw	4106.4
8	P10088R	Kennecott Uranium Co.	24N, 93W, 10, NWSW	Industrial, Temporary Use	7/27/1994	Unadjudicated	Sweetwater Pit Reservoir	Road Draw	3809.32
9	P7871R	Green Mountain Mining Venture	24N, 93W, 10, SWNW	Wildlife, Stock	7/28/1977	Unadjudicated	Blue No. 5 Reservoir	Minerals Draw	4106.4
10	P10088R	Kennecott Uranium Co.	24N, 93W, 10, SWSW	Industrial, Temporary Use	7/27/1994	Unadjudicated	Sweetwater Pit Reservoir	Road Draw	3809.32
11	P10671R	Kennecott Uranium Co.	24N, 93W, 11, SESW	Industrial, Temporary Use	1/21/1998	Unadjudicated	Blue No. 10 Reservoir	Battle Spring Draw	2040.42
12	P10671R	Kennecott Uranium Co.	24N, 93W, 11, SWSW	Industrial, Temporary Use	1/21/1998	Unadjudicated	Blue No. 9 Reservoir	Battle Spring Draw	2040.42

3.5.2 Wetlands

Evaluation of potential wetland areas was initially conducted by reviewing aerial photographs of the Permit Area for topographic low areas and drainages. Other than the Crooked Well Reservoir, no potential wetland areas were identified from the aerial photographs. Three potential wetlands were identified using the Geographic Information System (GIS) layers from the National Wetlands Inventory (NWI) database (National Wetlands Inventory, 2006), and their locations are shown in **Figure 3.5-8**. The National Hydrography Dataset (NHD) was also referenced (National Hydrography Dataset, 2011), this dataset only showed the Crooked Well Reservoir (**Figure 3.5-8)** as a potential wetland.

The potential wetland areas were visited in the field during the 2006 growing season and again in the spring of 2009. The sites were evaluated using the criteria listed in the USACE wetland delineation manual (Department of the Army, 1987). Two of the three locations were not wetlands, as none of the criteria related to hydrology, soils, or vegetation were met. A more detailed evaluation of the vegetation at one potential location, the Crooked Well Reservoir, was conducted because of the potential for inundation of the area during some seasons. The indicator status for wetland species has been developed by the USFWS, and a specific publication for Region 9 (which includes western Wyoming) is available (Reed, 1988).

Based on more detailed field observations during April 2006 (vegetation survey, surface water sampling, and other site activities), the Crooked Well Reservoir was determined not to be a wetland under the 1987 USACE criteria (hydrology, soils, and vegetation). **Figure 3.5-4** shows the reservoir conditions in April of 2006, 2007, and 2009. Hydrology is the criteria most likely to be met in a given year; however, the variability and timing of precipitation do not result in inundation for at least five days during the growing season each year. There may be sufficient snowmelt for water to accumulate for five days in some years, but because of the variability in temperatures, snowmelt often occurs (and the reservoir dries) before the growing season starts in June (National Climatic Data Center, 2008). There may also be water present after an intense summer thunderstorm, but only at rare intervals from year to year.


N
Crooked Well Potential Wetland
Unamed Potential Wetland
Off-Site Potential Wetland
T25N R93W
T25N R92W
Battle
Spring
Stratton
Draw
Legend
Potential Wetlands
LC Permit Area
Lost Creek ISR Project
Sweetwater County, WY
AATA INTERNATIONAL, INC.
Fort Collins, Colorado, USA
FIGURE 3.5-8
Potential Wetlands
Delineated by NWI
Issued For: BLM NEPA Analysis
Issued/Revised: 14 September 2011
0 0.125 0.25 Miles
Drawn By: WK
No warranty is made by the BLM for use of the data for purposes not intended by BLM

The bottom of the reservoir is composed of sand, silt, and clay, with no surficial evidence of extensive organic material or anaerobic conditions. The bottom of the reservoir is essentially bare, probably due in part to wind scour. Although there is no specific vegetation density requirement for wetlands, the density is a factor that should be taken into account (Department of the Army, 1987). Scattered small sagebrush and grasses are present along the edges of the bare area; these grade quickly to the more dense sagebrush community, however hydrophytic plants were not observed.

Of the other two potential wetlands identified in the NWI, one is off channel in the northern portion of Township 25 North (T25N), Range 93 West (R93W), Section 24 (**Figure 3.5-9**). The other location is near a channel and just south of the Permit Area. It was apparently associated with the BLM Battle Spring Draw Well No. 4451 in the northern portion of T25N, R92W, Section 21. When the site was first visited in April 2006, and again in November 2007, the well was not in use. However, the well is back in service and was visited in April 2009 and October 2011 (**Figure 3.5-10**).

3.5.3 USACE Jurisdiction

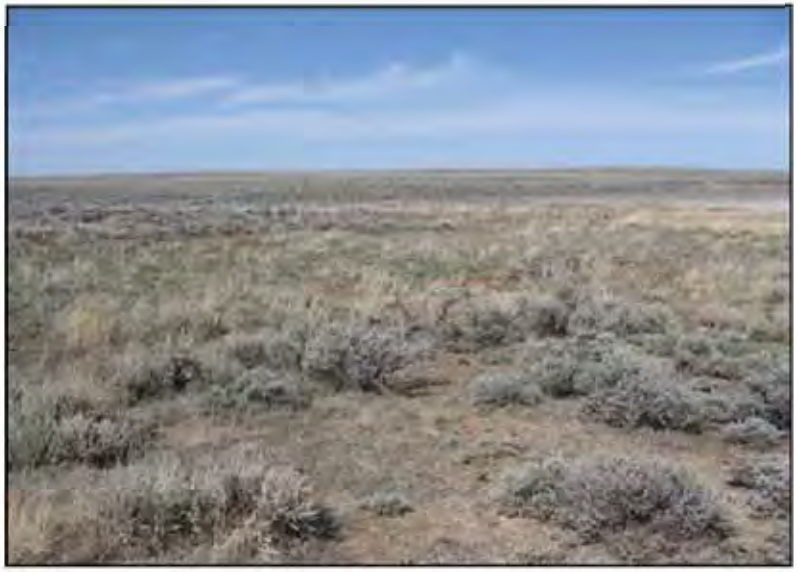
In May 2010, LCI submitted a request to USACE for a jurisdictional determination of waters within the Permit Area, based on the information in Appendix D11 of the WDEQ-LQD Permit to Mine (LCI, 2011b), which is essentially the same information in this EIS. The USACE's jurisdictional determination is in a letter dated August 10, 2010 (Appendix A). The information provided was determined to provide an accurate depiction of potential wetlands and other waters within the Permit Area. In addition, "all waters within the permit area do not contain any areas that meet the definition of waters of the United States". The water bodies are considered isolated since: they have no surface connection to a traditional navigable water; they occur within a closed hydrologic basin; they do not provide habitat suitable for migratory birds; and they do not support any form of interstate commerce.

3.5.4 Aquatic Ecology

Research and field investigations confirmed that aquatic life was determined not to exist within the boundaries of the Permit Area. Surface water may be present occasionally, but it does not sustain aquatic life.

Figure 3.5-9 NWI Potential Wetland in T25N, R93W, Section 24

Looking East, April 2009.



Looking West, April 2009.

Figure 3.5-10 NWI Potential Wetland at BLM Battle Spring Draw Well No. 4451

Battle Spring Draw Well No. 4551. November 2007.

Battle Spring Draw Well No. 4551. April 2009.

Pipeline from Battle Spring Draw Well No. 4551 to dirt 'tank'. April 2009.

Battle Spring Draw Well No. 4551. October 2011.

Pipeline outlet from Battle Spring Draw Well No. 4551 to dirt 'tank'. April 2009.

Dirt 'tank' at pipeline outlet from Battle Spring Draw Well No. 4551. April 2009.