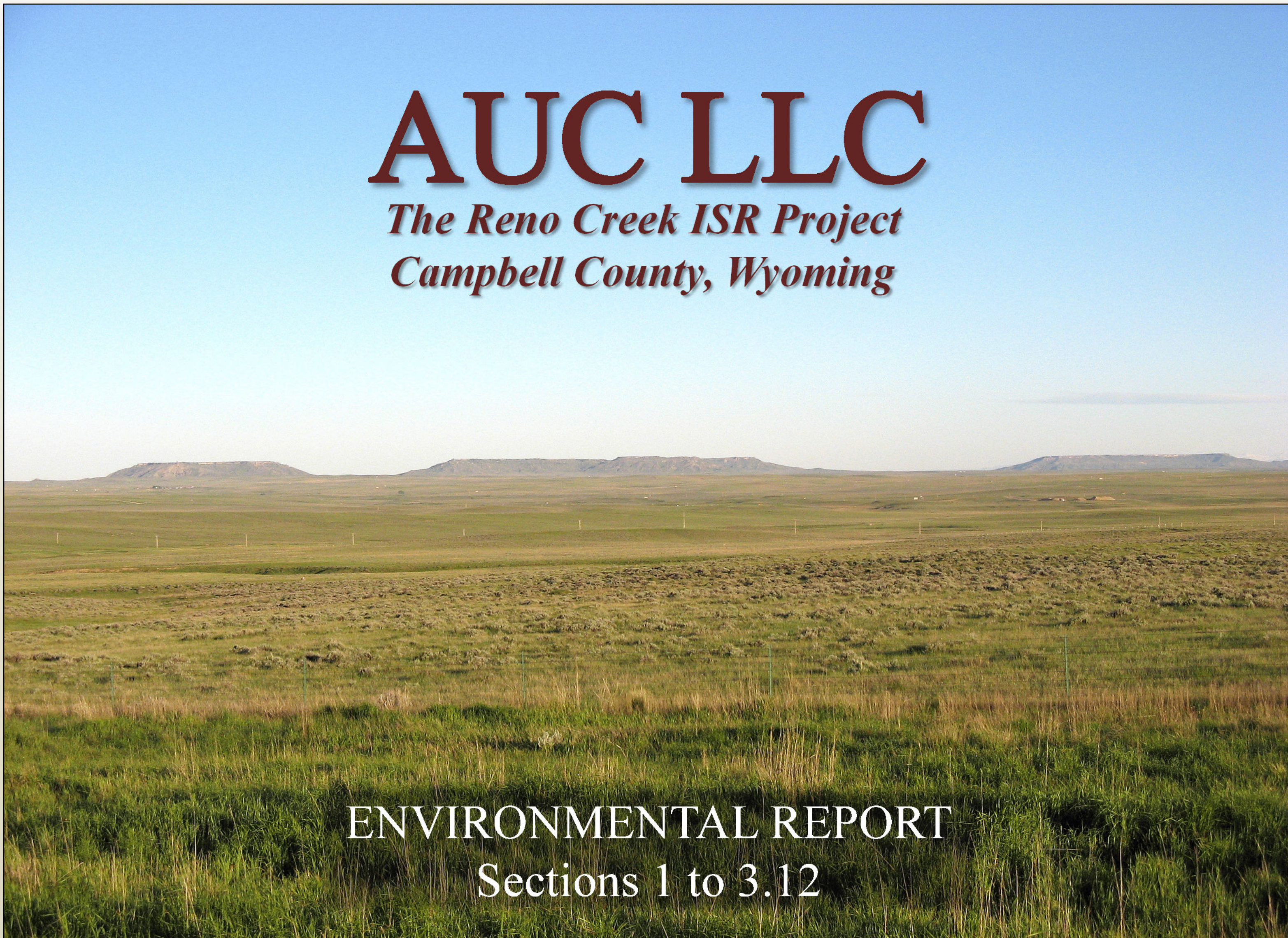
<u>USNRC APPLICATION</u>

Combined Source and 11e.(2) Byproduct Material License



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ABBREVIATIONS AND ACRONYMS

-A-

AADT	Annual Average Daily Traffic
ALARA	As Low As Reasonably Achievable
ALI	Annual Limit Intake
amsl	above mean sea level
ANSI	American National Standards Institute
AP	Airport
APD	Application for Permit to Drill
APE	Area of potential effect
API	American Petroleum Institute
AQD	Air Quality Division
ASME	American Society of Mechanical Engineers
ASOS	Automated Surface Observing System
AUC	AUC, LLC

-B-

BACT	Best Available Control Technology
BCA	Benefit-Cost Analysis
BEA	United States Bureau of Economic Analysis
bgs	below ground service
BKS	BKS Environmental Associates, Inc.
BLM	United States Department of the Interior, Bureau of Land Management
BMP	Best Management Practices
BOE	Bureau of Explosives
BPT	Best Practicable Technology

-C-

CA/T	Central Artery/Tunnel
CAD	Computer-Aided Design
CBM	Coal Bed Methane
CBNG	Coal Bed Natural Gas
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental, Response, Compensation and Liability Act
CESQG	Conditionally Exempt Small Quantity Generator
CGA	Compressed Gas Association

ABBREVIATIONS AND ACRONYMS (CONTINUED)

CGP	Construction General Permit
CMF	Central Measuring Facility
CO_2	Carbon Dioxide
COOP	Cooperative Observer Program
CPP	Central Processing Plant
CPVC	Chlorinated Polyvinyl Chloride

-D-

DAC	Derived Air Concentration
DDE	Deep Dose Equivalent
DDW	Deep Disposal Well
DEQ	Department of Environmental Quality
DHS	Department of Homeland Security
DVD	Digital Video Disk

-E-

E	East
EA	Environmental Assessment
EDR	Electro Dialysis Reversal
EFI	Energy Fuels Inc.
Eh	oxidation-reduction potential
EIS	Environmental Impact Statement
EJ	Environmental Justice
EJ Study Area	Environmental Justice Study Area
ER	United States Nuclear Regulatory Commission Environmental Report
ESA	Endangered Species Act
ESO	Ecological Services Office
ESRI	Environmental Systems Research Institute

-F-

FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FIDLER	Field Instrument for the Detection of Low Energy Radiation
FSER	Final Safety Evaluation Report

-G-

ABBREVIATIONS AND ACRONYMS (CONTINUED)

GIS	Geographical Information System
GPS	Global Positioning System
GWR	Ground Water Restoration

-H-

H_2O_2	Hydrogen Peroxide
HDPE	High Density Polyethylene
HMR	Hazardous Materials Regulations
HPIC	High Pressure Ionization Chamber
HTF	Heat Transfer Fluid
HUC	Hydrologic Unit Code
HVAC	"Heating, Ventilation, and Air Conditioning"

-I-

IBC	International Building Code
ICF	ICF International
ICRP	International Commission on Radiological Protection
IDLH	Immediately Dangerous To Life And Health
IML	Inter-Mountain Labs
IMPLAN	Impact Analysis for Planning
ISC3	Industrial Source Complex
ISR	In Situ Recovery
IUC	International Uranium Corporation
IX	Pressurized Downflow Ion Exchange

-J-
-K-

-L-

LLD	Lower Limits Of Detection
LQD	Land Quality Division
LSA	Low Specific Activity

-M-

MCL	Maximum Containment/Concentration Level
MDL	Method Detection Limit
MET	Meteorological

ABBREVIATIONS AND ACRONYMS (CONTINUED)

MIT	Mechanical Integrity Test
MP wells	Baseline production monitor wells
MSL	Mean Sea Level Elevation

-N-

N	North
NAAQS	National Ambient Air Quality Standards
Na_2CO_3	Sodium Carbonate or Soda Ash
NAD	North American Datum
$NaHCO_3$	Sodium Bicarbonate (commonly known as baking soda)
NAICS	North American Industrial Classification System
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NHD	National Hydrography Dataset
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
NRC	United States Nuclear Regulatory Commission
NRCS	Natural Resource Conservation Service
NRHP	National Register of Historic Places
NVLAP	National Voluntary Laboratory Accreditation Program
NWI	National Wetlands Inventory
NWP	Nationwide Permit
NWS	National Weather Service

-O-

OHV	Off-Highway Vehicle
OA	Overlying aquifer
OM	Overlying aquifer well
OSHA	Occupational Safety and Health Administration
OSL	Optically-Stimulated Luminescent Dosimeter
OWUS	Other Waters of the United States

-P-

PBL	Performance Based License
PBLC	Performance Based License Condition
PCN	Pre-construction Notification
PFYC	Potential Fossil Classification System

ABBREVIATIONS AND ACRONYMS (CONTINUED)

PM_{10}	Particulate Matter 10 Microns or Larger
PRB	Powder River Basin
PRI	Power Resources, Inc.
PSM	Process Safety Management
PV	Pore volumes
PVC	Polyvinyl Chloride
PZA	Production zone aquifer
PZM	Production zone monitor well

-Q-

QA	Quality Assurance
QAM	Quality Assurance Manual
QC	Quality Control

-R-

R	Range
RAP	Restoration Action Plan
RCRA	Resource Conservation and Recovery Act
REIS	Regional Economic Information System
Reno Creek Project	Reno Creek ISR Uranium Project (Proposed Project)
RM	Monitor well ring wells during production
RME	Rocky Mountain Energy
RMP	Risk Management Plan
RO	Reverse Osmosis
ROD	Record of Division
RPC	Regional Purchase Coefficient
RPP	Radiation Protection Program
RQ	Reporting Quantities
RSO	Radiation Safety Officer
RST	Radiation Safety Technician
RTV	Restoration Target Values
RWP	Radiation Work Permit

-S-

S	South
SA	Shallow water aquitard
SCS	Soil Conservation Service
SDR-17	Standard Dimension Ratio 17

ABBREVIATIONS AND ACRONYMS (CONTINUED)

SDWA	Safe Drinking Water Act
SEO	State of Wyoming Engineering Office
SER	Safety Evaluation Report
SERP	Safety and Environmental Review Panel
SGCN	Species Of Greatest Conservation Need
SHPO	Wyoming State Historic Preservation Office
SIL	Significant Impact Level
SM	Shallow water monitor well
SM unit	Shallow water table unit present in some locations
SODAR	Sonic Detection and Ranging
SOP	Standard Operating Procedures
SP	Spontaneous Potential
SRWP	Standard Radiation Work Permit
SSC	"Structure, System, or Component"

-T-

T	Township
T&E	Threatened and Endangered
TCP	Traditional Cultural Places
TDS	Total Dissolved Solids
TEDE	Total Effective Dose Equivalent
TENORM	Technologically Enhanced Naturally Occurring Radioactive Material
TER	Technical Evaluation Report
TLD	Thermo Luminescent Dosimeters
TPQ	Threshold Planning Quantities
TR	United States Nuclear Regulatory Commission Technical Report
TQ	Threshold Quantities

-U-

UA	Underlying aquitard
UM	Underlying aquitard well
U.S.	United States
U_3O_8	"Triuranium Octoxide, or Yellowcake"
UBC	Uniform Building Code
UCL	Upper Control Limit
UIC	Underground Injection Control
USACE	United States Army Corps of Engineers

ABBREVIATIONS AND ACRONYMS (CONTINUED)

USDA	United States Department of Agriculture
USDW	Underground Source Of Drinking Water
USEPA	United States Environmental Protection Agency
USFWS	"United States Department of the Interior, Fish and Wildlife Service"
USGS	United States Geological Survey
UTM	Universal Transverse Mercator

-V-

VRM	Visual Resource Management

-W-

W	West
WAAS	Wide Area Augmentation System
WDEQ	Wyoming Department of Environmental Quality
WDEQ-LQD	Wyoming Department of Environmental Quality – Land Quality Division
WDEQ-SHWD	Wyoming Department of Environmental Quality – Solid and Hazardous Waste Division
WDEQ-WQD	Wyoming Department of Environmental Quality – Water Quality Division
WGFD	Wyoming Game and Fish Department
WL	Working Level
WLM	Working Level Month
WOGCC	Wyoming Oil and Gas Conservation Commission
WoUS	Waters of the United States
WQD	Water Quality Division
WRCC	Western Regional Climate Center
WY	Wyoming
WYDOT	Wyoming Department of Transportation
WYGISC	Wyoming Geographic Information Science Center
WYPDES	Wyoming Pollutant Discharge Elimination System

-X-
-Y-
-Z-

UNITS OF MEASURE

%	percent
% g	percent of gravitational acceleration
µg/Kg	micrograms per kilogram or parts per billion
µg/L	micrograms per liter or parts per billion
µCi/g	microcuries per gram
µCi/Kg	microcuries per kilogram
µCi/L	microcuries per liter
µCi/m^3	microcurie(s) per cubic meter
µrem	microrem
µR/h	microrem per hour
µSv	microsievert
^{o}	degrees
^{o}C	degrees Celsius
^{o}F	degrees Fahrenheit
ac	acre
ac-ft	acre-feet
cfm	cubic feet per minute
cfs	cubic feet per second
Ci/yr	Curies per year
cm	centimeters
cm^3	cubic centimeter(s)
cpm	counts per minute
dB	decibel
dBA	decibel A-weighting
DPM	disintegrations per minute
ft	foot
ft^3	cubic foot (feet)
g/l	grams per liter
gpm	gallon per minute
in	inch
Km	kilometer
lpm	liter per minute
m	meter
m^2	square meter
mg/L	milligrams per liter or part per million
mi	mile
mph	miles per hour
mR	milli Roentgens
mrem	millirem

UNITS OF MEASURE (CONTINUED)

mrem/hr	millirem per hour
mSv	millisievert
pCi/g	picocuries per gram
pCi/L	picocuries per liter
pCi/Kg	picocuries per kilogram
pCi/m^3	picocurie(s) per cubic meter
ppm	parts per million
psi	pound per square inch
psig	pound per square inch
R	rem
Sv	sievert
yd^3	cubic yard(s)

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1 INTRODUCTION

AUC, LLC (AUC) is providing this Environmental Report (ER) in support of an application to the United States Nuclear Regulatory Commission (NRC) for a combined Source and 11e.(2) Byproduct Material License to construct and operate an in-situ recovery (ISR) facility at the proposed Reno Creek Project (hereinafter the “Proposed Action”) in Campbell County in the State of Wyoming. This ER has been prepared using suggested guidelines and standards found in NRC’s NUREG-1748, to ensure that all information provided for NRC Staff is adequate to complete the environmental review portion of this license application. AUC also incorporated into this ER the results of NRC’s Request for Additional Information (RAI) process from recent applications for ISR facilities and comments received from the NRC Pre-submission Audit. The Proposed Action will consist of significant features associated with ISR recovery operations as described below:

- A series of sequentially developed Production Units (12 total) consisting of multiple well fields of production (injection and recovery) wells to inject barren lixiviant and to recover pregnant lixiviant;
- Horizontal and vertical excursion monitoring well networks for detection of lixiviant migrating outside of the ore body/recovery zones (excursions);
- Central Processing Plant (CPP) consisting of pressurized, down-flow ion exchange (IX) columns, elution circuit, precipitation circuit, and yellowcake drying and packaging facilities. The CPP also will be used to facilitate the necessary solutions and processes for groundwater restoration after uranium recovery operations have ceased;
- The CPP will be equipped to receive and process equivalent feed, pursuant to NRC RIS 2012-06;
- On-site laboratory, office and maintenance building, reagent storage facilities, and other facilities or areas used to house work areas or equipment storage; and
- Up to four Class I UIC disposal wells (DDW) to dispose of liquid 11e.(2) byproduct material in the form of production bleed and groundwater restoration fluids generated during ISR operations with adequate backup storage capacity.

The Proposed Action will be conducted in a series of “roll front” uranium deposits that have been demonstrated previously to be amenable to the ISR process. Such deposits occur in permeable sandstone aquifers that are hydrologically confined both above and below by low permeability mudstones and claystones. The natural geologic and hydrologic confinement, which occurs across the entire site, helps enable the accumulation of uranium in mineralized areas. Uranium is deposited in roll fronts under natural conditions as a result of groundwater containing small quantities of soluble uranium flowing through the permeable sandstones while between the overlying and underlying confining strata. When the uranium-bearing ground water reaches a reducing environment in the absence of dissolved oxygen, the uranium precipitates onto the surface of the sandstone grains.

The ISR process contemplated by AUC is a phased, iterative approach, in which AUC will sequentially construct and operate a series of up to 12 Production Units. Each Production Unit will have from three to seven wellfields, each of which will be equipped with its own header house. Uranium will be recovered using the ISR process, and when the uranium is depleted, AUC will commence ground water restoration. When the ground water in each Production Unit is restored to approved conditions, the property will be reclaimed, decommissioned, and returned to unrestricted use by the land owners.

During the ISR process, uranium bearing ground water from the well fields will be piped to the CPP where it will be passed through pressurized, downflow IX columns to remove uranium, which will subsequently be recovered, converted into yellowcake product, and packaged for shipment to a conversion facility. The now-barren groundwater will be refortified to lixiviant specifications and recycled to the aquifer for additional uranium recovery. All byproducts from the ISR process that are determined to be 11e.(2) byproduct material will be disposed of in a manner consistent with the Atomic Energy Act of 1954 (AEA), as amended by the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), and applicable NRC regulations and guidance documents.

In addition to the combined Source and 11e.(2) Byproduct Material license process, AUC is subject to 10 CFR Part 51, the National Environmental Policy Act requirements, and regulations of other non-NRC regulatory agencies, including Environmental Protection Agency (EPA) and Wyoming regulations related to the Safe Drinking Water Act (SWDA) and its Underground Injection Control (UIC) regulations, and the Wyoming Department of Environmental Quality's (WDEQ) Permit to Mine.

1.1 Purpose and Need for the Proposed Action

The Proposed Action is projected to produce up to a maximum of two million pounds of uranium annually over an approximate 11 year production lifespan. AUC is requesting that the proposed CPP be licensed to produce up to two million pounds of yellowcake per year. This application also requests that AUC be licensed to receive and process uranium bearing IX resins from AUC owned and operated ISR projects and/or other ISR licensees. Based on that request, this license application includes a detailed assessment of all potential impacts associated with the Proposed Action.

The purpose and need for the Proposed Action arises from the fact that, according to the U.S. Energy Information Administration (EIA, 2011), the total domestic recovery of U_3O_8 yellowcake in the first quarter of 2011 was only 1.06 million pounds, down seven percent from the previous quarter. In 2010, total domestic recovery was only 4.23 million pounds in contrast with domestic demand for approximately 47 million pounds U_3O_8 (EIA 2011). Demand for uranium to fuel nuclear power plants is set to grow rapidly as the nuclear power industry expands dramatically in the future.

Domestically, currently there are 104 operable commercial nuclear reactors at 65 nuclear power plants in the United States (EIA 2011). As of early 2011, NRC has active applications for a total of 28 new reactors, although it is unknown how many of the proposed reactors will be built. Even a single additional reactor will increase demand for uranium to fuel the new reactor.

The Proposed Action represents an important new source of domestic uranium production that is essential to provide a continuing source of fuel to current and future domestic nuclear electrical power generation facilities. This additional domestic recovery will help alleviate U.S. dependency for yellowcake from foreign suppliers located in Canada, Russia, Kazakhstan, and Australia among others.

1.2 The Proposed Action

1.2.1 Background

Substantial historical exploration, development, and mine permitting were performed on the Reno Creek Property. Beginning in the late 1960s and continuing into the mid-1980s, Rocky Mountain Energy (RME), a wholly owned mining subsidiary of the Union Pacific Railroad, drilled thousands of exploration borings on the Reno Creek Property. Summary reports indicate over 5,800 exploratory holes were drilled by RME in the greater Pumpkin Buttes area, with at least 1,083 borings completed on that portion of lands that make up the project boundary of the Proposed Project area. Significant permitting studies, including the construction, successful operation, groundwater restoration, and subsequent reclamation of an ISR pilot plant, were also performed over the years. These activities are detailed below.

The Proposed Project area was acquired by RME and was initially explored in the late 1960s and early 1970s. Exploration drilling at the time delineated several miles of roll front uranium deposits. By the mid 1970's, a partnership was formed between RME, Mono Power Company, and Halliburton Services. The partnership, informally called "ISLCO", was formed to develop the Reno Creek Project.

By the mid 1970's, RME delineated a significant mineral resource at Reno Creek and a decision was made to bring the property to full-scale production using the ISR method. In January 1979, an ISR testing program commenced with the completion of a 100 gallon per minute (gpm) pilot plant (shown in ER Figure 1-2). Two test patterns were installed and operated. The first pattern (Pattern 1) utilized sulfuric acid lixiviant because of the higher recoveries indicated in the amenability tests. Pattern 1 was operated with H_2SO_4 at a pH of 1.7.

The Pattern 1 testing began in February 1979 and was terminated in November 1979 because results from this pattern were unsatisfactory. Severe permeability loss resulted from high levels of calcium mobilized by the acid precipitating as gypsum within the ore sand, sealing off the formation to the point operations had to be curtailed. In addition to significant calcium levels in the pregnant solution, a fungus strain propagated, causing fouling of the IX columns. Analysis indicated that over 20 pounds of calcium were being mobilized from dissolution of calcareous material in the formation for each pound of uranium recovered. Despite attempts to improve recovery and injectivity, the acid pattern ultimately proved that this formation could not be leached effectively using acid lixiviants. Restoration and stabilization of the groundwater of Pattern 1 was acknowledged and signed off by NRC in March of 1986 (Accession #8604040293 / Docket #04008697).

Unfavorable results with Pattern 1 testing led to the installation and operation of a second pattern (Pattern 2) in October 1980 using a Na_2CO_3/$NaHCO_3$ lixiviant and H_2O_2 oxidant. Pattern 2 was constructed as a modified 5-spot, consisting of two recovery wells, four injection wells, and six monitor wells. Pattern 2 was operated from October 1980 to December 1980. The results, coupled with the column leach test results, led RME to the decision to switch to carbonate lixiviant for further testing and commercial development. Uranium recovery and average head grade were especially encouraging.

Restoration of Pattern 2 began in December 1980. Analysis of water quality data following completion of the restoration program indicated that restoration of groundwater affected during ISR was successful. All parameters were returned to baseline ranges with the exception of pH, uranium and vanadium. Of these parameters, all were either below WDEQ Class I Groundwater Standards (domestic use) or did not have Class I maximum concentration limits (WY DEQ, 1980).

Pattern 2 pilot testing culminated in regulatory signoff in June 1983 with the approval of carbonate leaching for commercial operations at Reno Creek under Materials License Number SUA-1338 as part of NRC Docket #04008697/Accession #8306200160. A more detailed discussion on specific historical ISR operations of Rocky Mountain Energy's (RME) Research and Development (R&D) efforts can be found in Addendum 1-A of the TR.

In 1992, the Reno Creek property and other nearby properties were acquired by Energy Fuels Inc. (EFI) from RME. Over the next decade, EFI and its merger successor

International Uranium Corporation (IUC) (now "Denison") continued to advance the main Reno Creek property toward full permitting and uranium recovery. In 2001, the Reno Creek property was sold by IUC to Rio Algom Mining Corp. Thereafter, the property was acquired by Power Resources Inc. (US subsidiary of Cameco) which dropped its claims in 2003. In 2004 Strathmore staked and filed new mining claims in the area acquiring over 16,000 acres of prospective lands including the proposed Reno Creek Project.

In May 2007, Strathmore entered into a joint venture partnership with American Uranium Corporation Inc. of Nevada, to bring the Reno Creek property into a commercial ISR operation. Strathmore and American Uranium subsequently sold the Reno Creek Project (the subject of this license application) and the nearby Pine Tree Trend Properties located approximately seven to eight miles to the west and northwest respectively of the Proposed Project, including its corporate owner AUC LLC, to AUC Holdings.

Table 1-1 outlines all information known regarding the historical ownership and joint ventures of the proposed property.

1.2.2 Corporate Entities Involved

AUC's license application, including its ER and TR, are submitted by AUC LLC, a Delaware corporation registered to do business in the State of Wyoming. AUC LLC is a United States-based corporation and is the wholly owned subsidiary of AUC Holdings, also a U.S. based corporation, whose shares are held by Bayswater Uranium Corporation, a Canadian corporation located at 1111 Melville Street, Suite 100, Vancouver, British Columbia, V6C 3V6, Canada, and Pacific Road Resource Funds, an Australian registered company located at 1 Alfred Street, Level 23, Sydney, NSW, Australia. The corporate headquarters of AUC LLC and AUC Holdings is 1536 Cole Blvd, Suite 330 Lakewood, CO. Bayswater Uranium is a publicly traded corporation with shares traded (BYU) on the TSX Venture Exchange and Pacific Road is a privately held corporation.

For purposes of conducting NRC-licensed ISR operations, AUC LLC will be the holder of the NRC combined source and 11e.(2) byproduct material license, and its managers and employees will be solely responsible for complying with the NRC's financial and technical qualification regulations under 10 CFR Part 40, Appendix A Criteria, specific license conditions, and relevant guidance and policy.

1.2.3 Description of the Proposed Action

The Proposed Action is located in Campbell County, Wyoming, between the communities of Wright, Edgerton, and Gillette as illustrated in Figure 1-1. The Proposed

Project area comprises of approximately 6,057 acres of all or portions of 15 sections described below:

- T42N R73W:
  Diagonal portion of the north half of the northwest quarter of the northwest quarter of Section 5; West half of Section 6, west half of the northeast quarter of Section 6, and the northeast quarter of the northeast quarter of Section 6;
- T42N R74W:
  East half of Section 1, east half of the southwest quarter of Section 1, northeast quarter of Section 12 and east half of the northwest quarter of Section 12;
- T43N R73W:
  South half of Section 21, southwest quarter of Section 22, west half of Section 27, all of Section 28, south half of Section 29, northeast quarter of Section 29, south half of the northwest quarter of Section 29, southeast quarter of Section 30, southeast quarter of the northeast quarter of Section 30, all of Section 31, all of Section 32, north half of Section 33, north half of the south half of Section 33, west half of the northwest quarter of Section 34 and the northwest quarter of the southwest quarter in Section 34; and
- T43N R74W:
  All of Section 36 and the east half of the southeast quarter Section 35.

Primary Access to the Proposed Project area is along Wyoming State Highway 387, which traverses the Proposed Project area. Access throughout the site is available via Campbell County-maintained gravel roads and private two-track roads established from coal bed methane (CBM) development and agricultural activity as illustrated in Figure 1-2. AUC will utilize existing access roads to navigate the Proposed Project area although the primary, secondary, and tertiary roads may be improved or constructed as part of the Proposed Action.

The Proposed Project consists of 157 unpatented lode mining claims (SC 1-47, WR 3-80, BFR 1-18, 21-83), one State of Wyoming mineral lease, and one private mineral lease.
The minerals leased in the Proposed Project area are on private lands, with the exception of Section 36, T43N R74W, which is a State owned section. Figure 1-3 and Figure 1-4 depict the land and mineral ownership respectively in the Proposed Project area, and further characterized in Table 1-2. With the exception of 2,873 acres of mineral federal ownership, none of the land in the Proposed Action area is owned or managed by any Federal agency.

Although the Proposed Action covers a total of 6,057 acres, not all lands will be affected by the proposed operations. Potentially affected lands during the Proposed Action's 16 year life span include:

- Disturbed lands will total approximately 154 acres or around 2.5 percent of the Proposed Project area. Of the 154 acres, there will be two types of disturbance:
  1) Short term- disturbance will be small in time duration (< six months) including trunklines, drill pits and drill pads, top soil storage;
  2) Long term- disturbance will be extended in time duration (> six months) including the fenced area around the CPP and, backup pond, Deep Disposal Well (DDW) pad, and top soil storage.
- Controlled areas will be fenced to limit access to project associated operations and is estimated to encompass 481 acres or approximately 8 percent of the Proposed Project Area. Anticipated controlled areas include all fenced areas around the CPP, wellfields, backup pond, and DDWs. Restricted areas can be located within controlled areas;
- Restricted areas will control access to protect individuals from exposure to radiation and 11e.(2) byproduct materials including selected areas within the CPP building, 11e.(2) byproduct storage areas, backup pond, DDW buildings, and/or areas exceeding 2 mrem per hour; and
- Unrestricted areas are within the Proposed Project area to which access is neither limited nor controlled by the Proposed Action. These areas encompass approximately 5,576 acres or around 92 percent of the Proposed Project area.

No disturbance is planned outside of the Proposed Project area unless required to convey utilities to the Proposed Project area from nearby transmission lines. However, AUC may continue exploration drilling within adjacent properties under a WDEQ/LQD Mineral Exploration Permit/Drilling Notification. Figure 1-5 illustrates the Proposed Project infrastructure while Table 1-3 provides a detailed assessment of disturbance calculations based on proposed infrastructure.

1.2.4 Proposed Reno Creek ISR Project Ore Body

In the Pumpkin Buttes Uranium District, almost all important economic uranium deposits occur in medium to coarse-grained sand facies of the Eocene Wasatch Formation. The Eocene Wasatch Formation is approximately 500 to 700 feet thick in the Proposed Project area though uranium mineralization is confined to the sandy facies and clay/sand boundaries in the lower part of the formation. Uranium deposits accumulated along roll-fronts at the down-gradient terminations of oxidation tongues within the host sandstones. The deposits occur within sandstones which are intermittently interbedded with lenses of siltstone and claystone, commonly referred to as mudstones due to the mixture of particle sizes.

The host sandstones of the Production Zone Aquifer (PZA) were deposited as the result of northward flowing fluvial systems. The thickness of the ore is controlled by the thickness of the sandstone host containing the solution-front. Uranium deposits are generally found within sand units ranging from 50 to 200 feet in thickness, and at depths ranging from 170 to 450 feet below ground surface. Uranium intercepts are variable in thickness ranging from one to 30 feet thick. Thin low-grade residual upper and lower limbs of the roll fronts are found in the less permeable zones at the top and bottom of oxidized sand units bounded by unoxidized mudstones.

As noted in NUREG-1910 (GEIS Section 2.1), the main ore minerals in the unoxidized zone are coffinite and pitchblende (a variety of uraninite). Based on metallurgical testing conducted by AUC, low concentrations of vanadium (~100 ppm) are sometimes associated with the uranium deposits at the Proposed Project. More details regarding the geology of the site and results of metallurgical testing can be found in ER Section 3.3.

Although total recoverable resources for the Proposed Project are not fully developed at this time, AUC estimates, for the purposes of this License Application, mineral resources of approximately 15.7 million pounds of uranium at an average grade of approximately 0.065 percent U_3O_8. Based on AUC analysis and a review of the NUREG-1910 (GEIS p.3-49), the Proposed Project's ore body closely resembles the roll-front deposits assessed previously by NRC in the Nebraska-South Dakota-Wyoming Region, which includes the Proposed Project area, as well as those in all of the other ISR GEIS regional analyses.

1.2.5 ISR Production Units

The ISR process contemplated by AUC is a phased approach, in which AUC will sequentially construct and operate a series of up to 12 Production Units. Each Production Unit will have from three to seven wellfields, each of which will be equipped with its own header house.

AUC anticipates that injection/recovery well patterns will typically follow the conventional 5-spot pattern, consisting of a recovery well surrounded by four injection wells. However, depending on the ore configuration, as delineated post license-issuance, more or fewer injection wells may be associated with each recovery well. In order to recover uranium effectively, and to complete groundwater restoration, all production wells will be completed so that they can be used as either injection or recovery wells. The dimensions of the patterns vary depending on the configuration of the mineralized zone, ore grade and accessibility, but the injection wells typically will be between 75 and 120 feet apart.

Monitor wells will be placed in each of the Production Units, and will include both interior and exterior wells. Interior monitor wells will be located within the wellfield boundaries and will be screened in the Overlying Aquifer above the confining PZA aquitard to monitor potential vertical movement of in situ recovery fluids. As discussed in detail in Section 3.3.2 and 3.4.2.2.2 of this ER, the underlying water bearing units do not exhibit aquifer characteristics. As a result, AUC does not propose to monitor those units. Each Production Unit will also be surrounded by an exterior Monitor Well Ring to monitor for the potential lateral movement of the uranium recovery fluids beyond the wellfields. The screened interval of these exterior monitor wells will be in the PZA. The typical monitor well spacing in the fully saturated portion of the PZA will be 500 feet from the outer edge of the Production Unit and a 500 foot spacing between monitor wells. For the partially saturated portion of the PZA, AUC expects to use a 400 foot spacing from the outer edge of the Production Unit and a 400 foot spacing between monitor wells. A numerical groundwater flow model included as TR Addendum 2.7-C indicates that these monitor well spacing distances are sufficient to detect potential lateral excursions and discusses monitor well spacing in more detail.

During ISR operations, a slightly greater volume of water will be recovered from the PZA than is injected, to create a flow gradient inward towards the center of the Production Unit. The difference between the amount of water recovered and injected is the wellfield “bleed”. The minimum bleed rate is anticipated to be approximately 0.5 percent of the total Production Unit recovery rate and the maximum bleed rate typically will be approximately 1.5 percent. The bleed rate will be adjusted as necessary to ensure that the inward flow gradient is maintained. The numerical groundwater flow model indicates that an average production bleed rate of one percent will be sufficient to maintain an inward gradient in both the fully and partially saturated portions of the PZA during uranium recovery operations.

Injection and recovery feeder pipelines will convey injection and recovery solutions between the main trunk lines which deliver solutions to and from the CPP and the header houses. In order to transfer injection and recovery solutions to and from individual wells, each header house will have an injection and recovery manifold which are connected to the respective feeder pipelines. The injection or recovery wells will be connected to either the injection or recovery manifold through individual meter runs. AUC expects each header house will contain between 15 to 30 recovery wells and 25 to 50 injection wells depending on the design of each wellfield. An estimated 67 header houses are planned for the Proposed Project. A more detailed discussion on wellfield design can be found in Section 3.1.5 of the TR.

1.2.5.1 Well Completion and Integrity Testing

Well completion materials, methods, development, and integrity testing are described below. All work will be performed by a Wyoming-licensed water well contractor under the direction and supervision of qualified AUC personnel.

1.2.5.1.1 Well Completion Materials

During the life of the Proposed Action, AUC will install production and monitor wells. The production wells will consist of injection and recovery wells. The injection wells will be used to convey the barren lixiviant to the PZA, while the recovery wells will be used to recover the pregnant lixiviant after contact with the uranium ore. These wells will be installed using the same completion method so that the wells can be used for either injection or recovery. The ability to change the well function allows for improved uranium recovery and more efficient groundwater restoration as well as an improved ability to respond to potential excursions of lixiviant. These wells will be installed using well completion Method 1, which is discussed below.

All recovery wells are planned to be constructed of Standard Diameter Ratio (SDR) 17 polyvinyl chloride (PVC) with a sufficient pressure rating to withstand the maximum anticipated injection pressure and the anticipated resistance to hydraulic collapse pressure during cementing of the well. Additionally, the wells will be constructed in accordance with Section 6, Chapter 11, “Non Coal In Situ Mining”, of the WDEQ Land Quality Division (LQD) Rules and Regulations. The specifications embodied in Chapter 11 have been previously proposed by Uranium One for Moore Ranch, Uranerz for Nichols Ranch and Hank, and Ur-Energy for Lost Creek, and have had such specifications accepted by NRC in their license approvals. The wells are planned to be installed using 4.5, 5.0, or 6.0 inch SDR17 casings

PVC casing is typically supplied in 20 feet lengths, and the lengths will be mechanically joined with either threaded connections or a water tight O-ring seal, secured in place by a high strength nylon spline.

In accordance with Section 6 of Chapter 11, AUC plans to use an annular seal consisting of a neat cement slurry or a cement bentonite mixture approved by the LQD Administrator. A cement bentonite mixture was approved by the LQD Administrator for the installation of AUC’s regional baseline monitor wells (DN 401). The purpose of sealing the annular space is to assure structural integrity of the casing, stabilize the upper formations, protect against contamination of the well from the surface, and to prevent migration of ground water from one aquifer or water-bearing stratum to another.

The monitor well network is discussed in Section 3.1.5 of the TR. The interior monitor wells will be screened in the Overlying Aquifer, while the perimeter monitor wells will be screened in the PZA. The completion intervals for these wells will be predetermined; therefore they will be installed either by Method 2, Method 3 or Method 4, which are described below. Method 2 and Method 3 will use the same materials of completion as the production wells. Method 4 monitor wells are planned to be installed using 2 to 4 inch Schedule 40 or Schedule 80 PVC glued bell casing.

1.2.5.1.2 Well Completion Methods

The recovery and injection wells will be installed with identical completion methods (see Method 1 below) to allow the ability to change the well function for improved uranium recovery, more efficient restoration, and improved ability to respond to potential excursions. The monitor wells will be installed utilizing Method 2, Method 3 or Method 4 also described briefly below. Detailed well completion methods are found in Section 3.1.3.2 in the TR.

- **Method 1** (TR Figure 3-2):
  Drill a pilot hole with a diameter of 5 to 6.5 inches through the projected mineralization. After performing geophysical logs, ream the hole to a diameter of 8 to 10 inches to a depth approximately 15 feet past the bottom of mineralization. Install well casing to a depth approximately 10 feet past the bottom of mineralization and cement with approved cement slurry from the bottom of the casing to the surface. After allowing the cement to harden, under-ream the well through the mineralized zones to a diameter of 9 to 14 inches and install factory-slotted well screen, if necessary, within the under-reamed intervals. Gravel pack sand may be placed between the screen and the under-reamed hole or a natural gravel pack will be emplaced while the well is being developed;
- **Method 2** (TR Figure 3-2):
  Drill a pilot hole with a diameter of 5 to 6.5 inches through the projected completion interval. After performing geophysical logs, ream the hole to a diameter of 8 to 10 inches to the top of the completion zone. The pilot hole below the bottom of the reamed hole is filled with drill cuttings during the reaming process. Install well casing to the bottom of the reamed hole and cement with approved cement slurry from the bottom of the casing to the surface. After allowing the cement to cure, clean out the designated completion interval and under-ream if necessary. If necessary, install a factory-slotted screen assembly in the completed interval. Gravel pack sand may be placed between the screen and the under-reamed hole or a natural gravel pack will be emplaced while the well is being developed;

- **Method 3** (TR Figure 3-2):
  Drill a pilot hole with a diameter of 5 to 6.5 inches to the top of the projected completion interval. After performing geophysical logs, ream the hole to a diameter of 8 to 10 inches to the top of the completion zone. Install well casing to the bottom of the reamed hole and cement with approved cement slurry from the bottom of the casing to the surface. After allowing the cement to harden, drill the completion interval using a bit that is smaller than the well casing. If necessary, under-ream the completed interval and install a factory-slotted screen assembly in the completed interval. Gravel pack sand may be placed between the screen and the under-reamed hole or a natural gravel pack will be emplaced while the well is being developed; and
- **Method 4** (TR Figure 3-2):
  Drill a pilot hole with a diameter of 4.5 to 6.5 inches through the projected completion interval. Geophysical logs will be performed. If necessary, ream the hole to a diameter of a minimum of three inches larger than the nominal casing OD through the zone to be completed. Install glue belled casing in the reamed hole with the screen attached to the bottom of the casing. A silica sand filter pack will be emplaced to a minimum of three feet above the top of the screen. Three feet of finer grained sand will be placed in the annulus on top of the pack sand. Coated bentonite pellets will be emplaced on top of the sand filter pack to a thickness of five feet. A specified volume of cement slurry will be pumped upward from the top of the bentonite chip seal to the surface.

1.2.5.1.3 Well Development

Following well installation, but before water quality samples are taken for determining “baseline” conditions per 10 CFR Part 40, Appendix A, Criterion 5, for groundwater restoration and water quality monitoring purposes, the wells will be developed to restore the natural hydraulic conductivity and geochemical equilibrium of the screened aquifer. All wells will be developed immediately after construction using air lifting, swabbing or other accepted development techniques. Well development removes water and drilling fluids from the casing, by flushing it with water from the screened interval. The purpose of well development is to allow representative formation water to enter the well screen and casing. This process is necessary to allow representative samples of groundwater to be collected for monitor wells, and to ensure efficient injection and recovery operations from the production wells.

Final development of monitor wells will be performed by pumping the well, or swabbing for the amount of time necessary, to ensure that stable formation water is present. pH and conductivity measurements on the development water will be taken during this process to ensure that development activities have been effective. The field parameters must be stable at representative formation values before baseline sampling will begin.

1.2.5.1.4 Well Integrity Testing

Prior to being placed into operation and after well completion, the integrity of the production wells will be verified by a pressure based mechanical integrity test. Mechanical integrity testing (MIT) is required by State and Federal UIC Programs and the NRC. NUREG-1569, the ISR GEIS and EPA guidance (Geraghty and Miller 1980) address MIT for injection wells.

The MIT is conducted by placing inflatable packers near the top of the casing and directly above the riser pipe connected to the screen interval. The packers are inflated and the interval between the packers is filled with water and pressurized to the test pressure (120 percent of the maximum allowable injection pressure). A well should maintain 90 percent of this pressure for 10 minutes to pass the MIT. An alternative to using a top inflatable packer may be utilized. Instead of an inflatable packer, the top of the casing may be sealed by a specially designed flange top. A well integrity record will be completed for each tested well. If a well shows an unacceptable pressure drop during the integrity test, the packers may be reset and the equipment checked for leaks. If in successive tests the well passes the integrity requirements, the well will be deemed acceptable for use as an injection or recovery well.

If a well casing does not pass the MIT, the well will be taken out of service and the casing repaired, if possible. After being repaired, the well will be re-tested. If it is determined that the well cannot be repaired it will be plugged and abandoned in accordance with WDEQ and WSEO requirements. Once a well has been repaired and passes the MIT, it will be placed in its intended service. The WDEQ/LQD will be notified in the event a well fails the MIT, and will only be placed in service upon approval from the LQD Administrator, once the well successfully passes the MIT.

In addition to the initial testing completed during installation, an MIT will be conducted on the well after any work that involves a down-hole drill bit or under-reaming tool used within the well. Any well with evidence of suspected subsurface damage will require an MIT prior to the well being returned to service. In accordance with WDEQ requirements, MITs will be repeated once every five years for all injection and recovery wells.

The well integrity information will be documented and filed on site to be available to NRC and also provided to WDEQ/LQD on a quarterly basis.

1.2.5.2 Wellfield Operational Monitoring

As discussed in Section 5.7 of the TR, an extensive groundwater sampling program will be conducted prior to, during and following ISR recovery operations at the Proposed Project to identify any potential impacts to groundwater resources in the area. The groundwater monitoring program is designed to establish baseline groundwater quality prior to ISR operations; detect any potential excursions of lixiviant either horizontally or vertically outside of the recovery zone during active ISR, and determine when the PZA has been restored adequately following ISR.

Injection and recovery well flow rates will be monitored at each header house so that injection and recovery can be balanced for each pattern and each wellfield. The flow rates of each injection and recovery well will be monitored continuously through the use of individual electronic flow meters in each wellfield header house. The pressure of the injection and recovery manifolds will be monitored at each header house with electronic pressure transducers. The flow meters and pressure transducers will be connected electronically to the header house control panel, which will be in constant communication with the process monitoring and control systems in the Proposed Action CPP control room.

High and low pressure along with flow rate alarms will be in place to alert wellfield and plant operators if pressures or flow rates in a particular header house are operating outside of acceptable operating parameters. In conjunction with the alarm system, the pumps in each recovery well will be automatically shut off and automatic valves on the injection and recovery manifolds will be directed to close to stop the flow of injection and recovery solutions to and from the wells if significant changes in flow or pressure occur. This action will isolate the header house from the rest of the production circuit to prevent or limit a possible leak, spill, or excursion in the Production Unit.

The groundwater monitoring program at the proposed Reno Creek Project will be designed to detect horizontal excursions of lixiviant outside the Production Unit and vertically into the overlying water bearing strata. After baseline water quality is established for the monitor wells for a particular Production Unit, AUC will use the EPA-developed program, ProUCL to calculate upper control limits (UCLs) for chemical constituents which would be indicative of a migration of lixiviant from the Production Unit. ProUCL is used to statistically characterize the groundwater in each aquifer and after treating for Non Detects, Outliers, and other anomalies, develop UCLs. The statistically sound characterization of water chemistry in each aquifer constitutes the baseline for each Production Unit, including identification of constituents and the statistically determined range of concentrations that characterizes the groundwater.

Chloride, conductivity, and total alkalinity are the constituents chosen by AUC as early warning indicators of lixiviant migration and for UCL determination. These constituents are used as excursion indicators for nearly all currently licensed and operating ISR facilities. Chloride is chosen due to its low natural levels in the native groundwater and because chloride is introduced into the lixiviant from the IX process. Chloride also is a very mobile constituent in the groundwater and will show up very quickly in the case of a lixiviant migration to a monitor well. Conductivity is chosen because it is an excellent general indicator of overall groundwater quality. Total alkalinity concentrations should be affected during an excursion because bicarbonate is the major constituent added to the lixiviant during ISR operations. UCLs will be set by analyzing the data using EPA's ProUCL program for each excursion indicator.

The currently proposed excursion indicator parameters will be adequate to identify that an impact has occurred to groundwater from ISR operations. In the event that different parameters are selected, AUC will document such changes through the SERP process and make such documentation available for inspection by NRC. Once an indication of impacts is observed, additional investigation is triggered to determine the cause of the impact, whether it is from ISR activities or some other source. Once an impact has been identified, additional indicator parameters will be evaluated. A more detailed discussion on excursion monitoring, corrective action, and reporting can be found in Section 7.2.2.2 of this ER.

Another potential concern during ISR is the occurrence of gas locking. Gas locking can occur when the hydrologic head pressure in an aquifer is low enough to allow dissolved oxygen to come out of solution before it chemically reacts with the minerals in solution or in the sandstone matrix. ISR well fields are designed and completed to focus lixiviant flow through the uranium bearing portions of the recovery zone, minimizing the risk of gas locking. Redirection of lixiviant flow due to gas locking (or other reasons), results in a dilution of the uranium content of the recovered lixiviant. A partial, or complete, gas lock at or near an injection well will be easily identified due to reduced flow or flow blockage in the well. This loss of flow can be detected by continuous flow and pressure measurements in the Production Unit within hours of its occurrence. A more detailed discussion including remedial action on gas locking is provided in TR Section 3.1.4.1.

1.3 Proposed Operating Schedule

Baseline data acquisition efforts in support of the Proposed Project were initiated in Fall 2010. AUC submitted a letter of intent to the NRC staff on November 3, 2010, which supplemented its original letter of April 9, 2010. This letter notified NRC staff that AUC intended to submit an application to operate an ISR facility at the Reno Creek site. By letter dated July 12, 2011, AUC requested a pre-submission audit of its Reno Creek application. This meeting occurred on November 15-17, 2011, in Wright, Wyoming. The pre-submission audit consisted of an a site tour and an audit of the preliminary draft application. Addendum 1-A presents the NRC staff comments compiled during the preliminary draft application audit, AUC's comments, and where they are addressed within this application. These comments represent the more important issues discussed with the NRC during the debrief meeting.

AUC anticipates that, after the issuance of its requested combined source and 11e.(2) byproduct material license, its WDEQ/LQD Permit to Mine, and other required licenses/permits, facility construction will commence. Initial activities include site grading and excavation; construction of the CPP and associated facilities including a lined backup storage pond, administrative building, and workshop; development of intial Production Unit and associated wellfields; and construction of supporting operations infrastucture such as access roads, transmission lines, control measures (fences, gates, cattle gaurds, etc.), and domestic sewage facilties.

Construction of each Production Unit is anticipated to take one to two years, including installation and development of injection, recovery, and monitor wells; and installation of header houses, piping, and utilities. Production Unit construction will be phased, with three to seven wellfields in various stages of construction at one time. Additional Production Unit plans are developed approximately one year prior to the planned commencement of the new wellfield operations. The overall duration of construction is anticipated to be approximately 9 years.

Uranium recovery operations are anticipated to begin approximately 9 to 12 months after initiating construction of the CPP and first Production Unit. The duration of operation of each Production Unit is estimated to be two to three years, but this interval may be longer or shorter depending on uranium recovery levels and available CPP capacity. The overall duration of operations is approximately 11 years for the Proposed Action.

Wellfields will be moved from a production status to a restoration status once the recovery of uranium has decreased to the point where the cost of producing that uranium is more than the value of the uranium produced. Other considerations that could impact the decision to move a wellfield from production to restoration would include, the dilution of the lixiviant stream to the point of non-economic operation, the current operational status of adjacent wellfields, the restoration capacity of the CPP, and the capacity of liquid 11e.(2) disposal.

Similar to Production Unit construction, groundwater restoration will be a phased approach and is anticipated that one to three Production Units will be in various stages of active restoration or stability monitoring at one time. The proposed plan incorporates water balance calculations so that the deep disposal well(s) and back up storage capacity can accommodate the proposed recovery and restoration efforts at any given time. The total duration of groundwater restoration is expected to be approximately 8 years for the Proposed Action.

Decommissioning and Demoltion (D&D) of the CPP, access roads, backup pond, and associated infrastructure is expected to last 12 to 18 months. D&D and reclamation activities described above for Production Units will likely commence after receiving NRC and WDEQ/LQD approval of successful groundwater restoration in each Production Unit. The total project lifespan is expected to be approximately 16 years; however, the duration of operations may be extended by processing uranium-loaded IX resin from AUC owned and/or operated satellite facilities or other company(ies). Once groundwater restoration, D&D, and reclamation activities conclude and AUC has met the requirements of 10 CFR 20, Subpart E, the site will be released for unrestricted use.

The anticapted project schedule is shown in Figure 1-6 and outlines the activities described above. The schedule is subject to change due to production schedules, variations with production area recoveries, CPP issues, economic conditions, etc. The exact annual production schedules will be updated in annual reports to NRC and WDEQ/LQD.

1.4 Central Processing Plant, Chemical Storage Facilities, Equipment Used, and Materials Processed

This section describes the proposed CPP facilities and details specifications that will be utilized for the Proposed Action. Processing plant facilities typically include the following major structures: a CPP building housing the processing equipment, drying and packaging equipment, groundwater restoration water treatment equipment, and on-site laboratory; a warehouse and maintenance building; and a reagent and liquid materials storage facility. The conceptual CPP facilities are illustrated in Figure 1-7.

The proposed CPP will contain various vessels to hold and process liquid solutions. The primary vessels will include pressurized, down-flow IX columns, elution columns, and yellowcake drying equipment. The main plant will contain tanks for storage of various liquids including barren lixiviant, barren eluant, yellowcake precipitation tanks, and washing, dewatering, process chemicals, and yellowcake slurry. Designated areas will also be provided for hydrocarbon storage (fuel, oil, etc.) and hazardous material storage (used oil, etc.). The conceptual plant layout is illustrated in Figure 1-8 and detailed descriptions of the CPP processes, equipment, and chemical storage facilities are included in Section 3.2 of the TR.

1.4.1 Central Processing Plant Design and Equipment

AUC proposes to construct and operate a single CPP within the Proposed Action area. Based on preliminary site evaluation, the proposed CPP will be located in the SENE quadrant of Section 1, T42N, R74W. This property, including the current residence, will be acquired by AUC prior to the commencement of construction. The proposed CPP will be housed in a building approximately 350 feet long by 200 feet wide. The size of the building will be refined during the process of detailed engineering design; however the CPP will include the following circuits and systems:

- Pressurized down-flow IX;
- Resin transfer;
- Chemical addition;
- Filtration;
- Elution;
- Precipitation;
- Product filtering, dewatering, vacuum drying, and packaging;
- Liquid byproduct stream; and
- Groundwater restoration.

The following sections will provide a summary of each processing circuit and the equipment and materials used. A more detailed discussion can be found in Section 3 of the TR including a complete process flow diagram which shows process flows and associated equipment (Figure 3-9).

1.4.2 Ion Exchange Circuit

The uranium-bearing solution, or pregnant lixiviant, recovered from the wellfield will be piped to the pressurized down-flow IX columns in the CPP for recovery of the uranium using specialized ion exchange resin. In accordance with data presented in NUREG-1910 (NRC GEIS), AUC will utilize pressurized down-flow IX columns. With this IX circuit the radon present in the barren recovery solution is forced back underground in the re-fortified groundwater which, thereby, provides for significantly reduced potential for occupational and/or public exposure to radon and its progeny. These columns will be operated in series as pairs to allow one column to be in the lead position and one in the tail position. This will allow the column in the tail position to be placed in the lead position once the original lead column is taken off-line for resin transfer. Resin will be transferred to an elution vessel, where the resin will be stripped, and then transferred back to a pressurized down-flow IX column.

As the pregnant lixiviant passes through the IX circuit, the uranyl dicarbonate and uranyl tricarbonate ions will be removed preferentially from the lixiviant. The barren lixiviant leaving the IX columns will normally contain less than two mg/l of uranium. After the barren lixiviant leaves the IX circuit, CO_2 and/or carbonate/bicarbonate will be added as necessary to refortify the barren lixiviant with the carbonate/bicarbonate concentration desired for recovery operations. The barren lixiviant will then be pumped back to the wellfields, with an oxidant added before the solution is re-injected into the PZA.

1.4.3 Elution Circuit

The elution circuit will consist of multiple elution vessels and multiple elution tanks. The process will be a batch system consisting of three stages. The different stages will all perform similar functions, but vary the concentration of uranium in the solution. Eluant will be washed over the resin in each stage, producing a concentrated solution for each batch.

1.4.4 Precipitation Circut

Once the eluant has been transferred to the precipitation circuit, a strong mineral acid (hydrochloric, sulfuric, etc.) will be added to cause the uranyl carbonate complex ion to break down, liberating carbonate ions such as carbon dioxide.

Once the pH required to release the carbonate ions is achieved, a short delay for degassing will be initiated, to allow all of the carbon dioxide to come out of solution. Following the degassing phase, sodium hydroxide will be added to the precipitation circuit to raise the pH to the optimal range for selective uranium precipitation. Once in the correct range, hydrogen peroxide will be added to the circuit to form an insoluble uranyl peroxide compound. The addition of hydrogen peroxide will also drive the pH of the solution down, so additional sodium hydroxide will be added to maintain the solution pH to the optimal range.

1.4.5 Yellowcake De-Watering/Drying/Packaging System

Yellowcake will be pumped into a plate and frame filter press for additional dewatering and washing. The yellowcake will be washed by pumping fresh water through the solids in the filter press, in order to remove excess chlorides and other soluble materials from the yellowcake. The uranium filtercake will drop from the filter press, through a grizzly to break up any large lumps, and into a hopper that has a shaftless auger mounted underneath. The shaftless auger aids in breaking up any lumps, and moves the uranium filtercake to a smaller, secondary hopper attached to a positive displacement pump. The positive displacement pump transfers the yellowcake to an oil heated, rotary vacuum dryer. Water will be added to the uranium filtercake in the hopper and shaftless auger to create slurry, which will facilitate pumping the solids to the vacuum dryer.

The yellowcake slurry will be dried to remove free water particles and some of the molecules of hydration, but not enough to change the chemical composition of the yellowcake. The gases generated during the drying cycle will be filtered through a baghouse and then be cooled in a surface condenser to further remove the smaller size particulates and the water vapor created during the drying process.

AUC proposes to utilize two rotary vacuum dryers at its proposed CPP as part of its overall yellowcake drying system, to minimize if not eliminate potential yellowcake particulate emissions. The dryers will be located in an enclosed area within the CPP, along with the baghouses on the dryers. The remainder of the process equipment will be located outside of the dryer room, and will include a surface condenser, vacuum pumps, condensate receiver tank, a cooling tower, cooling water transfer pumps and oil heaters. This is consistent with the NRC GEIS (pp 2-24) and recently approved at licensed facilities such as the Moore Ranch ISR Project.
The system will be instrumented sufficiently to operate automatically and to shut itself down in the event of malfunctions such as heating or vacuum system failures. The system will be capable of issuing an audible alarm if there is an indication that the emission control system is not performing within operational specifications or if air pressure falls outside specified levels. In the event an emissions control system instrument fails, the operator will perform and document hourly checks on the emissions control system parameters. Additionally, the operator will perform and document these checks once per shift during normal operations.

The use of vacuum dryers has proven to provide “zero emissions” of yellowcake particulate which provides for significant reductions in potential for occupational exposure from airborne yellowcake particulates. In addition, it minimizes or eliminates entirely the potential exposure to members of the public outside the fence-line or to members of the public who are permitted to be inside the project area but who are not part of the AUC’s operation such as oil and gas workers or ranchers. As stated in NUREG-1910, “radon gas is emitted from ISL wellfields and processing facilities during operations and is the only radiological airborne effluent for those facilities that use vacuum dryer technology.”

Liquid ring vacuum pumps will provide the vacuum source from the time the dryer is being loaded through the time the yellowcake is packaged into drums. The major components of the system are described below:

- Packaging:
  The packaging system will be operated on a batch basis. The dried yellowcake will be removed from the rotary vacuum dryer by passing through the plug valve on the bottom of the dryer, through a sealed hopper, then through an airlock into 55 gallon steel drums. The drums will be placed under a hood for the drum loading, which also will use the vacuum system to achieve a positive seal between the hood and the drum. The vacuum also will act to clear the air between the hood and the drum from fine, airborne particles and will be connected to the vacuum system before the condenser. These particles will be trapped in the filter between the packaging hood and the vacuum system, or in the condenser, condensate tank or liquid seal of the vacuum pump if passing through the filter.
- Effluent Monitoring:
  The vacuum pump exhaust will be piped back into the dryer room, but since it utilizes a liquid seal to create the vacuum, it is unlikely that solid particles will be able to be exhausted. The water that is collected from the condenser will be recycled to the precipitation system, eluant makeup or disposed with other process water. Room air will be monitored routinely for airborne uranium particles.
- HEPA Filtration:
  A HEPA filtration unit will be utilized in the dryer room to filter the air in the dryer room if the potential for airborne uranium particles exist. This unit will draw air from within the dryer room, pass that air through the HEPA filter then discharge that air back into the dryer room. An air conditioning unit may be added to this system if the temperatures created in the dryer room dictate that it is necessary.
- Controls:
  The system will be instrumented sufficiently to operate automatically and to shut itself down in the event of malfunctions such as heating or vacuum system failures. The system will be capable of issuing an audible alarm if there is an indication that the emission control system is not performing within operational specifications or if air pressure falls outside specified levels. In the event an emissions control system instrument fails after successful repair/maintenance, the operator will perform and document hourly checks on the emissions control system parameters. Additionally, the operator will perform and document these checks once per shift during normal operations.

1.4.6 Yellowcake Storage/Shipment

The dried yellowcake product in the U.S. Department of Transportation (DOT)-approved steel drums will be sealed with a drum lid and stored within a restricted storage area located adjacent to the drying area until shipment. AUC plans to use an appropriately licensed outside contractor using dedicated transport vehicles for all yellowcake shipments to Metropolis, Illinois for further processing. Shipment frequency will be weather and process dependent and will strictly adhere to the packaging and shipping requirements contained in the DOT Hazardous Materials Regulations (HMR) and 49 CFR 172, Subpart I, Security Plans.

1.4.7 Groundwater Restoration Circuit

The groundwater restoration circuit will be comprised of pressurized down-flow IX columns and reverse osmosis (RO) units. The pressurized down-flow IX columns will recover residual uranium from the wellfields, while the RO circuit will remove dissolved solids prior to reinjection into the wellfield.

1.4.8 Chemical Storage Facilities

The ISR process requires chemical storage and delivery systems to store and use chemicals at various stages in the extraction, processing, and byproduct treatment processes. Both hazardous and non-hazardous chemicals and materials will be stored at the Proposed Action facilities. Most of the bulk hazardous chemicals and materials will be stored in specially designed tanks or containers located within secondary containment structures as appropriate outside of the CPP building. Sodium hydroxide however will be stored in the CPP. Also, sodium chloride and sodium carbonate may be stored in liquid storage tanks within the CPP.

Each chemical storage and delivery system will be designed to safely store and accurately deliver process chemicals to the intended delivery points in the process. All chemical storage tanks will be clearly labeled to identify the contents. Design criteria for chemical storage and delivery systems include applicable regulations of the International Building Code (IBC), National Fire Protection Association (NFPA), Compressed Gas Association (CGA), Occupational Safety and Health Administration (OSHA), Resource Conservation and Recovery Act (RCRA), and the Department of Homeland Security (DHS).

1.4.8.1 Process Related Chemicals

Process-related chemicals stored in bulk at the Proposed Action CPP will potentially include sodium chloride, sodium carbonate, a strong mineral acid, sodium hydroxide, hydrogen peroxide, oxygen, and carbon dioxide. Generally, AUC anticipates storing sufficient process related chemicals to permit full production for at least 14 days.

1.4.8.2 Sodium Chloride Storage

Sodium chloride will be used to make up the barren eluant and will be stored either in a bulk silo outside the CPP or within the CPP in a brine liquid storage tank. Dry sodium chloride will be delivered by truck and will be blown into the storage silo or tank using air pressure.

1.4.8.3 Sodium Carbonate Storage

Sodium carbonate (soda ash) will be used to make up the barren eluant solution and and to produce sodium bicarbonate to refortify the barren lixiviant. It will be stored either in a bulk silo outside the CPP or within the CPP in a liquid storage tank. Dry sodium carbonate will be delivered by truck and will be blown into the storage silo or tank using air pressure.

1.4.8.4 Acid Storage and Delivery System

The acid storage and distribution systems at the CPP will be monitored closely. Strict unloading procedures will be utilized to ensure that safety controls are in place during the transfer of these acids. Process safety controls also will be in place at the CPP where a strong mineral acid (hydrochloric, sulfuric, etc.) is added to the precipitation circuit.

Anticipated acid storage should not exceed the screening threshold (11,250 lbs.) contained in Appendix A of 6 CFR 27, Chemical Facility Anti-terrorism Final Interim Standards, Department of Homeland Security. As the project is further developed and if it is determined that acid storage will exceed the screening threshold, AUC will undergo screening requirements for any acid utilized.

1.4.8.5 Sodium Hydroxide Storage and Delivery System

AUC plans to use sodium hydroxide (caustic soda) to raise the pH levels during the precipitation phase of the process at the proposed CPP. The sodium hydroxide storage tank will be appropriately placarded and located within the CPP building in a secondary containment basin designed to contain at least 110 percent of the tank volume. This secondary containment basin will be separate from the containment basins for other chemical systems.

The sodium hydroxide feed pump will be located inside the building, near the storage tank. The 50-percent sodium hydroxide solution bulk tank will be made of materials compatible with the chemical. The bulk tank will vent directly to the atmosphere outside above the CPP.

1.4.8.6 Hydrogen Peroxide Storage and Delivery System

The hydrogen peroxide system will include a storage tank and delivery pump. Hydrogen peroxide will be stored as a 50-percent solution, outside in an above-ground storage tank constructed of compatible material. The hydrogen peroxide storage tank will be located adjacent to the CPP building in the chemical storage area in a secondary containment basin designed to contain at least 110 percent of the tank volume. This secondary containment basin will be separate from the containment basins for other chemical systems. Specifically, the storage tank will be placarded and located a safe distance away from flammable sources, organic materials, and incompatible chemicals to avoid potential adverse chemical reactions. The hydrogen peroxide feed pump will be located inside the building, near the storage tank.

1.4.8.7 Oxygen Storage and Delivery System

Oxygen will be added to the injection stream either upstream of the injection manifolds or at each individual injection well meter run within the header house. Oxygen storage will be placarded and located adjacent to the CPP or at centralized position(s) to the Production Units. Each vessel will be equipped with safety relief devices and will be located at least 25 feet from buildings or as required by applicable NFPA and OSHA standards. The storage facility will be designed to meet industry standards in NFPA-502F and OSHA standards for the installation of bulk oxygen systems on industrial premises (29 CFR 1910.104).

Oxygen service pipelines and components must be cleaned of oil and grease since gaseous oxygen will cause these substances to burn much more rapidly if ignited, as it will any other combustible material. All components intended for use with the oxygen distribution system will be properly cleaned using recommended methods in CGA G-4.1. The design and installation of oxygen distribution systems will be based on CGA-4.4.

1.4.8.8 Carbon Dioxide Storage and Delivery System

The carbon dioxide storage and delivery system will be stored adjacent to the CPP where it may be added to the lixiviant prior to leaving the plant, and for the make-up of sodium bicarbonate for addition to the lixiviant stream.

1.4.8.9 <u>Chemical Reductant</u>

A chemical reductant will be utilized during groundwater restoration. Materials commonly used for restoration at ISR operations include sodium sulfide and hydrogen sulfide. These chemicals decrease the oxidation reduction potential that causes dissolved uranium and other heavy metals to stabilize at acceptable levels. AUC plans on utilizing sodium sulfide rather than hydrogen sulfide for worker safety reasons.

Prior to the use of sodium sulfide as a reducing agent, AUC will implement appropriate engineering controls and employee training to ensure safe storage, handling and use of sodium sulfide. When used, sodium sulfide will be stored at the CPP in a dry, clean, isolated environment.

1.4.8.10 <u>Non-Process Related Chemicals</u>

Non-process related chemicals that may be stored at the Proposed Action CPP site include petroleum products (diesel) and propane. Due to the flammable and/or combustible properties of these materials, all bulk quantities will be stored outside of process areas at the CPP site. Diesel storage tanks will be located above ground and within secondary containment structures designed to accommodate at least 110 percent of the volume of the largest tank in the containment structure. If the aboveground hydrocarbon storage capacity exceeds 1,320 gallons, AUC will prepare a Spill Prevention, Control, and Countermeasure (SPCC) plan in accordance with EPA requirements in 40 CFR Part 112.

1.4.9 Byproduct Material Management

This section describes the proposed byproduct management system. Liquid and solid byproducts are divided into two general categories: 11e.(2) byproduct material and non-11e.(2) byproduct material. The proposed byproduct management system is summarized below for each category of byproduct material. Additional details about byproduct material management are found in Section 4.13 of this document.

1.4.9.1 <u>Liquid 11e.(2) Byproduct Material</u>

1.4.9.1.1 <u>Brine</u>

Brine generated through the use of RO units will be sent to the CPP liquid byproduct tanks prior to disposal in the deep disposal wells (DDW). Occasionally RO brine will be temporarily discharged to the lined backup storage pond if DDW capacity is not sufficient due to maintenance or repair of a DDW. A process flow diagram along with the size of the liquid byproduct tanks and location of the backup storage pond can be found in Section 3 of the TR.

1.4.9.1.2 Permeate

A high percentage of permeate generated through the use of RO units will be injected either into the barren lixiviant stream or into the groundwater restoration circuit. Permeate which is not recycled back to operation or restoration activities will be used as plant makeup water.

1.4.9.1.3 Other Liquid 11e.(2) Byproduct Material

Other liquid 11e.(2) byproduct material includes spent eluate, resin transfer wash water, plant wash-down water, and fluids generated from wellfield release. Liquid byproducts generated in the CPP will be discharged to the DDWs or to the feed of the secondary RO Unit while water collected from wellfields will be collected in dedicated portable tanks or tanker trucks and disposed of in the same manner. Any water captured from leaking pipelines or equipment will also be discharged to the DDWs or to the feed of the secondary RO Unit in dedicated portable tanks or tanker trucks.

The anticipated water chemistry of the liquid byproduct stream that will be disposed of in the deep disposal well is presented in TR Table 4-3.

1.4.9.2 Non-11e.(2) Liquid Byproduct Material

1.4.9.2.1 TENORM

Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) drilling fluids will be stored and disposed of on-site in mud pits, which will be constructed adjacent to the drilling pads. During the regional hydrologic baseline activities, groundwater was discharged during PZA pump testing at four of the baseline well clusters. These discharges were authorized under temporary WYPDES permits issued by the WDEQ-WQD. In accordance with the permit, the discharge was monitored for flow, pH, radium, uranium, TDS, and TSS and reported to the WDEQ-WQD.

It is anticipated that other TENORM groundwater generated during operations and decommissioning will be disposed of in a similar manner.

1.4.9.2.2 Stormwater Runoff

Stormwater management is controlled under National Pollutant Discharge Elimination System (NPDES) permits issued by the WDEQ-WQD. As part of the permit, a storm water pollution plan (SWPPP) will be prepared describing best management practices (BMPs) used to keep pollutants out of surface waters and storm drains. Facility drainage will be designed to route storm runoff water away from or around the plant, ancillary buildings and parking areas, and chemical storage. The design and controls of the Proposed Action facility will be implemented such that runoff is not considered to be a potential source of pollution.

1.4.9.2.3 Domestic Liquid Effluents

Domestic liquid effluents from the restrooms and lunchrooms will be disposed of in a septic system that meets the requirements of the WYDEQ-WQD and will likely include one or more septic tanks for primary treatment. Septic tank effluent will be disposed of in a gravity or pressure-dosed drain field. The septic system will be separate from the liquid 11e.(2) byproduct material lines to prevent liquid 11e.(2) byproduct material discharge into the septic fluid. These systems are in common use throughout the United States and the potential impact of the system to the environment is known to be minimal.

1.4.9.2.4 Used Petroleum Products and Chemicals

At the Proposed Project, small quantities of used oil will be generated from equipment and vehicles used on-site. The used petroleum products will be temporarily stored on-site before being transported to a nearby recycling or disposal facility. These used products will not have been affiliated with the processing or generation of 11e.(2) byproduct material and will not be classified as such.

Used petroleum products will be stored in an aboveground storage tank located within the secure fenced area near the CPP. The storage tank will be cylindrical and constructed of steel with a locking cap and venting system. Secondary containment will be designed to contain 110 percent of the tank volume. Spills of material petroleum will be contained, mitigated, cleaned up, and reported in accordance with WDEQ requirements.

The Proposed Project is anticipated to be classified as a conditionally exempt small quantity generator (CESQG) by WDEQ-SHWD. As such, the project will be required to generate less than 220 pounds (100 kg) of hazardous material in any calendar month, generate less than 2.2 pounds (1.0 kg) of acutely hazardous material in any calendar month, and store less than 2,200 pounds (1,000 kg) of hazardous material at any one time.

1.4.9.3 Solid 11e.(2) Byproduct Material

All contaminated items during operations, ground water restoration and decommissioning that cannot be decontaminated to meet release criteria will be properly packaged, transported, and disposed of off-site at a licensed solid 11e.(2) byproduct material disposal facility. Solid 11e.(2) byproduct materials generated by the Proposed Action that may be contaminated with radioactive isotopes consist of items such as rags, trash, packing material, worn or replaced parts from equipment, piping, filters, protective clothing, solids removed from process pumps and vessels, and spent resin. Solid 11e.(2) byproduct material which has a contamination level precluding decontamination will be isolated in drums or equivalent DOT approved containers. AUC estimates that the Proposed Action will produce approximately 100 yd^3 of solid 11e.(2) byproduct material per year during operation

This solid 11e.(2) byproduct material will be collected and stored within a restricted area of the Proposed Action CPP in appropriate containers (e.g., 55 gallon drums with drum liners) approved by DOT, and will be appropriately labeled and placarded for the class of material being shipped. When these containers are full, they will be closed, sealed and stored within the byproduct storage area and stored in a strong, tight container as defined by DOT regulations. The strong, tight containers will be capable of preventing the spread of contamination and contact with precipitation. The Proposed Project plans to use covered roll-off containers with an approximate capacity of 20 cubic yards. Once full, these containers will be shipped for disposal to a 11e.(2) licensed byproduct disposal facility. Prior to beginning operations, AUC will have in place a signed contract for solid 11e.(2) byproduct disposal at such a facility. During storage, the containers will be located within a restricted area. Access to the byproduct storage facility will be controlled through the use of security fencing, locked gates, and proper posting as a restricted area.

Larger items such as contaminated equipment that cannot be stored in a roll-off container will be stored in the Proposed Project CPP or covered/sealed in manner that will prevent the spread of contamination in the solid 11e.(2) byproduct storage area.

1.4.9.4 Non-11e.(2) Solid Byproduct Material

1.4.9.4.1 Solid Waste

AUC estimates that the Proposed Action will produce approximately 1,500 yd^3 of uncontaminated solid waste per year. Uncontaminated solid waste will be collected on the site on a regular basis and disposed of in the nearest approved sanitary landfill, compliant with the rules and regulations of WDEQ-SHWD.

1.4.9.4.2 Septic System Waste

Domestic liquid effluents from the restrooms and lunchrooms will be disposed of in an approved septic system that meets the requirements of the WDEQ. Occasionally, it will be necessary to dispose of sludge material collected in septic systems holding tanks. The disposal of these sludge materials must be performed in accordance with WDEQ-SHWD rules and regulations.

1.4.9.4.3 Hazardous Wastes

Hazardous wastes are defined by WDEQ-SHWD's Hazardous Waste Management Chapter 2 or by USEPA in 40CFR Part 261. Generated materials defined by these regulations as hazardous byproducts will be consolidated in appropriate containers upon generation and shipped off-site for disposal or recycling at a facility permitted for the acceptance of hazardous materials. Materials that may be generated at the Proposed Action that may be classified as hazardous waste include solvent rags, expired laboratory reagents, solvents, cleaners, or degreasers. It is also expected that the Proposed Action will generate Universal Wastes such as batteries, fluorescent light bulbs and used oil.

It is anticipated that the Proposed Action facility will be classified by WDEQ-SHWD as a Conditionally Exempt Small Quantity Generator (CESQG). As such, the project will generate less than 220 pounds (100 kg) of hazardous byproducts in any calendar month, generate less than 2.2 pounds (1.0 kg) of acutely hazardous byproducts, and store less than 2,200 pounds (1,000 kg) of hazardous byproducts at any one time. This classification as a CESQG does not relieve AUC from complying with CESQG regulations and those requirements to dispose of classified hazardous byproducts at a properly permitted hazardous byproduct material disposal facility. AUC will comply with the EPA and WDEQ-SHWD CESQG requirements and monitor the generation of hazardous byproducts to ensure compliance with the weight generation rules of those regulations.

1.5 Instrumentation and Control

1.5.1 Wellfield Operations/Ion Exchange Circuit

Section 3.4 of the TR provides details of the proposed process instrumentation and control systems. Instrumentation will be provided to monitor process variables, especially pressure and flow, throughout the wellfield and CPP. The wellfield and ion exchange circuits will operate continuously and deviations from the normal operating flow rates and pressure profiles (±10 percent or greater) will be indicative of operating upsets. An automatic emergency bypass system or shutdown sequence, consisting of pressure and flow rate monitoring, will be provided for these circuits in the event that normal operating parameters are exceeded. Instrumentation and controls related to these circuits to accommodate emergency bypass systems and alarms are listed below:

- Instrumentation in the CPP control room will be provided to measure recovery and injection flow rates and pressures on the main trunk lines. Flows and pressures will be monitored continuously and will be displayed in the facility control room. These values also will be displayed locally on, or near, the metering instrumentation. An automatic bypass and alarming will be provided for cases when the recovery process runs outside the operating parameters; and
- The individual well flows will be adjusted and controlled within the header houses. Manifold pressures inside the header houses will be maintained below the maximum operating pressure. Instrumentation will be provided to measure individual well recovery and injection flow rates, as well as the pressures coming into and going out of the individual header houses. Flows and pressures will be monitored continuously and will be displayed locally in the header house. These values will also be displayed in the facility control room. In addition, total recovery and injection flows could be derived from the sum of the individual flows. Flows will also be continuously monitored to trigger and log an alarm in the event set parameters are exceeded. Production Unit header houses will also be equipped with sensors to detect the presence of liquids in the sump and initiate alarms. Automatic shutoff valves and alarms will be provided for deviations outside of established operating parameters for the systems controlled within the header house.

In the event of an automatic bypass, an alarm will notify the operator of the situation. Once the upset (broken piping, leaking vessels, etc.) is identified and corrective action taken, only then can the circuit be manually restarted. This type of control system provides protection against fluid leaks or spills to the environment by limiting the amount of fluid released and providing immediate notification to facility operators, enhancing response to any upset conditions. Back-up for the automatic emergency bypass systems will be provided by local displays and controls for the metering instrumentation or header house displays if systems controls or displays in the CPP should become temporarily unavailable.

1.5.2 Process Areas

All process tank levels will be able to be monitored both locally on the tank and will be continuously displayed in the facility control room. Areas that require monitoring of pressure, pH levels, and flow rates also will be monitored and will be visible continuously in the facility control room. These measurements will also be displayed locally to provide redundancy where practicable.

1.5.3 Yellowcake Drying System

The yellowcake drying facilities at the Proposed Project CPP will consist of vacuum dryers. The system will be instrumented sufficiently to operate automatically and to shut itself down in the event of malfunctions such as heating or vacuum system failures. The system will be capable of issuing an audible alarm if there is an indication that the emission control system is not performing within operational specifications or if air pressure falls outside specified levels. In the event an emissions control system instrument fails, the operator will perform and document hourly checks on the emissions control system parameters. Additionally, the operator will perform and document these checks once per shift during normal operations.

Effluent control devices will be operative at all times during drying and packaging operations. The drying and packaging operations will shut down if effluent controls become inoperative. If instrumentation shows that equipment is not operating within the prescribed ranges, then corrective actions will be taken to restore proper operating conditions. If this cannot be accomplished without shutdown and repairs, then drying operations must cease as soon as practicable. Operations will not be restarted after cessation until all necessary corrective actions have been completed. Any cessation, corrective actions, and restarts of dryer operations will be reported to the NRC in writing within 10 days of the subsequent restart as required by 10 CFR 40, Appendix A, Criterion 8A. This reporting requirement does not apply to routine maintenance of dryer system components.

1.6 Applicable Regulatory Requirements, Permits, and Required Consultations

Prior to AUC commencing ISR operations, a Source and 11e.(2) byproduct materials license must be obtained from NRC and a permit to mine must be obtained from WDEQ/LQD. Table 1-4 lists the necessary environmental approvals and status from Federal and State Agencies required for the Proposed Action. All approvals are in-progress and all necessary approvals will be secured prior to commencement of commercial recovery at the site.

1.7 Financial Assurance

AUC will have in place a financial assurance arrangement for the Proposed Action consistent with 10 CFR 40, Appendix A, Criterion 9. The NRC currently requires that

ISR license applicants provide an Restoration Action Plan (RAP) or the equivalent in a license application to provide NRC staff with financial assurance calculation methodologies and accompanying preliminary cost estimates for all aspects of the Proposed Action, including groundwater restoration, surface reclamation, and D&D of Proposed Action facilities. The financial assurance amount will be revised prior to commencement of initial operations, and annually thereafter to reflect the estimated costs of final reclamation activities for the Proposed Action. The methodology for estimating reclamation cost and potential financial assurance arrangements are discussed in more detail in Section 6 of the TR and in the RAP found in Addendum 6-A of the TR.

Pursuant to these requirements, AUC will comply with Criterion 9 requirements for these annual financial assurance updates and will have, in place, an NRC-approved financial assurance mechanism after receiving its NRC license but before beginning active ISR operations.

Table 1-1: Proposed Reno Creek Project Area Historical Ownership

Company(s)	Partner(s)	Date	Transaction Type	Partnership Name
Rocky Mountain Energy	Union Pacific Railroad	1967 (Est.)	Purchase	None
Rocky Mountain Energy	Mono Power Company and Halliburton Services	1975 (Est.)	Joint Venture	ISLCO
Energy Fuels, Inc.	None	1992	Purchase	None
International Uranium Corporation	Energy Fuels, Inc.	2000 (Est.)	Merger Acquisition	None
Rio Algom Mining Corporation	None	2001	Purchase	None
Power Resources, Inc.	CAMECO	2002 (Est.)	Purchase	None
Strathmore Mining Corporation	David Miller and Associates	2004	Claim Acquisition	None
Strathmore Mining Corporation	American Uranium Corporation, Inc.	2007	Joint Venture	None
AUC, LLC.	Bayswater Uranium Corporation; Pacific Road Resource Funds	2010	Purchase	AUC Holdings

Table 1-2: Surface and Mineral Ownership

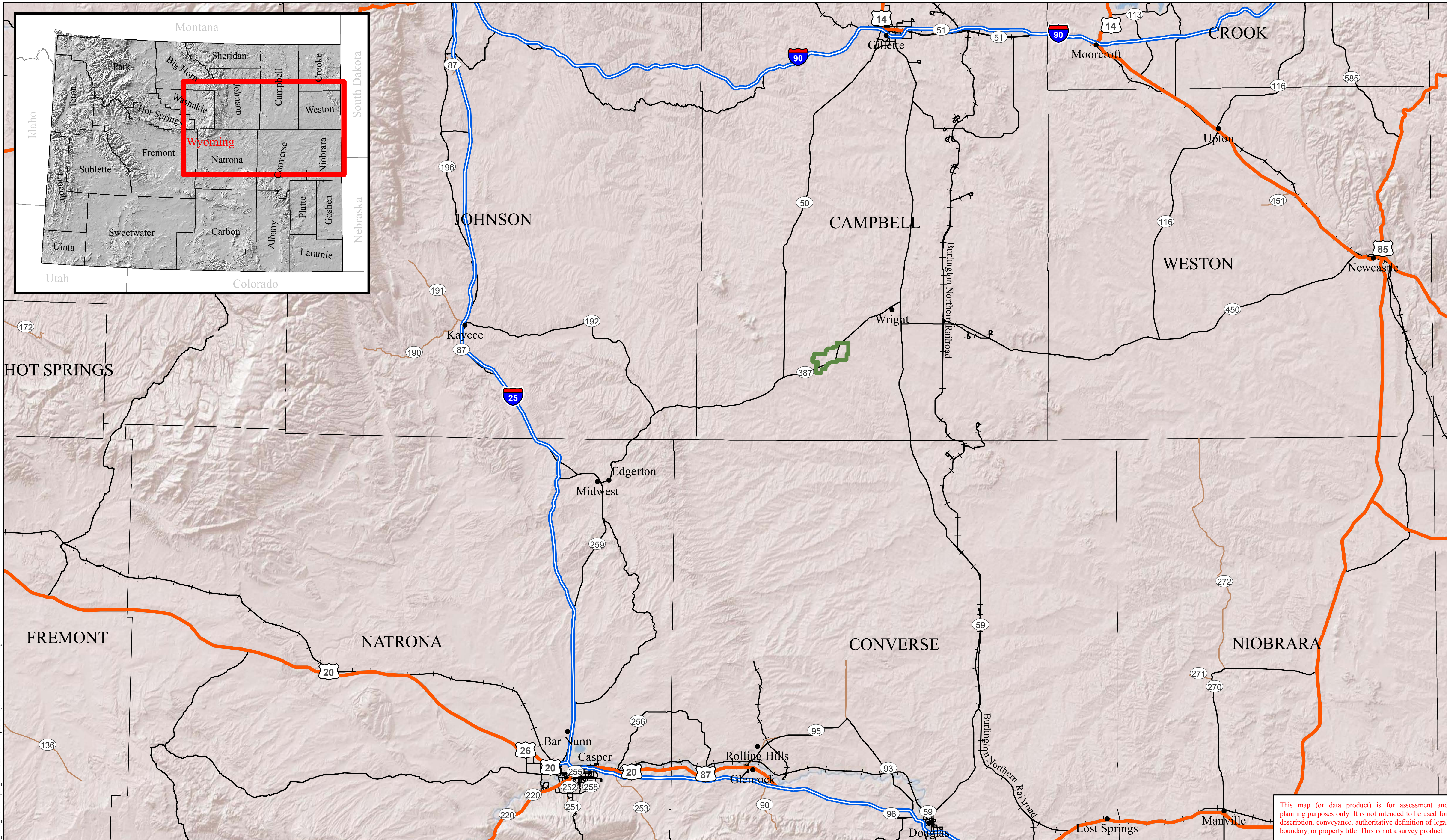
Ownership Type	Surface Ownership		Mineral Ownership	
	Acres	% of Total Proposed Action Property	Acres	% of Total Proposed Action Property
Federal	0	0%	2,873	47.4%
Municipal	0	0%	0	0%
Private	5,417	89.4%	2,544	42.0%
State	640	10.6%	640	10.6%
Total Proposed Action Acreage	6,057	100%	6,057	100%

Table 1-3: Disturbance Calculations

Estimated Production Unit Area Disturbance	**Patterns**	**Area/Pattern (ft^2)**	**Total Area (ft^2)**	**Acres**
Total Pattern Area per Header House (HH); 67 total	30	10,000	300,000	6.9
Long Term Top Soil Storage (> 6 months)	**Width (ft)**	**Length (ft)**	**Total Area (ft^2)**	**Acres**
Area per Header House	12	30	360	0.01
Proposed Secondary Access Roads to HHs	12	225	2,700	0.06
Long Term Top Soil Storage per HH			3,060	0.07
HH Long Term Top Soil Storage				4.7
Proposed Additional Secondary Roads within Project Boundary	12	18,614	223,369	5.1
Proposed Tertiary Roads (monitor well ring)	8	99,366	794,928	18.2
Total Acres Long Term Disturbance 67 HHs plus Additional New Roads				***28.1***
Short Term Top Soil Disturbance (< 6 Months)	**Width (ft)**	**Length (ft)**	**Total Area (ft^2)**	**Acres**
Well Installation Drill Pit (per pit)(72 total)	7	20	10,080	0.2
Lateral Trenches for pipe from HH to wells	6	5,247	31,482	0.7
Total Area of Short Term Disturbance per HH			***41,562***	***0.95***
Total HH Short Term Top Soil Storage				63.9
Lateral Trunklines to HHs (for 67 HHs)	15	54,269	814,041	18.7
Overlying Monitor Well Installation Drill Pits (134 total)	7	20	18,760	0.4
Ring Monitor Well Installation Drill Pits (469 total)	7	20	65,660	1.5
Total Acres Short Term Disturbance				***84.6***
Estimated Long Term Surface Disturbance (CPP Site Infrastructure)	**Width (ft)**	**Length (ft)**	**Total Area (ft^2)**	**Acres**
Central Processing Plant (CPP)	200	350	70,000	1.6
Backup Pond	100	210	21,000	0.5
Office Building	60	100	6,000	0.1
Maintenance Building	60	100	6,000	0.1
Parking Lot, Chemical Storage Tanks, Laydown area (grading)			570,636	13.1
Total Site Layout			***673,636***	***15.5***
Deep Disposal Well Pad (x4)			174,240	4.0
Total Area of CPP Site Infrastructure Long Term Disturbance			***847,876***	***19.5***
Estimated Short Term Trunkline Top Soil Disturbance (< 6 Months)	**Width (ft)**	**Length (ft)**	**Total Area (ft^2)**	**Acres**
Main Trunklines	25	28,347	708,675	16.3
DDW pipeline	8	32,138	257,104	5.9
Total Area of Short Term Trunkline Disturbance			***965,779***	***22.2***
				Acres
Total Long Term Surface Disturbance				**47.5**
Total Short Term Surface Disturbance				**106.7**
Total Disturbance Area for Removal of Vegetation and Topsoil				**154.3**
				Acres
Total Controlled Area (fenced with or without the removal of topsoil and/or vegetation)				**480.9**
Total Unrestricted Area (all areas outside of controlled area and 2mrem per hour)				**5,576.1**

Table 1-4: Environmental Approvals for the Proposed Reno Creek ISR Uranium Project

Issuing Agency	Description	Status
State		
Wyoming Department of Environmental Quality 122 West 25th St Herschler Building Cheyenne, Wyoming 82001	Underground Injection Control Class III Permit (WDEQ Title 35-11)	Class III UIC Permit application under review; expected approval by WDEQ in third quarter 2013
	Aquifer Reclassfication (WDEQ Title 35-11)	Aquifer reclassfication application under preparation; approval by WDEQ in the third quarter 2013
	Underground Injection Control Class I (WDEQ Title 35-11)	Class I UIC Permit application under review; expected approval by WDEQ in fourth quarter 2012
	Industrial Stormwater NPDES Permit (WDEQ Title 35-11)	An Industrial Stormwater NPDES will be required for the CPP Area. Expected submittal second quarter 2013
	Construction Stormwater NPDES Permit (WDEQ Title 35-11)	Construction Stormwater NPDES authorizations are applied for and issued annually under a general permit based on projected construction activities. The Notice of Intent will be filed at least 30 days before construction activities begin in accordance with WDEQ requirements.
	Mineral Exploration Permit (WDEQ Title 35-11)	Drilling Notification (DN) #401 Approved: Permit Amendment 2, TFN 5 6/175 February 9, 2011
	Underground Injection Control Class V (WDEQ Title 35-11)	The Class V UIC permit will be applied for following installation of an approved site septic system during facility construction
	Air Quality Permit	Application will be submitted third quarter 2013
Federal		
U.S. Nuclear Regulatory Commission Washington, DC 20555	Materials License (10CFR40)	Application submitted herein
U.S. Environmental Protection Agency 1200 Pennsylvania Ave, NW, Washington, DC 20460	Aquifer Reclassfication (40CFR 144, 146)	Aquifer reclassfication application forwarded to EPA following WDEQ action
U.S. Army Corps of Engineers 2232 Dell Range Blvd., Suite 210 Cheyenne, WY 82009-4942	Nation Wide Permit (NWP) # 12 Authorization	All necessary information provided to the USACE, anticipate concurrence in third quarter 2012 that activities associated with the Proposed Reno Creek project are consistent with activities authorized in NWP #12.



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PROPOSED RENO CREEK PROJECT

CAMPBELL COUNTY, WY

PREPARED FOR AUC LLC
LAKEWOOD, CO

Legend

- Proposed Reno Creek Project Boundary
- Railroad
- Cities and Towns
- County Line
- Interstate
- Highway
- Major Road
- Local Road

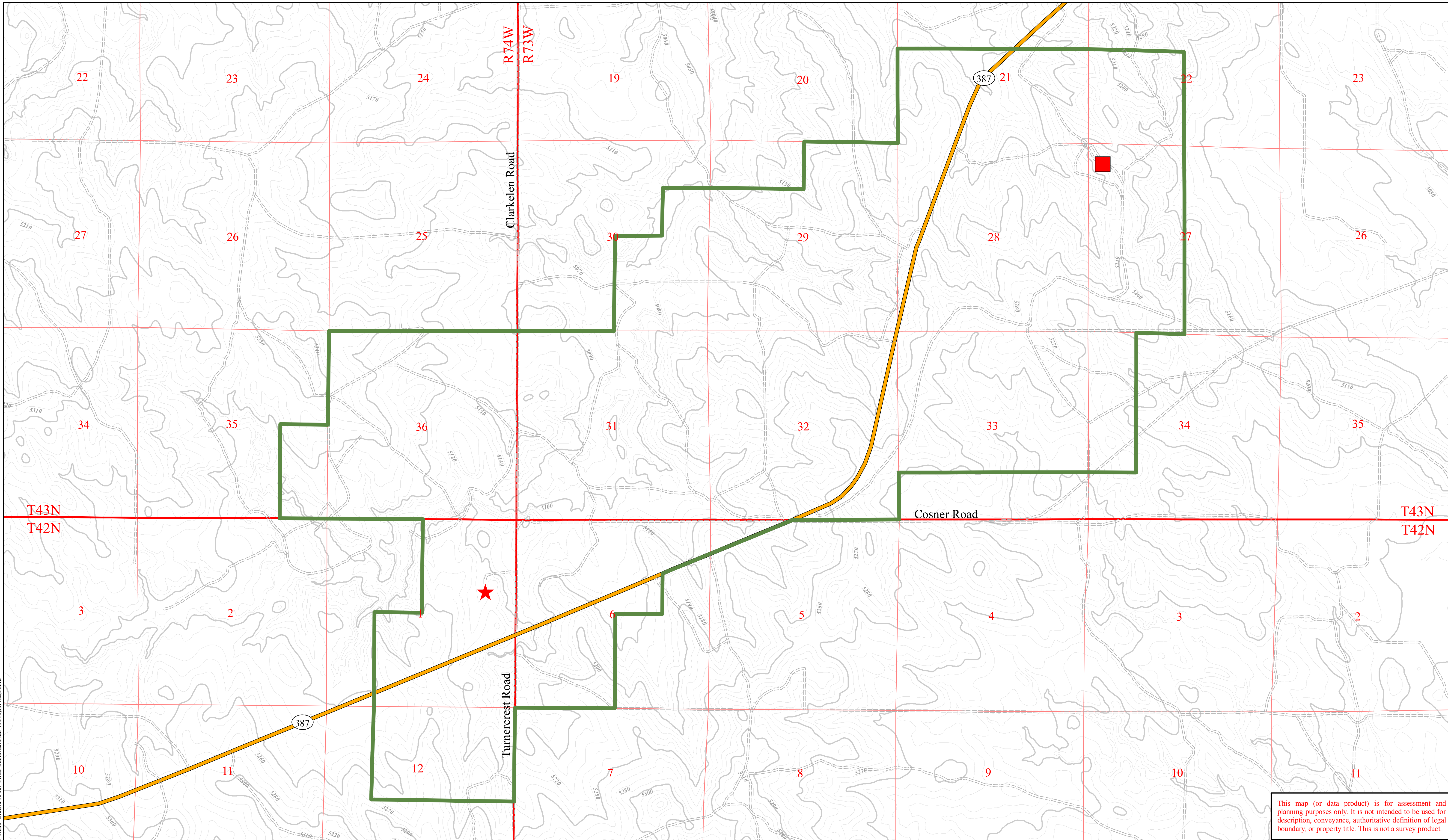
0 5 10 20 Miles

1:750,000

DRAWN BY: RHK
CHECKED BY: RMD
APPROVED BY: JEY

Proposed Reno Creek Project
General Location Map

REV #	DESCRIPTION	BY	DATE	FIGURE
0	Draft	RHK	08/18/11	1-1
1	Revised Draft for Review	RHK	10/14/11	
2	Final	RHK	01/17/12	



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PROPOSED RENO CREEK PROJECT

CAMPBELL COUNTY, WY

PREPARED FOR AUC LLC
LAKEWOOD, CO

Legend

- Proposed Project Boundary
- Central Processing Plant
- Historical RME R&D Site
- Major (Paved)
- Minor (Unpaved)

0 0.25 0.5 1 Miles

Contour Interval = 10 feet

1:30,000

N S E W

DRAWN BY: RHK
CHECKED BY: RMD
APPROVED BY: JEY

Proposed Project Map

REV #	DESCRIPTION	BY	DATE
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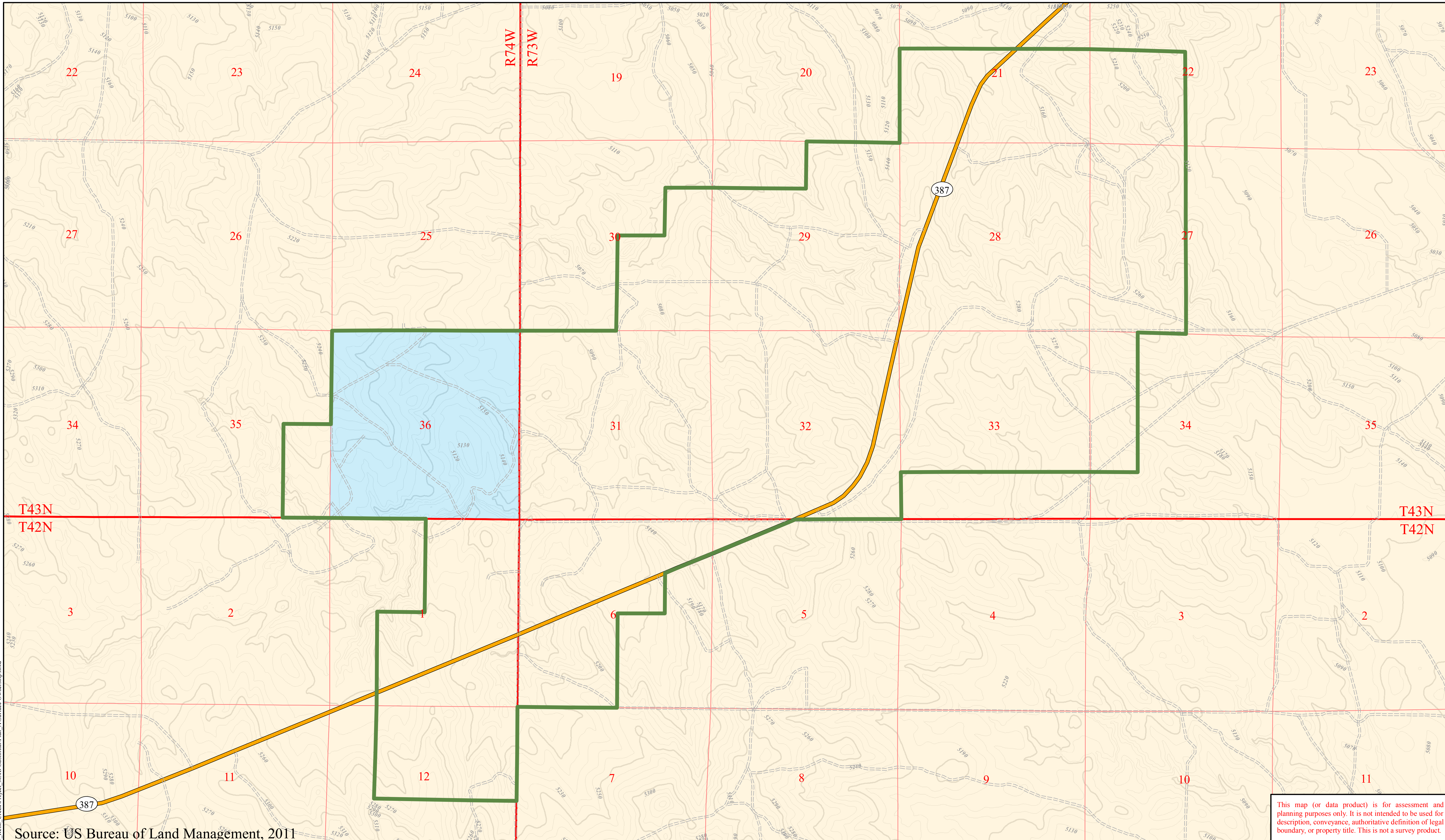
1	Revised Draft for Review	RHK	10/14/11
2	Final	RHK	10/20/11

FIGURE 1-2



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PROPOSED RENO CREEK PROJECT
CAMPBELL COUNTY, WY

PREPARED FOR **AUC LLC**
LAKEWOOD, CO

Legend
- Proposed Project Boundary
- State
- Private
- Major (Paved)
- Minor (Unpaved)

Contour Interval = 10 Feet

1:30,000

0 0.25 0.5 1 Miles

N S E W

DRAWN BY: RHK
CHECKED BY: RMD
APPROVED BY: JEY

Site Surface Ownership

REV #	DESCRIPTION	BY	DATE	FIGURE
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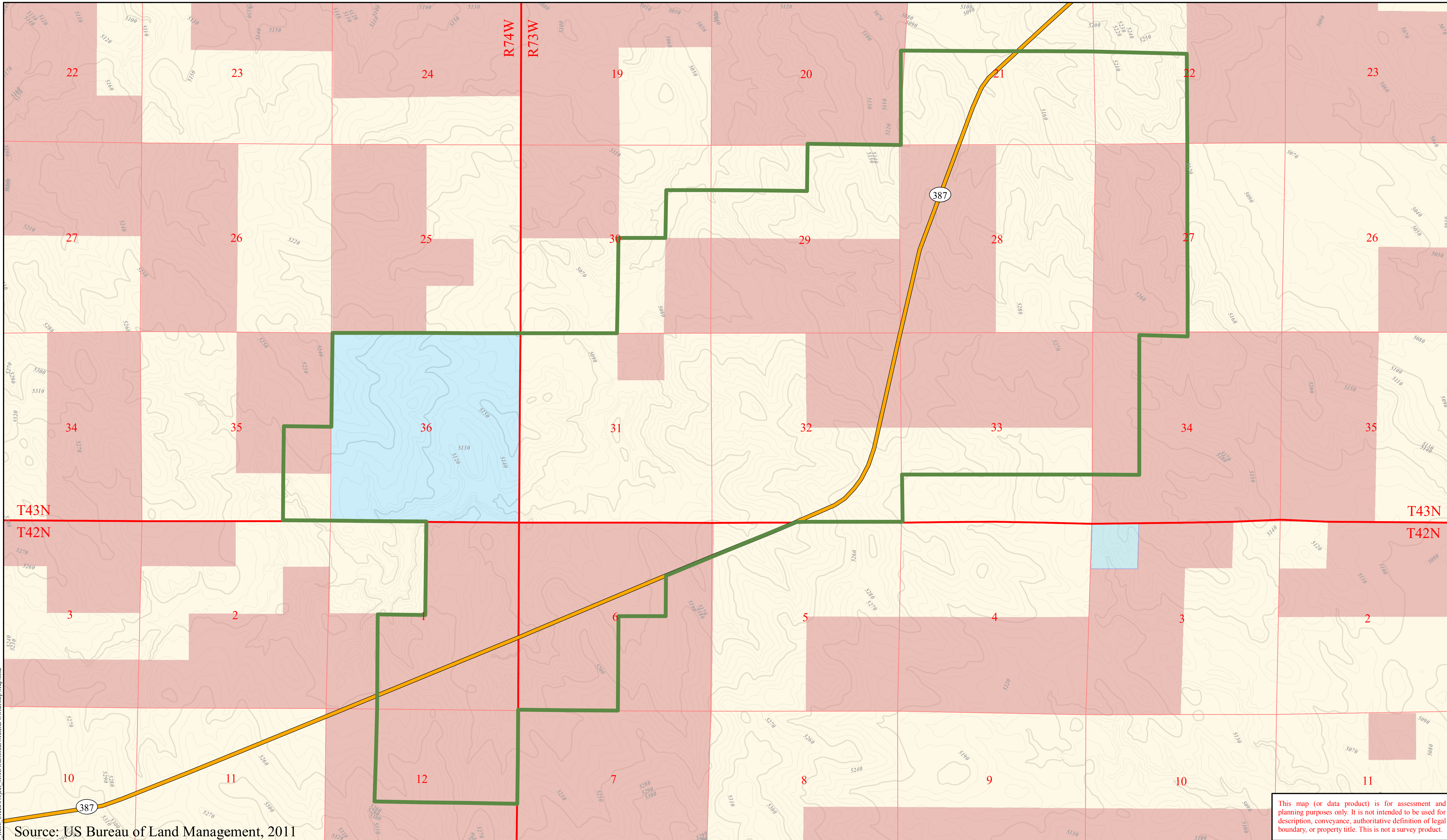
1	Revised Draft	RHK	08/19/11	
2	Final	RHK	10/21/11	



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PROPOSED RENO CREEK PROJECT
CAMPBELL COUNTY, WY

PREPARED FOR **AUC LLC**
LAKEWOOD, CO

Legend

- State Mineral
- Federal Mineral
- Private Mineral
- Proposed Reno Creek Project Boundary
- Major Road (Paved)

Contour Interval = 10 feet

1:30,000

0 0.25 0.5 1 Miles

N S E W

DRAWN BY: RHK
CHECKED BY: RMD
APPROVED BY: JEY

Site Mineral Ownership

REV #	DESCRIPTION	BY	DATE
0	Draft	RHK	07/11/11
1	Revised Draft for Review	RHK	08/19/11
2	Final	RHK	10/24/11

FIGURE 1-4

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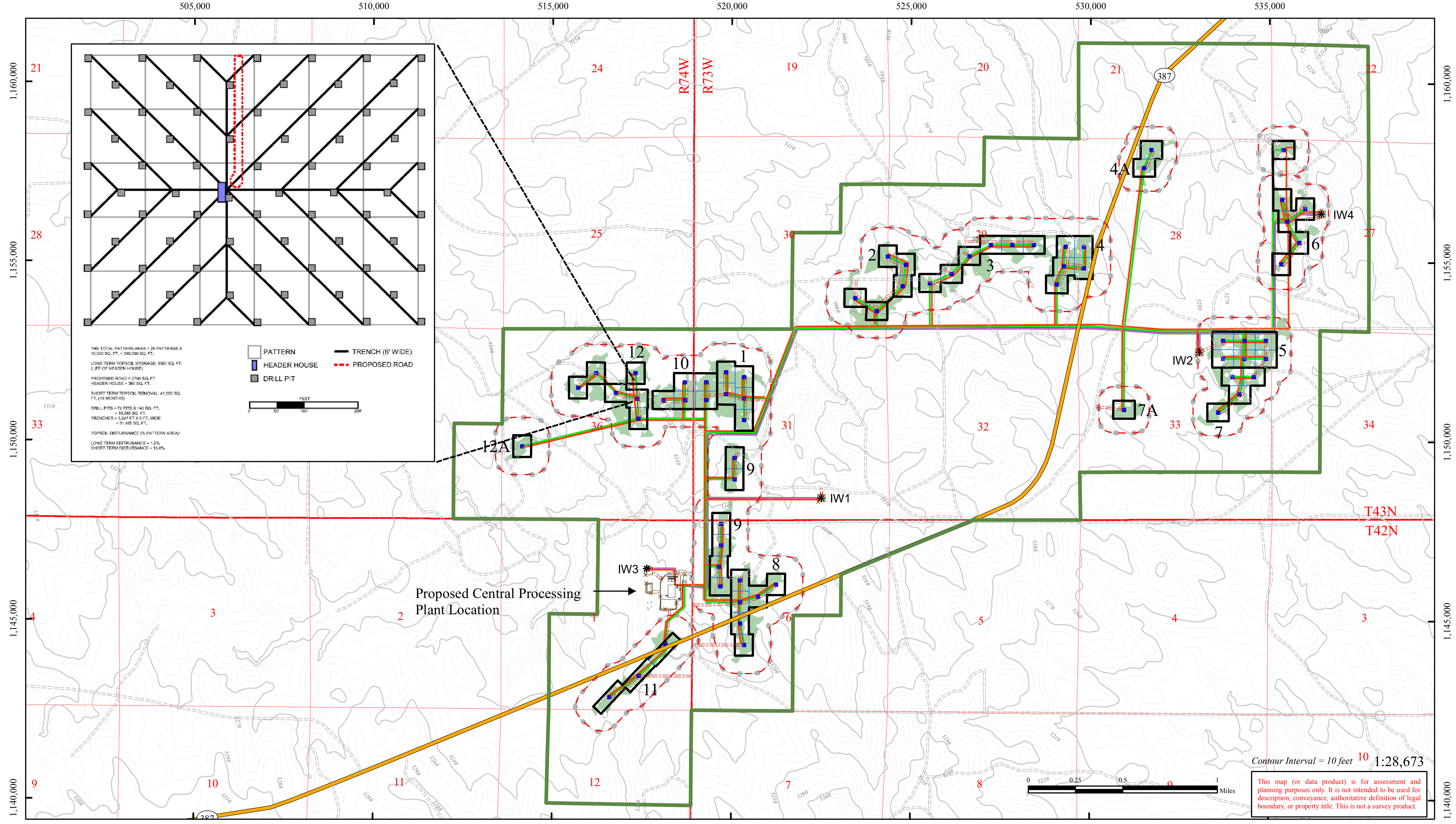

TREC, Inc. Engineering & Environmental Management 900 Werner Court Suite 150 Casper, WY 82601 Phone (307) 265-0696 Fax (307) 265-2498 www.treccorp.com	**PROPOSED RENO CREEK PROJECT** CAMPBELL COUNTY, WY PREPARED FOR AUC LLC LAKEWOOD, CO	Conceptual Site Plan

Legend

- Proposed Project Boundary
- Ore Body
- Production Unit
- Proposed Header House Location
- Proposed Header House Pattern
- Proposed Header House Location
- Proposed Monitor Wel Rring
- Deep Disposal Well
- Proposed Trunkline
- Proposed Powerline
- Proposed Deep Disposal Well Pipeline
- Existing Primary and Secondary Access Road
- Proposed Secondary Road
- Proposed Tertiary Road
- Major Road (Paved)
- Minor Road (Unpaved Existing Access Road)

NAD 1983 StatePlane Wyoming Wast FIPF 4901 Feet

DRAWN BY: RHK
CHECKED BY: WFC
APPROVED BY: RMD

REV #	DESCRIPTION	BY	DATE
0	Draft for Review	RHK	08/29/11
1	Final	RHK	02/27/12
2	Revisions made per Client Request	RHK	07/24/12

FIGURE 1-5

Installation and Construction
Operate Plant
Operate Production Unit
Groundwater Restoration/Stability
Reclamation
Plant/ DDW Decom. and Reclamation
Regulatory Review Period

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PROPOSED RENO CREEK PROJECT
CAMPBELL COUNTY, WY

PREPARED FOR AUC LLC
LAKEWOOD, CO

DRAWN BY: RHK
CHECKED BY: RMD
APPROVED BY: JEY

Proposed Project Schedule

REV #	DESCRIPTION	BY	DATE	FIGURE
0	Draft	RHK	09/08/11	1-6
1	Revised Draft for Review	RHK	12/22/11	
2	Revised Schedule per Client Request	RHK	07/20/12	

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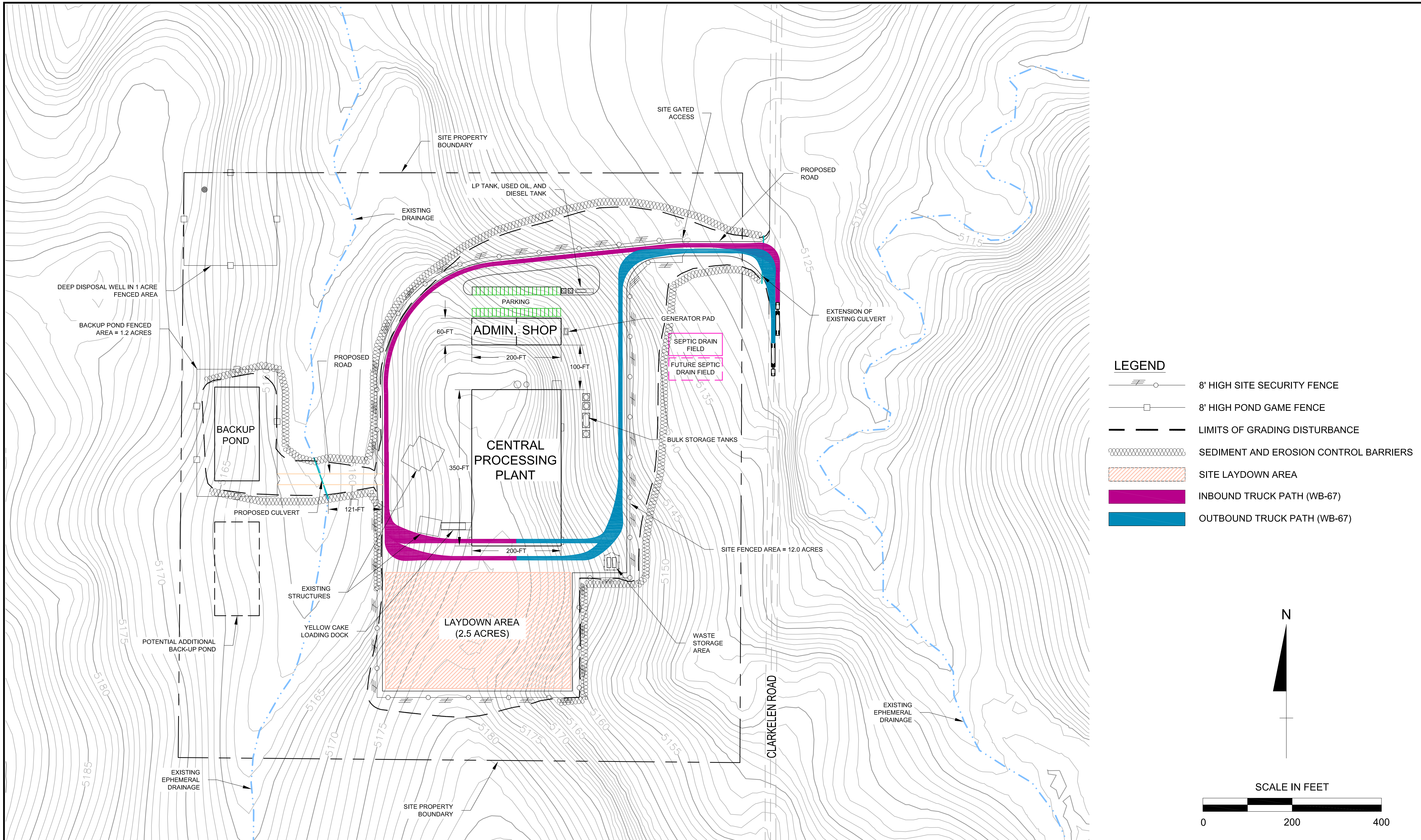

NOTE:
EXISTING CONTOURS SHOWN ARE BASED ON USGS NED DATA AND ARE SHOWN AT 1-FT INTERVALS

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Conceptual Plant Facility Layout
Reno Creek Permit Application
AUC, LLC
Campbell County, Wyoming

FIGURE 1-7

Drawn: TBK	Checked: RL	Approved: DHG
Rev. #	Description	Date
-	-	-
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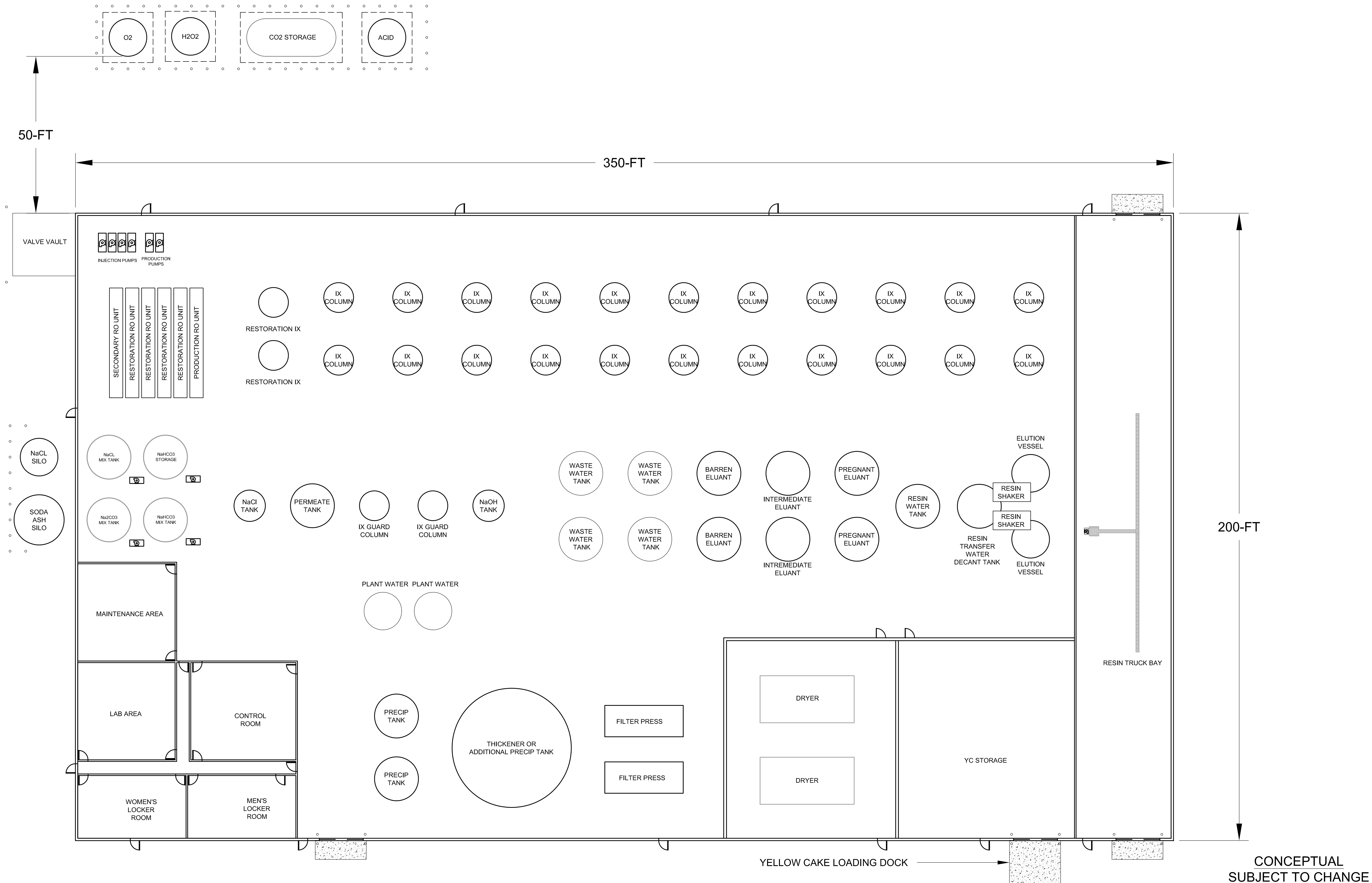

CONCEPTUAL
SUBJECT TO CHANGE

TREC, Inc.
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Conceptual CPP Building Layout
Reno Creek Permit Application
AUC, LLC
Campbell County, Wyoming

FIGURE 1-8

Drawn: TBK | Checked: RL | Approved: DHG

Rev. #	Description	Date
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-	-	-

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2 ALTERNATIVES

2.1 Description of Alternatives

NRC regulations 10 CFR Part 51 and guidance at NUREG-1748 require this chapter to provide realistic alternatives to the Proposed Action which is of the proposed Reno Creek Project (Proposed Project). These alternatives include but are not limited to (1) the No-Action alternative; (2) the Proposed Action; and (3) reasonable alternatives although deemed not suitable. As noted in NUREG-1748 (Appendix F), the Proposed Action is considered the action under consideration while reasonable alternatives are those alternatives which are practicable from both technical and economic standpoints. These alternatives are discussed below. Comparable and/or further discussions can be found in:

- Section 1.1 of this ER (The Proposed Action);
- Section 1 and Addendum 1-A of the TR (Proposed Activities);
- Section 8 of the TR (Alternatives); and
- Section 9 of the TR and Section 8 of this ER (Benefit-Cost Analysis).

2.1.1 No-Action Alternative

Under the provisions of the National Environmental Policy Act (NEPA), as implemented by NRC in 10 CFR Part 51, AUC is required to assess the No-Action alternative. Under the No-Action alternative, NRC will not approve the Proposed Project combined Source and 11e.(2) Byproduct Materials License Application to construct, operate, and decommission the Proposed Project. Licensed ISR operations will not occur at the Proposed Project site and, accordingly, none of the associated potential impacts identified and analyzed as part of the Proposed Action will occur.

The No-Action alternative will result in significant negative financial impacts to AUC, and the loss of significant financial benefits to Campbell County, Wyoming and the surrounding communities. AUC has invested significant resources to develop the Proposed Project that will be irretrievably lost under the No-Action alternative. In addition, the No-Action alternative will adversely affect the economic growth of Campbell, Natrona and Converse Counties. As discussed in further detail in ER Section 8, the Proposed Project is expected to provide significant positive economic impacts to the local and State economies, including stakeholders with which AUC has surface leases and which own the mineral rights in the Proposed Project area.

A decision to not issue an NRC combined Source and 11e.(2) Byproduct Materials License to AUC would leave a large resource unavailable for domestic energy production. AUC is continuing to develop estimates of the resources at the Proposed Reno Creek Project and currently approximates the mineral resource is 15.7 million pounds of uranium.

According to the U.S. Energy Information Administration (EIA 2011), the total domestic production of U_3O_8 in the first quarter of 2011 was only 1.06 million pounds, down 7 percent from the previous quarter. In 2010, total domestic production was only 4.23 million pounds in contrast with domestic demand for approximately 47 million pounds U_3O_8 (EIA 2011). The Proposed Project represents an important new source of domestic uranium which is essential to provide a continuing source of fuel to US nuclear power generation facilities. This additional domestic uranium production will help alleviate U.S. dependency on foreign suppliers located in Canada, Russia, Kazakhstan and Australia among others.

Under the No-Action alternative, baseline conditions will be influenced by natural processes and potentially by other industrial, commercial, and residential development in the area. Groundwater in the ore-bearing zone will remain unsuitable for drinking without any licensed ISR operation due to the high levels of naturally occurring radionuclides and other constituents described in Section 3.4 of this ER.

2.1.2 Proposed Action

As described in Section 3.1 of the TR, the Proposed Action involves AUC utilizing ISR processes and methodologies to recover uranium from ore bodies known to be amenable to such processes and methodologies. The ISR process is accomplished by installing a series of injection and recovery wells into the uranium ore bodies. Utilizing the injection wells, a carbonate/bicarbonate and oxidant leaching solution, or barren lixiviant, is injected into the ore body. To promote flow across the mineralized areas, corresponding recovery wells are used to pump water from the ore body, and allow for the collection of the uranium bearing carbonate leach, or pregnant lixiviant, solution. Once the pregnant lixiviant reaches the CPP, the uranium is removed from the lixiviant through the use of pressurized down-flow ion exchange (IX) columns. Once the resin in an individual exchange column can no longer hold additional uranium ion complexes, the resin from that vessel is moved to another vessel where the uranium ion complexes are eluted from the resin. After the elution process is complete, the resin is moved back into the ion exchange column and re-introduced to the ion exchange process. After the lixiviant has passed through the ion exchange system, the solution is re-fortified with a carbonate/bicarbonate and oxidant , making barren lixiviant, and can then be recycled to the injection wells for further uranium recovery.

The next phase of the process is further processing of the uranium rich solution to create a marketable product called yellowcake. This is accomplished by precipitating the dissolved uranium out of the eluent solution, dewatering the uranium solids, and drying the uranium slurry. The dried uranium product, yellowcake, is then packaged for safe transportation.

Initial Production Unit(s) for the Proposed Action will be developed concurrently with construction of the proposed CPP and ancillary ISR facilities. Groundwater restoration will take place in the initial Production Unit(s) when the uranium resource has been depleted such that it is no longer economically viable and, simultaneously, additional sequential wellfield development will occur. The goal of groundwater restoration will be to return the concentration of an identified constituent in the production zone consistent with baseline or a relevant MCL, whichever is higher, or to an alternate concentration limit (ACL) approved by NRC pursuant to 10 CFR Part 40, Appendix A, Criterion 5(B)(5) using Best Practicable Technology (BPT). Successful groundwater restoration of a pilot ISR facility was demonstrated within the Proposed Project area by the RME R&D with detailed discussions found in TR Addendum 1-A. A detailed description of the Proposed Action is presented in Section 3 of the TR.

Following groundwater restoration activities, all injection and recovery wells will be reclaimed using WDEQ-LQD mandated plugging and abandonment procedures. In addition, a sequential land reclamation and re-vegetation program will be implemented on the site. This surface reclamation (i.e., decommissioning and decontamination (D&D) will be performed on all disturbed areas, including the CPP, wellfields, ponds and roads such that upon license termination, the site can be released for unrestricted use. AUC will maintain financial assurance for groundwater restoration, plant decommissioning and surface reclamation until NRC approves license termination and site release. Financial assurance is discussed in Section 6.6 of the TR and in the Restoration Action Plan (RAP) in TR Addendum 6-A.

2.1.3 Reasonable Alternatives Considered But Rejected

2.1.3.1 Open Pit and Underground Mining and Conventional Milling

As a part of the alternatives analysis conducted by AUC, three uranium recovery alternatives were considered:

1) Underground mining with conventional milling facilities;
2) Open pit mining with conventional milling facilities; and
3) Underground and open pit mining with heap leach facilities.

These represent the three currently available alternatives to ISR operations for uranium deposits in the Proposed Project area. These alternatives were eliminated based on economics, potential health, safety, and environmental impacts.

Conventional uranium recovery methods are less suitable for the recovery of lower grade ores due to the significant capital costs associated with the construction and operation of a conventional mine and associated mill. Further discussion of conventional mining/milling methods is provided below.

2.1.3.2 Open Pit Mining

Open pit mining requires the removal of all material covering the ore body. This overburden must be removed and stockpiled to allow removal of the uranium-bearing ore. Once removed, the ore must be transported to a conventional uranium mill for further processing and uranium recovery.

Open pit mining of the relatively low grade Proposed Project ore will require a capital investment that is not supported by the current uranium market. In relation to the Proposed Project the nearest conventional mill with an operating license that could receive uranium ore for toll milling is the Denison Mines White Mesa Mill located in Blanding, Utah, nearly 600 miles away. The combination of capital costs to develop an open pit mine at the Proposed Project, the operating and maintenance costs to mine the ore, and the transportation costs to Blanding, Utah, coupled with the accompanying processing payment, far exceed the current value of the ore as a feedstock for White Mesa. The nearest conventional uranium mill, Kennecott Uranium Corporation's Sweetwater Mill, located in the Great Divide Basin in Wyoming, is currently actively licensed but is in a standby status. However, if the Sweetwater Uranium Mill was currently licensed for operation, similar economic factors will preclude mining the Proposed Project deposit under reasonably projected current and future uranium market conditions.

In addition to the economic factors, environmental factors associated with open pit mining must also be considered. Open pit mining produces large piles of byproduct rock and, even with reclamation, will permanently alter the topography of the Proposed Project site. In addition, substantial dewatering of the pit on the order of several thousand gpm will be required to depress the potentiometric surface to allow mining. Large quantities of groundwater with naturally elevated ^{226}Ra and uranium will be discharged requiring treatment and necessary subsequent disposal of solid 11e.(2) byproduct. Moreover, large volumes of groundwater will be consumed by this necessary dewatering process, compared to the small usage of water using the ISR method.

2.1.3.3 Underground Mining

Underground mining of the Proposed Project uranium deposit will involve sinking recovery shafts into the vicinity of the ore bodies, horizontally driving crosscuts and drifts to the ore bodies at different levels, physically removing the ore and transporting the recovered ore to a conventional uranium mill for further processing. The economic factors involved with this alternative are similar to those in open pit; although, depending on depth to the deposit they can be significantly more costly and potentially more dangerous for workers.

From an environmental perspective, underground mining in conjunction with the associated milling process involves significantly higher risks to employees, the public, and the environment. Radiological exposure to personnel underground is increased, not only from the underground recovery process but also from milling and the resultant mill tailings. The milling process generates a significant amount of byproduct relative to the amount of ore processed and extensive mill tailings impoundments are needed for the disposal of these byproducts. The potential non-radiological health and safety risks to workers as well as the environmental impacts associated with underground mining are recognized as being considerably greater than those associated in ISR operations.

2.1.3.4 Heap Leaching

As an alternative to conventional milling, uranium can be extracted from low-grade ore by heap leaching. This may be done if the uranium content is too low for the ore to be transported to and economically processed at a uranium mill. The crushed ore is mounded above grade on a leaching pad with a liner. The heap leaching pads must be constructed with the same standards as conventional mill tailings impoundments including a double liner per 10 CFR Part 40, Appendix A. A sulfuric or alkaline leaching agent is introduced on the top of the pile via a sprinkler or drip system which percolates down through the ore until it reaches the liner below the pile, where it is captured and pumped to a processing plant. After completion of the leaching process (within months to years), the leached ore is either left in place, or removed to a disposal site, and new ore is placed on the leach pad (so-called on/off scheme, or dynamic heap leaching).

After completion of heap leaching, the depleted materials are 11e.(2) byproduct materials that must be placed in a tailings impoundment. Mainly used experimentally in the 1970s and 1980s, the impacts from heap leaching may be less than those of conventional milling, but will still be substantial if only for the necessary required perpetual control of the 11e.(2) byproduct material. For these reasons, this alternative was deemed not suitable for the Proposed Project.

2.1.4 Central Processing Plant versus Satellite Facilities

Shipping uranium-laden resin is a standard industry practice for satellite plants in conjunction with central processing facilities. However, the option of shipping resin for processing and drying versus an on-site central processing facility was eliminated for the following reasons:

- Productivity and Efficiency: The Proposed Project anticipates a production rate of two million pounds U_3O_8 per year. The average load of resin will be 500 ft^3 at a loading rate of eight pounds/ft^3, or 4,000 pounds U_3O_8 per transfer (load). This will require a shipment of loaded resin to a separate facility approximately every 0.75 days. The Proposed Project will process the resin on-site and will not require the transport of resin to a processing facility;
- Environmental Health and Safety: The transport of resin versus on-site processing will increase the time an equipment operator will spend in transit and the potential of an accident or spill; and
- Operating Cost: Processing the uranium at the proposed CPP will reduce not only the transportation cost, but will reduce the number of trucks, trailers and equipment operators. Standby materials, such as resin and transport equipment, will also not be required. In addition, the cost for toll processing of resin will be recovered against the plant investment over the life of the Proposed Project, yielding a more valuable asset to be used in processing for other projects or toll processing of resin.

2.1.5 Lixiviant Chemistry

AUC proposes to use a sodium bicarbonate lixiviant which is an alkaline solution. Where the groundwater contains bicarbonate, an alkaline lixiviant mobilizes fewer potentially deleterious constituents from the ore body and requires less chemical addition than an acidic lixiviant. Also, test results at other, similar uranium ISR projects indicate only limited success with acidic lixiviants, while the sodium bicarbonate has proven highly successful at commercial ISR operations in Wyoming to date. Another alternate leach solution is an ammonium carbonate solution which has been used at ISR operations at other locations; however, at those locations operators have experienced difficulty in restoring and stabilizing the aquifer. Therefore, these alternative solutions were excluded from AUC consideration for the Proposed Project.

2.1.5.1 Acidic Leach Solutions

Acid-based lixiviants, such as sulfuric acid, have been used in the United States and are widely used internationally. Acid leach has historically produced a majority of the world's ISR production. Acid-based lixiviants generally achieve a higher degree of recovery (70-90 percent), better leaching kinetics, and a shorter leaching period. However, acid-based lixiviants dissolve heavy metals and other solids associated with uranium in the host rock and other chemical constituents that may require additional groundwater restoration (IAEA, 2001).

In the United States, acid-based lixiviants have been used only for small-scale research and development (R&D) operations including an ISR pilot plant in the Proposed Project area. In January 1979, RME commenced an ISR testing program with the completion of a 100 gallon per minute (gpm) pilot plant in which two test patterns (Pattern 1 and Pattern 2) were installed and operated. Sulfuric acid lixiviant was tested first because of the higher recoveries indicated in the amenability tests. Pattern 1 testing began in February 1979 and was terminated in November 1979 because results from this pattern were unsatisfactory. Severe permeability loss resulted from high levels of calcium mobilized by the acid precipitating as gypsum within the ore sand void spaces, sealing off the formation to the point operations had to be curtailed. For this reason, acid-based lixiviants have not been found to be as cost effective as alkaline lixiviants, particularly in light of difficulties in achieving acceptable groundwater restoration results. A more detailed discussion on specific historical ISR operations of Rocky Mountain Energy's (RME) Research and Development (R&D) efforts can be found in Addendum 1-A of the TR.

The commercial use of alkaline lixiviants in the United States is related to the need to restore affected groundwater and alkaline lixiviant recovery zones are recognized to be technically easier to restore. For this reason, a commercial ISR facility using an acid-based lixiviant has not been developed in the United States and AUC determined an acid-based lixiviant is not a suitable alternative for the Proposed Project.

2.1.5.2 Ammonia-Based Lixiviants

Ammonia-based lixiviants have been used in the United States in Texas and Wyoming. However, operational experience has shown ammonia tends to adsorb onto clay minerals in the subsurface and then desorbs slowly from the clay during restoration, therefore, the use of ammonia requires much larger volume of groundwater to be removed and processed during aquifer restoration (Mudd, 2000). In addition, concerns arose in the early 1980s over the potential post recovery oxidation of ammonia in the groundwater to form nitrate and nitrite species. When combined with the slow desorption from clay this potential concern resulted in a movement away from ammonia-based lixiviants including an outright ban on their use in Texas. Due to the additional consumptive use of groundwater to meet groundwater restoration requirements, AUC determined that an ammonia-based lixiviant is not a suitable alternative for the Proposed Project.

2.1.5.3 Other Potential Lixiviants

Other lixiviants which have been evaluated in laboratory scale and limited field tests include potassium based lixiviants, a range of oxidants including air, iodine, potassium permanganate, and a variety of trace additives such as clay stabilizing agents to increase the selective oxidation and mobilization of uranium minerals. To date, these alternatives have consistently proven to be far less economical than the planned oxidant-sodium bicarbonate system.

2.1.6 Groundwater Restoration

The groundwater restoration techniques proposed by AUC have been successful at other ISR operations in Wyoming. Groundwater sweep, permeate/reductant injection and groundwater treatment have successfully restored the groundwater consistent with pre-mining quality or designated regulatory limits. No practicable alternative(s) to the groundwater restoration method noted herein currently is available. The NRC and the WDEQ consider the method proposed to be the Best Practicable Technology available.

2.1.7 Alternate 11e.(2) Byproduct Management Options

Liquid byproducts generated from production and restoration activities generally are managed at ISR facilities by solar evaporation ponds, deep well injection, land application or some combination thereof. The use of deep byproduct disposal well(s) is considered by AUC to be the best alternative to dispose of these types of byproducts. The Proposed Project deep injection well(s) will isolate liquid 11e.(2) byproducts generated by the project from any underground source of drinking water as defined by the Safe Drinking Water Act. These wells must be authorized by the State of Wyoming under an appropriate underground injection control (UIC) Permit. AUC has submitted a Class I Permit that is under review by the WDEQ which can be found in Addendum 4-B of the TR.

AUC has considered a wide range of liquid treatment/disposal methods for use at the Proposed Project. The alternatives analysis considers three primary liquid 11e.(2) byproduct streams from ISR operation:

- Plant eluent;
- Wellfield purge water; and
- RO reject produced during wellfield restoration.

A "design basis influent" was developed for the three typical ISR liquid 11e.(2) byproduct streams to be managed as well as the projected water quality characterization for blending the liquid 11e.(2) byproduct. The alternatives analysis was completed stepwise with the development of a common evaluation basis, screening of potentially applicable treatment technologies, development of candidate treatment trains, and technical and cost evaluation of the treatment trains. The initial screening of treatment technologies includes evaluation of each technology for implementability, flexibility, maintainability, and relative capital and operating costs. The retained technologies have been developed into treatment options and then the comparative evaluation of each option was conducted in parallel for each byproduct stream.

Both capital and annual operating costs were developed for each option in order to calculate a net present value. The costs developed were comparative order-of-magnitude estimates intended for comparison purposes and were based on an ISR model case that could then be scaled to a particular operation. Costs that were common to all options such as regulatory reporting, project management, and administrative costs were not included.

Land application is practicable and historically has been used at some ISR facilities as a liquid byproduct treatment/disposal method, generally in conjunction with deep well disposal and/or spray/solar evaporation. Discharges through land application may have to be treated to meet surface water quality standards and 10CFR20 Appendix B Table 2, and perhaps, soil concentration limits to assure that there is no potential for future environmental liability due to accumulation of contaminants in the soil or groundwater below the land application surface area. For this reason, land application is not chosen in the screening process for further consideration at this time.

The following discussion provides a description of each treatment/disposal method considered and the relevant characteristics that led to the selection of deep well injection as the preferred alternative.

2.1.7.1 Deep Well Disposal

On any site where geologic and hydrogeologic conditions will allow deep well injection, it is the preferred method for liquid 11e.(2) byproduct material disposal. Deep well injection is permitted primarily on the condition that potential sources of drinking water cannot be adversely impacted by disposal operations, rather than by the quality and characteristics of the liquid 11e.(2) byproduct material injected. NRC, however, requires characterization of the liquid 11e.(2) byproduct material stream with respect to worker health and safety and analyses of potential consequences of leaks or spills at the wellhead (Part 20 requirements). Accordingly, deep well “discharge standards” as incorporated into a permit are based on the operator’s characterization of the liquid 11e.(2) byproduct material stream. This method is considered potentially suitable for all ISR liquid 11e.(2) byproduct material streams, and has been used by AUC in this license application.

2.1.7.2 Mechanical Evaporation

Mechanical evaporation utilizing equipment that requires either gas or electric power was considered. Evaporation is energy-intensive, but produces the smallest possible volume of liquid 11e.(2) byproduct for disposal. Disposal costs per unit volume can be evaluated against the evaporator operations cost to determine the economic viability of evaporation as a post-treatment step. For this evaluation it is assumed that a volume reduction of approximately 95 percent is achieved. This method is considered potentially suitable for all ISR liquid 11e.(2) byproduct material streams but results in 11e.(2) solid byproduct material that must be managed..

2.1.7.3 Chemical Precipitation and Reverse Osmosis

Chemical precipitation and reverse osmosis which can utilize the chemical precipitation step to either pre-treat the byproduct water for more efficient operation of the reverse osmosis system or use the chemical precipitation step to treat the brine was considered. Both brine residual and sludge are formed. This method is considered potentially suitable for all ISR 11e.(2) byproduct streams.

2.1.7.4 Spray/Solar Evaporation

Spray/solar evaporation utilizing natural evaporation and enhancing the rate by spraying water to increase the surface area, which is assumed to provide a 95 percent volume reduction for this evaluation, was considered. While solar evaporation is potentially a suitable alternative, the evaporation rate and length of the evaporation season must be considered in parallel with the flow rate of water to be treated. Pond size may become unreasonably large if the evaporation rate is low. If sprayers are used for evaporation enhancement, overspray due to high winds must be controlled. Additional issues with ponds include windblown accumulations of dust and dirt and the eventual need to remove salts and accumulated solids then managed as solid 11e.(2) byproduct material.

Table 2-1 provides a summary of the technical evaluation of candidate water treatment and management options for a combination of the process byproduct waters. For each of the alternatives considered, the table lists the advantages and disadvantages, the chemicals required, and environmental and safety considerations.

As shown by Table 2-1, the deep well option presents environmental, safety and health benefits including the following:

- Minimize worker exposure to concentrated brine streams that may contain uranium and byproduct material;

- Minimize the required footprint and therefore land disturbed by the system;
- Minimize the residual, either solid or liquid, stored onsite and also shipped offsite. There is no offsite transportation of residue required with a deep well; and
- Minimize the requirement for chemicals and other commodities.

Based on this comparative evaluation the deep well water management option for ISR liquid 11e.(2) byproduct provides clear economic and environmental advantages. All solid materials will be properly managed. Solid non-11e.(2) material will be disposed in an off-site solid material landfill permitted by the county in which it is located. All solid 11e.(2) byproduct material will be shipped to an NRC or Agreement State licensed facility for disposal.

2.1.8 Uranium Processing Alternatives

2.1.8.1 Single Stage RO

The Proposed Action includes two phases of RO for treatment to minimize the amount of liquid 11e.(2) byproduct material. The brine generated from the production and restoration RO units will be passed through the secondary RO unit. Brine from the secondary RO unit will be discharged to the deep disposal wells, while permeate will be recycled to wellfields undergoing groundwater restoration or used as CPP process make-up water.

An alternative considered by AUC was to use only one phase of RO treatment. Permeate from this single-stage RO would be handled just like the permeate described above, but the brine would be discharged directly to the deep disposal wells rather than being passed through a second phase of RO treatment. The two-stage RO treatment creates about one-half the amount of brine as a single-stage treatment and allows much more of the process byproduct water to be converted to permeate. This permeate will be put to beneficial use through injection into wellfields undergoing groundwater restoration and plant makeup water. Reducing the amount of brine through the use of two-stage RO treatment reduces the amount of water disposed of by deep well injection. An additional advantage of using a two-stage RO system is the increased volume of permeate produced which will be recycled to wellfields undergoing groundwater restoration thereby decreasing the overall percent bleed during restoration. The advantages of two-stage RO treatment in reducing brine volume and providing more permeate for beneficial uses, the single phase of RO treatment was not further considered by AUC.

2.1.8.2 Higgins Loop

In coordination with the NRC GEIS, AUC's Proposed Project includes the use of a pressurized down-flow IX system. With this IX system the radon present in the pregnant lixiviant is retained in solution and returned back underground in the re-fortified barren lixiviant. This provides for a significantly reduced potential for occupational and/or public exposure to radon and its progeny.

An alternative considered by AUC was to utilize a Higgins Loop IX system. The Higgins Loop is a closed-loop system in which uranium-laden resin advances through the system in the different stages of adsorption, backwash, regeneration, and rinse in preparation for another adsorption cycle. The IX system is a vertical cylindrical loop, containing a packed bed of resin that is separated into four operating zones by butterfly, or "loop" valves. These operating zones, adsorption, regeneration, backwashing and pulsing, function like four separate vessels thus increasing the resin loading efficiency.

The Higgins loop resin exchange process is unfavorable as it may result in significant attrition of the resin. The flow system used to load and strip the resin of uranium generates a significant back pressure. The back pressure can result in excessive compressive forces on the resin itself and results in damage to the resin particles. The damaged resin particles will often increase the back pressure in the system, resulting in accelerated damage to the resin. Additionally, the cycling of the resin between the loading chamber and the stripping chamber can result in damage to the resin as the resin particles experience significant physical impact with other resin particles, the chamber walls and plumbing, valves, etc. The damage to and loss of the resin results in significant additional costs for replacement resin.

2.1.9 Comparison of the Predicted Environmental Impacts

As discussed above, AUC has identified and developed the Proposed Action as the best approach to recovering uranium resources from the Proposed Project. Table 2-2 provides a summary of the potential environmental impacts for the No-Action alternative (Section 2.1.1), the Proposed Action (Section 2.1.2), and the reasonable alternatives although deemed not suitable (Section 2.1.3). The predicted impacts for the recovery alternatives discussed in Section 2.1.3 are not included for comparison because these alternatives were eliminated due to potentially significant adverse occupational, environmental and economic impacts. Section 4 of this ER provides a more detailed discussion of potential environmental impacts of the Proposed Action and No-Action alternatives.

Table 2-1: Comparison of Treatment Alternatives

Evaluation Factor	Deep Well	Mechanical Evaporation	Chemical Precipitation/RO	Spray/Solar Evaporation
Advantages	Economical, no residuals yielding no onsite storage or offsite transport required, no concentrated chemicals required, minimal operating requirements, minimal space requirements, flexible with regard to water quality and disposal rate.	Produces very low volume brine for disposal or further processing by solidification or to dry salt for zero liquid discharge, produces treated water with essentially zero contaminants (distilled water), can be operated campaign style.	Broadly applicable to metals and common anion contaminants, chemical precipitation pretreatment allows operation of RO system to produce less brine, produces high quality treated water stream for reuse or discharge.	Primary treatment is simple system consisting of ponds, pumps, piping and nozzles. No complicated equipment, low capital cost. Commonly used for management of brine in arid climates. Can allow complete evaporation to dryness or remove low volume brine for solidification and offsite disposal.
Disadvantages	Site geology will dictate reasonably achievable disposal flow rate. Site hydrogeology (presence of potential drinking water aquifers) will dictate disposal well depth. Permitting process may be lengthy. Attention to water chemistry and need for antiscalant is required to minimize wellscreen scaling and fouling issues. Changes in water chemistry may require re-permitting. No recovery of treated water.	Long equipment lead, distillate is corrosive and will need conditioning for reuse or discharge, high capital and power cost, concentrates radionuclides into the evaporator brine by 20 times or more.	Produces both liquid and solids residues with higher volume liquid residues that other options. Highest labor. Requires bulk concentrated chemicals. Highest truck traffic of options evaluated for chemical deliveries and residuals transport.	Treatment rate dependent upon weather. “Overdesign” required to account for weather shutdowns. Potential for birds and other wildlife to drink and contact water. Treatment time affected by wind with high potential for overspray. Reduced efficiency and operating difficulty due to freezing in winter so large storage capacity required. Windborne dust and dirt reduce efficiency and increase maintenance (cleanouts). Large quantities of chemicals required for solidification and large quantities of solidified brine produced for offsite disposal.

Table 2-1: Comparison of Treatment Alternatives (Continued)

Evaluation Factor	Deep Well	Mechanical Evaporation	Chemical Precipitation/RO	Spray/Solar Evaporation
Chemicals Required	None to minimal. Antiscalent may be required depending on water characteristics.	Minimal for evaporator and limited to antiscalent compounds and some cleaning products. Lime, soda ash, and polymer required for solidification.	Lime; Concentrated acid, Polymer; antiscalent and RO cleaning chemicals; Lime, soda ash and polymer for solidification.	Lime, soda ash, and polymer for solidification.
Environmental /Safety	Safest and lowest environmental impact of options. Smallest carbon footprint with low operating power requirement and no truck traffic. No residuals stored onsite, no potential for wildlife exposure to holding ponds. No requirement for chemicals. No potential exposure to concentrated residues.	Large carbon footprint with over 10 times the power requirement of a deep well and 20 times the power requirement of the RO/precipitation option. Requires high operating temperatures and pressures. Low to moderate footprint primarily for brine storage tanks. Requires storage of brine as feed to solidification system and offsite transportation of solidified brine stream. High chemical requirements for solidification chemicals. High operating temperature and pressure.	Moderate carbon footprint with the lowest operating power requirement but the most truck traffic of any option evaluated. Handling of highest quantity of residues required including onsite storage and offsite disposal. Higher labor requirements with more potential for exposure to chemicals and residuals during sludge dewatering operations and residuals management.	Moderate carbon footprint with greater the power required of a deep well and some truck traffic for offsite brine disposal. Greatest risk to wildlife due to large volume ponds. Greatest potential for release of salts from overspray. Potential for exposure to labor from the sprays.

Table 2-2: Comparison of Predicted Environmental Impacts

Potential Impact	Alternative	Potential Impacts
Potential Land Surface Impacts	Proposed Action	Surface disturbance will range from short term for construction of well pads and utility/pipeline corridors that will be reclaimed after construction to long term for roads, buildings, parking areas, and backup pond that will remain until final D&D. All disturbance will be reclaimed to be suitable for pre-construction uses. Disturbance areas and values are listed in ER Table 1-3.
	No Action	None
	Conventional Mining/Milling Including Heap Leach	Open-pit mining will result in significant surface disturbance due to the pit overburden stockpiling and will create permanent topographic changes, increase fugitive dust, and the potential for subsidence. Both heap leaching and open-pit mining methods require crushing the ore and disposing of the tailings, creating long term or permanent solid 11e.(2) byproduct material.
	CPP versus Satellite Plant	Satellite plant will result in a smaller surface disturbance due the smaller facility size than the proposed central processing plant.
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Byproduct Management	Disposal in evaporation ponds will result in slightly more surface disturbance than the proposed backup pond due to the increased surface area to aid in the evaporation process.
	Uranium Processing Alternatives	Use of single-stage rather than the proposed two-stage RO system would create approximately twice as much brine as the Proposed Action, requiring greater disposal capacity for liquid 11e.(2) byproduct material disposal.

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Land Use Impacts	Proposed Action	Small impacts on agricultural production (livestock grazing) and hunting on up to 481 acres for duration of the Proposed Project.
	No Action	None
	Conventional Mining/Milling Including Heap Leach	Area used for pit, ramps, haul roads, overburden stockpiles, and topsoil stockpiles will be restricted from any other uses for the duration of the Proposed Project.
	CPP versus Satellite Plant	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Byproduct Management	Same as Proposed Action plus additional land use impact from installation of evaporation ponds and/or land application areas.
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Transportation Impacts	Proposed Action	An estimated 23.3 acres will be disturbed to construct infrastructure access roads(secondary and tertiary). A small risk of spills of process chemicals and small quantities of 11e.(2) byproduct material during the project life.
	No Action	None
	Conventional Mining/Milling Including Heap Leach	Conventional mining methods will require more employees which will increase traffic on local roads.
	CPP versus Satellite Plant	A satellite plant will increase the traffic volume due to the shipment of loaded resin to a central processing facility
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Byproduct Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Geology and Soil Impacts	Proposed Action	Approximately 154 acres (short and long term) will potentially be disturbed over the life of the Proposed Project. Topsoil will be stripped for construction of recovery facilities and access to these facilities. Topsoil will be stockpiled and seeded with a temporary seed mix to protect from erosion until it is replaced during reclamation. Once replaced, topsoil will be revegetated and support pre-construction land use resulting in no significant impacts on geology. Disturbance areas and values are listed in ER Table 1-3.
	No Action	None
	Conventional Mining/Milling Including Heap Leach	Open pit mining will have significant impacts on geology and soil since all overburden from the surface to the ore zones will be removed. The overburden will be stockpiled and seeded with a temporary seed mix to protect form erosion until replaced during reclamation.
	CPP versus Satellite Plant	Same as the Proposed Action
	Use of Alternate Lixiviants	Same as the Proposed Action
	Alternate Byproduct Management	Evaporation ponds would require a larger surface area disturbance than the Proposed Action resulting in more topsoil removal and stockpiling.
	Uranium Processing Alternatives	Use of single-stage RO treatment would require more DDWs for additional liquid 11e.(2) byproduct disposal which would require more topsoil to be removed

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Surface Water Impacts	Proposed Action	Surface disturbance may pose a small risk of increased sediment load to ephemeral drainages. Minimal risk of fuel or chemical spills.
	No Action	None
	Alternate Milling Method	Open pit mining will alter the surface drainage network requiring the restoration of all drainages during reclamation. The surface disturbance is significantly increased from the Proposed Action and will pose a larger risk of sediment load to surface waters. In addition, the potential for large amounts of groundwater to be discharged from the open pit will impact ephemeral drainages that only see flow during runoff or storm events.
	CPP versus Satellite Plant	Same as the Proposed Action
	Use of Alternate Lixiviants	The potential spill of an acid or ammonia based lixiviant will have more of an adverse effect on surface water than a sodium-bicarbonate based lixiviant.
	Alternate Byproduct Management	Evaporation ponds will disturb more surface area resulting in the increased risk of sediment load to drainages.
	Uranium Processing Alternatives	Same as the Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Groundwater Impacts	Proposed Action	Excursion of lixiviant may have a small potential to contaminate adjacent groundwater. Minimal risk of fuel or chemical spills leaching to shallow groundwater. Small net withdrawal of water from the ore zone aquifer to contain fluids. Water consumed will naturally recharge with time.
	No Action	None
	Alternate Milling Method	Open-pit and underground mining will drastically alter the hydrogeology of the area. All aquifers from the bottom of the ore zone to the surface will be exposed. Groundwater exposed in pit will need to be discharged altering surface water flow.
	CPP versus Satellite Plant	Same as the Proposed Action
	Use of Alternate Lixiviants	The potential migration of an acid or ammonia based lixiviant will have more of an adverse effect on groundwater than a sodium-bicarbonate based lixiviant.
	Alternate Byproduct Management	Same as the Proposed Action
	Uranium Processing Alternatives	Use of single-stage RO or not treating groundwater sweep recovery solutions with RO will increase net amount of groundwater withdrawn from ore zone aquifer.

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Ecological Impacts	Proposed Action	BMPs will minimize wildlife access to lined backup pond and storage facilities. No threatened or endangered species will be impacted as none where identified in baseline studies. Loss of habitat will be minimal and temporary.
	No Action	None
	Alternate Milling Method	Open pit mining will disturb much more habitat by increased surface disturbance.
	CPP versus Satellite Plant	Same as the Proposed Action
	Use of Alternate Lixiviants	Same as the Proposed Action
	Alternate Byproduct Management	More habitat loss could result due to increased impoundment size.
	Uranium Processing Alternatives	Same as the Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Air Quality Impacts	Proposed Action	Slight increases in fugitive dust will occur, primarily during construction. An increase in fugitive dusts over baseline levels will occur during the life of the project.
	No Action	None
	Alternate Milling Method	Open-pit mining will increase fugitive dust emissions by exposing much more disturbed soil surface. Large equipment will increase gaseous greenhouse emissions. Tailings will increase risk of airborne contaminants, including radioactive materials.
	CPP versus Satellite Plant	The potential for impact to air quality increases due to the potential exposure to dried yellowcake particulates from an accident.
	Use of Alternate Lixiviants	Same as Proposed Action, possibly for an extended amount of time if alternate lixiviant requires more time for restoration.
	Alternate Byproduct Management	Increased emissions may occur if larger lined evaporation ponds are constructed.
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Noise Impacts	Proposed Action	Noise will increase over background levels. Nearest residence could experience noise levels above the annoyance (55 dBA) threshold during construction.
	No Action	None
	Alternate Milling Method	Increased noise levels will result from open-pit mining due to heavy equipment operation.
	CPP versus Satellite Plant	A CPP will potentially produce less noise with the absence of resin shipping trucks.
	Use of Alternate Lixiviants	Same as Proposed Action, possibly for an extended amount of time if alternate lixiviant requires more time for restoration.
	Alternate Byproduct Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Historical and Cultural Impacts	Proposed Action	Potential impacts will be minimal, since NRHP eligible sites do not exist on the Proposed Project site. A stop-work provision will be used if any previously undiscovered cultural resources are found.
	No Action	None
	Alternate Milling Method	Open-pit mining disturbs more area than that of ISR facilities increasing the chance of disturbing unknown cultural resources.
	CPP versus Satellite Plant	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Byproduct Management	Similar to Proposed Action, although potential impacts could increase with increased evaporation pond size.
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Visual/Scenic Impacts	Proposed Action	Minimal visual impacts will result from new structures and equipment but will remain consistent with the BLM visual resource classification of the area.
	No Action	None
	Alternate Milling Method	Open-pit mining will create a significant visual impact with large stockpiles and a large tailings impoundment.
	CPP versus Satellite Plant	Similar to the Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action, possibly for an extended amount of time if alternate lixiviant requires more time for restoration.
	Alternate Byproduct Management	More and larger impoundments than required under the Proposed Action will have localized visual impacts.
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Socioeconomic Impacts	Proposed Action	Most of the workforce is expected to come from the local area minimizing impacts on housing and local services. Project will have slight, positive benefit to the State on severance tax, royalty, and sales and use tax collections and moderate benefits to Campbell County on property and production taxes. Remoteness of the site might slightly increase the need for increased emergency services (fire and ambulance service).
	No Action	None
	Alternate Milling Method	Conventional mining and milling methods require more employees than ISR facilities. Revenues to the State, which are based on production, will be similar to Proposed Action, but Campbell County revenues from property taxes will be more due to additional equipment required for conventional mining.
	CPP versus Satellite Plant	A CPP will require more employees than a satellite facility which will have a direct positive impact on the local economy
	Use of Alternate Lixiviants	Same as Proposed Action, possibly for an extended amount of time if alternate lixiviant requires more time for restoration.
	Alternate Byproduct Management	Same as Proposed Action possibly extending the construction period due to the need to construct more impoundments.
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Non-Radiological Impacts	Proposed Action	Minimal risk of public exposure through chemical leaks and spills will be mitigated by employing BMPs.
	No Action	None
	Alternate Milling Method	Conventional mining and milling methods have an increased risk and more severe accidents compared to that of the Proposed Action. Safety hazards are compounded due to the depths of the mineral ore to be recovered.
	CPP versus Satellite Plant	A CPP has additional equipment and chemicals that could present safety hazards not found in a satellite facility
	Use of Alternate Lixiviants	Similar to Proposed Action; acid or ammonia-based lixiviant will introduce additional non-radiological health risks.
	Alternate Byproduct Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Radiological Impacts	Proposed Action	The estimated radiological impacts resulting from routine site activities will be compared to applicable public dose limits as well as naturally occurring background levels.
	No Action	None
	Alternate Milling Method	Radiological exposure to the personnel in these processes is increased, not only from the mining process but also from milling and the resultant mill tailings. The milling process generates a significant amount of byproduct relative to the amount of ore processed. Extensive mill tailings impoundments are needed for the disposal of these byproducts.
	CPP versus Satellite Plant	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate byproduct Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Byproduct Management Impacts	Proposed Action	The Proposed Project deep injection well(s) will isolate liquid byproducts generated by the project from any underground source of drinking water. A slight risk of exposure to the public during transportation exists though will be minimized by employing BMPs.
	No Action	None
	Alternate Milling Method	Conventional mining and milling creates considerably more waste than ISR, including solid 11e.(2) byproduct material (tailings), and residue left from the treatment of water.
	CPP versus Satellite Plant	A CPP will potentially create more 11e.(2) and non-11e.(2) byproducts than a satellite plant requiring more byproduct to be transported and disposed at a licensed facility.
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Byproduct Management	Evaporation ponds accumulate salts and windblown material such as dust that will need eventual removal increasing the risk for potential impacts during transport to an off-site facility.
	Uranium Processing Alternatives	Same as Proposed Action

3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

The information in this section (Sections 3.1-3.12) provides relevant data concerning the existing resource areas including land use, transportation, geology and soils, water resources, ecology, noise, air quality, historic and cultural resources, socioeconomics, public and occupational health, and current waste management practices. The area of review includes the approximately 6,057 acres within the Proposed Project boundary plus additional potentially affected area that varies according to resource as described in the following sections. Preliminary data were obtained from several sources followed by field studies to collect on-site data. The information in this section forms the basis for assessing the potential impacts (see Section 4) of the Proposed Action and No Action Alternative (see Section 2). Subject to the site specific differences noted in this ER and in the TR, the Proposed Project is representative of the conditions in the Wyoming East Region, as discussed in NUREG-1910.

The Proposed Project is located in the southern portion of the Powder River Basin (PRB), in the Pumpkin Buttes Uranium District in Campbell County, Wyoming (WY) within the Wyoming East Milling Region as defined by NUREG-1910 (GEIS Section 3.3). ER Figure 1-1 shows the general site location of the Proposed Project site and surrounding area in relation to surrounding population centers, interstates and highways, and county boundaries. As noted in the GEIS, this region contains past, current and potential for future uranium ISR projects such as this Proposed Project.

The Proposed Project area is 7.5 miles southwest of Wright, WY and contains all or portions of 15 Sections (6,057 acres). Its location is described as follows:

- T42N R73W – Diagonal portion of the north half of the northwest quarter of the northwest quarter of Section 5; West half of Section 6, west half of the northeast quarter of Section 6, and the northeast quarter of the northeast quarter of Section 6;
- T42N R74W – East half of Section 1, east half of the southwest quarter of Section 1, northeast quarter of Section 12 and east half of the northwest quarter of Section 12;
- T43N R73W – South half of Section 21, southwest quarter of Section 22, west half of Section 27, all of Section 28, south half of Section 29, northeast quarter of Section 29, south half of the northwest quarter of Section 29, southeast quarter of Section 30, southeast quarter of the northeast quarter of Section 30, all of Section 31, all of Section 32, north half of Section 33, north half of the south half of Section 33, west half of the northwest quarter of Section 34 and the northwest quarter of the southwest quarter in Section 34; and
- T43N R74W – All of Section 36 and the east half of the southeast quarter Section 35.

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3.1 Land Use

This section includes discussions and summaries of the land use within the proposed Reno Creek Project (Proposed Project) area. Further discussions regarding land use can be found in:

- Section 3.4 of this ER (Water Resources);
- Section 4.1 of this ER (Potential Land Use Impacts);
- Section 6.1 of this ER (Mitigation);
- Section 8.4.2.2 of this ER (Long-Term Costs);
- Section 2.2 of the TR (Land Use);
- Section 2.7 of the TR (Water Resources);and
- Sections 7.1.1 and 7.2.1 of the TR (Environmental Effects).

3.1.1 General Setting

The Proposed Project landscapes are characterized by a flat to gently rolling topography with small ephemeral drainages and large, open upland grassland mixed with sagebrush shrubland that are typical landscapes within the PRB. The Pumpkin Buttes are visible from the Proposed Project area, but range from 7.5 to 14 miles away from the Proposed Project. The Proposed Project is at least 5.5 miles away from the boundary of the Pumpkin Buttes Programmatic Agreement. As a result, they do not constitute a significant on-site scenic feature, nor will any of the activities proposed by AUC pose a significant visual impact from anywhere on the Buttes.

The Proposed Project area's landscape is rural in character with a number of ranch access roads and industrial development from oil and gas and CBM activities. Figure 1-1 of this ER shows the general location of the Proposed Project site and surrounding area in relation to surrounding population centers, interstates and highways, and county boundaries. The Proposed Project area is 7.5 miles southwest of Wright, 31 miles northeast of Edgerton, 32.5 miles northeast of Midwest, 41 miles south of Gillette, and 63 miles northeast of Casper The Proposed Project area is located in the Wyoming East Milling Region as defined by NUREG-1910 (GEIS, p. 1-2).

Surface ownership within the Proposed Project area includes private and state owned lands and no federal surface ownership. The distribution of land surface ownership is detailed in ER Table 1-2 in addition to being depicted in ER Figure 1-3. Mineral holdings in the Proposed Project area consist of federal unpatented mining claims, private (fee) mineral leases, and state mineral leases. Mineral ownership is shown on Figure 1-4 of this ER. AUC has executed surface use agreements with all land owners who hold surface ownership in the Proposed Project area, including leases on state land.

Wyoming is a state with active mineral development. Within the Proposed Project area, existing land uses include: oil and gas production, CBM production, transportation, livestock grazing, and wildlife habitat. There are several maintained roads and two natural gas lines that currently pass through the Proposed Project area. The main roads which provide access to the Proposed Project area include Highway 387, County Road 22 (Clarkelen Road), and County Road 25 (Cosner Road). Several improved and unimproved access roads used for agricultural, and oil and gas activities provide access around the Proposed Project area. A more detailed discussion of transportation is found in Section 3.2 of this ER.

3.1.2 Land Use Classification

Land use and land cover within the Proposed Project area and a five mile land use review area that is consistent with or exceeding NUREG-1569 (Section 2.2) is illustrated in Figure 3.1-1 and correlating Table 3.1-1.

Within the Proposed Project area, existing land uses include: oil and gas production, CBM production, transportation, livestock grazing, and wildlife habitat. There is limited opportunity for most recreational activities due to private surface ownership. The mapped land use review area categories within five miles of the Proposed Project area include the following:

- Non-Agricultural Land: plots of land which are not used for agricultural purposes;
- Non-Irrigated Cropland: non-irrigated cultivated lands that are used for the production of grain crops (harvested and/or grazed), orchard, and field crops.
- Industrial: Industrial areas include land uses from light to heavy manufacturing and mining operations. Light manufacturing includes industries focused on design, assembly, finishing, processing, and packaging of products. Heavy industries use raw materials such as iron or coal. This category also includes surface structures associated with mining operations.
- Reservoirs: Reservoirs are artificial impoundments of water used for irrigation, flood control, municipal water supplies, recreation, hydroelectric power generation, and so forth
- Transportation: areas include transportation routes (highway or railway) and communication and utility corridors such as those involved in processing, treatment, and transportation of water, gas, oil, and electricity.

All of the land within the Proposed Project area is non-crop and non-agricultural (Figure 3.1-1 and Table 3.1-1). In the surrounding five mile land use review area, the surface use is nearly entirely livestock grazing rangeland, with some areas classified as non-irrigated cropland (Figure 3.1-1).

Oil and gas and CBM production/transmission infrastructure is located on rangeland throughout the Proposed Project area and five mile review area. Gas transmission pipelines cross the lands within the five mile land use review area as well as an oil transmission outside of the Proposed Project boundary. Existing minor gas pipelines and infrastructure associated with CBM development in the Proposed Project area is shown in Figure 3.1-2.

3.1.3 Aesthetics

The Proposed Project landscapes are characterized by a flat to rolling topography with small ephemeral drainages and large, open upland grassland mixed with sagebrush shrubland that are typical landscapes in the PRB. The Proposed Project area's landscape is rural in character; crossed by State Highway 387 with a number of ranch access roads. Human influence is evident in existing grazing activities and facilities (stock tanks, fences), oil and gas production facilities, CBM production facilities, and infrastructure that support these activities. Oil and gas field infrastructure in the Proposed Project area and the surrounding two mile buffer area includes access roads, overhead electric distribution lines, and cleared rights-of-way for underground utilities which are generally found along access roads.

The Pumpkin Buttes are visible from the Proposed Project area, but range from 7.5 to 14 miles away. As a result, they do not constitute a significant on-site scenic feature, nor will any of the activities proposed by AUC be visible from anywhere on the Buttes, or within the Programmatic Agreement area.

3.1.4 Agriculture

Predominant current land use within the five mile land use review area is rangeland. In 2007, the year of the most recent Census of Agriculture, Campbell County ranked fifth in Wyoming for numbers of sheep and lambs, and sixth for cattle and calves. Campbell County had 633 farms and ranches with a total of 2,345,915 acres. The average size of a farm or ranch was 3,706 acres. Of the land in farms and ranches 91.6 percent was pasture/rangeland. In 2007 cash receipts for livestock sales totaled $37.7 million in Campbell County. Table 3.1-2 shows the 2007 livestock inventory estimate for Campbell County (NASS 2009).

3.1.5 Residences

There currently is one residence (the Taffner homestead) located within the Proposed Project boundary (ER Figure 3.1-2), and five residential sites located within the five mile land use review area outside of the Proposed Project boundary. Based on landowner correspondence, there are currently two occupants at the Taffner homestead and approximately eight occupants currently living in the five residences located outside the Proposed Project boundary. There are no known vegetable gardens located at any of these five residences.

The Taffner homestead is currently positioned where the proposed CPP will be located. AUC will acquire the Taffner property prior to construction and it will not thereafter be used as a residence. The domestic water well located at the Taffner residence will be plugged in accordance with all WDEQ Rules and Regulations and will not be used for consumption once construction begins. Once operations begin, there will be no residences located within the Proposed Project's boundary.

Table 3.1-3 shows the distance to the nearest residence from the center of the Proposed Project for each 22-1/2 degree sector centered on each of 16 compass points. It also shows distance to the nearest site boundary for residences outside of the Proposed Project area. Outside of the Proposed Project area, the nearest residence site is approximately 0.42 miles from the Proposed Project boundary as depicted in Figure 3.1-3 (this figure is based off Table 3.1-3).

3.1.6 Transportation and Utilities

The Proposed Project area contains a number of overhead power lines associated with CBM development. As a result, electrical power will be readily available for the Proposed Project facilities and operations without requiring large-scale installation of new electrical transmission lines. Some large scale oil and gas pipelines exist in the five-mile land use review area and within the Proposed Project area as shown in Figure 3.1-1. Smaller pipelines and utility lines exist in the Proposed Project area as a result of CBM operations. Interaction with this existing infrastructure is discussed in further detail in Section 7 of the TR.

The primary transportation route to the Proposed Project area from nearby communities is on State Highway 387, which connects the Proposed Project area to regional population and economic centers along Interstate 25 to the west. According to the Wyoming Department of Transportation (WYDOT 2010) Annual Average Daily Traffic (AADT) counts along the approximate 13 mile segment of State Highway 387 between the Campbell/Johnson county line and the State Highway 387 junction is 827 vehicles. Several private access roads extend in various directions from State Highway 387 to access existing agricultural, as well as oil and gas and CBM facilities in the Proposed Project area. Highway 387, Clarkelen Road, and Cosner Road provide access to residences or other public destinations.

Interstate 25 is a Federal Interstate Highway designed for high-volume, high-speed traffic. It is a four-lane, divided highway with two lanes in each direction separated by a wide median. State Highways 59, 50, and 387 are bi-directional (two-lane opposing travel), asphalt-paved highways in good to average condition. State Highway 59, 50, and 387 are all classified by WYDOT as Rural Minor Arterial highways. The lanes on all three highways are 12 feet wide. The total width of paved roadway ranges from 26 to 40 feet based on the varying paved shoulder widths and the presence of a periodic passing lane. All state highways adjacent to the Proposed Project area are access controlled and are maintained year-round by WYDOT. Highway maintenance includes snow removal, debris removal and road repairs.

During the construction, operation, restoration and decommissioning phases of the Proposed Project, immediate access to the Proposed Project will be from State Highway 387, from either or both the east and the west. The workforce for each phase will be primarily from Gillette using State Highway 59 then westbound State Highway 387, and from Casper using Interstate Highway 25 then eastbound State Highway 387.

3.1.7 Recreation

Recreational lands for public use within 50 miles of the Proposed Project are limited due to the lack of or infrequent availability of many types of recreational structures such as navigable waterways or developed recreational facilities (Table 3.1-4). The regional setting of the Proposed Project provides broad, panoramic prairie landscapes, which provide a setting for a variety of outdoor recreational activities such as hunting, fishing camping, hiking, boating, biking, and horseback riding. Nearby recreation areas are shown on Figure 3.1-4. Local attractions include Thunder Basin National Grassland, Fort Reno historic site, and the historic Bozeman Trail. The Fort Reno site is under private ownership as is much of the Thunder Basin National Grassland and Bozeman Trail. Table 3.1-4 lists some major attractions and their distances from the Proposed Project area.

In addition to the recreational sites shown in Table 3.1-4, communities (Gillette, Wright, Kaycee, Midwest, and Edgerton) in the 50 mile area provide a variety of recreational opportunities. The western edge of the Wyoming East Uranium Milling Region offers a variety of recreational activities, including sightseeing, museums, historic sites, and small state parks (NUREG-1910, p. 3.3-4). These include municipal and private campgrounds, golf courses, rodeo grounds, parks, ball parks, recreation centers, and swimming pools.

Within the project area there is limited opportunity for most recreational activities due to private surface ownership and ephemeral nature of surface waters. As shown on Figure 1-3 in ER Section 1, there is only one parcel of state land in public ownership within the Proposed Project area. This state-owned section is accessible via County Road 22

(Clarkelen Road) and provides potential dispersed recreational opportunities, such as hunting.

3.1.8 Mineral Resources

3.1.8.1 Fossil Fuel Development

The Proposed Project is located within the PRB which extends across portions of southern Montana, and Sheridan, Campbell, Johnson, and Converse counties in Wyoming. In addition to uranium, the PRB contains major deposits of coal, CBM, and other petroleum resources. These resources are more prevalent in the central and northern portion of the PRB in Campbell and Johnson Counties (Office of Federal and State Materials, 2009, p. 3.3-4).

There are no active coal mines in the five mile land use review area. The closest coal mines are the North Antelope, Rochelle, and Thunder Basin Coal Mines, approximately 16 miles east of the Proposed Project.

There is also extensive CBM production within and around the Proposed Project area. There are 324 wells within the two-mile buffer area used for CBM production. A list of all CBM wells is listed in Table 2.7B-19 of Addendum 2.7-B of the TR. Additionally, all CBM wells are depicted in TR Figure 2.7B-59 in Addendum 2.7-B of the TR. Other non-CBM wells exist within a two mile buffer and these locations are depicted in TR Figure 2.7B-58 in Addendum 2.7-B of the TR in relation to residences. Table 2.7B-18 of Addendum 2.7B lists those non-CBM wells.

The administering agency for split estate minerals (private surface and federal subsurface minerals) is the Casper Field Office of the United States Department of the Interior Bureau of Land Management (BLM). Surface ownership is provided in Figure 1-3 of this ER.

CBM recovery methods, potential environmental impacts, existing CBM recovery facilities, and potential cumulative environmental impacts of existing CBM development, and the Proposed Project are discussed in detail in Section 5 of this ER.

AUC has performed a review of oil and gas fields, producing wells, and producing formations in the vicinity of the Proposed Project. The purpose of this review was to compare the proposed injection interval for the Proposed Project Class I wells (Teckla-Teapot-Parkman [TTP]) to intervals that have been pursued for oil and gas production. A type log with the TTP interval is shown in TR Addendum 2.6A on Figure 2.6A-4.

A search of non-CBM oil and gas wells within a 10 mile radius of the Proposed Project initially was performed to identify wells in the area. Locations of those wells and associated fields are shown on Figure 3.1-5. Due to the large number of wells within 10 miles, a more focused review was performed for a five mile radius identified as five mile oil and gas review area.

Within the five-mile oil and gas review area there are a total of 144 wells, 56 that currently are producing. Table 3.1-5 shows all wells located in the oil and gas review area and Table 3.1-6 shows currently producing oil and gas wells. Production in the Proposed Project area occurs primarily from the Sussex to Muddy section (approximate depths 8,700 feet to 12,500 feet bgs). The shallowest production in this section, the Sussex, is separated from the base of the Parkman by more than 400 feet of Steele Shale. There is limited Parkman production in the area, mainly to the North of the Proposed Project. Some of the wells in the vicinity produce from a section referred to by the Wyoming Oil & Gas Conservation Commission (WOGCC) as Parkman-Turner. A detailed review of WOGCC records shows that the majority of production for these wells comes from the Sussex-Turner section rather than the Parkman. There is no identified production from the Teckla or Teapot in the vicinity of the Proposed Project. Current exploration in the area has been focused on the deeper section (e.g., Turner-Muddy).

A detailed discussion of producing fields and wells within five miles of the Proposed Project follows.

3.1.8.1.1 Oil and Gas Fields within a Five Mile Radius of the Proposed Project

There are numerous oil and gas fields that are located within five miles of the Proposed Project. Described below are the known fields and production information:

- K-Bar Field: The field is one of the largest oil and gas producing fields in the review area, and part of the field is immediately adjacent to the northeast section of the Proposed Project boundary. There are a total of 19 producing wells within the K-Bar field (shown in Table 3.1-6); eight produce in the Turner, four in Parkman, three in the Lakota, one in the Shannon, one in the Dakota, one in the Steel and one in the Sussex formation. Historical production data show that the majority of wells used only the Turner formation or the Parkman formation. Current vs. historical production of multiple producing formations is shown in Table 3.1-7 (WOGCC data). Depths in this field for potential producing formations are: Parkman (7,610 feet to 7,800 feet); Sussex (8,408 feet to 8,494 feet); Turner (10,460 feet to 10,800 feet); Niobrara (9,926 feet to 10,100 feet); and Muddy (11,498 feet to 11,561 feet). The average total depth of the wells in the K-Bar field is 9,965 feet;

- House Creek Field : The field is located on the northeastern edge of the five mile oil and gas review area. The field includes a total of nine producing wells completed in the Sussex formation (Table 3.1-6). Depths in the Sussex range from 8,240 feet to 8,252 feet. The average total drilled depth of the wells in the House Creek field is 8,500 feet;
- Tuit Draw Field : The field is located on the eastern edge of the five mile oil and gas review area. There are a total of five producing wells completed only in the Turner formation, while one of the well produces in the Morrison formation. Historical production data show that two of the Turner wells have produced in that formation only. Current vs. historical production of multiple producing formations can be found in Table 3.1-7. The range of depths for production in the field is 7,380 feet to 7,400 feet (Parkman) and 10,150 feet to 10,200 feet (Turner). The average total drilled depth of the wells in the Tuit Draw field is 10,500 feet.
- Buck Draw North Field : The field is located on the southern edge of the five mile oil and gas review area. There are a total of three producing wells within the Buck Draw North field that produce from the Frontier, Morrison and Lakota formations. The average total depth of the wells in the Buck Draw North field is 12,600 feet; the Dakota is encountered between 12,365 feet and 12,400 feet.
- Turnercrest Field: The field is located on the Southern part of the five mile oil and gas review area. There are three producing wells completed in the Morrison and Fuson formations. Morrison production is encountered between 11,359 feet and 11,364 feet; Fuson production depths range from 12,350 feet to 12,370 feet. The average total depth of the wells in the Turnercrest field is 12,500 feet.
- WC Field: The field is located just north of the AUC property (a specific field outline is not available). WOGCC records indicate that the field includes three producing wells; two produce from the Turner while one produces from multiple formations (Parkman-Turner). Historical production data show one well that produced from the Turner, while the other well produced from the Parkman. Current vs. historical production of multiple producing formations is presented in Table 3.1-7. The average total depth of the wells in the WC field is 11,200 feet. Parkman production is encountered between depths of 7,750 feet and 7,760 feet; Turner production occurs between depths of 10,750 feet and 11,928 feet;
- Archibald Field: The field is located south, west, and east in the five mile oil and gas review area. There are two producing wells within the field that produce from the Frontier and Morrison formations. The average total depth of the wells in the Archibald field is 12,400 feet; production is encountered between 11,400 feet and 11,415 feet.

- Night Creek Field: The field is located just northwest of the Proposed Project boundary. There is one producing well in the field that produces from Morrison formation (11,226 feet to 11,258 feet). The well's total depth is 12,454 feet.
- Butte Field: The field is located north of the review area, however there are currently no producing wells located within this field.
- Sievers Field: The field is located in the western portion of the five mile oil and gas review area. There is one producing well within the field completed in the Belle Four formation (9,928 feet to 9,940 feet). The total depth of the well is 11,745 feet.

3.1.8.2 Uranium Fuel Cycle Facilities

The NRC website (NRC 2012) provides the locations of all licensed materials facilities in the United States, including fuel cycle facilities (enrichment and conversion) and uranium mills. The website was reviewed to identify the location of fuel cycle facilities and ISR facilites within 50 miles (80 km) of the Proposed Project area. No fuel cycle facilities were located within 50 miles of the Proposed Project area. The nearest facility is the Honeywell International, Inc. uranium fuel fabrication facility, located in Metropolis, Illinois (NRC, 2012).

Several properties in the Pumpkin Buttes Uranium District owned by Cameco Corporation (North Butte), Uranium One (Moore Ranch), and Uranerz (Hank and Nichols Ranch) have been deemed feasible for ISR uranium production and are licensed by NRC for ISR development and are currently operating or highly likely to be in operation in the future.

Several uranium ISR projects occur within a 50 mile radius of the Proposed Project site as shown on Figure 3.1-6. These sites are listed below:

- Smith Ranch-Highland Uranium Project (SUA-1548, Power Resources, Inc.) - The Smith Ranch plant is located in T36N, R74W, Section 36 (37 miles SSE of the Proposed Reno Creek Project) and is operational. The Highland plant is located in T36N, R72W, Section 29 (39 miles SSE of the Proposed Project) and is currently on standby status. Three satellite ion exchange facilities are in operation and two more are planned for construction in the Smith Ranch-Highland license area;
- Moore Ranch Project (SUA-1596 Uranium One Americas, Inc.) – The Moore Ranch Project is located in Campbell County, T41N, R74W, Section 35 (Eight miles SW of the Proposed Project). This project has an approved materials license;

- Nichols Ranch Project (SUA-1597 Uranerz Energy Corp.) The Nichols Ranch Project is located in Johnson County, T43N, R76W, Section 17 (16 miles SW of the Proposed Reno Creek Project) and currently the CPP is in construction. The Hank satellite plant is located in Campbell County, T44N, R75W Section 6 (12 miles SW of the Proposed Reno Creek Project area) and currently is under construction;
- Willow Creek Project (SUA-1341 Uranium One Americas, Inc.) - The Christensen Ranch satellite is located in Johnson County, T44N, R76W, Section 7 (19 miles NNW of the Proposed Reno Creek Project) and the Irigaray central plant is located in Johnson County, T45N, R77W, Section 9 (26 miles NNW of the Proposed Reno Creek Project). Both of these sites are in operation;
- North Butte Project (SUA-1548, Power Resources Inc.) - The North Butte Project is located in Campbell County, T44N, R76W, Section 24 (16 miles NNW of the Proposed Reno Creek Project). This is a proposed satellite project for the Smith Ranch/Highland project and is not constructed or in operation, but is in timely renewal with applications submitted early in 2012; and
- Ruth Project (SUA-1548, Power Resources, Inc.)- The Ruth Project is located in Johnson County, T42N, R77W, Section 23 (12 miles W/WNW of the Proposed Project). This is a proposed satellite project for the Smith Ranch-Highland project and is not constructed or in operation, but is in timely renewal with applications submitted early in 2012.

The nearest operational ISR CPP is the Willow Creek site, located approximately 17 miles northwest of the Proposed Project area. The Smith Ranch facility is in operations and is located in Converse County about 40 miles south of the Proposed Project area (U.S. NRC 2007, Wise Uranium 2007).

Table 3.1-1: Land Use within Five Miles of the Proposed Project Area

Land Use Classification	Approximate Area and Percent of Total	
	Project Area	Study Area (5-mile buffer)
Non-Agricultural Land	6,019.6 acres (99.4%)	96,061.4 acres (92.3%)
Non-Irrigated Cropland	0.0 acres (0.0%)	7,604.4 acres (7.3%)
Reservoirs	8.4 acres (0.2%)	241.4 acres (0.2%)
Transportation	24 acres (0.4%)	131.6 (0.1%)
Industrial	5.0 acres (0.1%)	5.0 acres (0.1%)

Table 3.1-2: Livestock Inventory for Campbell County, 2007

Type of Livestock	Number	Percent of Total	Animal Units[1] Pounds	Percent
All Cattle	76,835	70.7	76,835	92.4
Breeding Sheep and Lambs	31,792	29.3	6358.4	7.6
Total Animals	108,627	100	83,193	100

[1] Animal unit conversions: 1 cow = 1,000 lb; 1 sheep = 200 lb

Source: USDA-NASS 2011

Table 3.1-3: Distance to the Nearest Residence and Site Boundary for Each Compass Sector

Sector	Distance from Project Center to Nearest Site Boundary (miles)	Distance from Site Boundary to Nearest Residence (miles)	Distance from Project Center to Nearest Residence (miles)
N	1.04	>2.0	>5.0
NNE	1.07	2.69	4.74
NE	2.18	> 2.0	>5.0
ENE	2.34	1.70	4.11
E	2.03	> 2.0	>5.0
ESE	0.90	1.12	3.18
SE	0.87	> 2.0	>5.0
SSE	0.76	> 2.0	>5.0
S	0.77	> 2.0	>5.0
SSW	0.90	> 2.0	>5.0
SW	2.09	> 2.0	>5.0
WSW	1.93	> 2.0	>5.0
W	1.50	> 2.0	>5.0
WNW	0.82	>2.0	>5.0
NW	0.92	0.42	1.50
NNW	0.95	> 2.0	>5.0

Note: The distance from the project center to the site boundaries are measured along each 22 1/2-degree sector centered on the 16 cardinal compass points, per NUREG-1569 Section 2.2-1 while the distance from the residences to the nearest site boundaries are the closest straight line distances. The sum of these two values (columns 1 and 2) generally does not equal the straight line distance from the project center to the residences (column 3).

Source: WYGISC.

Table 3.1-4: Nearby Recreational Areas

Name of Recreational Facility	Types of Activities Available	Distance from Project Area	Direction
Wright (WY) Rec Center	Swimming, gymnasium, weight room, racquetball, picnic area, playgrounds	7.5 miles	E
Thunder Basin National Grassland	Biking, camping, fishing, hiking/backpacking, hunting, horseback riding, off-road vehicles	[1]within project	---
Crazy Woman Campground	RV & tent spaces, playground, basketball, volleyball, horseshoes, hiking, swimming	41 miles	N
High Plains Campground	Fishing, swimming, golf, hiking, RV spaces, playground	41 miles	N
Campbell County Rec Center	Swimming, indoor climbing wall, weight room, indoor tennis, basketball, racquetball	41 miles	N
Bozeman Trail	Museums and historical sites	12 miles	W
Fort Reno	Museum tour and historical site	38 miles	NW
Powder River Campground	RV and tent spaces, fishing, hiking, hunting, off-road vehicles, horseback riding, picnic area	47 miles	W

[1]Although the Thunder Basin National Grassland exists within the Proposed Project area, all lands encompassed by the Grassland are Private. Therefore, none of the mentioned activities are allowed within, nor near, the Proposed Project area.

Source: WYGISC (2011)

Table 3.1-5: All Oil and Gas Wells within Five-Miles of the Proposed Reno Creek Project

API #	Company	Well #	Well Name	Oil/Gas Field	Producing Formation	Total Depth	PB	TD Formation	Class[1]	Status[2]	Township-Range-Section-Quarter-Quarter	Longitude	Latitude	Status Date	Spud Date	Completion Date
49-005-23773	WOODS PETROLEUM CORPORATION	1	ARCHIBALD	ARCHIBALD	FRONTIER	12677	11368	MORRISON	O	PA	42N 74W 35 NW SW	-105.722490	43.566970	19860831	19741016	19750324
49-005-24856	MONCRIEF W A JR	36-2	BATES CR ST 67-18806	ARCHIBALD	MUDDY	12566	0	MORRISON	O	PA	42N 74W 36 SW SW	-105.703130	43.563380	20020516	19771130	19770205
49-005-24927	MONCRIEF W A JR	25-1	TURNER FEE	ARCHIBALD	Dakota	12512	0	FUSON	O	PA	42N 74W 25 SW SW	-105.702360	43.577900	19921013	19780313	19780622
49-005-25102	WOODS PETROLEUM CORPORATION	26-1	CRANMER FEDERAL	ARCHIBALD		12558	0	LAKOTA	O	PA	42N 74W 26 SW NE	-105.712930	43.584790	19781204	19780926	19781126
49-005-25164	WOODS PETROLEUM CORPORATION	24-1	TURNER	ARCHIBALD	FRONTIER	12580	12569	LAKOTA	O	PA	42N 74W 24 SW SW	-105.699890	43.594100	19950123	19790207	19790412
49-005-29841	BASS ENTERPRISES PRODUCTION CO	1	UTC UNIT	ARCHIBALD		12647	0	MORRISON	O	PA	42N 74W 23 SW NE	-105.711490	43.599210	19900409	19900221	19900327
49-005-28746	MONCRIEF W A JR	11-1	MANION PATENTED	ARCHIBALD	FRONTIER	12642	0	MORRISON	O	PO	42N 74W 11 NW SE	-105.712040	43.624800	19860408	19860220	19860313
49-005-35842	BALLARD PETROLEUM HOLDINGS LLC	33-3H	IBERLIN RANCH	ARCHIBALD	FRONTIER	12396	12193	FRONTIER	O	PO	42N 74W 3 NW SE	-105.731530	43.639720	20011029	19991015	20000427
49-005-28148	APACHE CORPORATION	30-10	NEELEY	BUCK DRAW		12527	0	MORRISON	O	PA	42N 73W 30 NW SE	-105.671930	43.581540	19850829	19850321	19850425
49-005-29261	MONCRIEF W A JR	25-2	TURNER	BUCK DRAW NORTH		12500	0	LAKOTA	O	PA	42N 74W 25 NW SE	-105.690070	43.580690	19871224	19871129	19871220
49-005-27836	MERIT ENERGY COMPANY	23-31	BUCK DRAW NORTH UNIT	BUCK DRAW NORTH	Dakota	12530	12385	MORRISON	G	PG	42N 73W 31 C SW	-105.677710	43.566530	20040527	19841121	19850205
49-005-28383	MERIT ENERGY COMPANY	32-36	NBDU	BUCK DRAW NORTH	Dakota	12585	12493	LAKOTA	O	PO	42N 74W 36 SW NE	-105.690260	43.571930	19991101	19850724	19850907
49-005-29031	MERIT ENERGY COMPANY	41-1	NBD	BUCK DRAW NORTH	Dakota	12555	11743	FRONTIER	O	PO	41N 74W 1 NE NE	-105.686040	43.560700	20051215	19870410	19870312
49-005-07813	LINC ENERGY OPERATIONS INC	7-MW02-UB-364574	WELL	BUFF	WYODAK	1210	0		MW	MW	45N 74W 36 SW SE	-105.698680	43.731620	20110307		
49-005-07814	LINC ENERGY OPERATIONS INC	1-MW04-WY-364474	WELL	BUFF	WYODAK	1150	0		MW	MW	44N 74W 36 NE NE	-105.688050	43.750230	20110307		
49-005-07809	LINC ENERGY OPERATIONS INC	7-MW11-S	WELL	BUFF LMU	Surface ground water	53	0		MW	MW	44N 74W 36 SW NE	-105.694980	43.744860	20990909		
49-005-07810	LINC ENERGY OPERATIONS INC	7-MWQW-FX	WELL	BUFF LMU	FELIX COAL	148	0		MW	MW	44N 74W 36 SW NE	-105.694920	43.744660	20990909		
49-005-07811	LINC ENERGY OPERATIONS INC	7-MW13-OB	WELL	BUFF LMU	FT UNION SANDSTONE	1190	0		MW	MW	44N 74W 36 SW NE	-105.695580	43.744920	20990909		
49-005-07812	LINC ENERGY OPERATIONS INC	7MW15-UN	WELL	BUFF LMU	FT UNION SANDSTONE	1210	0		MW	MW	44N 74W 36 SW NE	-105.695230	43.744750	20990909		
49-005-25604	LOUISIANA LAND & EXPLORATION CO	1	MARQUISS	BUTTE	Parkman	8525	0	Sussex	O	PA	44N 73W 32 SW SW	-105.663300	43.738540	19950208	19800612	19800701
49-005-25688	LOUISIANA LAND & EXPLORATION CO	32-31	MARQUIS FEE	BUTTE	Parkman	7662	0	Parkman	O	PA	44N 73W 31 SW NE	-105.672470	43.745910	0	19801001	19801014
49-005-24551	XTO ENERGY INC	3161	STATE 67-18841	HARTZOG DRAW	SHANNON	9719	0	SHANNON	O	PA	43N 74W 16 NW NW	-105.762640	43.705170	20010809	19770401	19770513
49-005-24891	WOODS PETROLEUM CORPORATION	18-1	VAN BUGGENUM	HARTZOG DRAW		9920	0	SHANNON	O	PA	43N 74W 18 NE SE	-105.787610	43.697410	19780124	19780107	19780124
49-005-24981	BP AMERICA PRODUCTION COMPANY	1	AMOCO-FEDERAL	HARTZOG DRAW		9754	0	SHANNON	O	PA	43N 74W 17 SW NE	-105.770080	43.703700	19780609	19780520	19780608
49-005-21021	DEVON ENERGY PRODUCTION COMPANY LP	86-1	MARQUISS W-241794	HOUSE CREEK	Sussex	11384	0	FUSON	I	AI	44N 73W 25 SW SW	-105.580390	43.752910	20021104	19690112	19690303
49-005-22892	DEVON ENERGY PRODUCTION COMPANY LP	88-1	HOUSE CREEK	HOUSE CREEK	Sussex	8480	8338	Sussex Sandstone	I	AI	44N 73W 35 NW NE	-105.588200	43.749400	20010119	19711215	19711226
49-005-23208	DEVON ENERGY PRODUCTION COMPANY LP	117-1	FED W-0325474	HOUSE CREEK	Sussex	8353	0	Sussex	I	AI	43N 72W 6 NE NW	-105.557090	43.734970	20050631	19721022	19721204
49-005-23243	DEVON ENERGY PRODUCTION COMPANY LP	109-1	STATE 68-1319	HOUSE CREEK	Sussex	8410	0	Sussex	I	AI	44N 73W 36 C SE	-105.567490	43.740520	19920429	19730106	19730115
49-005-23478	DEVON ENERGY PRODUCTION COMPANY LP	126-1	WRIGHT W-0325474	HOUSE CREEK	Sussex	8265	0	Sussex	I	AI	43N 72W 5 SW SW	-105.540310	43.724740	20050631	19731111	19731125
49-005-23499	DEVON ENERGY PRODUCTION COMPANY LP	134-1	COSNER	HOUSE CREEK	Sussex	8204	0	Sussex	I	AI	43N 72W 8 SW NE	-105.529960	43.717140	19930119	19731226	19740210
49-005-25198	DEVON ENERGY PRODUCTION COMPANY LP	84-1	FRYE B W-0323688	HOUSE CREEK	Sussex	8470	0	Sussex	I	AI	44N 73W 26 NE SW	-105.596630	43.755740	19920406	19790418	19790510
49-005-33085	DEVON ENERGY PRODUCTION COMPANY LP	140-3	HOUSE CREEK UNIT	HOUSE CREEK	Sussex	8300	0	Sussex Sandstone	I	AI	43N 72W 9 SW SW	-105.521390	43.708330	20051116	19980925	19981014
49-005-61015	DEVON ENERGY PRODUCTION COMPANY LP	3643-1D	STATE WRIGHT	HOUSE CREEK	Dakota	11598	0		O	NI	44N 73W 36 SW NW	-105.582500	43.745670	20110308	20101201	20110320
49-005-23153	LUFF EXPLORATION	1-2	WOODS-FEDERAL	HOUSE CREEK		8470	0	Sussex	O	PA	43N 73W 2 NE NE	-105.585610	43.734760	19720906	19720828	19720906
49-005-23518	LUFF EXPLORATION	1-35	WRIGHT	HOUSE CREEK		8380	0	Sussex	O	PA	44N 73W 35 NE NE	-105.585840	43.748990	19740324	19740312	19740324
49-005-21255	DEVON ENERGY PRODUCTION COMPANY LP	89-1	STATE 68-1319	HOUSE CREEK	Sussex	8400	0	Sussex	O	PO	44N 73W 36 SW NW	-105.580180	43.745470	19930709	19690321	19690408
49-005-22825	DEVON ENERGY PRODUCTION COMPANY LP	83-1	HOUSE CREEK UNIT	HOUSE CREEK	Sussex	8475	0	Sussex	O	PO	44N 73W 27 NE SE	-105.605480	43.756640	19711111	19711011	19711112
49-005-23138	DEVON ENERGY PRODUCTION COMPANY LP	110-1	FED W-0195902	HOUSE CREEK	Sussex	8383	0	Sussex	O	PO	44N 72W 31 SW SW	-105.560600	43.739070	19890606	19720531	19720615
49-005-23333	DEVON ENERGY PRODUCTION COMPANY LP	118-1	FED W-0325474	HOUSE CREEK	Sussex	8272	0	Sussex	O	PO	43N 72W 6 SW NE	-105.550820	43.732590	19890515	19730322	19730513
49-005-23389	DEVON ENERGY PRODUCTION COMPANY LP	133-1	FEDERAL	HOUSE CREEK	Sussex	8321	0	Sussex	O	PO	43N 72W 8 NW NW	-105.540320	43.720530	0	19730628	19730727
49-005-23520	DEVON ENERGY PRODUCTION COMPANY LP	139-1	COSNER	HOUSE CREEK	Sussex	8279	0	Sussex	O	PO	43N 72W 8 C SE	-105.527440	43.712110	0	19740212	19740418
49-005-25200	DEVON ENERGY PRODUCTION COMPANY LP	119-1	WRIGHT W-0325474	HOUSE CREEK	Sussex	8253	0	Sussex	O	PO	43N 72W 5 NE NW	-105.542600	43.735510	19790602	19790321	19790530
49-005-32707	DEVON ENERGY PRODUCTION COMPANY LP	139-2	HOUSE CREEK	HOUSE CREEK	Sussex	8300	8255	Sussex	O	PO	43N 72W 8 NE SE	-105.523330	43.714440	19980720		19980619
49-005-32818	DEVON ENERGY PRODUCTION COMPANY LP	146-2	HOUSE CREEK UNIT	HOUSE CREEK	Sussex	8300	8365	Sussex	O	PO	43N 72W 16 SW NW	-105.519170	43.703890	19980928		19980824
49-005-33013	DEVON ENERGY PRODUCTION COMPANY LP	89-2	HOUSE CREEK UNIT	HOUSE CREEK	Sussex	8300	8371	Sussex Sandstone	O	PO	44N 73W 36 NE NW	-105.576190	43.748610	19981002		19980901
49-005-33691	DEVON ENERGY PRODUCTION COMPANY LP	109-2	HOUSE CREEK	HOUSE CREEK	Sussex	8300	8328	Sussex Sandstone	I	SI	44N 73W 36 NE SE	-105.564300	43.743300	20021120	19981207	19990115
49-005-60990	DEVON ENERGY PRODUCTION COMPANY LP	3643-1PH	ROCKY BUTTE	HOUSE CREEK	Parkman	12100	0		O	SP	44N 73W 36 SW NW	-105.582480	43.745500	20101223	20101223	20110114
49-005-61085	DEVON ENERGY PRODUCTION COMPANY LP	3643-2PH	ROCKY BUTTE	HOUSE CREEK	Parkman	12422	0		O	SP	44N 73W 36 SW SW	-105.582610	43.737060	20110228	20110303	
49-005-61131	DEVON ENERGY PRODUCTION COMPANY LP	3543-1PH	ROCKY BUTTE	HOUSE CREEK	Parkman	12459	0		O	SP	44N 73W 35 NE NE	-105.583640	43.749800	20110324	20110324	
49-005-23357	DEVON ENERGY PRODUCTION COMPANY LP	125-1	WRIGHT A	HOUSE CREEK	Sussex	8285	0	Sussex	I	SR	43N 72W 6 NW SE	-105.550090	43.727340	20101028	19730503	19730601
49-005-20576	DEVON ENERGY PRODUCTION COMPANY LP	90-1	STATE 68-1319	HOUSE CREEK	Sussex	11486	0	MORRISON	O	TA	44N 73W 36 SW NE	-105.570290	43.745690	20030303	19680630	19680809
49-005-24915	ANADARKO E AND P COMPANY LP	1	KAMON 22-14	KAMON	Parkman	9565	7944	Parkman	O	PA	42N 73W 14 SE NW	-105.596340	43.614310	19841214	19780205	19780608
49-005-39839	YATES PETROLEUM CORPORATION	42	GROVES SWD	K-BAR	Parkman	7800	7580	Parkman	D	AI	43N 73W 8 SE NW	-105.658880	43.716940	20081016	20000325	20000531
49-005-29105	TRUE OIL LLC	22-22	WILLARD	K-BAR	Dakota	12090	0	MORRISON	O	PA	43N 73W 22 SE NW	-105.610560	43.687310	19960611	19870808	19870907
49-005-31509	BISSELL OIL OPERATING CO INC	1-17	NOAH GROVES	K-BAR		7750	0	Parkman	O	PA	43N 73W 17 NW NW	-105.662650	43.705300	20070328	19970425	19970502
49-005-31820	YATES PETROLEUM CORPORATION	8	GROVES	K-BAR	Parkman and Turner	10728	10668	TURNER	G	PG	43N 73W 7 SE SE	-105.669560	43.710970	19991008	19970720	19990824
49-005-39686	YATES PETROLEUM CORPORATION	2	TED	K-BAR	Parkman and Turner	10450	0	TURNER	O	PG	43N 73W 24 SE NE	-105.566100	43.686900	20010417	20000315	20000510
49-005-24167	BLACK BEAR OIL CORPORATION	1-21	ANDERMAN	K-BAR	Parkman	8868	0	Sussex	O	PO	43N 73W 21 SE SE	-105.626580	43.679780	19760423	19760211	19760520
49-005-24260	MARLIN OIL COMPANY LLC	1-23	SKYLINE FEDERAL	K-BAR	Parkman	7717	0	Parkman	O	PO	43N 73W 23 NE SE	-105.585650	43.683280	19861231	19760613	19760815
49-005-24517	DNR OIL & GAS INC	1-7	ALL NIGHT CREEK	K-BAR	Parkman	9500	0	SHANNON	O	PO	43N 73W 7 NE SW	-105.677090	43.712590	19770609	19770223	19770602
49-005-31281	YATES PETROLEUM CORPORATION	1	GROVES	K-BAR	Parkman and Turner	11785	11365	LAKOTA	O	PO	43N 73W 9 NW NW	-105.641620	43.719550	19980120	19961022	19970424
49-005-31401	YATES PETROLEUM CORPORATION	2	GROVES	K-BAR	Parkman, Turner, Muddy	11875	11668	LAKOTA	O	PO	43N 73W 6 SE SW	-105.678100	43.723520	20091114	19961119	19970218
49-005-31497	YATES PETROLEUM CORPORATION	1	BUNN	K-BAR	Parkman, Turner, Sussex	11700	11630	LAKOTA	O	PO	43N 73W 13 SE NE	-105.566240	43.701420	20090309	19970913	19970410
49-005-31537	YATES PETROLEUM CORPORATION	1	AMPOLEX STATE	K-BAR	Parkman and Turner	11891	11750	Dakota	O	PO	43N 73W 16 SE NW	-105.638940	43.702330	19970804	19970203	19970710

Table 3.1-5: All Oil and Gas Wells within Five-Miles of the Proposed Reno Creek Project (cont.)

API #	Company	Well #	Well Name	Oil/Gas Field	Producing Formation	Total Depth	PB	TD Formation	Class[1]	Status[2]	Township-Range-Section-Quarter-Quarter	Longitude	Latitude	Status Date	Spud Date	Completion Date
49-005-31613	YATES PETROLEUM CORPORATION	3	GROVES	K-BAR	Parkman, Turner, Niobrara	10700	10550	TURNER	O	PO	43N 73W 6 SE SE	-105.667410	43.723720	19971120	19970616	19970702
49-005-31625	YATES PETROLEUM CORPORATION	6	ROCKY BUTTE	K-BAR	Parkman and Turner	10659	10557	TURNER	O	PO	43N 73W 4 NW NW	-105.641420	43.735110	20090928	19970324	19970601
49-005-31626	YATES PETROLEUM CORPORATION	4	GROVES	K-BAR	Parkman, Turner, Niobrara	10662	0	TURNER	O	PO	43N 73W 6 SW NE	-105.671810	43.731800	20100121	19970331	19970816
49-005-31635	YATES PETROLEUM CORPORATION	5	GROVES	K-BAR	Parkman and Turner	10690	10601	TURNER	O	PO	43N 73W 6 SE NW	-105.678160	43.730990	19971031	19970607	19970929
49-005-31798	YATES PETROLEUM CORPORATION	1	OPAL	K-BAR	Parkman and Turner	10659	10606	TURNER	O	PO	44N 73W 33 SW SW	-105.641070	43.738990	19971124	19970707	19970717
49-005-31825	YATES PETROLEUM CORPORATION	9H	BELLE FEDERAL COM	K-BAR	Parkman	9269	0	Parkman COAL	O	PO	43N 73W 5 SE SW	-105.657500	43.723610	20001207	20000510	20000621
49-005-31857	YATES PETROLEUM CORPORATION	1	ICKES COM	K-BAR	Parkman and Turner	10848	10751	TURNER	O	PO	43N 73W 18 SW NW	-105.680110	43.703580	19980123	19970907	19971223
49-005-39685	YATES PETROLEUM CORPORATION	18	K-BAR STATE	K-BAR	Parkman	7850	7809	Parkman	O	PO	44N 74W 36 SE NW	-105.698330	43.746110	20100924	20000219	20000403
49-005-39760	YATES PETROLEUM CORPORATION	1H	STARLIGHT FEDERAL	K-BAR	Parkman	9168	0	Parkman	O	PO	43N 73W 7 SE NE	-105.666660	43.716110	20100915	20000406	20000524
49-005-56671	BALLARD PETROLEUM HOLDINGS LLC	31-29	DRAKE	K-BAR	Parkman	8076	8030	STEEL	O	PO	43N 73W 29 NW NE	-105.652720	43.676580	20080325	20060814	20061114
49-005-31824	YATES PETROLEUM CORPORATION	1	THIELEN	K-BAR	Parkman-TU	10760	10696	TURNER	O	SI	43N 73W 17 NE NE	-105.649020	43.704300	20081029	19970731	19980126
49-005-27979	JUSTICE OIL & GAS LLC	33-26	LAUR	NIGHT CREEK	Turner	12454	0	MORRISON	O	PO	43N 74W 26 NW SE	-105.712500	43.668700	19850315	19850114	19850611
49-005-24411	REUNION ENERGY COMPANY	1-32	MARATHON-FEDERAL	SIEVERS		10125	0	SHANNON	O	PA	43N 74W 32 NW NW	-105.782410	43.660650	19770128	19770106	19770128
49-005-25573	FOREST OIL PERMIAN CORPORATION	34-34	HODGES-FEDERAL	SIEVERS		9820	0	SHANNON	O	PA	43N 74W 34 SW SE	-105.732820	43.650260	19810319	19801122	19810319
49-005-27593	MIDGARD ENERGY COMPANY	33-33	DONOHUE-FEDERAL	SIEVERS		9900	0	SHANNON	O	PA	43N 74W 33 NW SE	-105.752750	43.653960	19840721	19840703	19840720
49-005-24095	BLACKJACK OIL INC	33-1	BURLEIGH TAYLOR	SIEVERS	Shannon	11745	0	BELLE FOUR	O	PO	43N 74W 33 SW SW	-105.762910	43.650370	0	19751016	19760102
49-005-28883	BURLINGTON RESOURCES OIL & GAS COMPANY	11-33	UNDERWOOD RANCH-FED	TUIT DRAW		10140	0	TURNER	O	PA	43N 72W 33 NW NW	-105.518450	43.661070	19860909	19860827	19860909
49-005-28617	BLACK BEAR OIL CORPORATION	29-1	COSNER FEE	TUIT DRAW	Turner	11495	0	MORRISON	O	PO	43N 72W 29 SW NE	-105.528540	43.674790	19851203	19850203	19860205
49-005-30414	BLACKJACK OIL INC	1-20	COSNER	TUIT DRAW	Turner	10400	10266	TURNER	O	PO	43N 72W 20 SE SE	-105.526060	43.680740	20001213	19921029	19921126
49-005-30728	BLACKJACK OIL INC	2-20	COSNER	TUIT DRAW	Parkman and Turner	10340	10281	TURNER	O	PO	43N 72W 20 NW NW	-105.538930	43.689820	20001222	19940915	19941128
49-005-30860	BLACKJACK OIL INC	1-18	COSNER	TUIT DRAW	Turner	10400	0	TURNER	O	PO	43N 72W 18 SE SE	-105.546450	43.695510	19980608	19950622	19950719
49-005-30866	YATES PETROLEUM CORPORATION	1	COSNER	TUIT DRAW	Parkman and Turner	10358	10255	TURNER	O	PO	43N 72W 19 C NE	-105.548600	43.689580	19980116	19960317	19960518
49-005-28293	SM ENERGY COMPANY	22-32	TIGER	TURNERCREST	Dakota	12562	0	MORRISON	G	PG	42N 73W 32 SE NW	-105.658920	43.572340	19850905	19850529	19850905
49-005-28602	SM ENERGY COMPANY	33-29	OLE PETERSON	TURNERCREST	Dakota	12525	0	MORRISON	G	PG	42N 73W 29 NW SE	-105.651870	43.581530	20070514	19851215	19860521
49-005-24984	KAISER FRANCIS OIL CO	2-1	PINE TREE RANCH	TURNERCREST	Frontier	12625	0	FUSON	O	PO	41N 74W 2 SE NE	-105.707410	43.556080	19780817	19780525	19780817
49-005-26880	DEVON ENERGY PRODUCTION COMPANY LP	19-15	MOORE	TURNERCREST	Dakota	12530	12450	LAKOTA	G	SR	42N 73W 19 SW SE	-105.670000	43.593510	20050421	19821222	19830412
49-005-07748	LINC ENERGY OPERATIONS INC	1-MW-S	WELL	WC	surface ground water	50	0		MW	AP	44N 74W 36 NE NE	-105.687770	43.749350	20990909		
49-005-07749	LINC ENERGY OPERATIONS INC	1-MW-FX	WELL	WC	FELIX COAL	100	0		MW	AP	44N 74W 36 NE NE	-105.687770	43.749220	20990909		
49-005-07750	LINC ENERGY OPERATIONS INC	1-MW-OB	WELL	WC	FORT UNION	1120	0		MW	AP	44N 74W 36 NE NE	-105.687770	43.749450	20990909		
49-005-61214	YATES PETROLEUM CORPORATION	29	K-BAR STATE	WC	Parkman	7835	0		O	AP	44N 74W 36 NW NE	-105.692270	43.749070	20110411		
49-005-61216	YATES PETROLEUM CORPORATION	31	K-BAR STATE	WC	Parkman	7825	0		O	AP	44N 74W 36 SE NE	-105.688870	43.746400	20110411		
49-005-61217	YATES PETROLEUM CORPORATION	32	K-BAR STATE	WC	Parkman	7855	0		O	AP	44N 74W 36 NW SE	-105.693970	43.741670	20110411		
49-005-61218	YATES PETROLEUM CORPORATION	33	K-BAR STATE	WC	Parkman	8000	0		O	AP	44N 74W 36 NW SW	-105.703940	43.741610	20110411		
49-005-61219	YATES PETROLEUM CORPORATION	34	K-BAR STATE	WC	Parkman	8000	0		O	AP	44N 74W 36 SE SW	-105.698870	43.738020	20110411		
49-005-61220	YATES PETROLEUM CORPORATION	35	K-BAR STATE	WC	Parkman	7825	0		O	AP	44N 74W 36 SE SE	-105.687670	43.738020	20110411		
49-005-07751	LINC ENERGY OPERATIONS INC	1-MW-UB	WELL	WC	FORT UNION SANDSTONE	1260	0		MW	MW	44N 74W 36 NE NE	-105.687980	43.749310	20990909		
49-005-07757	LINC ENERGY OPERATIONS INC	13-MW-S	WELL	WC	surface groundwater	50	0		MW	MW	44N 74W 36 SW SW	-105.703130	43.738060	20990909		
49-005-07758	LINC ENERGY OPERATIONS INC	13-MW-FX	WELL	WC	FELIX COAL	280	0		MW	MW	44N 74W 36 SW SW	-105.703130	43.738240	20990909		
49-005-07759	LINC ENERGY OPERATIONS INC	13-MW-OB	WELL	WC	FORT UNION sandstone	1230	0		MW	MW	44N 74W 36 SW SW	-105.703130	43.738420	20990909		
49-005-07760	LINC ENERGY OPERATIONS INC	13-MW-UB	WELL	WC	FORT UNION sandstone	1364	0		MW	MW	44N 74W 36 SW SW	-105.702940	43.738150	20990909		
49-005-07761	LINC ENERGY OPERATIONS INC	16-MW-S	WELL	WC	surface groundwter	50	0		MW	MW	44N 74W 36 SE SE	-105.688720	43.738300	20990909		
49-005-07762	LINC ENERGY OPERATIONS INC	16-MW-FX	WELL	WC	FELIX COAL	140	0		MW	MW	44N 74W 36 SE SE	-105.688730	43.738500	20990909		
49-005-07763	LINC ENERGY OPERATIONS INC	16-MW-OB	WELL	WC	FORT UNION sandstone	1090	0		MW	MW	44N 74W 36 SE SE	-105.688720	43.738140	20990909		
49-005-07764	LINC ENERGY OPERATIONS INC	16-MW-UB	WELL	WC	FORT UNION sandstone	1250	0		MW	MW	44N 74W 36 SE SE	-105.688480	43.738410	20990909		
49-005-07765	LINC ENERGY OPERATIONS INC	16-MW-WY	WELL	WC	WYODAK	1150	0		MW	MW	44N 74W 36 SE SE	-105.688480	43.738230	20990909		
49-005-07766	LINC ENERGY OPERATIONS INC	7-MW14-WY	WELL	WC	WYODAK	1200	0		MW	MW	44N 74W 36 SW NE	-105.695130	43.744750	20990909		
49-005-07789	LINC ENERGY OPERATIONS INC	7-MW01-WY-36457	WELL	WC	WYODAK	1205	0		MW	MW	45N 74W 36 SE NW	-105.698450	43.731780	20990909		
49-005-05024	NATIONAL COOPERATIVE REF ASSOC	1	GOVT	WC		8286	0	Parkman	O	PA	42N 74W 12 SE SE	-105.687170	43.621400	19610907	19610824	19610907
49-005-05026	ARROWHEAD EXPLORATION CO	1	E R WILLARD	WC		7887	0	Parkman	O	PA	43N 73W 26 NW NW	-105.600950	43.676100	19580829	19580810	19580829
49-005-05027	VESSELS TOM JR ETAL	1	WRIGHT	WC		8551	0	Sussex	O	PA	43N 73W 12 SE SE	-105.565460	43.709260	19620107	19611210	19620107
49-005-22834	WOODS PETROLEUM CORPORATION	12-1	WRIGHT	WC	Sussex	8500	0		O	PA	43N 73W 12 SE SE	-105.565460	43.709260	19720225		19711028
49-005-22918	WOODS PETROLEUM CORPORATION	6-1	WRIGHT	WC		8318	0	Sussex	O	PA	43N 72W 6 NE SW	-105.557640	43.726840	19720124	19720111	19720124
49-005-23013	WOODS PETROLEUM CORPORATION	1	WILLIAMS-FEDERAL	WC		11220	0	SKULL CREE	O	PA	43N 72W 17 SE NE	-105.525300	43.702590	19720706	19720616	19720706
49-005-23133	INEXCO OIL COMPANY	1	USA 29 PRE	WC		12248	0	SKULL CREE	O	PA	43N 74W 22 SW SW	-105.742620	43.679700	19720823	19720724	19720820
49-005-23865	KISSINGER PETROLEUM CORP	13-24	FEDERAL	WC		8914	0	Sussex	O	PA	42N 73W 24 SW SW	-105.580770	43.593300	19750318		19750318
49-005-24014	YATES PETROLEUM CORPORATION	1	RENO FLATS	WC		8568	0	Sussex	O	PA	42N 72W 6 NW NW	-105.560830	43.647590	19750811	19750725	19750810
49-005-24156	WOODS PETROLEUM CORPORATION	4-1	TAYLOR-A	WC		9948	0	SHANNON	O	PA	42N 74W 4 NW SE	-105.752480	43.639550	19760204	19760111	19760203
49-005-24181	WOODS PETROLEUM CORPORATION	28-1	LAUR-FEDERAL	WC		9880	0	SHANNON	O	PA	43N 74W 28 SW SW	-105.762860	43.664960	19760313	19760219	19760313
49-005-24281	LADD & LUKOWICZ	1	GOOD	WC		7685	0	Parkman	O	PA	43N 72W 18 NE SW	-105.555490	43.698480	19760715	19760629	19760715
49-005-24324	WOODS PETROLEUM CORPORATION	9-1	GOVT-TAYLOR	WC		10030	0	SHANNON	O	PA	42N 74W 9 NE SW	-105.757660	43.625100	19761021	19760928	19761017
49-005-24570	INEXCO OIL COMPANY	1-22	FEDERAL TODD	WC		9602	0	STEELE	O	PA	43N 74W 22 NW NW	-105.741460	43.689750	19770603	19770513	19770602
49-005-24601	SOUTHLAND ROYALTY COMPANY	1-12	ALL NIGHT CREEK-FED	WC		7940	0	Parkman	O	PA	43N 74W 12 NE NE	-105.687780	43.720210	19770508	19770426	19770506
49-005-24699	WOODS PETROLEUM CORPORATION	28-1	BIRDSONG FEDERAL	WC		11654	0	FRONTIER	O	PA	42N 74W 28 NE SE	-105.749600	43.579910	19770916	19770618	19770916
49-005-24704	BP AMERICA PRODUCTION COMPANY	1	SINADIN	WC		9456	0	SHANNON	O	PA	43N 73W 31 SW SE	-105.671470	43.650590	19770727	19770626	19770727

Table 3.1-5: All Oil and Gas Wells within Five-Miles of the Proposed Reno Creek Project (cont.)

API #	Company	Well #	Well Name	Oil/Gas Field	Producing Formation	Total Depth	PB	TD Formation	Class[1]	Status[2]	Township-Range-Section-Quarter-Quarter	Longitude	Latitude	Status Date	Spud Date	Completion Date
49-005-24801	WOODS PETROLEUM CORPORATION	1	BATES CREEK UNIT	WC		9850	0	CRETACEOUS	O	PA	42N 74W 24 SW NW	-105.700690	43.601390	19771025	19771007	19771022
49-005-24835	INEXCO OIL COMPANY	1-22	TODD-SKYLAND	WC		9468	0	SHANNON	O	PA	43N 74W 22 NE NE	-105.728860	43.689770	19771118	19771101	19771116
49-005-25146	CHAMPION VENTURES INC	3	SPRING CREEK 32-18	WC		9702	0	SHANNON	O	PA	42N 73W 18 SW NE	-105.672530	43.614010	19790307	19790209	19790306
49-005-25924	LOUISIANA LAND & EXPLORATION CO	14-9	ICKES	WC	Parkman	8055	0	Parkman	O	PA	43N 73W 9 SW SW	-105.642130	43.709180	19820711	19810225	19810320
49-005-27403	SOUTHLAND ROYALTY COMPANY	1-14	WRIGHT-FEDERAL	WC		11946	0	MORRISON	O	PA	43N 73W 14 NW NE	-105.590870	43.704870	19840304	19840125	19840304
49-005-27626	APACHE CORPORATION	27-6	APACHE TURNER	WC		12204	0	MORRISON	O	PA	42N 73W 27 SE NW	-105.619170	43.586780	19840707	19840430	19840614
49-005-28213	LOUISIANA LAND & EXPLORATION CO	34-15	BASSINGER-FEDERAL	WC		12752	0	MORRISON	O	PA	42N 74W 15 SW SE	-105.732560	43.606920	19850417	19850314	19850412
49-005-28702	PRENALTA CORPORATION	33-20	BOBCAT-FEDERAL	WC		8117	0	Parkman	O	PA	42N 73W 20 NW SE	-105.651700	43.595940	19860309	19860228	19860309
49-005-28909	MONCRIEF W A JR	13-1	TURNER-FEDERAL	WC		12561	0	LAKOTA	O	PA	42N 74W 13 NW SE	-105.692530	43.610980	19861030	19861006	19861029
49-005-29240	ENCANA OIL AND GAS USA INC	23-31	CARLOTTA	WC		13800	0	MINNELUSA	O	PA	43N 73W 31 NE SW	-105.677280	43.654520	19960424	19900727	19871213
49-005-30187	AXEM RESOURCES INC	11-21	SPRING CREEK	WC		12400	0	MORRISON	O	PA	42N 73W 21 NE SW	-105.636080	43.594890	19921102	19910330	
49-005-30900	DAVIS PETROLEUM CORPORATION	1	ATWOOD	WC		9934	0	SHANNON	O	PA	43N 74W 29 NE SW	-105.777260	43.668520	20000424	19950911	19950921
49-005-32355	BALLARD PETROLEUM HOLDINGS LLC	23-24	FEDERAL	WC		12039	0		G	PA	42N 73W 24 NE SW	-105.575900	43.596490	19980423	19980208	19980311
49-005-37518	YATES PETROLEUM CORPORATION	1	BUCKIN BRONC FED	WC	Parkman and Turner	12114	11210	Parkman/TURNER	O	PO	43N 73W 20 NW SE	-105.652140	43.685170	20050602	19991115	20001207
49-005-45589	YATES PETROLEUM CORPORATION	1H	RAGING BULL COM	WC	Parkman	10690	10204	TURNER	O	PO	43N 73W 19 SE SE	-105.668020	43.679970	20031124	20020929	20031123
49-005-60530	YATES PETROLEUM CORPORATION	5	BORIS FEDERAL COM	WC	Parkman and Turner	10786	10693	TURNER	O	PO	43N 73W 9 SW SE	-105.631860	43.708950	20100311	20091121	20100310

[1]Classification Codes
- O = Oil Well
- G = Gas Well
- I = Injector Well
- MW = Monitor Well

[2]Status Codes
- PO = Producing Oil Well
- PG = Producing Gas Well
- SI = Shut - In
- TA = Temporarily Abandoned
- PA = Permanently Abandoned
- AI = Active Injector
- NI = Notice of Intent to Abandon
- SR = Subsequent Report of Abandonment
- AP = Permit to Drill

Source: WOGCC (2012)

Table 3.1-6: Producing Oil and Gas Wells within Five-Miles of the Proposed Reno Creek Project

API #	Company	Well #	Well Name	Oil/Gas Field	Producing Formation	Total Depth	PB	TD Formation	Class[1]	Status[2]	Township-Range-Section-Quarter-Quarter	Longitude	Latitude	Status Date	Spud Date	Completion Date
49-005-35842	BALLARD PETROLEUM HOLDINGS LLC	33-3H	IBERLIN RANCH	ARCHIBALD	Frontier	12,396	12,193	FRONTIER	O	PO	42N 74W 3 NW SE	-105.731530	43.639720	20011029	19991015	20000427
49-005-28746	MONCRIEF W A JR	11-1	MANION PATENTED	ARCHIBALD	Frontier	12,642	0	MORRISON	O	PO	42N 74W 11 NW SE	-105.712040	43.624800	19860408	19860220	19860313
49-005-27836	MERIT ENERGY COMPANY	23-31	BUCK DRAW NORTH UNIT	BUCK DRAW NORTH	Dakota	12,530	12,385	MORRISON	G	PG	42N 73W 31 C SW	-105.677710	43.566530	20040527	19841121	19850205
49-005-29031	MERIT ENERGY COMPANY	41-1	NBD	BUCK DRAW NORTH	Dakota	12,555	11,743	FRONTIER	O	PO	41N 74W 1 NE NE	-105.686040	43.560700	20051215	19870410	19870312
49-005-28383	MERIT ENERGY COMPANY	32-36	NBDU	BUCK DRAW NORTH	Dakota	12,585	12,493	LAKOTA	O	PO	42N 74W 36 SW NE	-105.690260	43.571930	19991101	19850724	19850907
49-005-23499	DEVON ENERGY PRODUCTION COMPANY LP	134-1	COSNER	HOUSE CREEK	Sussex	8,204	0	SUSSEX	I	AI	43N 72W 8 SW NE	-105.529960	43.717140	19930119	19731226	19740210
49-005-25200	DEVON ENERGY PRODUCTION COMPANY LP	119-1	WRIGHT W-0325474	HOUSE CREEK	Sussex	8,253	0	SUSSEX	O	PO	43N 72W 5 NE NW	-105.542600	43.735510	19790602	19790321	19790530
49-005-23478	DEVON ENERGY PRODUCTION COMPANY LP	126-1	WRIGHT W-0325474	HOUSE CREEK	Sussex	8,265	0	SUSSEX	I	AI	43N 72W 5 SW SW	-105.540310	43.724740	20050631	19731111	19731125
49-005-23333	DEVON ENERGY PRODUCTION COMPANY LP	118-1	FED W-0325474	HOUSE CREEK	Sussex	8,272	0	SUSSEX	O	PO	43N 72W 6 SW NE	-105.550820	43.732590	19890515	19730322	19730513
49-005-23520	DEVON ENERGY PRODUCTION COMPANY LP	139-1	COSNER	HOUSE CREEK	Sussex	8,279	0	SUSSEX	O	PO	43N 72W 8 C SE	-105.527440	43.712110	0	19740212	19740418
49-005-32707	DEVON ENERGY PRODUCTION COMPANY LP	139-2	HOUSE CREEK	HOUSE CREEK	Sussex	8,300	8,255	SUSSEX	O	PO	43N 72W 8 NE SE	-105.523330	43.714440	19980720		19980619
49-005-32818	DEVON ENERGY PRODUCTION COMPANY LP	146-2	HOUSE CREEK UNIT	HOUSE CREEK	Sussex	8,300	8,365	SUSSEX	O	PO	43N 72W 16 SW NW	-105.519170	43.703890	19980928		19980824
49-005-33013	DEVON ENERGY PRODUCTION COMPANY LP	89-2	HOUSE CREEK UNIT	HOUSE CREEK	Sussex	8,300	8,371	SUSSEX SANDSTONE	O	PO	44N 73W 36 NE NW	-105.576190	43.748610	19981002		19980901
49-005-33085	DEVON ENERGY PRODUCTION COMPANY LP	140-3	HOUSE CREEK UNIT	HOUSE CREEK	Sussex	8,300	0	SUSSEX SANDSTONE	I	AI	43N 72W 9 SW SW	-105.521390	43.708330	20051116	19980925	19981014
49-005-23389	DEVON ENERGY PRODUCTION COMPANY LP	133-1	FEDERAL	HOUSE CREEK	Sussex	8,321	0	SUSSEX	O	PO	43N 72W 8 NW NW	-105.540320	43.720530	0	19730628	19730727
49-005-23208	DEVON ENERGY PRODUCTION COMPANY LP	117-1	FED W-0325474	HOUSE CREEK	Sussex	8,353	0	SUSSEX	I	AI	43N 72W 6 NE NW	-105.557090	43.734970	20050631	19721022	19721204
49-005-23138	DEVON ENERGY PRODUCTION COMPANY LP	110-1	FED W-0195902	HOUSE CREEK	Sussex	8,383	0	SUSSEX	O	PO	44N 72W 31 SW SW	-105.560600	43.739070	19890606	19720531	19720615
49-005-21255	DEVON ENERGY PRODUCTION COMPANY LP	89-1	STATE 68-1319	HOUSE CREEK	Sussex	8,400	0	SUSSEX	O	PO	44N 73W 36 SW NW	-105.580180	43.745470	19930709	19690321	19690408
49-005-23243	DEVON ENERGY PRODUCTION COMPANY LP	109-1	STATE 68-1319	HOUSE CREEK	Sussex	8,410	0	SUSSEX	I	AI	44N 73W 36 C SE	-105.567490	43.740520	19920429	19730106	19730115
49-005-25198	DEVON ENERGY PRODUCTION COMPANY LP	84-1	FRYE B W-0323688	HOUSE CREEK	Sussex	8,470	0	SUSSEX	I	AI	44N 73W 26 NE SW	-105.596630	43.755740	19920406	19790418	19790510
49-005-22825	DEVON ENERGY PRODUCTION COMPANY LP	83-1	HOUSE CREEK UNIT	HOUSE CREEK	Sussex	8,475	0	SUSSEX	O	PO	44N 73W 27 NE SE	-105.605480	43.756640	19711111	19711011	19711112
49-005-22892	DEVON ENERGY PRODUCTION COMPANY LP	88-1	HOUSE CREEK	HOUSE CREEK	Sussex	8,480	8,338	SUSSEX SANDSTONE	I	AI	44N 73W 35 NW NE	-105.588200	43.749400	20010119	19711215	19711226
49-005-21021	DEVON ENERGY PRODUCTION COMPANY LP	86-1	MARQUISS W-241794	HOUSE CREEK	Sussex	11,384	0	FUSON	I	AI	44N 73W 25 SW SW	-105.580390	43.752910	20021104	19690112	19690303
49-005-24260	MARLIN OIL COMPANY LLC	1-23	SKYLINE FEDERAL	K-BAR	Parkman	7,717	0	PARKMAN	O	PO	43N 73W 23 NE SE	-105.585650	43.683280	19861231	19760613	19760815
49-005-39839	YATES PETROLEUM CORPORATION	42	GROVES SWD	K-BAR	Parkman	7,800	7,580	PARKMAN	D	AI	43N 73W 8 SE NW	-105.658880	43.716940	20081016	20000325	20000531
49-005-39685	YATES PETROLEUM CORPORATION	18	K-BAR STATE	K-BAR	Parkman	7,850	7,809	PARKMAN	O	PO	44N 74W 36 SE NW	-105.698330	43.746110	20100924	20000219	20000403
49-005-56671	BALLARD PETROLEUM HOLDINGS LLC	31-29	DRAKE	K-BAR	Parkman	8,076	8,030	STEEL	O	PO	43N 73W 29 NW NE	-105.652720	43.676580	20080325	20060814	20061114
49-005-24167	BLACK BEAR OIL CORPORATION	1-21	ANDERMAN	K-BAR	Parkman	8,868	0	SUSSEX	O	PO	43N 73W 21 SE SE	-105.626580	43.679780	19760423	19760211	19760520
49-005-39760	YATES PETROLEUM CORPORATION	1H	STARLIGHT FEDERAL	K-BAR	Parkman	9,168	0	PARKMAN	O	PO	43N 73W 7 SE NE	-105.666660	43.716110	20100915	20000406	20000524
49-005-31825	YATES PETROLEUM CORPORATION	9H	BELLE FEDERAL COM	K-BAR	Parkman	9,269	0	PARKMAN COAL	O	PO	43N 73W 5 SE SW	-105.657500	43.723610	20001207	20000510	20000621
49-005-24517	DNR OIL & GAS INC	1-7	ALL NIGHT CREEK	K-BAR	Parkman	9,500	0	SHANNON	O	PO	43N 73W 7 NE SW	-105.677090	43.712590	19770609	19770223	19770602
49-005-39686	YATES PETROLEUM CORPORATION	2	TED	K-BAR	Parkman and Turner	10,450	0	TURNER	O	PG	43N 73W 24 SE NE	-105.566100	43.686900	20010417	20000315	20000510
49-005-31625	YATES PETROLEUM CORPORATION	6	ROCKY BUTTE	K-BAR	Parkman and Turner	10,659	10,557	TURNER	O	PO	43N 73W 4 NW NW	-105.641420	43.735110	20090928	19970324	19970601
49-005-31798	YATES PETROLEUM CORPORATION	1	OPAL	K-BAR	Parkman and Turner	10,659	10,606	TURNER	O	PO	44N 73W 33 SW SW	-105.641070	43.738990	19971124	19970707	19970717
49-005-31626	YATES PETROLEUM CORPORATION	4	GROVES	K-BAR	Parkman, Turner, and Niobrara	10,662	0	TURNER	O	PO	43N 73W 6 SW NE	-105.671810	43.731800	20100121	19970331	19970816
49-005-31635	YATES PETROLEUM CORPORATION	5	GROVES	K-BAR	Parkman and Turner	10,690	10,601	TURNER	O	PO	43N 73W 6 SE NW	-105.678160	43.730990	19971031	19970607	19970929
49-005-31613	YATES PETROLEUM CORPORATION	3	GROVES	K-BAR	Parkman, Turner, and Niobrara	10,700	10,550	TURNER	O	PO	43N 73W 6 SE SE	-105.667410	43.723720	19971120	19970616	19970702
49-005-31820	YATES PETROLEUM CORPORATION	8	GROVES	K-BAR	Parkman and Turner	10,728	10,668	TURNER	G	PG	43N 73W 7 SE SE	-105.669560	43.710970	19991008	19970720	19990824
49-005-31857	YATES PETROLEUM CORPORATION	1	ICKES COM	K-BAR	Parkman and Turner	10,848	10,751	TURNER	O	PO	43N 73W 18 SW NW	-105.680110	43.703580	19980123	19970907	19971223
49-005-31497	YATES PETROLEUM CORPORATION	1	BUNN	K-BAR	Parkman, Turner, and Sussex	11,700	11,630	LAKOTA	O	PO	43N 73W 13 SE NE	-105.566240	43.701420	20090309	19970913	19970410
49-005-31281	YATES PETROLEUM CORPORATION	1	GROVES	K-BAR	Parkman and Turner	11,785	11,365	LAKOTA	O	PO	43N 73W 9 NW NW	-105.641620	43.719550	19980120	19961022	19970424
49-005-31401	YATES PETROLEUM CORPORATION	2	GROVES	K-BAR	Muddy, Parkman, and Turner	11,875	11,668	LAKOTA	O	PO	43N 73W 6 SE SW	-105.678100	43.723520	20091114	19961119	19970218
49-005-31537	YATES PETROLEUM CORPORATION	1	AMPOLEX STATE	K-BAR	Parkman and Turner	11,891	11,750	DAKOTA	O	PO	43N 73W 16 SE NW	-105.638940	43.702330	19970804	19970203	19970710
49-005-27979	JUSTICE OIL & GAS LLC	33-26	LAUR	NIGHT CREEK	Turner	12,454	0	MORRISON	O	PO	43N 74W 26 NW SE	-105.712500	43.668700	19850315	19850114	19850611
49-005-24095	BLACKJACK OIL INC	33-1	BURLEIGH TAYLOR	SIEVERS	Shannon	11,745	0	BELLE FOUR	O	PO	43N 74W 33 SW SW	-105.762910	43.650370	0	19751016	19760102
49-005-30728	BLACKJACK OIL INC	2-20	COSNER	TUIT DRAW	Parkman and Turner	10,340	10,281	TURNER	O	PO	43N 72W 20 NW NW	-105.538930	43.689820	20001222	19940915	19941128
49-005-30866	YATES PETROLEUM CORPORATION	1	COSNER	TUIT DRAW	Parkman and Turner	10,358	10,255	TURNER	O	PO	43N 72W 19 C NE	-105.548600	43.689580	19980116	19960317	19960518
49-005-30414	BLACKJACK OIL INC	1-20	COSNER	TUIT DRAW	Turner	10,400	10,266	TURNER	O	PO	43N 72W 20 SE SE	-105.526060	43.680740	20001213	19921029	19921126
49-005-30860	BLACKJACK OIL INC	1-18	COSNER	TUIT DRAW	Turner	10,400	0	TURNER	O	PO	43N 72W 18 SE SE	-105.546450	43.695510	19980608	19950622	19950719
49-005-28617	BLACK BEAR OIL CORPORATION	29-1	COSNER FEE	TUIT DRAW	Turner	11,495	0	MORRISON	O	PO	43N 72W 29 SW NE	-105.528540	43.674790	19851203	19850203	19860205
49-005-28602	SM ENERGY COMPANY	33-29	OLE PETERSON	TURNERCREST	Dakota	12,525	0	MORRISON	G	PG	42N 73W 29 NW SE	-105.651870	43.581530	20070514	19851215	19860521
49-005-28293	SM ENERGY COMPANY	22-32	TIGER	TURNERCREST	Dakota	12,562	0	MORRISON	G	PG	42N 73W 32 SE NW	-105.658920	43.572340	19850905	19850529	19850905
49-005-24984	KAISER FRANCIS OIL CO	2-1	PINE TREE RANCH	TURNERCREST	Frontier	12,625	0	FUSON	O	PO	41N 74W 2 SE NE	-105.707410	43.556080	19780817	19780525	19780817
49-005-45589	YATES PETROLEUM CORPORATION	1H	RAGING BULL COM	WC	Parkman	10,690	10,204	TURNER	O	PO	43N 73W 19 SE SE	-105.668020	43.679970	20031124	20020929	20031123
49-005-60530	YATES PETROLEUM CORPORATION	5	BORIS FEDERAL COM	WC	Parkman and Turner	10,786	10,693	TURNER	O	PO	43N 73W 9 SW SE	-105.631860	43.708950	20100311	20091121	20100310
49-005-37518	YATES PETROLEUM CORPORATION	1	BUCKIN BRONC FED	WC	Parkman and Turner	12,114	11,210	PARKMAN/ TURNER	O	PO	43N 73W 20 NW SE	-105.652140	43.685170	20050602	19991115	20001207

[1]Classification Codes: O = Oil Well; G = Gas Well; I = Injector Well
[2]Status Codes: PO = Producing Oil Well; PG = Producing Gas Well;AI = Active Injector

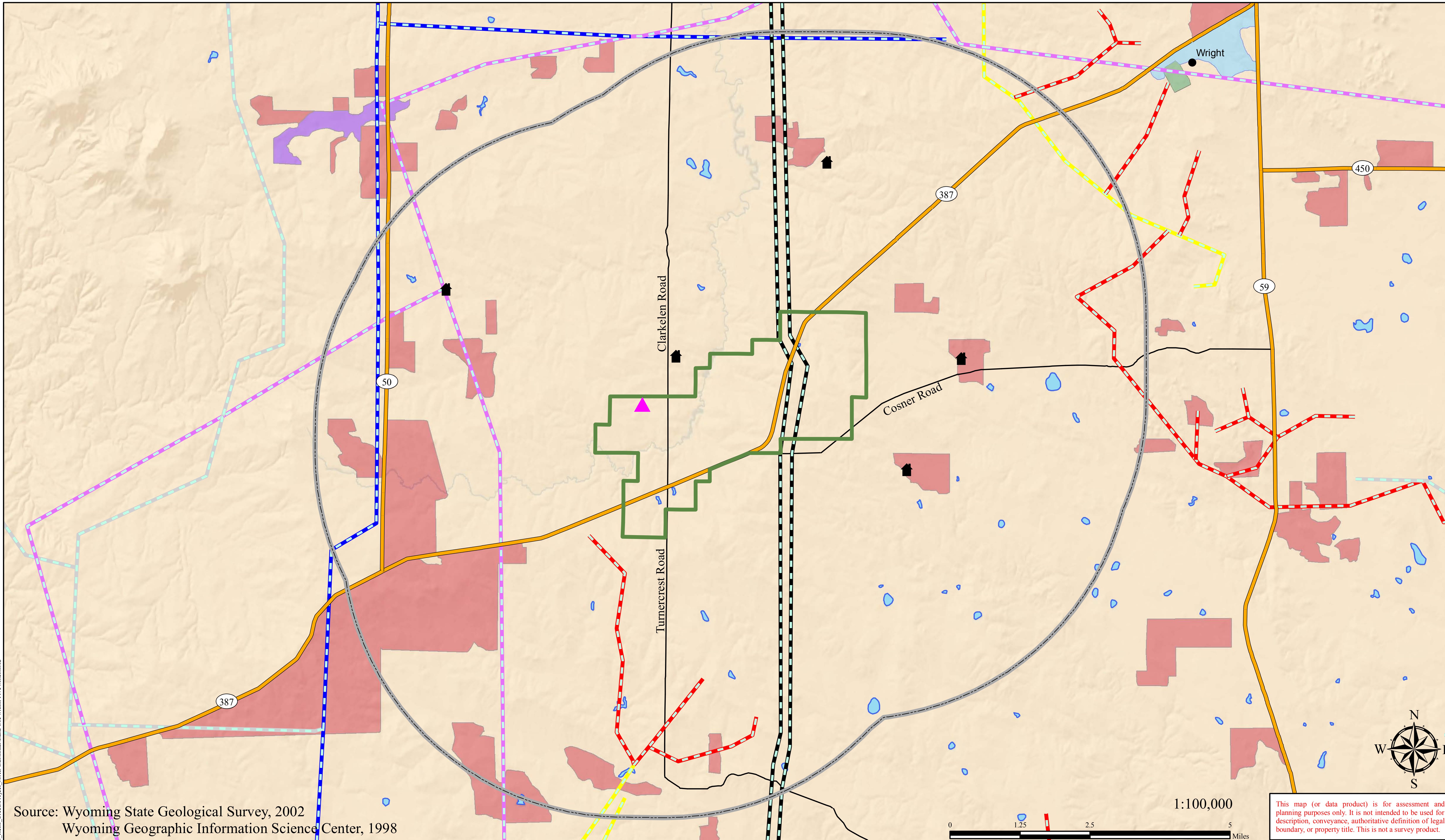
Source: WOGCC (2012)

Table 3.1-7: Historical Producing Wells within Five-Miles of the Proposed Project

API #	Company	WN	Unit Lease	Field Name	Producing Formation	Current Formation Produced	Current Produced Formation Oil (BBLS)	Current Produced Formation Gas (Mcf)	Current Produced Formation Water (BBLS)	Historical Oil (BBLS)	Historical Gas (Mcf)	Historical Water (BBLS)	Total Depth	PB	Status[1]	Township-Range-Section
49-005-39686	YATES PETROLEUM CORPORATION	2	TED	K-BAR	Parkman (7,458'-7,468') Turner (10,237'-10,243')	Parkman and Turner	29,292	26,173	33,041	29,292	26,173	33,041	10,450	0	PG	43N 73W 24
49-005-31625	YATES PETROLEUM CORPORATION	6	ROCKY BUTTE	K-BAR	Parkman (7,568'-7,583') Turner (10,463'-10,473')	Parkman and Turner	47,746	38,328	148,027	**Turner** 10,660	**Turner** 16,800	**Turner** 9,330	10,659	10,557	PO	43N 73W 4
49-005-31798	YATES PETROLEUM CORPORATION	1	OPAL	K-BAR	Parkman (7,550'-7,593') Turner (10,445'-10,457')	Parkman and Turner	35,829	41,299	131,569	**Parkman** 2,158	**Parkman** 3,100	**Parkman** 2,178	10,659	10,606	PO	44N 73W 33
49-005-31626	YATES PETROLEUM CORPORATION	4	GROVES	K-BAR	Parkman (7,520'-7,595') Turner (10,458'-10,468')	Parkman/ Turner/ Niobrara	7,941	5,308	4,965	**Park-Turn** 46,552 **Turner** 19,200	**Park-Turn** 37,575 **Turner** 9,558	**Park-Turn** 29,918 **Turner** 7,820	10,662	0	PO	43N 73W 6
49-005-31635	YATES PETROLEUM CORPORATION	5	GROVES	K-BAR	Parkman (7,546'-7,627') Turner (10,500'-10,512')	Parkman and Turner	70,592	54,617	87,710	70,592	54,617	87,710	10,690	10,601	PO	43N 73W 6
49-005-31613	YATES PETROLEUM CORPORATION	3	GROVES	K-BAR	Parkman (7,548'-7,552') Turner (10,478'-10,520') Niobrara (9,910'-9,940')	Parkman/ Turner/ Niobrara	51,957	42,494	76,210	**Parkman** 3,719	**Parkman** 2,052	**Parkman** 1,524	10,700	10,550	PO	43N 73W 6
49-005-31820	YATES PETROLEUM CORPORATION	8	GROVES	K-BAR	Parkman (7,581'-7,671') Turner (10,525'-10,539')	Parkman and Turner	58,252	60,473	77,173	**Turner** 5,063	**Turner** 4,380	**Turner** 2,329	10,728	10,668	PG	43N 73W 7
49-005-31857	YATES PETROLEUM CORPORATION	1	ICKES COM	K-BAR	Parkman (7,650'-7,665') Turner (10,636'-10,669')	Parkman and Turner	90,849	64,107	122,938	**Parkman** 4,706	**Parkman** 436	**Parkman** 28,836	10,848	10,751	PO	43N 73W 18
49-005-31497	YATES PETROLEUM CORPORATION	1	BUNN	K-BAR	Dakota (11,540'-11,562') Parkman (7,516'-7,526') Turner (10,319'-10,847') Sussex (8,480'-8,494')	Dakota/ Sussex/ Parkman/ Turner	3,214	6,337	14,597	**Parkman** 1,263 **Park-Turn-Suss** 8,265 **Turner** 1,186	**Parkman** 1,090 **Park-Turn-Suss** 11,805 **Turner** 2,525	**Parkman** 152,860 **Park-Turn-Suss** 9,898 **Turner** 797	11,700	11,630	PO	43N 73W 13
49-005-31281	YATES PETROLEUM CORPORATION	1	GROVES	K-BAR	Parkman (7,522'-7,535') Turner (10,398'-10,421')	Parkman and Turner	22,852	32,915	16,354	**Dakota** 1,297 **Turner** 4,960	**Dakota** 400 **Turner** 7,097	**Dakota** 3,155 **Turner** 9,507	11,785	11,365	PO	43N 73W 9
49-005-31401	YATES PETROLEUM CORPORATION	2	GROVES	K-BAR	Mowry (11,348'-11,426') Muddy (11,498'-11,561') Parkman (7,556'-7,570' and 7,630'-7,634') Turner (10,508'-10,548')	Mowry/ Muddy/ Parkman/ Turner	10,920	7,668	5,508	**Mud-Park-Turn** 65,912 **Parkman** 1,849 **Turner** 7,061	**Mud-Park-Turn** 56,060 **Parkman** 783 **Turner** 4,881	**Mud-Park-Turn** 40,635 **Parkman** 783 **Turner** 773	11,875	11,668	PO	43N 73W 6
49-005-31537	YATES PETROLEUM CORPORATION	1	AMPOLEX STATE	K-BAR	Parkman (7,662'-7,672') Turner (10,562'-10,573')	Parkman and Turner	57,189	41,481	85,578	**Parkman** 13,285	**Parkman** 22,160	**Parkman** 8,252	11,891	11,750	PO	43N 73W 16
49-005-30728	BLACKJACK OIL INC	2-20	COSNER	TUIT DRAW	Parkman (7,362'-7,372') Turner (10,139'-10,164')	Parkman and Turner	20,506	14,159	392	**Turner** 82,110	**Turner** 171,150	**Turner** 3,961	10,340	10,281	PO	43N 72W 20
49-005-30866	YATES PETROLEUM CORPORATION	1	COSNER	TUIT DRAW	Parkman (7,402'-7,429') Turner (10,172'-10,176')	Parkman and Turner	148,097	176,657	19,058	**Turner** 29,325	**Turner** 60,774	**Turner** 2,214	10,358	10,255	PO	43N 72W 19
49-005-60530	YATES PETROLEUM CORPORATION	5	BORIS FEDERAL COM	WC	Parkman (7,674'-7,682' and 7,690'-7,698') Turner (10,555'-10,561')	Parkman and Turner	9,362	6,419	46,651	**Turner** 1,895	**Turner** 1,482	**Turner** 1,278	10,786	10,693	PO	43N 73W 9
49-005-37518	YATES PETROLEUM CORPORATION	1	BUCKIN BRONC FED	WC	Parkman (7,768'-7,777') Turner (10,711'-10,718')	Parkman and Turner	100,142	45,506	120,728	**Parkman** 7,494	**Parkman** 5,012	**Parkman** 14,044	12,114	11,210	PO	43N 73W 20

[1]Status Codes
PO = Producing Oil Well
PG = Producing Gas Well

Source: WOGCC (2012)



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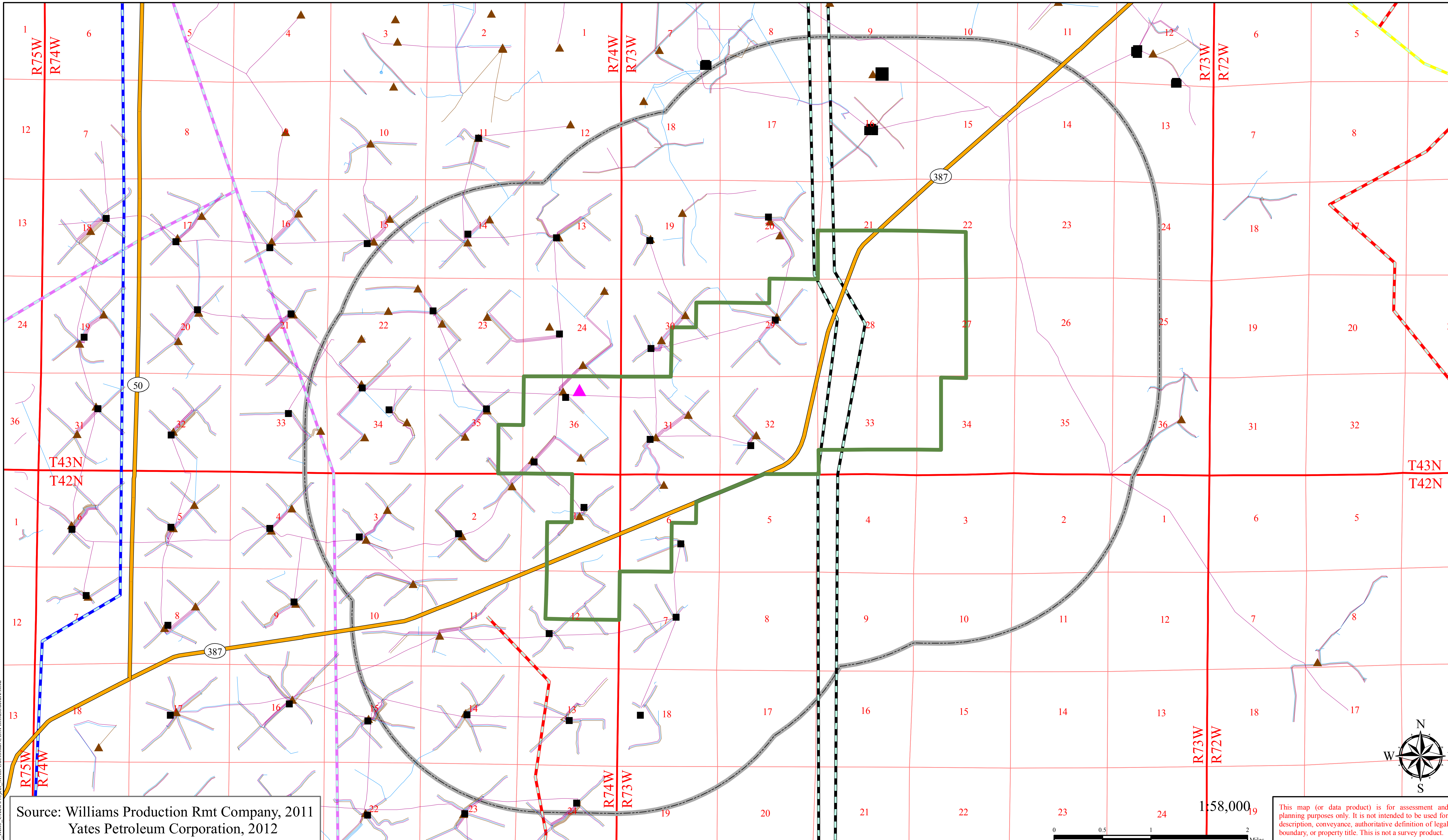
PROPOSED RENO CREEK PROJECT
CAMPBELL COUNTY, WY
PREPARED FOR AUC LLC
LAKEWOOD, CO

DRAWN BY: RHK
CHECKED BY: RMD
APPROVED BY: JEY

Land Use within Five Miles of the Proposed Project Area

REV #	DESCRIPTION	BY	DATE	FIGURE
0	Draft	RHK	07/05/11	3.1-1
1	Revised Draft for Review	RHK	08/19/11	
2	Final	RHK	12/05/11	



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PROPOSED RENO CREEK PROJECT

CAMPBELL COUNTY, WY

PREPARED FOR AUC LLC
LAKEWOOD, CO

Legend

- Proposed Reno Creek Project Boundary
- Proposed Reno Creek Project Area Two Mile Buffer
- Compressor Station
- Structure
- Overhead Power Drop
- Buried Water Line
- Buried Power
- Buried Gas Pipeline
- Major Road

Pipeline Operator

- Belle Fourche (Crude Oil)
- Fort Union Gas Gathering (Natural Gas)
- Kansas-Nebraska Gas Gathering (Natural Gas)
- Kinder Morgan Operating, LP. (Natural Gas)
- Thunder Creek Gas Services, L.L.C. (Natural Gas)
- Western Gas Resources (Natural Gas)

DRAWN BY: RHK
CHECKED BY: RMD
APPROVED BY: JEY

Existing CBM Infrastructure

REV #	DESCRIPTION	BY	DATE
0	Draft for Review	RHK	02/06/2012
1			
2			

FIGURE 3.1-2

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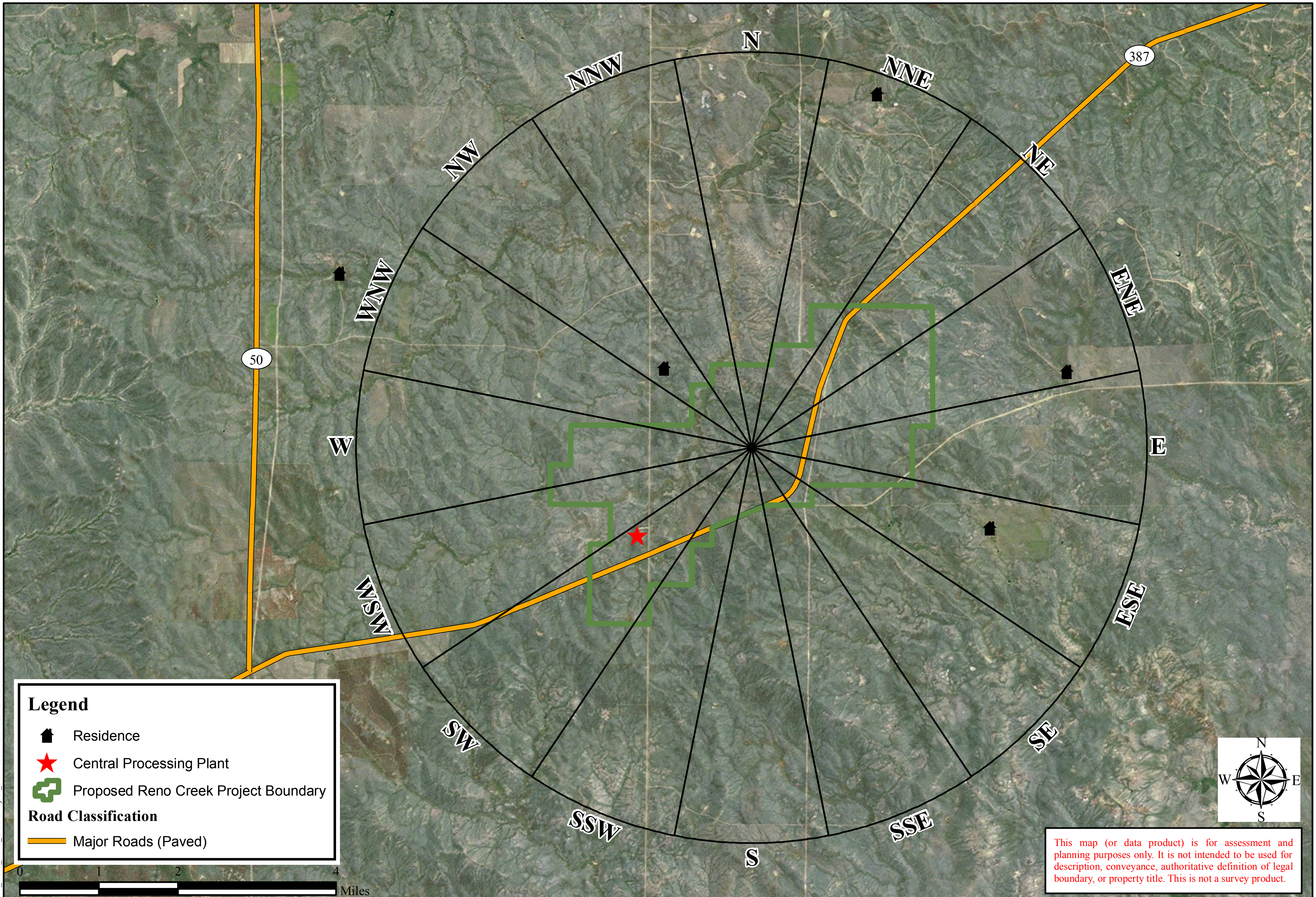

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PROPOSED RENO CREEK PROJECT
CAMPBELL COUNTY, WY

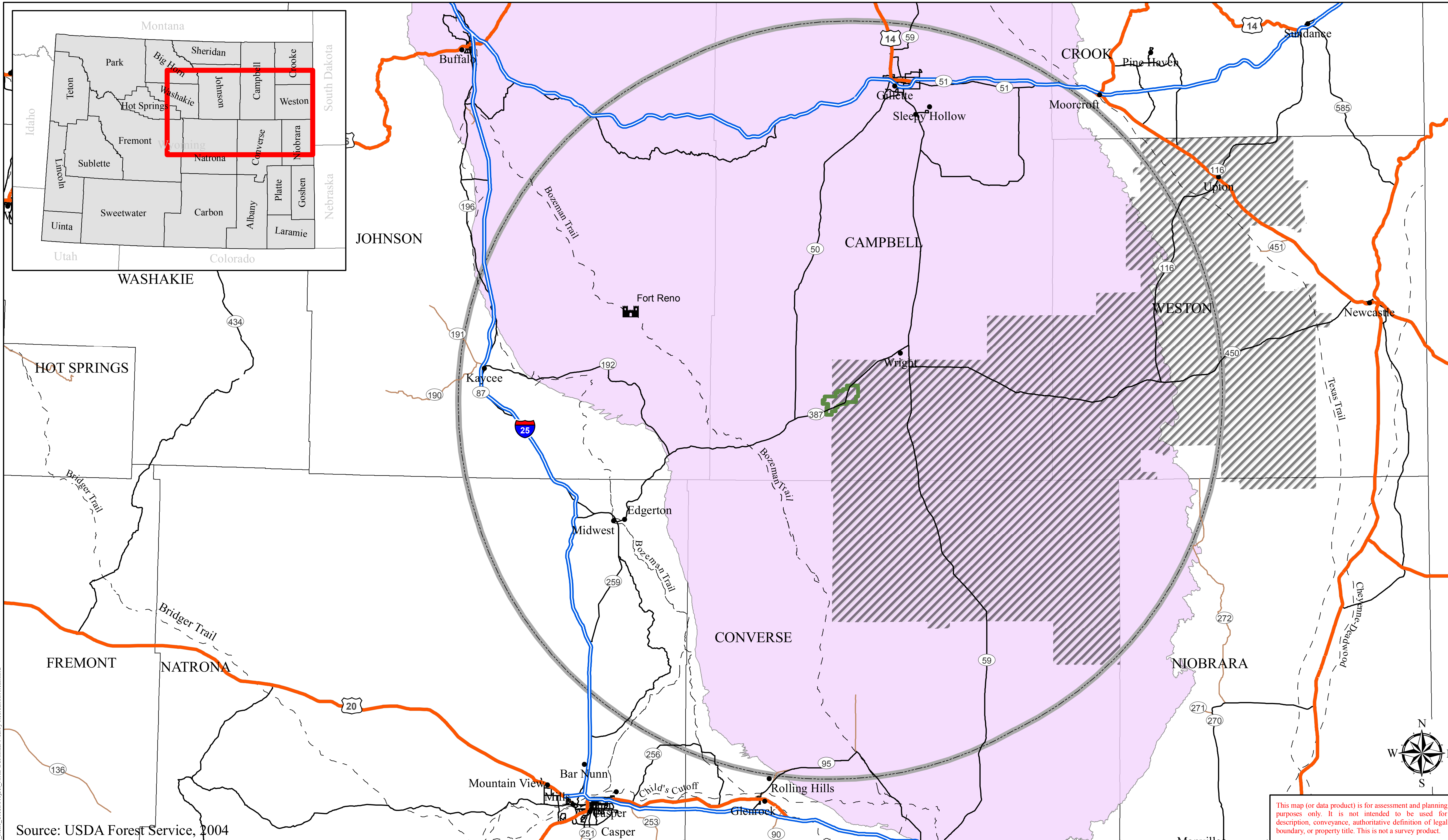
PREPARED FOR: AUC LLC
LAKEWOOD, CO

Residences within Two Miles of the Proposed Reno Creek Project Area

Drawn: RHK
Checked: RMD
Approved: JEY

Figure 3.1-3

Rev. #	Description	Date
0	Draft	09/26/2011
1	Revised Draft for Review	10/19/2011
2	Final	10/25/2011



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PROPOSED RENO CREEK PROJECT
CAMPBELL COUNTY, WY

PREPARED FOR **AUC LLC**
LAKEWOOD, CO

Legend
- Proposed Reno Creek Project Boundary
- Fort Reno
- 50 Mile Review
- Thunder Basin National Grassland
- Powder River Basin
- Historical Trails

0 5 10 20 Miles
1:770,000

DRAWN BY: RHK
CHECKED BY: RMD
APPROVED BY: JEY

Nearby Recreation Locations

REV #	DESCRIPTION	BY	DATE
0	Draft	RHK	07/11/11
1	Draft Revision	RHK	07/18/11
2	Final	RHK	10/24/11

FIGURE 3.1-4

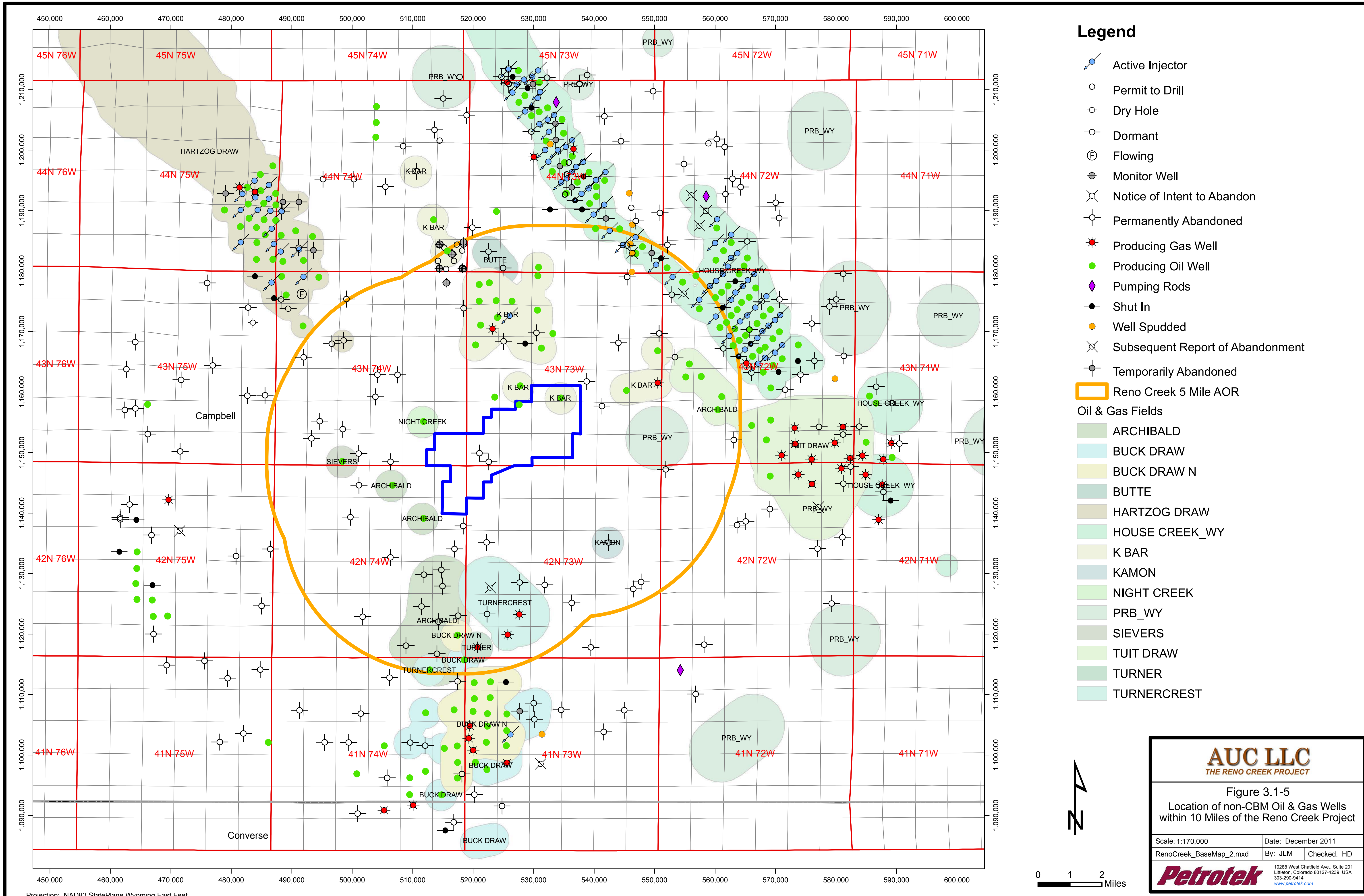
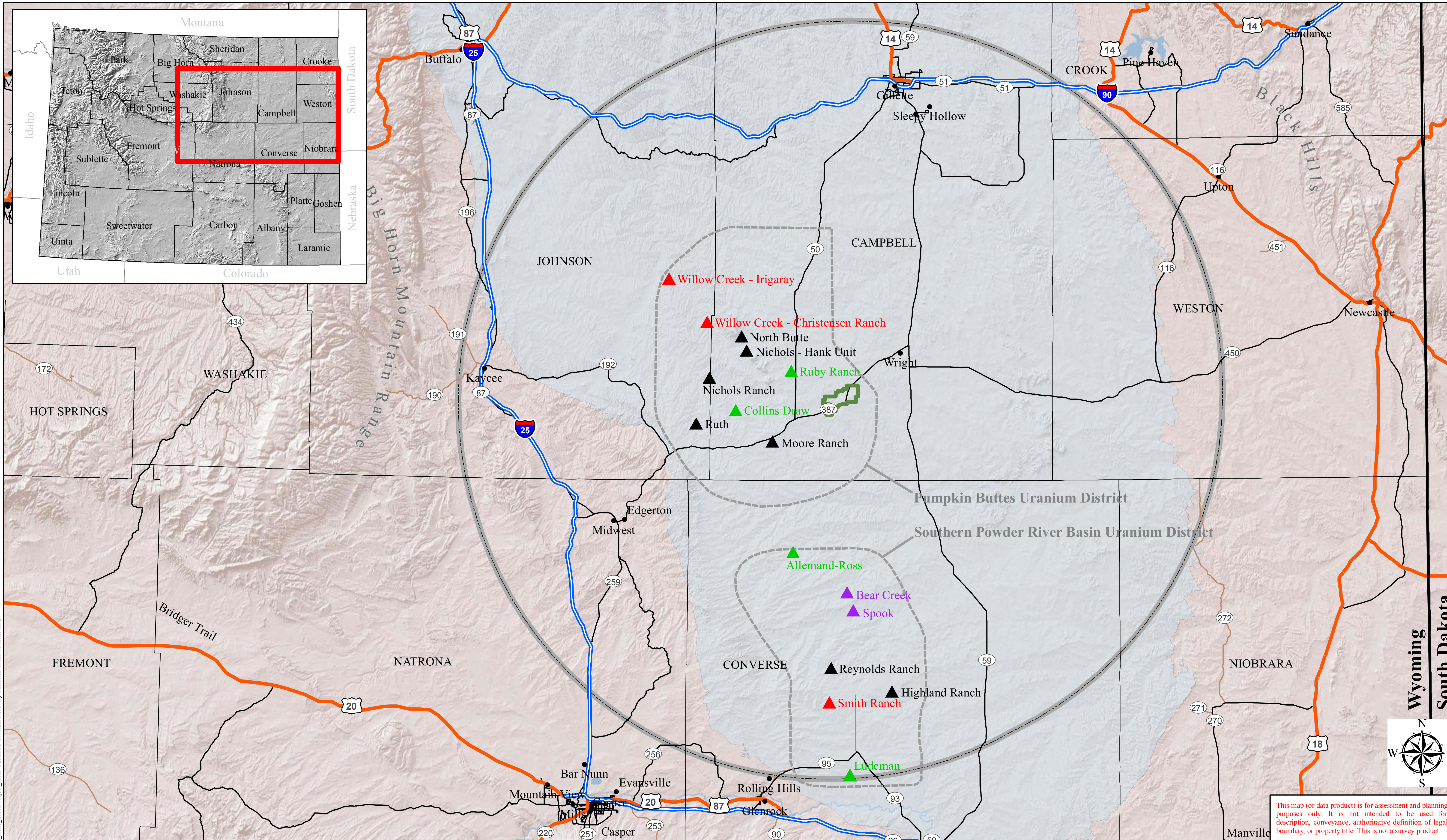


Figure 3.1-5
Location of non-CBM Oil & Gas Wells within 10 Miles of the Reno Creek Project



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PROPOSED RENO CREEK PROJECT
CAMPBELL COUNTY, WY
PREPARED FOR AUC LLC
LAKEWOOD, CO

Legend
Uranium Projects Status
- Licensed - Operating
- Licensed - Not Operating
- Proposed
- Legacy Conventional Uranium Project
- Uranium Districts
- Proposed Reno Creek Project Boundary
- 50 Mile Review
- Powder River Basin
- Interstate
- Highway
- Major Road
- Local Road

0 5 10 20 Miles
1:770,000

DRAWN BY: RHK
CHECKED BY: RMD
APPROVED BY: JEY

Uranium Recovery Facilities within 50 miles (80 km) of the Proposed Reno Creek Project Area

REV #	DESCRIPTION	BY	DATE
0	Draft	RHK	07/11/11
1	Draft Revision	RHK	07/18/11
2	Final	RHK	10/24/11

FIGURE 3.1-6

Path: O:\WY_Projects\2010-100_AUC_Reno_Creek\Project_MXD\Submittal\Uranium Recovery Facilities within 50 miles.mxd

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3.2 Transportation

This section provides a description of the regional and on-site transportation network that is relevant to the proposed Reno Creek Project (Proposed Project). The road network will be used for: 1) shipments of construction materials, process chemicals, office supplies, and related materials from suppliers to the Proposed Project; 2) shipment of yellowcake to an off-site fuel conversion facility; 3) shipments of byproduct materials (both solid 11e.(2) and non-11e.(2) byproduct materials) to be disposed of off-site; and 4) movement of personnel, both licensee and non-licensee to and from the site and within the Proposed Project area. Further discussions regarding transportation can be found in:

- Section 4.2 of this ER (Potential Transportation Impacts);
- Section 6.2 of this ER (Mitigation of Potential Transportation Impacts);
- Section 5.6.2 of the TR (Transportation Security);and
- Section 7.5.3. of the TR (Transportation Accident Risk).

3.2.1 Highways and Local Roads

Past experience at NRC-licensed ISR facilities indicates these facilities rely on roads for transportation of goods and personnel (NUREG-1910, GEIS p. 3.2-4). Transportation routes within 50 miles (80 km) of the Proposed Project include Interstate highways, non-Interstate U.S. highways, state highways, county roads and local roads. Regional transportation routes are shown in Figure 1-1 of this ER and Proposed Project area transportation corridors are shown in Figure 1-2 of this ER.

The primary transportation route to the Proposed Project area from nearby communities is along State Highway 387 that connects the Proposed Project area to regional population and economic centers along I-25 to the west and State Highway 59 to the east. Highway 387 runs east to west from the town of Wright to I-25 at the town of Midwest, traversing the project area. The City of Gillette is located approximately 41 miles north of the Proposed Project and has two transportation routes available to access the Proposed Project area, State Highway 50 and 59. Highway 50 originates in Gillette and runs to the south and connects with Highway 387 approximately 4.5 miles west of the Proposed Project. Highway 59 connects with Highway 387 at Wright, located approximately 7.5 miles northeast of the Proposed Project. Transporation routes to the Proposed Project area are described in Table 3.2-1.

Interstate 25 is a Federal Interstate Highway designed for high-volume, high-speed traffic. It is a four-lane, divided highway with two lanes in each direction separated by a wide median. Highways 387, 50, and 59 are classified by WYDOT as Rural Minor Arterial highways. all and are bidirectional (two-lane, opposing travel), asphalt-paved highways in good to average condition. The lanes on these highways are approximately 12 feet wide, and the total width of paved roadway ranges from 26 to 40 feet, based on the varying width of the paved shoulder.

Local access roads within the Proposed Project area are County Roads 22 (Clarkelen/Turnercrest Road) and 25 (Cosner Road). Clarkelen Road accesses the general location selected for construction of the CPP and is currently used for agricultural and oil and gas activities in the area. The proposed location of the CPP is approximately 1,800 feet from the intersection of Highway 387 and Clarkelen Road. Clarkelen Road may require minor improvements to accommodate trucks and heavy equipment access during construction and operation phases of the Proposed Project.

Clarkelen and Cosner Road are improved, all-weather, unpaved roads. In addition to the designated routes, there are a number of routes that traverse the Proposed Project area for grazing access, oil/gas facility access, and mineral exploration. Ranchers, oil and gas workers, hunters, and recreationists are the main users of these roads.

The primary state and U.S. highways are well maintained year around. Routine maintenance includes snow removal, debris removal, blading and grading operations, and miscellaneous road repairs. The county roads within the Proposed Project area that receive less traffic, generally speaking, are maintained and are in fair condition, depending on the season and how recently maintenance occurred. However, the two-track roads in some portions of the Proposed Project area can be difficult to navigate in winter months due to minimal maintenance and lack of drainages. Many of the two-track roads are indistinct, difficult to delineate, or do not have obvious end points.

3.2.2 Traffic

As noted in NUREG-1910 (GEIS Sec. 3.3.2), there are three automated traffic counter locations operated by the Wyoming Department of Transportation (WYDOT) in the Proposed Project region shown in Figure 3.2-1. Data obtained from WYDOT can be used as a baseline and to provide insight into the seasonal variations in traffic volumes. The Average Annual Daily Traffic (AADT) for each site is as follows (WYDOT 2010):

1) Pine Tree Junction East on State Highway 387 at mile post 136.20
    - AADT for the 2010 year was 788 down slightly from 827 the previous year. A detailed yearly transportation analysis for this site is found in Table 3.2-3;
2) Reno Junction on State Highway 59 at mile post 75.21
    - AADT for the 2010 year was 3,679 down slightly from 3,700 the previous year. A detailed yearly transportation analysis for this site is found in Table 3.2-4 ; and

3) Gillette South on State Highway 59 at milepost 103.12
   - AADT for the 2010 year was 5,681 down slightly from 5,818 the previous year. A detailed yearly transportation analysis for this site is found in Table 3.2-5

During the construction, operation, restoration and decommissioning phases of the project, immediate access to the Proposed Project area will be from State Highway 387, from either the east and the west. The workforce for each phase will be primarily from Gillette using State Highway 59 then westbound State Highway 387, and from Casper using Interstate Highway 25 then eastbound State Highway 387.

The 20 year projected traffic volumes for the traffic counter locations are calculated using a 1.5 percent annual rate of increase, which is considered standard practice among transportation officials. WYDOT uses a 1.5 percent annual traffic increase rate unless more site specific data are available (Wiseman 2012). Since the three traffic counter locations used for projected traffic volume analyis had only three years worth of historical data a linear regression model was not utilized due to the limited data set. The 2010 WYDOT traffic volumes are used in the analysis and the results can be found in Table 3.2-6. Traffic volumes are not available for county roads as these roads receive little traffic for most of the year. However, use does peak in the summer and fall when dispersed recreation is greatest. Potential impacts related to transportation of 11e.(2) and non-11e.(2) byproduct material is discussed in more detail in Section 4.2 of this report.

3.2.3 Railroads

The Burlington Northern Santa Fe (BNSF) Railroad runs in a north-south direction approximately 12.5 miles east and 53 miles south of the Proposed Project area. This rail line primarily accommodates coal shipping from the coal mining operations in eastern Wyoming. There are no rail lines within the Proposed Project boundary or the two mile review area. It is not anticipated that these railroads will be utilized as a transportation option for any aspect of Proposed Project operations. Regional railways are depicted in Figure 1-1 of this ER.

Table 3.2-1: Routes to the Proposed Project

Origin	Destination	Major Links	Distance
Casper	Proposed Project	-Take I-25 north for 23 miles to exit 210 (paved); -Take Exit 210 and turn right on WY Hwy 259 for 18 miles (paved); -Turn right on Hwy 387 for 51 miles to Clarkelen Road (paved); then -Turn left on Clarkelen Road for one mile (maintained unpaved).	93 miles
Gillette	Proposed Project	-Take Hwy 59 south for 39 miles (paved); -At Wright, Wyoming take Hwy 387 west for 11 miles (paved); then -Turn right on Clarkelen Road for one mile (maintained unpaved).	51 miles

Table 3.2-2: Local and Regional Road Traffic Counts

2010 AADT (Vehicles/Day)		
Highway	All Vehicles	Trucks
Pine Tree Junction (Hwys 50 and 387)	827	183
Reno Junction (Hwys 59 and 387)	3,679	497
Gillette South (Hwy 59 milepost 102)	5,681	838

Source: WYDOT (2010)

Table 3.2-3: Pine Tree Junction Traffic Counter Yearly Analysis

Year	Sundays	Mondays	Tuesdays	Wednesdays	Thursdays	Fridays	Saturdays	AADT
2010	715	784	838	858	883	974	740	827
2009	699	746	811	824	846	915	673	788

Source: WYDOT (2010)

Table 3.2-4: Reno Junction Traffic Counter Yearly Analysis

Year	Sundays	Mondays	Tuesdays	Wednesdays	Thursdays	Fridays	Saturdays	AADT
2010	2,857	3,841	3,902	3,994	4,105	4,175	2,880	3,679
2009	2,848	3,800	3,979	4,060	4,157	4,227	3,050	3,700

Source: WYDOT (2010)

Table 3.2-5: Gillette South Traffic Counter Yearly Analysis

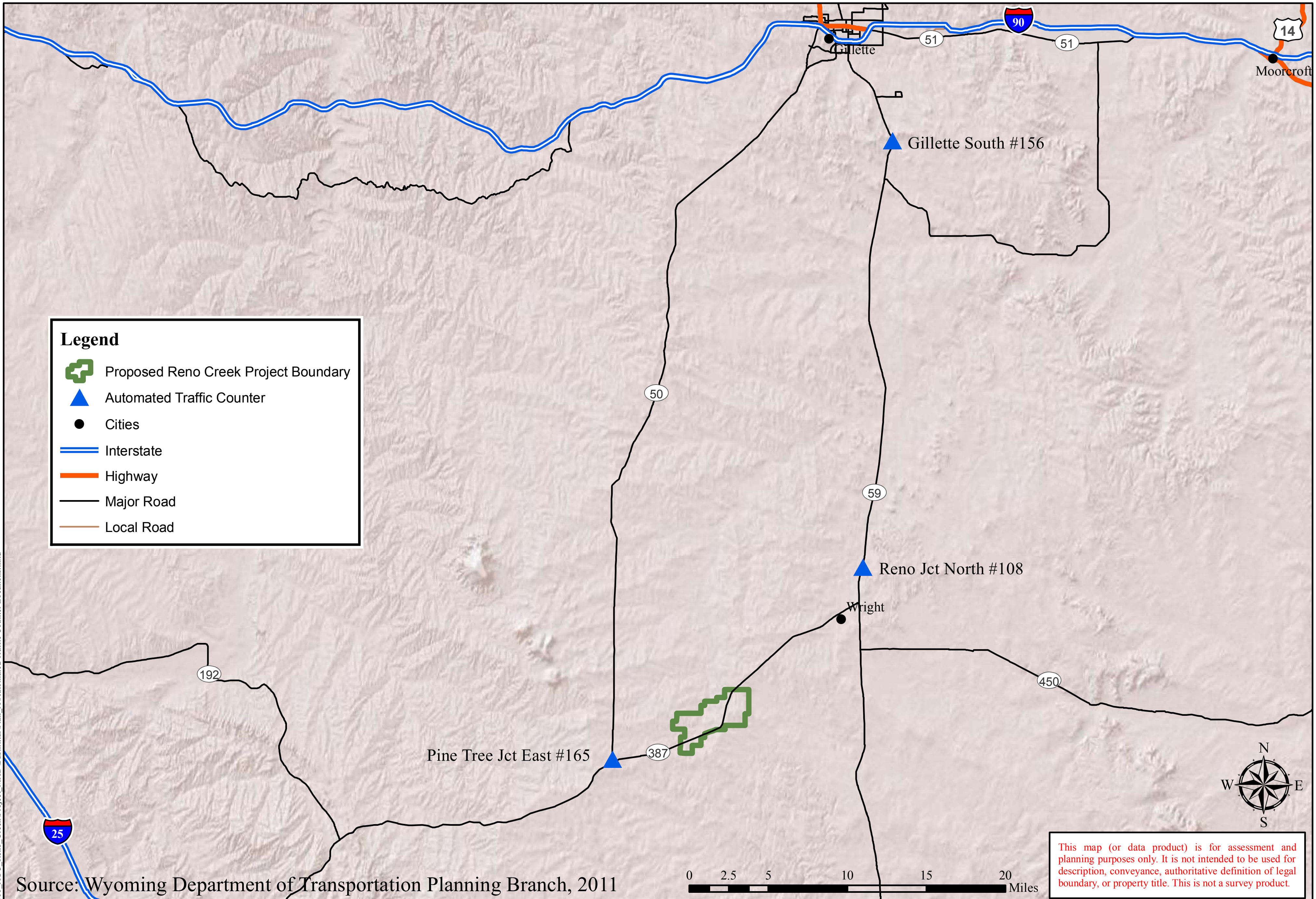
Year	Sundays	Mondays	Tuesdays	Wednesdays	Thursdays	Fridays	Saturdays	AADT
2010	4,081	6,090	6,254	6,296	6,434	6,408	4,242	5,681
2009	4,096	6,156	6,510	6,594	6,545	6,556	4,266	5,818

Source: WYDOT (2010)

Table 3.2-6: Projected Traffic Volumes

Project Area Roads	2010		2015		2020		2030	
	All vehicles	Trucks	All vehicles	Trucks	All vehicles	Trucks	All vehicles	Trucks
	(vehicles/day)		(vehicles/day)		(vehicles/day)		(vehicles/day)	
Pine Tree Junction	874	183	942	197	1,014	212	1,177	246
Reno Junction	3,679	497	3,963	535	4,270	577	4,955	669
Gillette South	5,681	838	6,120	903	6,593	973	7,652	1,129

Source: 2010 numbers from WYDOT then 1.5 percent annual increase



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PROPOSED RENO CREEK PROJECT
CAMPBELL COUNTY, WY

PREPARED FOR: AUC LLC
LAKEWOOD, CO

Automated Traffic Counter Locations

Drawn: RHK
Checked: RMD
Approved: JEY

Figure 3.2-1

Rev. #	Description	Date
0	Draft	09/24/2011
1	Revised Draft	10/13/2011
2	Final	10/20/2011

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3.3 Geology

The discussions of geology, soils, and seismicity related to the proposed Reno Creek Project (Proposed Project) are contained in this section. Detailed information about the Proposed Project area and its immediate surroundings is provided to the extent that AUC is permitted to acquire such data under 10 CFR Part 40.32(e) and the regulations of the State of Wyoming. The Proposed Project is representative of the geologic and soil conditions found throughout the Wyoming East Region, as discussed in NUREG-1910. More comparable and/or detailed discussions regarding geology and soils can be found in:

- Addenda 3.3-A through 3.3-G of this ER;
- Section 4.3 of this ER (Potential Impacts);
- Section 5.5 of this ER (Cumulative Impacts);
- Section 6.3 of this ER (Mitigation);
- Section 7.1.3 of this ER (Environmental Measurements and Monitoring);
- Section 2.6 of the TR (Geology);
- Addenda 2.6-A through 2.6-C of the TR; and
- Sections 7.1.5 and 7.2.5 of the TR (Environmental Effects).

A discussion of the Production Zone Aquifer (PZA) and the mudstone units providing geologic confinement above and below the PZA is found in Section 3.3.2 of this chapter. The PZA is an Eocene-age sandstone formation which hosts the uranium mineralization for the Proposed Project. There is continuous geologic confinement of the PZA over the entire Proposed Project area. As a consequence, ISR operations in the PZA can be conducted without significant potential impacts to ground water resources. All figures listed in Section 3.3.1 can be found in Addendum 2.6-A in the TR.

3.3.1 Regional Geology

The Proposed Project is located in the Pumpkin Buttes Uranium District in the central PRB of Northeast Wyoming as shown in Figure 2.6A-1 in Addendum 2.6-A of the TR. Outcrop geology of the district is also depicted on Figure 2.6A-1.

Active ISR projects in the Pumpkin Buttes District are depicted on the map including Reno Creek (AUC LLC), Moore Ranch, Willow Creek and Irigaray (Uranium One), and Uranerz' Hank Unit and Nichols Ranch projects. Willow Creek is currently producing uranium using ISR methods.

According to NUREG-1910 (GEIS Section 3.3.3), the PRB encompasses an area of about 31,000 km^2 (12,000 mi^2) in Campbell and Converse counties within the Eastern Wyoming Uranium District. The first uranium discoveries in the PRB near Pumpkin Buttes were in 1951 (Davis, 1969). Other uranium deposits were found along a 60 mile northwest-southeast trend in the southwest portion of the PRB. Production began in 1953.

3.3.1.1 Structural Geology

The PRB extends over much of northeastern Wyoming and southeastern Montana, and consists of a large north-northwest trending asymmetric syncline depicted in Figure 2.6A-2, Structure Map, showing contours on the top of the Fox Hills Sandstone which lies at approximately 6,500 feet in depth in the Proposed Project area (Figures 2.6A-3 and 2.6A-4). The basement axis lies near the western edge of the basin, and the present surface axis lies to the east of the basement axis near the Pumpkin Buttes approximately 10 miles west of the Proposed Project. The basin is bounded by the Big Horn Mountains to the west, the Black Hills to the east, and the Hartville Uplift and Laramie Mountains to the south.

The PRB is filled with sediments of marine and continental origin ranging in age from early Paleozoic through Cenozoic as shown in Figure 2.6A-3. Sediments reach a maximum thickness of about 20,000 feet in the deepest parts of the basin. The top of the Precambrian is projected to be 17,500 feet deep in the Proposed Project area.

Figure 2.6A-4 is an oil and gas log (Yates Petroleum, API # 49-005-45589) located immediately to the north of the Proposed Project area in Section 19, T43N, R73W. The total depth of the well is 10, 690 feet. The location of the well is shown on Figure 2.6A-5, a location map for oil and gas (non-CBM) tests in and adjacent to the Proposed Project.

During Paleozoic time most of northeastern Wyoming lay beneath shallow marine waters on the continental shelf. Throughout this time, gentle subsidence of the shelf and intermittent uplifts were accompanied by the deposition of marine limestone, shale and sandstone.

Periods of oceanic regression and transgression began in the region during the late Paleozoic and increased in the Mesozoic. These cycles resulted in the deposition of layers of marine sand and carbonates interbedded with coarse-grained, non-marine clastic sediments.

Following a long period of stability during the Mesozoic, tectonic forces of late Paleocene to early Eocene ushered in mountain building events related to the Laramide orogeny. Uplift began to affect the western continental margin and modify the landscape of central and eastern Wyoming (Seeland, 1988). As a result of these tectonic forces, the

PRB was the site of active subsidence surrounded by orogenic uplifts (Big Horn Mountains, Laramie Mountains, Black Hills, etc). The Tullock Member of the Fort Union marks the first evidence of basin downwarp and synorogenic filling (outcrop geology shown on Figure 2.6A-1).

Throughout the Paleocene, uplift of the Big Horn Mountains, Laramie Mountains and Black Hills continued on the margins of the PRB. Erosion of these highlands produced clastic material which now constitutes the upper members of the Fort Union Formation in the basin's flood plain. Thick sequences of mudstone in the Lebo Shale Member around the margins of the basin indicate a typical Laramide depositional environment. The Laramide orogeny was near its peak activity in Tongue River time as indicated by a marked increase in the deposition of coarse sandstones. A period of deformation and erosion accompanied by westward tilting of the basin preceded a final Laramide surge and deposited the clastic rocks of the Eocene Wasatch Formation, the uranium-bearing host rock in the Proposed Project. The Wasatch dips northwestward at approximately one degree to two and a half degrees in this portion of the PRB (Sharp et al., 1964).

During the Oligocene, regional volcanism to the west of the basin resulted in the deposition of tuffaceous claystone, sandstone and conglomerate of the White River Formation. Downwarping of the basin was completed in early Cenozoic time and subsidence of the enclosing mountain ranges after deposition of the White River Formation caused local tilting of these and older beds toward the mountains. Remnants of the White River Formation overlie the Wasatch Formation in the center of the Pumpkin Buttes District (Figure 2.6A-1).

Throughout the Miocene, most of Wyoming was an upland over which windblown sands were deposited. Erosion prevailed throughout most of the region during the Pliocene but locally tuffaceous clay and fresh water limestone were deposited in low lying, regional lakes.

In the late Pliocene the region again underwent uplift and, since the Pleistocene the area has been undergoing erosion. Most of the White River Formation and much of the Wasatch Formation have been removed. Remnants of the White River conglomerate resisted erosion to form the mesa caps of the Pumpkin Buttes. Concurrently, upper Cenozoic and Quaternary gravels were deposited on terraces, flood plains and valley floors. More recently, Holocene alluvium has filled channels eroded in the older rocks and windblown sand has formed dunes, predominantly in the southwest corner of the basin.

3.3.1.2 <u>Regional Stratigraphy</u>

Outcrops of post-marine formations in the southern part of the basin consist of the Lance, Fort Union, Wasatch and White River Formations (Figures 2.6A-1, 2.6A-3, and 2.6A-4). The Upper Cretaceous Lance Formation is the oldest of these units, and consists of 1,000 to 3,000 feet of thinly-bedded, brown to gray sandstones and shales. The upper part contains minor, dark carbonaceous shales and thin coal seams, indicating a changing depositional environment over time.

The Paleocene Fort Union Formation conformably overlies the Lance and consists of continental and shallow non-marine deposits in two members. The lower member consists of fine-grained, clay-rich, drab to pink sandstone, with minor claystone and coal. The sandstones were deposited as alluvial fans and braided stream channels during erosion of the uplifted Black Hills, Bighorn, and Laramie Mountains. The upper member consists of shale, clayey sandstone, fine-to-coarse-grained sandstone, and some extensive sub bituminous coal beds. The total thickness of the Fort Union Formation varies between 2,000 and 3,500 feet (Sharp et al., 1964).

The Fort Union Formation is the water source for the City of Wright, located approximately 10 miles east of the Proposed Project. Due to its position (up dip) of the Proposed Project, the PZA (the host for uranium mineralization) is eroded away and is not present in the Wright area.

The early Eocene Wasatch Formation unconformably overlies the Fort Union Formation around the margins of the basin. However, the two formations are conformable and gradational towards the basin center and the Proposed Project area. The relative amount of coarse, permeable clastics increases near the top of the Fort Union, and the overlying Wasatch Formation contains numerous beds of sandstone which are sometimes correlatable over wide areas. Except in isolated areas of the PRB, the Wasatch-Fort Union contact is generally set at the top of the thicker coals or of some thick sequence of clays and silts. The Badger Coal is regarded as the approximate formation boundary in the Proposed Project area.

The Wasatch Formation crops out at the surface in the Proposed Project area. The Wasatch is similar to the Fort Union, but also contains thick lenses of coarse, crossbedded, arkosic sands deposited in a high-energy fluvial environment. The Wasatch Formation reaches a maximum thickness of approximately 500 to 700 feet within the Proposed Project area.

Remnants of the Oligocene White River Formation crop out on the Pumpkin Buttes, located approximately 10 miles to the west-northwest of the Proposed Project area. Virtually all of the White River has otherwise been eroded away. The youngest sediments consist of Quaternary alluvial sands and gravels locally present principally in drainages.

The central part of the PRB contains at least 10,000 feet of sediments underlying the Upper Cretaceous Lance Formation. Most of the rocks are marine shales and mudstones. Notable sandstones below the Lance are found in the Cretaceous Fox Hills Formation (transitional marine to non-marine), and the Teckla, Teapot, and Parkman members of the Mesa Verde Formation (Figure 2.6A-3 and 2.6A-4). The Teapot and Parkman sandstones are approximately 7,100 to 8,150 feet below land surface in the Proposed Project area, and are sandstones currently employed in the Basin for disposal of ISR 11e.(2) liquid byproduct through Class I UIC injection wells. AUC considers the Teckla to be a potential disposal zone as well.

The Upper Cretaceous Teapot and Parkman sandstone members of the Mesa Verde Formation lie approximately 7,500 feet below the PZA. AUC has applied for Class I UIC Permits from the WDEQ to inject 11e.(2) liquid byproduct into the Teapot and/or Parkman sandstones as part of the Proposed Project. More detailed information is found in Section 4 of this TR including a copy of the UIC Permit application in TR Addendum 4-B. The water quality of three well samples from the Teapot/Parkman sandstone from nearby oil wells in Campbell County contained total dissolved solids ranging from 12,130 to 13,800 mg/l.

The Teckla, Teapot, and Parkman Formations are regarded as potential oil and gas targets in this portion of the PRB. Deeper Cretaceous oil and gas targets below the Mesa Verde Formation shown on Figure 2.6A-4 include the Niobrara Shale and the Turner Sandstone. These formations occur over 2,000 feet deeper than the potential deep disposal zones. The great thickness of low-permeability units overlying and underlying the potential disposal zones effectively isolate the units from sandstones higher and lower in the geologic section.

The Madison limestone and Tensleep sandstone are approximately 15,000 feet below the land surface (Figure 2.6A-3).and approximately 7,000 to 8,000 feet below the Teckla, Teapot and Parkman Formations.

3.3.2 Site Geology

Discussions of local geologic conditions present at the site are included in the following sections.

3.3.2.1 Structure

The Proposed Project area lies within a portion of the PRB that generally dips to the northwest at approximately one degree (Figure 2.6A-2). Based on historic and recent geophysical and lithologic logs covering an area of more than 50 square-miles, including the Proposed Project area, mineralized host sandstone exhibits a dip ranging from 35 to 60 feet per mile.

A structure map (Figure 2.6A-6) drawn on the base of the Lower Felix Coal shows the local dip at the Proposed Project. The Upper and Lower Felix Coals occur within a mudstone unit immediately above the PZA and are locally continuous, making them excellent correlation markers in the Proposed Project area. As shown in Figure 2.6A-6, dips are gentle and do not suggest the presence of faults. Faulting has not been detected across the entirety of the Proposed Project area.

3.3.2.2 Stratigraphy

According to NUREG-1910 (GEIS Section 3.3.3), the primary hosts for uranium mineralization at the Proposed Project area are sandstones of the lower Wasatch Formation of Eocene age (49 to 54.8 million years). The formation consists of interbedded, arkosic sandstone, conglomerate, siltstone, mudstone and carbonaceous shale, all compacted but poorly cemented (Harshman, 1968).

The upper Wasatch has been largely eroded away in the Proposed Project area. The Wasatch Formation is a fluvial sedimentary sequence deposited during a period of wet, subtropical climatic conditions (Seeland, 1988). Laramide tectonic forces uplifted highlands to the south and southwest that provided sediments which were transported northward by rivers flowing into the PRB. Sands deposited by meandering streams formed channel and point bar deposits that typically fine upwards through the sequence. In addition to the fluvial sands, claystones, siltstones, carbonaceous shale, and thin coal seams were deposited in overbank environments. Fine grained sediments were deposited as levees, splays, and in backwater swamps adjacent to sands deposited by higher energy fluvial environments.

The Wasatch Formation occurs at the surface in the Proposed Project area, except where it is occasionally covered by recent alluvium in shallow drainages. The generally accepted base of the Wasatch in the Proposed Project area is the top of the Badger Coal, located approximately 250 feet below the sandstone horizon proposed for uranium recovery operations.

Unconformably underlying the Wasatch is the Paleocene age Fort Union Formation. The Paleocene Fort Union Formation is composed of continental and shallow non-marine deposits associated with Laramie uplift and basin filling. Thicknesses noted by Hodson (1973) are approximately 2,300 feet in the eastern basin, 2,900 feet in the southwest, and almost 3,500 feet in the northwest part. The Fort Union is a heterogeneous unit of fine-grained sandstones, interbedded shales, carbonaceous shale and coal. The formation thickens to the southwest and is conformably underlain by the Lance Formation and unconformably overlain by the Eocene-age Wasatch Formation. Outcrops of the Fort Union Formation encircle most of the basin and beds dip basinward.

The Fort Union Formation is the major source of coal in the PRB and also hosts significant volumes of exploitable CBM reserves. The largest coal mines in the United States are located along the north-south trending outcrop of the Fort Union approximately eight-miles east of Wright, Wyoming, and extending north to the Gillette, Wyoming area. The mines produce coal from the Anderson/Big George coal seams that reach thicknesses of over 100 feet.

The CBM production that is present in parts of the Proposed Project area is from the Anderson/Big George Coal, at approximately 1,000 to 1,100 feet below ground surface. The coal seams occur approximately 600 feet below the base of the PZA, the sandstone unit proposed for uranium ISR operations. This depth relationship is illustrated on the Deep Oil and Gas Type Log (Figure 2.6A-4).

Research by the Wyoming State Geological Survey (Clarey, 2009) has shown that the CBM production in the Anderson/Big George has had no measurable effect on water levels in any Wasatch aquifer. More details about the relationship of CBM production and potential uranium production are found in Section 3.4.

The All Night Creek (ANC) well cluster was installed by the US Bureau of Land Management (BLM) to assess the effects of CBM dewatering activity in Section 36, Township 43N, Range 74 West, in the western portion of the Proposed Project area (Figure 2.7B-11 in TR Addendum 2.7-B, ANCVSS is within the well cluster, west side of map). Water levels in the well cluster were gauged for over 10 years providing an excellent historical record. Water level data from the ANC cluster regarding dewatering of the Big George Coal were used in the Clarey report.

The deepest well in the BLM's ANC cluster was completed in the Big George Coal at approximately 1,070 feet. After approximately six years of CBM dewatering activity in the area the well went dry in 2007, and has stayed dry to the present time. Other wells in the cluster were completed in shallower sandstone units including the Proposed Project's Production Zone Aquifer, and Overlying Aquifer. During the period from 2002 through the present, water levels in the Production Zone Aquifer and the Overlying Aquifer were unaffected by pumping (Figures 2.7B-55 through 2.7B-57) indicating that CBM dewatering will not impact AUC's ISR operations.

AUC contacted the BLM in 2010 and was granted access to the ANC wells for water level monitoring points during pump testing of AUC's PZM5, located approximately 4,000 feet to the east-southeast of the ANC cluster. Water levels in the ANC well cluster were unaffected by the PZM5 hydrologic test (Figure 2.7B-46), further evidence that CBM and ISR operations can coexist without adverse effects.

3.3.2.2.1 Hydrostratigraphic Units

A discussion of units immediately underlying the mineralized host sandstone, the host sandstone, and units overlying the host sandstone are discussed in the following section.
Geophysical logs representative of various portions of the Proposed Project area are found as Figures 2.6A-7 through 2.6A-10. A geological cross section index map (Figure 2.6A-11) and five cross sections (Figures 2.6A-12 through 2.6A-16) are also incuded to provide several views over the entire length and breadth of the Proposed Project. A second set of cross sections are provided to show more detail regarding each of the ore body areas (Figures 2.6A-17 through 2.6A-23). The individual geophysical logs and cross sections demonstrate the continuity of the PZA and the over and underlying confining aquitards.

The following summary provides the stratigraphic nomenclature and acronyms with descending depth utilized for the Proposed Project for the units of interest present in the Wasatch Formation.

- SM Unit (SM wells): Shallow water table unit present in some locations. Based on geologic and hydrologic data, this unit does not meet the requirements of an aquifer in the Proposed Project area;
- Overlying Aquifer (OM wells): Overlying aquifer relative to the production zone. This aquifer also represents the uppermost aquifer observed in the Proposed Project area;
- Overlying Aquitard (OA): Confining unit providing isolation between the production zone and overlying aquifer. The Overlying Aquitard confining unit is found across the entire area of the Proposed Project;
- Production Zone Aquifer (PZA): The PZA is a discrete, continuous sandstone, with occasional shale and mudstone units, across the entire area of the Proposed Project;
- Underlying Aquitard (UA): Confining unit providing isolation between the production zone and underlying unit. The Underlying Aquitard confining unit is found across the entire area of the Proposed Project; and
- Underlying Unit (UM wells): Discontinuous underlying sand units relative to the production zone. Based on geologic and hydrologic data, this unit does not meet the requirements of an aquifer in the Proposed Project area.

In the Proposed Project area, the lower-most unit of the Wasatch Formation comprises the UA Aquitard, which lies below the Production Zone Aquifer (PZA) and above the

Badger Coal. The aquitard is approximately 150 to 250 feet thick and consists of laterally continuous silt and clay rich mudstones, and locally, discontinuous lenticular sandstones. This confining unit is present under the entire Proposed Project area. An isopach map of the UA Aquitard is included (Figure 2.6A-24).

The first significant sandstone in closest proximity (subjacent) to the Production Zone Aquifer (PZA) is designated as the Underlying Unit. As depicted on the cross sections in TR Addendum 2.6-A, the Underlying Unit is not an aquifer or a continuous, correlatable zone.

The mineralized host sandstone, or PZA, overlies the UA Aquitard. The PZA is a discrete and laterally continuous sandstone ranging from under 75 feet to approximately 220 feet thick as shown in Figure 2.6A-25. In the central portion of the Proposed Project area, the PZA is divided into an upper sandstone and a lower sandstone by a five to 30 foot thick mudstone. This division occurs locally in other portions of the project as well, and multiple mudstone lenses of limited lateral extent are commonly observed throughout the Proposed Project area. In areas where the PZA is bifurcated mineralization can be found both above and below the mudstone lens.

At various localities within the Proposed Project area all horizons from the base to the top of the host sandstone can be favorable for uranium deposition. However, economically significant uranium mineralization occurs most frequently in the lower half of the PZA.

In the far eastern portion of the Proposed Project area the PZA is partially saturated, and in limited areas uranium mineralization is present above the potentiometric surface of the PZA. Based on recent work by AUC, the mineralization in the uppermost, unsaturated portion of the PZA does not represent a significant percentage of the overall uranium resource. Sections 3.4 and 4 of this ER and 2.7 of the TR describe these conditions and the hydrologic behavior in detail. Sections 3-6 of the TR also provide additional detail about the operations of the Proposed Project.

Sandstones within the PZA that host the uranium mineralization are commonly crossbedded, graded sequences fining upward from very coarse at the base to fine grained at the top, representing sedimentary cycles from five to 20 feet thick. Stacking of depositional cycles has resulted in sand body accumulations over 200 feet thick.

The unit overlying the PZA in the Proposed Project area is the Overlying (OA) Aquitard. Figure 2.6A-26, an isopach map of the unit, addresses the thickness of the zone from the top of the PZA to the first significant overlying sandstone. The unit consists of a laterally continuous sequence of silt and clay rich mudstones, thin coal seams, and discontinuous sandstones. The thickness of the OA Aquitard can change rapidly due to discontinuities in the overlying sandstone units contained within this portion of the section, but is present as a continuous confining unit across the entire Proposed Project area.

The Felix Coal seams form a laterally continuous marker bed within the lower part of the OA Aquitard. In the eastern portion of the Proposed Project area, there are Upper and Lower Felix Coal seams, separated by approximately five feet of mudstone. The Upper Felix Coal seam pinches out or climbs in the section in the western portion of the Proposed Project area, causing a correlation break from east to west. The Felix Coal seams range from five to 10 feet in thickness. A structure map drawn on the base of the Lower Felix Coal is shown in Figure 2.6A-6. Minor structural undulations are indicated by the mapping, but generally the dip is consistent and no faulting is evident.

The Felix coals are not CBM production targets in the Proposed Project area. The closest permits for possible usage of the Felix seam for CBM production is approximately 20 to 25 miles north of the Proposed Project area.

The first significant sandstone above the Felix Coal is designated as the Overlying Aquifer. Generally the sandstones comprising Overlying Aquifer are discontinuous, difficult to correlate over distances exceeding a few thousand feet, and are contained within mudstones of the OA Aquitard. This conceptual depositional relationship is depicted on cross sections in Addendum 2.6-A of the TR. In the central portion of the Proposed Project area the sandstone is well developed and attains a thickness of approximately 90 feet near the PZM4 well cluster.

A discontinuous, water table zone, referred to as the SM Unit, has also been identified by drilling at four of the well cluster locations. To determine if a water table zone is present at the well clusters, test borings were air-drilled to a depth of approximately 70 feet. Two-inch I.D. slotted PVC casing was temporarily installed for observation of groundwater infiltration. If a minimum of five feet of water was observed after standing a few days the temporary well was recompleted as a permanent monitoring well. The shallowest water level in the SM Unit was approximately 35 feet below ground surface.

Three of the seven SM tests proved to be dry, and the four that were converted to wells are poor producers. The term SM Unit has been used to describe the shallow water bearing zones as they do not fit the definition of aquifers. A discussion of this definition can be found in Section 3.4.2.3 of this ER.

The above data demonstrate that the PZA is geologically confined across the entire area of the Proposed Project, and that only the Overlying Aquifer exhibits characteristics of an aquifer. All other water bearing units outside of the PZA are not classed as aquifers.

Figures 2.6A-6 through 2.6A-10 are typical geophysical logs RC0005 (West), RC0004 (Central), RC0003 (Southeast), and RC0001 (East) that illustrate characteristics of the various units across the Proposed Project area.

As outlined in the above discussion, stratigraphic continuity of the OA Aquitard (including the Felix Coal seams), the PZA, and the UA Aquitard has been demonstrated by drilling and mapping of the units across the five mile length of the Proposed Project area.

3.3.2.3 Lithologic Characteristics

Lithologic data at the Proposed Project is extensive. Records from historic and recent drilling include descriptions of samples and geophysical logs from thousands of drill holes beginning with exploration drilling in the late 1960s.

Drilling a total of 807 plug holes, well pilot holes, and core holes has been conducted by AUC since August 2010. Cuttings samples were collected at five-foot continuous intervals for lithologic descriptions by AUC geologists from surface to total depth. A collection of cuttings samples have been saved for future reference. The new drilling has been incorporated into AUC's extensive database of historic log data providing thousands of geologic data points in the Proposed Project area. New and historical drill holes are shown on Figure 2.6B-1 through 2.6B-3 in Addendum 2.6-B in theTR.

A deep stratigraphic test hole penetrating the total thickness of the Wasatch Formation through the Badger Coal marker at the top of the Fort Union Formation, was drilled in each of AUC's seven well clusters. The stratigraphic hole was the first hole drilled in each cluster in order to provide lithologic and stratigraphic information for use in determining completion depths of each of the various wells in the group. Three additional stratigraphic test holes to the Badger Coal were drilled in the southwestern portion of the Proposed Project area to provide more detailed sub regional control.

AUC recovered core samples from the Overlying and Underlying Aquitards and the Overlying Aquifer in the PZM4 Well Cluster, and from the PZA in the west (Section 36, T43N, R74W) and southwest (Section 6, T42N, R73W) portions of the Proposed Project area. Cores from the multiple zones were recovered to evaluate characteristics of each of the lithologic units, and were obtained from 10 separate core hole locations during the past year. Figures 2.6B-1 through 2.6B-3 illustrate the locations of the core holes.

Cores were collected for multiple purposes and analyses as follows:

1) Visual inspection and lithologic logging of sandstones, mudstones, and the Felix Coal seams;

2) Vertical and horizontal permeability and porosity analyses by various methods in major lithlogic units including aquitards (claystones, mudstones, siltstones), unmineralized sandstones, and mineralized sandstones;
3) Effective Porosity;
4) Bulk density;
5) Grain size analysis;
6) Clay content and mineralogy;
7) PZA sandstone lithology, mineralogy, and petrology;
8) Uranium mineral(s) identification; and
9) Metallurgical testing by bottle roll and column leach using varied oxidants and lixiviant strengths. Testing will provide data regarding amenability of uranium leaching and insights regarding geochemistry at the Proposed Project.

Results are complete for the first six items listed above, and are summarized on Tables 2.6A-1 through 2.6A-3 of TR Addendum 2.6-A. The last three items listed above are yet to be completed.

Although petrograhic analyses on recent core has yet to be completed, general conclusions regarding lithologic characteristics of the major units can be made on the basis of recent core and cuttings examinations and historical data originally generated by Rocky Mountain Energy.

The three lithologies encountered most commonly at the Proposed Project are mudstones, sandstones and coal (lignite). A thin veneer of soil is developed at the ground surface due to weathering of the lithologic units of the Wasatch Formation.

Mudstone is the term used for silt and clay dominated sediments at the Proposed Project. Very fine grained sands are also found within these low-energy depositional sequences. Depending on clay and silt content these units can range from siltstones to claystones. Mudstones closely adjacent to the Felix Coal seams often have the visual appearance of true claystones. Petrographic studies, clay analysis, and grain size distribution analyses are underway and/or planned to more definitively determine the type and percentage of sediments comprising the mudstone sequences.

As observed in core, mudstone units are often dark to medium gray, thinly laminated, and occasionally contain carbonaceous material. Carbonaceous clayey units grading to lignites adjacent to the Felix Coal seams have been observed in core. Increasing clay content often imparts a dense waxy appearance in zones with very low visual permeability.

Sandstones at the Proposed Project are described as arkosic and/or feldspathic in composition. Sands range from very fine to very coarse grained. Occasional pebble size clasts are also present. Colors range from light gray to dark gray in unoxidized areas, and yellowish gray (limonitic) to pink (hematitic) in oxidized areas. Cores often exhibit low angle cross bedding, but can be massive with only minor visible bedding planes. Fining upward sequences are often observed within depositional sequences. Accessory minerals include pyrite (trace to five percent) and calcium carbonate that form isolated hard lenses up to ten feet thick. Carbonaceous material is occasionally present in reduced portions of the sandstone. Grains have undergone considerable transport and range in appearance from sub angular to well rounded. Sorting ranges from good to poor with interstitial clay and/or silt forming a less permeable matrix in isolated areas.

3.3.2.4 Permeability and Porosity Measurements

Core samples from the PZM4 Well Cluster were collected for analysis of permeability and porosity (P&P) from the Overlying Aquifer, Overlying Aquitard, and Underlying Aquitard. Additional core samples from wide spaced core holes in the southwest portion of the Proposed Project area (RC0001C, 2C, 6C, 7C, and 9C) were recovered for analysis of properties of the PZA.

Permeability, porosity, and measurements of other rock properties were conducted by Core Laboratories and Weatherford Laboratories. Results are found in Tables 2.6A-1, 2.6A-2, and 2.6A-3.

Overlying Aquifer

Klinkenberg air permeability results from the Overlying Aquifer (two horizontal, one vertical) ranged from 1376 to 1775 md. Porosity measurements ranged from 35.65 percent to 40.63 percent.

Production Zone Aquifer

Klinkenberg air permeability results from the PZA sandstone (five horizontal, one vertical) ranged from 1073 to 3121 md. Porosity measurements ranged from 32.30 percent to 34.43 percent.

Klinkenberg air permeability results from the PZA cemented by calcium carbonate (one horizontal, one vertical) ranged from .178 to 2022 md (2022 md is a high, questionable result apparently due to a fractured core plug). Porosity measurements ranged from 12.67 percent to 15.07 percent, consistent with the observed tight, highly cemented condition.

One analysis of effective porosity was made on a PZA sandstone sample from core hole RC0007C. In this case the Klinkenberg permeability was 1801 md, the non-effective porosity was 31.8 percent; however the effective porosity measurement of this sample was 23.7 percent. Effective porosity excludes porosity related to bound water in clays resulting in a lower number.

Underlying Aquitard

Klinkenberg air permeability results from the Underlying Aquitard mudstone (two vertical) ranged from 5.2 to 10.1 md. Porosity measurements ranged from 21.95 percent to 29.92 percent.

This same Underlying Aquitard interval was also tested using a liquid permeability test (cap rock analysis) by Core Laboratory. In this case the vertical permeability result was 0.000584 md, a much lower result due to the method used. Liquid permeability measurement methods are regarded as a much more appropriate method for this type of analysis; therefore while the air permeability results of 5.2 to 10.1 md are useful in a qualititative sense, AUC regards the 0.000584 md liquid permeability result to be the accurate measurement. Pump test results also confirm that the aquitard is a very effective non-leaky hydrostratigraphic unit.

Overlying Aquitard

The Overlying Aquitard was also tested using a liquid permeability test (cap rock analysis) by Core Laboratory. The vertical permeability result was 0.0005877 md, very low and similar to the result from the Underlying Aquitard.

Based on these data, the permeability and porosity of the PZA appears to be favorable for ISR operations. Liquid vertical permeability tests performed on core from the Overlying and Underlying Aquitards indicated they are highly impermeable, favorable conditions for confinement of fluids within the PZA.

3.3.2.5 Mineralogy

Sandstones at the Proposed Project are described as arkosic and/or feldspathic in composition. Quartz grains are a major component with moderate amounts of potassium and calcium feldspars. Accessory minerals include pyrite (less than five percent) and calcium carbonate cement. Carbonaceous material is occasionally present in reduced portions of the sandstone.

Recent whole rock mineralogy work by AUC and reports from analytical work by Rocky Mountain Energy in the late 1970s indicate that quartz ranges from 50 to 60 percent,

feldspars comprise approximately 20 to 25 percent, and clays are present as smectite, kaolinite, and illite may comprise up to 20 percent of the total.
AUC has collected core for submission for analytical work to determine the uranium mineralogy. Analyses of core from mineralized sandstones will be conducted to determine the type of uranium minerals present at the Proposed Project. In addition AUC will test for any associated elements that may be present such as vanadium to provide a basic understanding of the geochemistry of the deposit.

As noted in NUREG-1910 (GEIS Section 2.1), the main ore minerals in the unoxidized zone are coffinite and pitchblende (a variety of uraninite). Low concentrations of vanadium (~100 ppm) are sometimes associated with the uranium deposits at the Proposed Project, based on metallurgical testing conducted by AUC. Of five recently tested core samples, only one exhibited molybdenum (0.6 mg/kg) Also, selenium was only detected in one sample at 6.9 mg/kg. Arsenic was detected in all samples ranging from 1.4 to 14 mg/kg. Scattered lenses of calcium carbonate cement occur throughout the area, but only rarely contain anomalous uranium.

AUC will verify past work and will have petrographic work conducted to more accurately determine the composition of the host sandstones, siltstones, and claystones.

3.3.2.6 Uranium Mineralization

Uranium deposits accumulated along roll-fronts (also referred to as redox fronts) at the down-gradient terminations of oxidation tongues within the PZA sandstone. According to NUREG-1910 (GEIS Section 3.3.3), these roll fronts are stratabound and genetically related to geochemical interfaces. The oxidation tongues are extensive, covering square miles down dip of oxidized outcrops. Ore grade concentrations occur on the reduced side of the geochemical interface.

The Eocene Wasatch Formation is approximately 500 to 700 feet thick in the Proposed Project area. Uranium mineralization is confined to the host sandstone of the Production Zone Aquifer (PZA). The PZA occasionally contains significant mudstone sequences with varying silt and clay content. Uranium deposits are found within a sand unit ranging from 50 to 200 feet in thickness, and at depths ranging from 170 to 450 feet below ground surface.

Uranium intercepts are variable in thickness ranging from one foot to over 40 feet thick. Thin low grade residual upper and lower limbs of the roll fronts often occur in reduced mudstones that form upper and lower boundaries of oxidized sand units.

The uranium mineralization occurs as coatings on sand grains within the host sandstone aquifer. Dissolved uranium carried in groundwater precipitated as groundwater flowed laterally (downgradient) through the redox boundary. The maximum dimensions of the ore bodies are at the leading edge of the solution-front where the alteration tongue protrudes down gradient of the original depositing groundwater flow direction (Anderson, 1969).

While in solution, uranium is readily transported and remains mobile as long as the oxidizing potential of the groundwater is not depleted. When the dissolved uranium encounters a reducing environment it is precipitated and deposited at the interface between the oxidizing and reducing environments known as the redox front. The redox front will progress down gradient as new influxes of oxidizing groundwater redissolve and transport the uranium. Although groundwater flow through porous sands can be in the range of a few feet per day, progression of the redox front is several magnitudes slower.

Alteration or oxidation of the PZA sandstone in the Reno Creek area was produced by the down-gradient movement of oxidizing, uranium bearing groundwater solutions. Uranium mineralization was precipitated by reducing agents and carbonaceous materials in the gray, reduced sands. The host sandstones, where altered, exhibit hematitic (pink, light red, brownish-red, orange-red) and limonitic (yellow, yellowish-orange, yellowish-brown, reddish-orange) alteration colors which are easily distinguished from the unaltered medium-bluish gray sands. Feldspar alteration, which gives a “bleached” appearance to the sands from the chemical alteration of feldspars into clay minerals, is also present. Limonitic alteration dominates near the “nose” of the roll fronts. The remote barren interior portions of the altered sands are usually pinkish-red in color. The uranium mineralization is contained in typical Wyoming roll-front deposits that are highly sinuous in map view. A diagram of a roll front using electric logs from the southwest portion of the Proposed Project area is included as TR Figure 2.6A-27.

Carbon trash is occasionally present in both the altered and reduced sands. In general, the unaltered sands have a greater percentage of organic carbon (~0.2 percent) than the altered sands (0.13 percent) in selected cores (historical data) analyzed. Carbon in unaltered sands is shiny; while it is dull and flaky in the altered sands.

3.3.2.7 History of Uranium Exploration and Development

Initially, Rocky Mountain Energy (“RME”) and subsequently Energy Fuels Nuclear, Inc. (“EFN”) and its successor International Uranium Corporation (IUC) performed exploratory drilling in the Reno Creek area from 1968 through 1994, including more than 2,000 drill holes. In the mid 1970’s RME formed a joint venture with Mono Power and Halliburton Company to develop the property for mining. The joint venture applied for and received a research and development (R&D) Pilot Plant license in 1978 from the NRC and DEQ. RME tested two injection/recovery patterns under the license.

Pilot Test Pattern 1 incorporated the use of an acid lixiviant. However, it was determined in pilot scale testing that severe permeability reduction caused a loss of injectivity and production, resulting in the test's early termination. The cause of permeability loss was the result of high levels of calcium mobilized by the acid and precipitating as gypsum within the void spaces of the target sand, thus sealing off the formation Restoration and stabilization of the groundwater of Pattern I was acknowledged and signed off by the NRC in March of 1986 (Accession #8604040293/Docket #04008697).

Subsequently, RME conducted a second test (Pattern 2) using a carbonate lixiviant. This model consisted of six monitor wells, four injection wells, and two production wells. Pattern 2's testing objectives were: to develop a successful and efficient system for commercial development, confirm the effectiveness of the carbonate lixiviant, and to substantiate groundwater restoration according to Wyoming DEQ standards. The Pattern 2 ISR pilot test was successful, showing both good recovery and a lack of permeability lost. Test production was terminated in 1980, and restoration was started Pattern 2 pilot testing culminated in regulatory signoff in June 1983 with the approval of carbonate leaching for commercial operations at Reno Creek under Materials License Number SUA-1338 as part of NRC Docket #04008797/Accession #8309220119.

The Reno Creek Pattern 2 restoration report can be viewed in Addendum 1-A of the TR. Addendum 1A provides more detail regarding the historical in-situ recovery operations of RME Research and Development (R&D) and restoration efforts in the Proposed Project area.

RME also conducted a large scale Hydrogeologic Integrity Test during 1982. The investigation had two objectives:

- Determine if historical exploration holes drilled prior to the enactment of drill hole abandonment regulations had naturally sealed themselves; and
- Determine if there is hydraulic communication between the PZA sandstones and the Overlying Aquifer using a series of pump tests in the PZA.

The tests of historical drill hole plugging involved re-entering 33 abandoned drill holes to check for closure. This was due to the swelling of naturally occurring mudstone layers. In addition, twenty-four monitoring/test wells were constructed, of which 18 were pump-and/or injection-tested. The Hydrogeologic Integrity Test report can be found in TR Addendum 2.7-E.

During re-entry of the old holes, obstructions were generally encountered at each of the mudstone horizons present from water table to the base of the PZA. An inflatable packer was set above each of these obstruction horizons as encountered and pressure-tested to see what hydrostatic pressure the obstruction could withstand. The obstructions in the mudstone units referred to herein as the Overlying Aquitard (lying above, between, and below the Felix Coal seams) consistently withheld surface gauge hydrostatic pressures of 120 to 150 psi without bleeding off. Clays in the Overlying Aquitard were recognized at the time to be of a swelling variety, contributing to the natural sealing observed by RME. All subsequent drill hole abandonment, including to the present, incorporated plugging of drill holes with bentonite or other material in accordance with WDEQ regulations. The current plug and abandonment practices can be found in Addendum 2.6-B in the TR.

RME's pump testing showed that there was no measurable communication between the PZA and the Overlying Aquifer. Full details concerning the pump testing and the hydrologic characteristics of the PZA are described in Section 3.4.2.6 of this ER.

EFN/IUC acquired the Reno Creek project from RME and submitted its applications to NRC for a commercial source materials license and to WDEQ for a Permit to Mine. Changing economic conditions caused IUC to withdraw its application in 1999, and ultimately the mining claims and fee mineral leases were dropped. Strathmore Minerals Corporation re-staked mining claims starting in 2004 and operated the project via AUC LLC. Bayswater Uranium Corporation and Pacific Road Resources Funds jointly acquired AUC LLC in 2010.

3.3.3 Drill Holes

The Reno Creek Project area was extensively explored from the late 1960s through 1991 by Union Pacific Railroad and its subsidiaries Rocky Mountain Energy (RME) and Union Pacific Resources. Energy Fuels Nuclear (later International Uranium Corporation, IUC—now Denison) and Power Resources (PRI) acquired the properties and drilled an additional 300 to 400 holes in the 1990's and early 2000's time frame. Drill holes locations are shown on Figures 2.6B-1through 2.6B-3 of Addendum 2.6-B in the TR.

Additionally, American Nuclear (ANC) and Tennessee Valley Authority (TVA) explored the southwest portion of the Proposed Project area during approximately the same time period that Rocky Mountain Energy was active in the area. ANC and TVA drilled approximately 695 holes in the general area on properties adjacent to RME's holdings.

AUC's properties span the former holdings several of the former operators, and include approximately 2,665 historical drill holes and plugged wells within the Proposed Project boundary. An additional 215 holes lie within the 0.5 mile drill hole review area (2,880 holes total). Approximately 100 of the holes were cased wells that were plugged and abandoned by previous operators.

AUC LLC drilled 807 holes in 2010 through 2012, 45 of which are cased wells that will remain in place for an unknown period of years for groundwater monitoring purposes.

The 762 holes that are not cased wells were plugged and abandoned in accordance with WDEQ/LQD Chapter 8 and per the WDEQ approved "AUC LLC Reno Creek Project Drilling Notification 401 Permit Amendment 2, TFN 5 6/175" dated February 9, 2011. AUC's Plug and Abandonment Plan can be found in TR Addendum 2.6-B.

All future exploration and delineation plug holes will be capped, sealed or plugged in accordance with WDEQ/LQD Non-Coal Rules and Regulations Chapter 8 "Exploration by Drilling" as amended. The plugging procedure is outlined in Section 2 of Chapter 8 and requires an approved grout be emplaced in the drill hole from the bottom of the hole to within five feet of the ground surface. Grout means sealant material that is stable, has low permeability and possesses minimum shrinking properties such that it is an optimal sealing material for well plugging and drill hole abandonment. Following the installation of the grout, the drill hole shall be backfilled to the surface with dry non-slurry materials or capped with a concrete cap set at least two feet below the ground surface and then backfilled to the surface with native earthen materials to ensure the safety of people, livestock, wildlife, and machinery in the area.

During the past year 12 historic holes were found in the southwest portion of the project area (Section 36 T43N, R 44W). The holes were surveyed and found to match coordinate locations of two ANC/TVA drill holes. The first hole was probed and found to be naturally plugged at approximately 60 feet in depth. The second hole had a cement plug at the surface and was found to be plugged to total depth. AUC opened the holes to total depth, ran geophysical logs and plugged with high solids bentonite grout per the procedure described above. AUC proposes to use a similar procedure for plugging other historic drill holes at the site during post licensing well field development, as follows:

- A search for old holes will be conducted in the southwest portion of the site where drilling was conducted by ANC and TVA in mineralized areas. AUC currently has no electric logs for the ANC or TVA holes so AUC will gain value by opening the holes to total depth, examining the type of plugging that currently exists (natural or otherwise), and probing the holes with down hole geophysical logging equipment. Once logged, the holes will be plugged using standard procedures described above;
- In other areas of the project where AUC possesses historic electric logs, AUC will be prepared to search for, and plug old drill holes in proximity to future production units if pump testing and hydrologic results indicate that leakage through old drill holes might be a problem. Holes will be plugged as described above;
- Integrity testing by Rocky Mountain Energy (Hydrogeologic Integrity Evaluation, 1982; Addendum 2.7-E) indicated that old drill holes have been sealed by either natural swelling clays or by plug gel which was in use following regulatory

requirements after approximately 1980. The integrity testing provides a strong indication that re-plugging of old drill holes may not be necessary; and

- AUC will plug any old open holes that may be encountered while working anywhere within the Proposed Project area.

In addition to uranium exploration logs, CBM drilling logs are publicly available and have been examined and correlated across the Proposed Project area. The US Bureau of Land Management completed a cluster of wells in the southwest portion of the project area, and logs and water level data from the wells has been incorporated into AUC's database. The wells were completed in the Big George Coal horizon and four sandstone aquifers above the Big George as reported by the Wyoming State Geological Survey (Clarey, 2009).

Common practice in the Pumpkin Buttes Uranium District was to drill bore holes using 4¾ to 5¼ -inch diameter bits by conventional rotary drill rigs circulating drilling mud. The cuttings were typically collected over five-foot intervals and laid out on the ground in rows of 20 samples (100 feet) by the driller. The site geologist examined the cuttings in the field to determine lithology and geochemical alteration.

Upon completion of the drilling, the bore holes were logged, from the bottom of the hole upward, with a gamma-ray, self-potential, and resistivity probe by either a contract logging company or possibly a company-owned logging truck. In some of the drill holes, after running the log, a drift tool (film-shot) was lowered into the hole for survey at 50 or 100 feet intervals to record drilling deviations from vertical. Deviations were typically less than 1-3º, and since the dip of the beds is very gentle (½º), the mineralized intercepts recorded represent essentially true thickness.

All of AUC's bore holes were logged by an independent down-hole geophysical contractor, Century Geophysical Corporation, immediately after the holes were drilled. Lithologic and geophysical logs are stored electronically and on hard copy by AUC for future use.

Table 2.6B-1 in TR Addendum 2.6-B lists all drill holes known to AUC in the Proposed Project area and ½ mile buffer.

3.3.4 Soils

The Proposed Project area was evaluated by BKS Environmental Associates, Inc., Gillette, Wyoming in 2010 and 2011. A total of approximately 6,057 acres were included in the final soil mapping of the Proposed Project area. Soils mapped by BKS Environmental Associates, Inc. are illustrated on the Soils Map in Addendum 3.3-A.

Stripping depths for the Proposed Project unit were evaluated during mapping and sampling. Soil depths within a given mapping unit will vary based on any combination of the five primary soil forming factors, i.e., climate including effective precipitation, organisms, relief or topography, parent material, and time. Subtle differences in any one of the previously mentioned factors will impact development between series and within series designation but may not be as noticeable as when topography is a major factor. The topsoil salvage depths for the Proposed Project area are based on laboratory data of the samples found within the perimeter of the area, as well as field observations and knowledge of the soils in Southern Campbell County, Wyoming. The parameters for suitable, marginal, and unsuitable topsoil material are taken from WDEQ Guideline 1, Table I-2 (August 1994 Revision).

Soils in the Proposed Project area are typical for semi-arid grasslands and shrublands in the Western United States. Parent material included colluvium, residuum, and alluvium. Most soils are classified taxonomically as Ustic Paleargids, Ustic Haplargids, Ustic Torriorthents, and Ustic Haplocambids.

Most soils have some suitable topsoil. The primary limiting chemical factor within the Proposed Project unit is Selenium. The primary limiting physical factor is texture.

Large scale soil surveys had been previously conducted, by the U.S. Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS) in 1972 and 1991. The major objective of the 2010-2011 assessment was to define the existing topsoil resource within the Proposed Project area and determine the extent, availability, and suitability of soils material for use in reclamation. The mapping and reporting for the Proposed Project area incorporated map unit information from the previous NRCS soil surveys. Three sample pedons were analyzed for soil series covering greater than 160 acres, two sample pedons were analyzed for soil series covering 40 to 160 acres, and one sample pedon was analyzed for each soil series covering less than 40 acres.

Refer to these ER addenda for the following soils information:

- Addendum 3.3-A for the Soils Map;
- Addendum 3.3-B for all tables cited in Section 3.3.4;
- Addendum 3.3-C for the Soil Mapping Unit Descriptions;
- Addendum 3.3-D for the Sampled Soils Series Descriptions;
- Addendum 3.3-E Laboratory Results of the sampled soils;
- Addendum 3.3-F for the Soil Sample Photos; and
- Addendum 3.3-G for the Prime Farmland Designation.

3.3.4.1 Soil Survey Methodology

Construction of the project area soil map (Addendum 3.3-A) was completed according to techniques and procedures of the National Cooperative Soil Survey. Guideline No. 1 (Updated August, 1994) of the Wyoming Department of Environmental Quality, Land Quality Division (WDEQ/LQD) was followed during all phases of the work.

3.3.4.1.1 Field Sampling

Soil series were sampled to reflect recommended sample numbers in WDEQ Guideline 1 (August 1994 Revision) based on preliminary mapping acreage identified at that time.

Series were sampled and described by coring with a mechanical auger, i.e., truck-mounted Giddings. The physical and chemical nature of each horizon within the sampled profile was described and recorded in the field. Although numerous holes were augured for soil series and map unit verification, only the field locations of profiles selected for laboratory analysis are plotted on the soils map included within this report. Sampled soil material was placed in clean, labeled, polyethylene plastic bags and kept cool to limit chemical changes. Samples were kept out of direct sunlight prior to analysis. A total of 30 sites in the Proposed Project area were sampled for analysis; all had corresponding soil profile descriptions written. Refer to Table 3.3B-1 Soils Series Sample Summary and Table 3.3B-2 Soil Sample Locations in ER Addendum 3.3-B.

3.3.4.1.2 Laboratory Analysis of Field Sampling

Samples were individually placed into lined aluminum pans to air dry. Coarse fragments were measured with a 10 mesh screen prior to grinding; the entire sample was then hand ground to pass 10 mesh. An approximate 20 ounce subsample was obtained through splitting with a series of riffle splitters and subsequently analyzed. A second subsample was maintained in storage at the laboratory. Approximately 10 percent of the samples are run for duplicate analysis. Actual laboratory analysis follows the methodology outlined in WDEQ/LQD Guideline 1 (August 1994 Revision). In general, samples were analyzed within 45 days of receipt of the samples at the laboratory. All analytical data is presented in Addendum 3.3-D, Original Laboratory Data Sheets.

Refer to Table 3.3B-3 for soil mapping unit designations and associated acreage within the Proposed Project area.

3.3.4.2 Soil Survey Results

General topography of the area includes rolling hills and ridges, as well as drainages. The soils occurring on the Proposed Project area were generally fine textured throughout with patches of sandy textures on upland areas and fine textured soils occurring near or in drainages. The project area contains deep soils on lower toe slopes and flat areas near drainages with shallow and moderately deep soils located on upland ridges and shoulder slopes.

3.3.4.2.1 Soil Mapping Unit Interpretation

The primary purpose of the 2010-2011 fieldwork was to characterize the soils within the Proposed Project area in terms of topsoil salvage depths and related physical and chemical properties. The total number of samples per series was established in line with WDEQ Guideline 1 (August 1994 Revision) recommendations based on estimated acreage of soil series known within the Proposed Project area. Samples were collected throughout the project area to allow for maximum flexibility in planning soil disturbing activities. Refer to Addenda 3.3-C and 3.3-D for soil mapping unit descriptions and soil series descriptions, respectively.

3.3.4.2.2 Analytical Results

Analyzed parameters, as defined in WDEQ Guideline 1 (August 1994 Revision), are in Addendum 3.3-E, Soil Laboratory Analysis. Laboratory soil texture analysis did not include percent fine sands. Field observations of fine sands within individual pedestals as well as sample site topographic position were used in conjunction with laboratory analytical results to determine series designation. Soil sample photos can be viewed in Addendum 3.3-F.

3.3.4.2.3 Evaluation of Soil Suitability as a Plant Growth Medium

Approximate salvage depths of each map unit series is presented in Table 3.3B-4 and ranged from 0.2 to 3.6 feet. Within the Proposed Project area, suitability of soil as a plant growth medium is generally affected by the physical factor of high clay. The chemical limiting factors were selenium (Se) and excessive calcium carbonate ($CaCO_3$) as determined in field with 10 percent hydrochloric acid (HCl). Marginal material, according to WDEQ Guideline 1, was found in seven of the 31 profiles. No unsuitable material, according to WDEQ Guideline 1, was found in any of the profiles. Marginal or unsuitable parameter information for sampled profiles is identified in Table 3.3B-5. Soils were also field tested for calcium carbonate ($CaCO_3$) with 10 percent HCl.

3.3.4.2.4 Topsoil Volume Calculations

Based on the 2010-2011 fieldwork with associated field observations and subsequent chemical analysis, the recommended topsoil average salvage depth over the Proposed Project boundary was determined to be 1.31 feet. Refer to Table 3.3B-4 in ER Addendum 3.3-B, Approximate Soil Salvage Depths.

In accordance with WDEQ Guideline 4, suitable topsoil shall be salvaged from planned disturbances, when possible. All long-term topsoil stockpiles will be constructed and maintained in accordance with WDEQ/LQD Rules and Regulations, Chapter 2.

Within the project area, an estimated 481 acres will be controlled and/or fenced for construction or production purposes. Within the controlled/fenced areas, it is anticipated that approximately 154 acres will be disturbed and require topsoil salvage. Within the 154 acres of disturbance, approximately 202 acre/feet of salvageable topsoil is present.

3.3.4.2.5 Soil Erosion Properties and Impacts

Based on the soil mapping unit descriptions, the hazard for wind and water erosion within the Proposed Project unit varies from slight to severe. The potential for wind and water erosion is mainly a factor of surface characteristics of the soil, including texture and organic matter content. Given the fine-loamy and sandy texture of the surface horizons throughout the majority of the Proposed Project unit, the soils are more susceptible to erosion from wind than water. See Table 3.3B-6 in ER Addendum 3.3-B for a summary of wind and water erosion hazards within the Proposed Project site.

The fenced controlled areas are underlain by soils with a moderate potential for water erosion and a slight to moderate potential for wind erosion. All topsoil will be stripped, stockpiled and maintained in accordance with WDEQ/LQD rules and regulations, the surface will be graded and stormwater will be routed. These measures will help reduce the effect of construction on soil erosion.

The soils underlying the proposed production units are at a moderate to severe risk of erosion from both wind and water. Though only small and non-contiguous areas of topsoil will be stripped from the wellfields, construction may result in an increase in the erosion hazard from both wind and water due to the removal of vegetation and the physical disturbance from heavy equipment. All areas are reseeded as soon as possible to keep the duration of bare soil to a minimum. Reseeding will help mitigate the increased erosion potential from the construction disturbance.

Detailed soil impact mitigation plans can be found in Section 6.3 (Mitigation of Potential Geology and Soils Impacts).

3.3.4.2.6 Prime Farmland Assessment

No prime farmland was indicated within the Proposed Project area based on a reconnaissance survey by the NRCS. Refer to Addendum 3.3-G, Prime Farmland Designation, for the NRCS letter of negative determination.

3.3.5 Seismology

The discussion of seismology within the Proposed Project and surrounding areas includes: an analysis of historic seismicity, 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. Intensity values and descriptions can be found in Tables 2.6C-1 and 2.6C-2 in TR Addendum 2.6-C.

3.3.5.1 Seismic Hazard Review

The seismic hazard review was based on analysis of available literature and historical seismicity for the Proposed Project area. Appendix A to 10 CFR Part 40 presents criteria relating to the operation of uranium mills and the disposition of tailings or wastes. Criterion 4 of that Appendix lists site and design criteria that must be adhered to whether tailings or wastes are disposed of above or below grade. Because there will be no mill or tailings impoundment at the Proposed Project, AUC contends that Criterion 4 design criteria are not necessary for either of the previously mentioned structures to support this application. Criterion 4(e) deals with seismic hazards and states that, "The impoundment may not be located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand. As used in this criterion, the term ‘capable fault’ has the same meaning as defined in section III (g) of Appendix A of 10 CFR Part 100. The term ‘maximum credible earthquake’ means that earthquake which would cause the maximum vibratory ground motion based upon an evaluation of earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material." There are no capable faults (i.e., active faults) with surface expression mapped within or near the Proposed Project area, according to the USGS (2009a).

3.3.5.2 Seismicity

The following discussion of seismicity in Wyoming and the Proposed Project area is based primarily on Wyoming State Geological Survey Information Pamphlet 6 (Case and Green 2000), Seismological Characterization

3.3.5.3 Historic Seismicity Near the Proposed Project Area

Historic seismic events for Campbell County and other counties surrounding the Proposed Project area including Natrona, Converse, and Johnson Counties are summarized below.

3.3.5.3.1 Campbell County

Five magnitude 2.5 and greater earthquakes have been recorded in Campbell County. The first earthquake recorded in the county occurred on May 11, 1967. This magnitude 4.8 earthquake was centered in southwestern Campbell County approximately seven miles west-northwest of Pine Tree Junction. The second event took place on February 18, 1972, when a magnitude 4.3 earthquake occurred approximately 18 miles east of Gillette. No damage was reported for either event.

Two earthquakes were recorded in Campbell County during the 1980s. On May 29, 1984, a magnitude 5.0, intensity V earthquake occurred approximately 24 miles west-southwest of Gillette. The earthquake was felt in Gillette, Sheridan, Buffalo, Casper, Douglas, Thermopolis, and Sundance. On October 29, 1984, a magnitude 2.5 earthquake occurred approximately 25 miles west-northwest of Gillette. No damage was reported.

Most recently, on February 24, 1993, a magnitude 3.6 earthquake occurred in southeastern Campbell County approximately 10 miles east-southeast of Reno Junction. No damage was reported.

3.3.5.3.2 Natrona County

Twelve magnitude 2.5 or intensity III and greater earthquakes have been recorded in Natrona County. The first earthquake that occurred in Natrona County took place on December 10, 1873, approximately two miles south of Powder River. People in the area reported feeling the earthquake as an intensity III event. Two of the earliest recorded earthquakes in Wyoming occurred near Casper. On June 25, 1894, an estimated intensity V earthquake was reported approximately three miles southwest of Evansville. Residents on Casper Mountain reported that dishes rattled to 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 riverbanks slumping into the river during the earthquake (Mokler, 1923). An even larger earthquake was felt in the same area on November 14, 1897. This intensity VI-VII earthquake, one of the largest recorded in central and eastern Wyoming caused considerable damage to a few buildings. On October 25, 1922, an intensity IV-V earthquake was detected approximately six miles north northeast of Barr Nunn. The event was felt in Casper; at Salt Creek, 50 miles north of Casper; and at

Bucknum, 22 miles west of Casper. No significant damage was reported at Casper.

One of the first earthquakes recorded near Midwest occurred on December 11, 1942. The intensity IV-V event occurred approximately 14 miles south of Midwest. Although no damage was reported, the event was felt in Casper, Salt Creek, and Glenrock. On August 27, 1948, another intensity IV earthquake was detected approximately six miles north-northeast of Bar Nunn. No damage was reported.

In the 1950's, two earthquakes caused some concern among Casper residents. On January 23, 1954, an intensity IV earthquake occurred approximately seven miles northeast of Alcova. No damage was reported. On August 19, 1959, an intensity IV earthquake was recorded north of Casper, approximately six miles north-northeast of Bar Nunn. People in Casper reported feeling this event. However, it is uncertain if this earthquake actually occurred in the Casper area, as it coincides with the Hebgen Lake, Montana, earthquakes that initiated on August 17, 1959.

Only one earthquake was reported in Natrona County in the 1960s. On January 8, 1968, a magnitude 3.8 earthquake occurred approximately 10 miles north-northwest of Alcova. No damage was reported.

An earthquake of no specific magnitude or intensity occurred approximately 13 miles southeast of Ervay on June 16, 1973. No one felt this earthquake and no damage was reported.

No other earthquakes occurred in Natrona County until March 9, 1993, when a magnitude 3.2 earthquake was recorded 17 miles west of Midwest. No damage was reported. A magnitude 3.1 earthquake also occurred in the far northwestern corner of the county on November 9, 1999. No one reported feeling this earthquake that was centered approximately 32 miles northwest of Waltman.

Most recently, on February 1, 2003, a magnitude 3.7 earthquake occurred approximately 16 miles north-northeast of Casper. Numerous Casper residents felt this event.

3.3.5.3.3 Converse County

Twelve magnitude 3.0 and greater earthquakes have been recorded in Converse County. These earthquakes are discussed below. The first earthquake recorded in Converse County occurred on April 14, 1947. The earthquake had an intensity of V, and was felt near LaPrele Creek southwest of Douglas.

On August 21, 1952, an intensity IV earthquake occurred approximately seven-miles north-northeast of Esterbrook, in Converse County. It was felt by several people in the area, and was reportedly felt 40 miles to the southwest of Esterbrook. Three additional earthquakes have occurred in the same location as the August 21, 1952 event. The first, a small magnitude event with no associated magnitude or intensity, occurred on September 2, 1952. The second, an intensity III event, occurred on January 5, 1957. The most recent, an intensity IV event occurred on March 31, 1964. No damage was reported for any of the events.

On January 15, 1978, a magnitude 3.0, intensity III earthquake occurred approximately three miles northeast of Esterbrook, in Converse County. No damage was reported.

Two earthquakes occurred in Converse County in the 1980's. On November 15, 1983, a magnitude 3.0, intensity III earthquake occurred approximately 15 miles northeast of Casper in western Converse County. No damage was reported. On December 5, 1984, a non-damaging magnitude 2.9 earthquake occurred in the Laramie Range in southern Converse County.

Four earthquakes occurred in Converse County in the 1990's. On June 30, 1993, a magnitude 3.0 earthquake was located approximately 15 miles north of Douglas. No damage was reported. On July 23, 1993, a magnitude 3.7, intensity IV earthquake occurred in southern Converse County, approximately 13 miles north-northwest of Toltec in northern Albany County. This event was felt as far away as Laramie. On December 13, 1993, another earthquake occurred approximately eight miles east of Toltec. This non-damaging event had a magnitude of 3.5. Most recently, on October 19, 1996, a magnitude 4.2 earthquake was recorded approximately 15 miles northeast of Casper in western Converse County. No damage was reported, although the event was felt by many Casper residents.

3.3.5.3.4 Johnson County

Eight magnitude 2.5 and greater earthquakes have been recorded in Johnson County. The first earthquake recorded in the county occurred on October 24, 1922. The location was originally determined to be near Buffalo, and classified the event as an intensity II earthquake. Based upon a description of the earthquake in the October 27, 1922 edition of the Sheridan Post, however, the location and assigned intensity may be in error. The Sheridan Post reported that at Cat Creek, eight miles east of Sheridan, houses were shaken and dishes were rattled. In addition, the October 26, 1922 edition of the Sheridan Post reports that only a slight earthquake shock was felt in Sheridan. Based upon this information, it seems reasonable to locate the earthquake eight miles east of Sheridan, and to assign an intensity of IV-V to the event.

On September 6, 1943, an intensity IV earthquake was felt in the Sheridan area, although the epicenter was determined to be approximately three- to four-miles south-southwest of

Buffalo. Beds and chairs were reported "to sway" in the Sheridan area.

Two earthquakes were recorded in Johnson County in the 1960s. A magnitude 4.7 earthquake occurred on June 3, 1965. This event was centered approximately 12 miles south of Kaycee. On April 12, 1966, an earthquake of no specified magnitude or intensity was detected approximately 25 miles southwest of Buffalo. No one reported feeling these events.

On September 2, 1976, a magnitude 4.8, intensity IV-V earthquake was felt in Kaycee. The event was located approximately 33 miles northeast of Kaycee. No damage was reported.

A magnitude 5.1, intensity V earthquake occurred on September 7, 1984, approximately 33 miles east-southeast of Buffalo. The earthquake was felt throughout northeastern Wyoming, including Buffalo, Casper, Kaycee, Linch, and Midwest, and in parts of southeastern Montana. No significant damage was reported.

Two earthquakes were detected in Johnson County in 1992. The first occurred on February 22, 1992. This magnitude 2.9 event was recorded approximately 18 miles east of Buffalo. As expected with such a small earthquake, no damage was reported. Most recently, a magnitude 3.6, intensity IV earthquake occurred on August 30, 1992. The earthquake was centered near Mayoworth, approximately 22 miles west-northwest of Kaycee. It was felt in Barnum and Kaycee, but no damage was reported.

3.3.5.4 Probablistic Seismic Hazard Analysis

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 will be met or exceeded in a shorter time frame. For example, a 10 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 USGS has recently generated new probabilistic acceleration maps for Wyoming (Case, 2000). Copies of the 500-year (10 percent probability of exceedance in 50 years), 1,000-year (five percent probability of exceedance in 50 years), and 2,500-year (two percent probability of exceedance in 50 years) maps can be found in TR Addendum 2.6-C. Until recently, the 500-year map was often used for planning purposes for average structures, and was the basis of the most current Uniform Building Code (UBC). Recently, the UBC has been replaced by the International Building Code (IBC), which is based upon probabilistic analyses. Campbell County adopted the IBC in 2005. The new IBC, however, uses a 2,500-year map as the basis for building design. The maps reflect current perceptions on seismicity in Wyoming. In many areas of Wyoming, ground accelerations shown on the USGS maps can be increased due to local soil conditions. For example, if fairly soft, saturated sediments are present at the surface, and seismic waves are passed through them, surface ground accelerations will usually be greater than would be experienced if only bedrock was present. In this case, the ground accelerations shown on the USGS maps would underestimate the local hazard, as they are based upon accelerations that would be expected if firm soil or rock were present at the surface. Intensity values and descriptions can be found in Tables 2.6C-1 and 2.6C-2 in TR Addendum 2.6-C.

Based upon the 500-year map (10 percent probability of exceedance in 50 years) (Figure 2.6C-1), the estimated peak horizontal acceleration in Campbell County ranges from approximately three percent/g in the northeastern corner of the county to greater than 6 percent/g in the southwestern corner of the county. These accelerations are roughly comparable to intensity IV earthquakes (1.4 percent/g – 3.9 percent/g) to intensity V earthquakes (3.9 percent/g – 9.2 percent/g). These accelerations are comparable to the accelerations to be expected in Seismic Zones 0 and 1 of the Uniform Building Code. Intensity IV earthquakes cause little damage. Intensity V earthquakes can result in cracked plaster and broken dishes. Gillette would be subjected to an acceleration of approximately five percent/g or intensity V.

Based upon the 1,000-year map (five percent probability of exceedance in 50 years) (Figure 2.6C-2), the estimated peak horizontal acceleration in Campbell County ranges from four percent/g in the northeastern corner of the county to greater than 10 percent/g in the southwestern quarter of the county. These accelerations are roughly comparable to intensity V earthquakes (3.9 percent/g – 9.2 percent/g) to intensity VI earthquakes (9.2 percent/g – 18 percent/g). Intensity V earthquakes can result in cracked plaster and broken dishes. Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Depending upon local ground conditions, Gillette would be subjected to an acceleration of approximately nine percent/g or greater and intensity V or VI.

Based upon the 2,500-year map (two percent probability of exceedance in 50 years) (Figure 2.6C-3), the estimated peak horizontal acceleration in Campbell County ranges from eight percent/g in the northeastern corner of the county to greater than 20 percent/g in the southwestern corner of the county. These accelerations are roughly comparable to intensity V earthquakes (3.9 percent/g – 9.2 percent/g), intensity VI earthquakes (9.2 percent/g – 18 percent/g), and intensity VII earthquakes (18 percent/g – 34 percent/g). Intensity V earthquakes can result in cracked plaster and broken dishes. Intensity VI earthquakes can result in fallen plaster and damaged chimneys. Intensity VII earthquakes can result in slight to moderate damage in well-built ordinary structures, and considerable damage in poorly built or badly designed structures, such as unreinforced masonry. Chimneys may be broken. Gillette would be subjected to an acceleration of approximately 18 percent/g or intensity VI to VII.

As the historic record is limited, it is nearly impossible to determine when a 2,500-year event last occurred in the county. Because of the uncertainty involved, and based upon the fact that the new International Building Code utilizes 2,500-year events for building design, it is suggested that the 2,500-year probabilistic maps be used for Campbell County analyses. This conservative approach is in the interest of public safety.

Current earthquake probability maps that are used in the newest building codes (2,500-year maps) suggest a scenario that would result in moderate damage to buildings and their contents, with damage increasing from the northeast to the southwest. More specifically, the probability-based worst-case scenario could result in damage at points throughout Campbell County and surrounding areas as mentioned in Tables 2.6C-1 and 2.6C-2.

3.3.5.5 <u>Deterministic Analysis of Regional Active Faults with a Surficial Expression</u>

There are no known exposed active faults with a surficial expression in Campbell County. As a result, no fault-specific analysis can be generated for Campbell County. Figure 2.6C-4 shows historic earthquakes and faults in relation to the Proposed Project.

3.3.5.6 <u>Floating or Random Earthquake Sources</u>

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

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

The U.S. Geological Survey identified tectonic provinces in a report titled “Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States” (Algermissen and others, 1982). In that report, Campbell 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° West longitude on the east, 40° North latitude on the south, and 45° North latitude on the north. Geomatrix (1988b) estimated that the largest “floating” earthquake in the “Wyoming Foreland Structural Province” would have a magnitude in the 6.0 – 6.5 range, with an average value of magnitude 6.25.

Federal or state regulations usually specify if a “floating earthquake” or tectonic province analysis is required for a facility. Usually, those regulations also specify at what distance a floating earthquake is to be placed from a facility. For example, for uranium mill tailings sites, the Nuclear Regulatory Commission requires that a floating earthquake be placed 15 kilometers from the site. That earthquake is then used to determine what horizontal accelerations may occur at the site. A magnitude 6.25 “floating” earthquake, placed 15 kilometers from any structure in Campbell County, would generate horizontal accelerations of approximately 15 percent/g at the site. Critical facilities, such as dams, usually require a more detailed probabilistic analysis of random earthquakes. Based upon probabilistic analyses of random earthquakes in an area distant from exposed active faults (Geomatrix, 1988b), however, placing a magnitude 6.25 earthquake at 15 kilometers from a site will provide a fairly reasonable estimate of design ground accelerations in the northeastern and eastern parts of Campbell County, but will be inadequate in the southerstern part of the county.

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3.4 Water Resources

The information in this section provides relevant data concerning the surface and ground water resource characteristics of the proposed Reno Creek Project (Proposed Project) and the surrounding region for NRC licensed ISR operations in accordance with NUREG-1748 and NUREG-1569 (Section 2.7). Comparable and/or more discussion of water resources can also be found in:

- Section 4.4 of this ER (Environmental Impacts);
- Section 5.6 of this ER (Cumulative Impacts);
- Section 6.4 of this ER (Mitigation Measures);
- Section 7.1.5 of this ER (Water Resource Monitoring);
- TR Addenda 2.7-A (Surface Water Tables and Figures) and 2.7-B (Groundwater Tables and Figures);
- TR Addenda 2.7-C (Groundwater Modeling Report), 2.7-D (Pump Test Report), and 2.7E (Hydrogeologic Integrity Test Report);
- Section 2.7 of the TR (Water Resources);
- Section 5.7.8 of the TR (Groundwater/Surface Water Monitoring Program);
- Section 6 of the TR (Groundwater/Surface Water Restoration);and
- Sections 7.1.6 and 7.2.6 of the TR (Enivronmental Effects).

As noted in NUREG-1910 (GEIS Sec. 3.3.4.1), the surface water characteristics of the PRB include ephemeral and intermittent water bodies, and stock ponds. None of the surface water bodies in the Proposed Project area are designated 'fisheries' due to the ephemeral nature of those surface waters. Section 3.3.4.3 of the GEIS (NUREG-1910) also details the groundwater characteristics of the regional systems. Included in the groundwater discussions which follow is reference to the Eocene-age aquifer sandstone formation. As noted in the GEIS (Section 3.3.4.3.3), this formation is a geologically confined aquifer and is the host production zone for uranium mineralization at the Proposed Project, More specific discussions of these surface water (Section 3.4.1) and groundwater (Section 3.4.2) characteristics follow below.

To evaluate water characteristics for the Proposed Project, two graphical methods were employed to prepare geochemical fingerprints of these different waters. Piper diagrams were prepared to provide an overall view of the surface waters and ground waters geochemistry. Stiff diagrams were also prepared to show individual water samples on a cross section for the ground waters.

The diagrams were prepared using the EnviroInsite program (HydroAnalysis, 2012). The points plotted on the Piper diagram represent average compositions if more than one set of results was available for the calculations.

3.4.1 Surface Water Hydrology

3.4.1.1 Regional Description

The Proposed Project is located within the eastern extent of the structurally bounded PRB on the divide between the Belle Fourche River and Cheyenne River Drainage Basins. The Proposed Project straddles a sub-regional surface water divide for those two drainages. The Belle Fourche and the Cheyenne Rivers are both tributaries to the Missouri River. The most significant drainage in the Proposed Project area is the Belle Fourche River drainage which extends NNE through the western portion of the project area and drains the area by way of ephemeral, tributary channels. The main channel of the Belle Fourche River is ephemeral in the Proposed Project area. In the Proposed Project area, the Belle Fourche River is part of the Belle Fourche-All Night Creek sub basin, Hydrologic Unit Code (HUC) 10120201. The eastern half of the Proposed Project area contains the upper portions of two sub drainage basins: Spring Creek-Antelope Creek and Upper Porcupine Creek-Antelope Creek, HUC 10120101. These drainages are shown in Figure 2.7A-1 in TR Addendum 2.7-A. The Spring Creek and Upper Porcupine Creek are tributaries to the Cheyenne River. The Belle Fourche joins the Cheyenne River in South Dakota which subsequently flows to the Missouri River. All drainages within the Proposed Project area are ephemeral in nature. However, CBM wells contribute co-produced water to these drainages.

According to data from the Western Regional Climate Center (WRCC) for Wright, Wyoming (located approximately 7.5 miles northeast of the Proposed Project), the mean annual precipitation from 1991 through 2010 was 13.52 inches. The average annual precipitation for Glenrock, Wyoming (located approximately 54 miles south of the Proposed Project) from 1948 to 2007 ranged from 11.96 to 15.19 inches (WRCC). Recorded data from the onsite meteorological station and long-term climate data is provided in ER Section 3.6.

Elevations near the Proposed Project area and its surrounding two mile buffer area are approximately 5,200 feet. Climate in the area is semi-arid, typical of a high desert area, with low annual precipitation and high evaporation rates. Hydrographs for streams in the upper portions of the Antelope and Upper Belle Fourche watersheds peak during snowmelt in the late spring/early summer. Summer thunderstorms also influence smaller hydrograph peaks.

3.4.1.2 Surface Water Monitoring Stations

There are no automated data collection sites within the Proposed Project or the two mile buffer area (Figure 2.7A-2 in TR Addendum 2.7-A), as all streams within the Proposed

Project area and two mile buffer are classified as 3B streams (NUREG 1910, GEIS Section 3.3.4). A class 3B stream is defined as an intermittent or ephemeral stream incapable of supporting fish populations or drinking water supplies. The nearest automated real time stream gage is the Belle Fourche River below Rattlesnake Creek (06425720) which is approximately 23.7 miles northeast of the Proposed Project near Gillette, Wyoming. The Cheyenne River near Dull Center (06365900) is a real time station located 32.7 miles southeast of the Proposed Project area. There is historical data from several sites around the Proposed Project area; however there are no gage sites within the project area itself.

There is historical data from five pertinent sites:

1) Caballo Creek Gaging Station (USGS 06425800);
2) Belle Fourche Gaging Station (USGS 06425780);
3) Coal Creek near Piney Gaging Station (USGS 06425750);
4) Porcupine Creek Gaging Station (USGS 06364300); and
5) Antelope Creek Gaging Station (USGS 06364700).

Caballo Creek, Belle Fourche River above Dry Creek, and Coal Creek gages are located within the Upper Belle Fourche River Basin while Porcupine Creek and Antelope Creek gages are located within the Antelope Creek Basin.

Caballo Creek

Caballo Creek near Gillette, Wyoming gaging station is located 32.4 miles northeast of the Proposed Project area and recorded the flow for 260 square miles. Caballo Creek is located northeast of the Proposed Project boundary, and is located 0.9 miles to the northwest of the confluence with the Belle Fourche River as shown on Figure 2.7A-2 in TR Addendum 2.7-A. The data is limited to August 31, 1977 through September 30, 1983. The historical daily mean discharge for this gage is an average flow of 2.45 ft^3/second (cfs) and a median flow of 0.62 cfs. The maximum daily mean flow was 1,500 cfs on May 19, 1978. The historical annual peak flows ranged from 129 cfs to 2,170 cfs; the maximum peak flow was recorded on May 19, 1978 (USGS, 2008).

Belle Fourche River

Belle Fourche River above Dry Creek gaging station is located 27.5 miles northeast of the Proposed Project boundary and potentially could receive runoff from the west portion of the Proposed Project area. Data was collected at this gage from October 1, 1975 to September 30, 1983 and historical daily mean discharge for this gage is an average daily flow of 4.33 cfs and median flow of 1.39 cfs. The maximum average daily flow from this historical period was 2,150 cfs on May 18, 1978. The historical annual peak discharge measurements from February 10, 1976 through February 14, 1983 produced an average peak flow of 259 cfs and the median peak flow was 677 cfs. The historical annual peak flows ranged from 21 cfs to 5,630 cfs; the maximum peak flow was recorded on May 18, 1978 (USGS, 2008).

Coal Creek

Creek near Piney gaging station is located 24.4 miles northeast of the Proposed Project boundary and is and is located 2.1 miles south of the confluence of the Belle Fourche River. Data was collected at this gage from October 1, 1980 to September 30, 1983. The historical daily mean discharge for this gage is an average daily flow of 1.09 cfs and median flow of 0.17 cfs. The maximum average daily flow from this historical period was 251 cfs on May 27, 1981. The historical annual peak discharge measurements for August 22, 1983 produced an average peak flow of 6.6 cfs and the median peak flow was 6.6 cfs.

Porcupine Creek

Porcupine Creek near Teckla gaging station is located 15.0 miles southeast of the Proposed Project boundary and is located 8.5 miles to the northwest of the confluence with Antelope Creek. Data was collected at this gage from October 1, 1975 to September 30, 1983. The historical daily mean discharge for this gage is an average daily flow of 0.29 cfs and median flow of 0.22 cfs. The maximum average daily flow from this historical period was 7.9 cfs on September 11, 2005. The historical annual peak discharge measurements from June 17, 2003 through September 11, 2005 produced an average peak flow of 6.9 cfs and the median peak flow was 4.6 cfs. The historical annual peak flows ranged from 3.1 cfs to 13 cfs; the maximum peak flow was recorded on September 11, 2005 (USGS, 2008).

Antelope Creek

Antelope Creek near Teckla, Wyoming gaging station is located 22.8 miles southeast of the Proposed Project boundary and is located at the confluence of Porcupine Creek and Antelope Creek southeast of the Proposed Project. Data was collected at this gage from September 8, 1977 to September 30, 1981. The historical daily mean discharge for this gage is an average daily flow of 9.37 cfs and median flow of 3.54 cfs. The maximum average daily flow from this historical period was 2,560 cfs on May 18, 1978. The historical annual peak discharge measurements from August 17, 1979 through August 5, 1981 produced an average peak flow of 836 cfs and the median peak flow was 677 cfs. The historical annual peak flows ranged from 70 cfs to 1,760 cfs; the maximum peak flow was recorded on August 5, 1981 (USGS, 2008).

3.4.1.3 Drainage Basin Description

All drainages in the Proposed Project area are ephemeral in nature. The predominant source of surface water is from summer thunderstorms and spring snowmelt. According to NUREG-1910 (GEIS Section 3.3.4.1), flow occurs in channels for a very short duration and is directly related to these surface runoffs as a result of the local precipitation events. The watershed hydrology within the Proposed Project area includes man-made reservoirs or stock ponds and WYPDES discharge sites from CBM de-watering activities. There are two watersheds within the Proposed Project boundary; the Upper Belle Fourche Basin and the Antelope Creek Basin.

Upper Belle Fourche Basin

The Upper Belle Fourche watershed has been broken down into three sub-basins, but only the Mud Spring Creek sub-watershed is present within the Proposed Project. Mud Spring Creek is the south-eastern most sub-watershed included in the Upper Belle Fourche watershed. Mud Springs Creek is the southern most drainage present in the Mud Springs Creek sub-watershed, however it is the northern most drainage within the Proposed Project. It drains 72.1 square miles and has a channel length of 13.1 miles. The maximum elevation is 5,400 feet and the minimum elevation is 5,000 feet at the confluence with the Belle Fourche River.

Mud Spring Creek has been divided into seven drainages, and only Mud Spring Creek 7 is present within the Proposed Project; it drains the majority of the Proposed Project to the west. Mud Spring Creek 7 is composed of 18,536 acres, of which 5,037 acres are within the project boundary.

Antelope Creek Basin

The Antelope Creek watershed is in the Proposed Project on the eastern most area and drains approximately 5,042 acres of which 1,019 acres are within the Proposed Project boundary.

Lower Antelope Creek is the northern most sub-watershed within the Antelope Watershed. Lower Antelope Creek has a channel length of approximately 32.6 miles and a total drainage area of 341.9 square miles. The maximum elevation within this drainage is approximately 5,200 feet and the minimum elevation is approximately 4,750 feet. Lower Antelope Creek has been further divided into five drainages, and only Lower Antelope Creek 4 is present within the Proposed Project area; it drains the eastern most portion of the Proposed Project area.

3.4.1.4 Surface Runoff Estimates

The total project is approximately 6,057 acres and is comprised of 29 watershed basins, either in whole or partial. For design purposes however, 37 watersheds were analyzed which includes areas upstream from the Proposed Project boundary. These were included to determine the most realistic runoff from the site. Portions of the design basis were determined by the NRC Regulatory Guide 3.8 and WDEQ Guideline 8- Hydrology Coal and Non-coal.

Peak runoff rates and volumes were calculated for the 2-yr, 10-yr, 25-yr, 50-yr, and 100-yr return intervals as suggested by WDEQ Guideline. Duration time periods include 1-hr, 6-hr, and 24-hr (Table 2.7A-1 in TR Addendum 2.7-A). Precipitation depths for the five return intervals were determined for the 6-hr and 24-hr duration periods using the NOAA Atlas 2 isopluvials maps. The 1-hr duration was only used for the 2-yr and 100-yr intervals because NOAA Atlas 2 only provides precipitation equations for these years. A nomogram was available for other return intervals, but it was decided not to estimate precipitation values for the 10-yr, 25-yr and 50yr periods. This is also consistent with the reporting within the Strata Ross ISR application.

Locations reported for flow and volumes include one location prior to entering the project site (Junction 5), four intermediate locations within the project boundary (Junctions 9, 10, 11, and 14), and six outflow locations from the site (Sinks 1, 2, 3, 5, 6, and 7). Figure 2.7A-3 in TR Addendum 2.7-A provides these locations for reference.

3.4.1.4.1 Methods

The HEC-HMS software program, developed by the U.S. Army Corp of Engineers, was used to perform the watershed and channel routing based on user specified parameters. This program utilizes the Soil Conservation Service (SCS) Unit Hydrograph Runoff Method which is an appropriate method for the large acreage, as well as, overland and river routing. This method is also applicable for areas with heterogeneous sub-basins. The Rational Method was discarded since it is more applicable to small areas and urbanized watersheds. HEC-HMS is also listed as an approved program in both NUREG-1623 and WDEQ guidelines. HEC-HMS simulates precipitation/runoff for dendritic streams and provides a large diversity of methods to choose from within the program. The program includes three aspects: the watershed model, meteorological data, and hydrologic simulation. Each is briefly described below. For additional information regarding the HEC-HMS program, please refer to the Hydrologic Modeling System HEC-HMS User's Manual and Technical Reference Manual. A website link is provided for these documents in the reference section.

The model used for the Proposed Project area consists of four elements: basins, reaches, junctions, and sinks. Basins are defined as an element which usually has no inflow and only one outflow. Runoff calculations for basins use the Soil Conservation Service (SCS) Unit Hydrograph for Type II storms over a 24-hr duration (Table 2.7A-2 in TR Addendum 2.7-A). Calculations and variables required for input include: SCS Curve Number (CN), initial abstraction, overland flow time to concentration, channel flow time to concentration, and lag time. Refer to Tables 2.7A-3 and 2.7A-4 in Addendum 2.7A.

The CN value was determined based upon vegetative cover and soil data provided by BKS Environmental Associates, Inc. BKS identified the vegetation to be semi-arid grassland and shrublands with some minimal grazing. Vegetation cover was estimated to be approximately 75 to 80 percent. Soils in the area indicate loamy sands to sandy clay loams. The area was determined to be homogenous for soil and vegetative conditions. The hydrologic soil group ranges between B and C. From this information a value of 72 was chosen from Table 2-2d of TR-55, for all watershed basins (NRCS 1986).

Reaches are defined as an element with one or more inflow and only one outflow. The Muskingum-Cunge method was used for translation of the water within the channel. Muskingum-Cunge provides river routing based on a combination of conservation of mass and a diffusion representation of conservation of momentum.

Junctions are defined as an element with one or more inflows and only one outflow. No calculations or variables are required for this element.

Sinks are defined as an element with one or more inflows but no outflow and are used to represent an outlet of the model. No calculations or variables are required for this element.

Precipitation Data

Precipitation depths for the design storms were obtained using both isopluvial maps and regression equations from NOAA Atlas 2, Volume II-Wyoming. Table 2.7A-5 in TR Addendum 2.7-A summarizes precipitation depths used for the design storms.

Design Assumptions

General Watershed Assumptions

Land cover and soil type are considered homogeneous through the watershed, thus only one CN value. Similarly, the sub-basins are considered to be homogeneous in terrain. No large bodies of water were identified in the license application. Multiple stock reservoirs are present within the design area, but for design purposes the sub-basins were assumed to have no reservoirs which served as storm water detention elements within the model; all stock reservoirs were assumed to be at full capacity prior to the start of the design storm simulation.

Manning's roughness coefficient is used within the velocity method to determine Tc for channel flow. Surface characteristics affect the runoff by slowing the flow. To determine the coefficient for channels within the model a base value was determined with corrections added to the base value to determine a final coefficient. The base value for the channels was assumed to be a fairly uniform section with a sandy bottom, akin to fine gravel. The correction for channel irregularity, defined as differences in the channel surface, was determined to be minor irregularity. The correction for cross-section variance is estimated to be an occasional variance; since the watershed has small slopes across the areas it is assumed that there are no drastic changes in cross-section shape. The correction for obstructions was assumed to be minor because it is assumed that there are no large boulders or downed trees to obstruct channel flow. The correction for vegetation was assumed to be low vegetation. Although the streams are ephemeral, the dry conditions of the area suggest the channel bottoms may have stands of grasses, but no large trees and few bushy growths. The correction for meandering, or sinuosity, was based off of a visual review of the channel paths and observed oxbows from the DEM file. The summation results in a Manning's roughness coefficent value of 0.045.

Post-Development Runoff Hydrologic Consequences

The majority of the land within the project boundary will remain in its natural state. Small locations throughout the boundary will have well housing, but the footprints of these buildings are anticipated to be insignificant when compared to the size of the sub-basin. One CPP will be constructed with a larger footprint size and this is expected to be built within sub-basin 24 (B24). The area of disturbance was provided by the client and anticipated to be eight acres. The entire area was assumed to be impervious which amounted to 3.6 percent of the sub-basin, which is 221.52 acres. This was entered into the sub-basin characteristics in the HEC-HMS model. The model was then run for the 100-yr, 24-hr storm. Pre- and post-development runoff volumes were compared at three locations downstream from the developed watershed. A summary of pre- and post-discharge and volumes are provided in Table 2.7A-6 in TR Addendum 2.7-A. The greatest disparity between pre- and post- analysis is at Sink 2 where flow discharges from the project site. The conclusion is that post-development in the project boundary has minimal effect on rates or volumes leaving the project boundary.

3.4.1.4.2 Results

The peak discharge (cfs) and volume (acre-foot) for the application are provided in Table 2.7A-7 in TR Addendum 2.7-A. HEC-HMS output of the drainage basin designation and watershed characteristics can be found in Tables 2.7A-8 and 2.7A-9 in Addendum 2.7-A.

3.4.1.5 Flood Inundation Study

Flood frequency is analyzed to determine the potential impact of flooding from nearby and adjacent rivers and creeks to the Proposed Project. Specifically, this determination looks at the potential for inundation of the well fields, the CPP, and the project's associated infrastructure. Inundation may create the potential of surface water being contaminated from process fluids.

As previously described, the Proposed Project area straddles a ridge that forms the divide between the Upper Belle Fourche and the southern basin is the Antelope Creek drainage basins. The Belle Fourche River originates approximately five miles to the west of the project such that runoff is primarily ephemeral (e.g. due to snow melt or rainfall events) at the project location. Drainage from the small watersheds collected by the Belle Fourche River are considered either shallow concentrated flow or very small ephemeral channels (i.e. gullies).

Project drainage basins and infrastructure are illustrated in Figure 2.7A-4 in TR Addendum 2.7-A. The CPP is proposed to be located on a hill within Basin B24 such that there is limited to no chance of flood inundation. Facility planning will ensure that surface runoff is directed away from the plant and associated infrastructure (e.g. backup storage pond). Approximate well field locations are depicted on the figure as elliptical Production Units. A number of the Production Units are expected to span small ephemeral channels with limited watershed area (< 1 square mile) and no floodplain. Runoff conditions for these small drainage areas do not warrant flood analysis.

The Belle Fourche River is the primary drainage feature, running from SW to NE through the Project area. Flood analysis is provided to quantify flooding depths and delineate the associated flooding limits as they relate to the Proposed Project infrastructure.

3.4.1.5.1 Methods

The Army Corps of Engineers' HEC-RAS software was used to model the hydraulic capacity of the Belle Fourche River. HEC-RAS was selected based on its universal acceptance in flood modeling applications. For additional information regarding the

HEC-RAS program, please refer to the HEC-RAS River Analysis System User's Manual (ACOE, 2010) and Hydraulic Reference Manual (ACOE, 2010).

The 100-year design flow rate of 2,742 cfs at Sink 2 is used based on the hydrologic calculations presented in Hydrology Section 3.4.1.3. This assumption is considered conservative as the flow rate is calculated at the location where the Belle Fourche River leaves the project boundary, which is downstream of the reach being analyzed.

Manning's n was selected as 0.035 based on the *Hydraulic Reference Manual Table 3-1* for a "high grass" floodplain. The longitudinal slope and cross-sectional areas were determined from USGS DEM topology which was generated based on 10 meter grids. This grid spacing does not allow for detailed channel characterization (e.g. channel width and depth). However, the DEM data does provide for accurate representation of large scale topographic features, specifically the Belle Fourche River floodplain and its associated longitudinal slope. As such, the DEM data is adequate in determining the capacity of the floodplain and providing 100-year water surface elevation with a level of accuracy sufficient for the intended design purposes (see Results section for detailed discussion).

Forty-nine (49) cross-sections are used to model approximately five miles of river. Additional cross-sections are interpolated between each of the 49 cross-sections to facilitate "model stability" associated with balancing energy and momentum equations in the water surface calculation.

3.4.1.5.2 <u>Results</u>

HEC-RAS results are presented in TR Addendum 2.7-A. Flow depths generally range from three feet deep in the wide floodplain sections and five feet deep in the narrow floodplain sections. Table 2.7A-10 provides detailed tabulation of results for each of the Belle Fourche floodplain cross-sections, including interpolated cross-sections. Figure 2.7A-5 provides cross-section views for each of the 49 cross-sections (non-interpolated) to illustrate section geometry and flow depth.

The calculated flood plain was delineated relative to the DEM surface to determine the limits of 100-year flood inundation area. The 25-year and 50-year flood inundation studies were not performed due to the ephemeral nature of the stream. The delineated floodplain is presented in the Flood Study figure located in Figure 2.7A-4.

The intended design purpose of the flood inundation study is to quantify potential flood inundation areas to identify if mitigation measures need to be incorporated into the design of proposed infrastructure as described in NUREG 1569. The below design items are provided as a direct response to NUREG 1569 criteria:

- ***"Assessment of the potential for erosion or flooding that may require special design features or mitigation measures to be implemented "***- The CPP is proposed to be located on a hill such that there is limited to no chance of flood inundation. Portions of multiple Production Units are located inside the calculated floodplain. The flood analysis presented provides for 100-year floodplain delineation for which to base future planning and mitigation decisions. If necessary, mitigation measures may include fitting well-heads with water tight seals, and any infrastructure that cannot be made flood resistant should be located beyond the flood plain (e.g. header houses); and
- ***"An assessment of typical seasonal ranges and averages and the historical extremes for levels of surface-water bodies"*** - The flood analysis provided herein represents a projected "historical extreme". Refer to Section 3.4.1.4 for "an assessment of typical seasonal ranges and averages".

Surface water runoff from precipitation (rain and snowmelt) at the Proposed Project facilities will flow from the facilities area to natural drainages. Precipitation runoff is not expected to significantly exceed natural condition, as the increase in runoff from some areas (e.g., building roofs) will be balanced by the decrease in runoff from other areas (flat, gravel parking lots, etc.). Figure 2.7A-4 in TR Addendum 2.7-A shows the location of the CPP and backup storage pond in relation to the location of the nearest natural drainages and shows that none of the runoff will flow directly into either artificial or natural streams or wetlands. The potential for contamination of surface-water runoff is also minimal because the CPP and backup storage pond are self-contained and all exterior chemical and fuel tanks will have a means of secondary containment. These secondary containment methods include cement curbs, berms and CPP walls. The CPP and backup storage pond area will be graded and sloped to direct precipitation runoff away from building foundations in all directions to a storm water conveyance system. Potential runon will also be intercepted and directed around the CPP and backup storage pond area. The stormwater conveyance system will be designed to pass the 50-year flood. Due to the location of the CPP, backup storage pond, and wellfield areas related to the surrounding topography, impacts from flooding are expected to be minimal.

Downstream gage data, presented below, is not sufficient to provide an adequate Log-Pearson Type III flood frequency analysis. According to USGS guideline 17B for determining flood flow frequency, a minimum of 10 years of gage data is needed to "warrant statistical analysis".

3.4.1.6 Surface Water Use

A query of all surface water uses was submitted using the Wyoming SEO Water Rights Database. The results are provided in Table 2.7A-11 in TR Addendum 2.7-A and shown in Figure 2.7A-6. The use of surface water is devoted to stock wells for the cattle which are rotated among various pastures. See Table 2.7A-12 in Addendum 2.7-A for a list of the Wyoming surface water classes and use designations.

3.4.1.7 Surface Water Features

As discussed earlier in ER Section 3.1, no land is used for crops or other irrigated vegetation within the Proposed Project boundary. The few water bodies that do exist across the Proposed Project area are scattered and small (Figure 2.7A-7). As stated above, all streams within the Proposed Project area are characterized as ephemeral.

Several small dams and ponds exist within and downstream of the project that provide a level of control and storage of surface water. During normal runoff conditions, these ponds will contain all upgradient runoff. Many of these water features may contain higher levels of water after spring runoff or after large precipitation events but are generally reduced to small, isolated pools or are completely dry by the end of the summer. Relatively small amounts of surface discharge from CBM operations may also maintain small pools of water in these ponds during dry summer months.

Properly sized culverts will be used for secondary access roads crossing across small drainages. Efforts will be made to construct secondary access roads to avoid crossing major drainages. However, if crossing a major drainage is required, then adequately sized culverts will be utilized and embankments will be protected from erosion using adequate best management practices (rip rap, rock, etc.) in accordance with WDEQ-LQD Rules and Regulations, Chapter 3. Culverts across significant drainages will be designed to pass the 25-year peak runoff event using head available at the entrance. The minimum culvert size of 18 inches will be utilized to divert drainage from roads or for crossing small drains or swales. Crossings for major drainages will be constructed at or near right angles.

3.4.1.8 Surface Water Quantity

Due to all streams being ephemeral and drainages only supporting water during storm events, snow melt, and CBM contributions, water quantity was not measured as part of baseline studies. Discussion of gaging stations within the vicinity of the Proposed Project is provided below.

3.4.1.9 Proposed Reno Creek Project Surface Water Quality

Surface water monitoring included the collection of water samples from 21 locations within the Proposed Project as part of baseline studies. The data are provided in Table 2.7A-13 in TR Addendum 2.7-A.

Water quality data were available from one USGS stream gage (06364700) located on Antelope Creek near Teckla, Wyoming (22.8 miles from the Proposed Project) from October 3, 1977 through September 7, 2005. This gage is located 22.8 miles southeast of the Proposed Project boundary. Water quality data analyses revealed a mean temperature of 10.4 degrees Celsius (°C) and a range from 0 to 30°C. Mean dissolved oxygen was 7.8 milligrams/Liter (mg/L) and ranged from 2.8 to 11.7 mg/L. Total nitrogen averaged 0.55 mg/L and ranged from 0.21 to 1.8 mg/L. Mean ammonia as nitrogen concentrations were 0.04 mg/L and ranged from 0 to 0.13 mg/L. Nitrite plus nitrate as nitrogen averaged 0.04 mg/L, with a range from 0 to 0.29 mg/L. Average phosphate was 0.03 mg/L and average dissolved selenium was 0.56 mg/L (USGS 2007).

Within the Proposed Project area, surface water samples were collected from 21 sampling locations at upstream and downstream locations from proposed production areas. Sampling began in early fall of 2010 and continued through January of 2012 (Table 2.7A-14 in TR Addendum 2.7-A). All locations are existing stock ponds or areas in drainages where ponding occurs. Locations of these sample sites are shown on Figure 2.7A-8 in Addendum 2.7-A.

In general, surface water contained in the ponds at the sampling locations will exhibit typical saline characteristics of coal-bed methane surface discharge (higher values for conductivity, TDS, and bicarbonate) during summer and fall months. Sampling data shows that surface water quality changes during spring months when dilution occurs from snow melt or heavy precipitation events. A list of the surface water monitoring constituents can be seen in Table 2.7A-15 in Addendum 2.7-A.

3.4.1.9.1 Water Quality Sampling

The sampling data from the 21 sites is provided in Table 2.7A-13 in TR Addendum 2.7-A. The locations are provided in both Figure 2.7A-8 and Table 2.7A-14 of Addendum 2.7-A.

Sampling began at some sites in the fall of 2010. Of the 21 sampling sites, 16 were dry at least six months during the four quarterly sampling efforts. This is due to the seasonal weather variations and ephemeral nature of these stock ponds, CBM outfalls and areas of drainage where ponding can occur. To date at least four quarterly sampling efforts for baseline studies have been conducted for all 21 sites.

3.4.1.9.2 Surface Water Quality Analysis

Per NUREG 1569 and WDEQ LQD Chapter 11, the objectives of the overall surface water characterization required to permit ISR operations included:

- Evaluating the occurrence of surface water with respect to location and seasonal variability in flow and water quality;
- Determining the dominant water types; and
- Assessing potential impacts from non-ISR operations (e.g., CBM production).

Geochemical assessment of water quality is a key component to the overall characterization. A summary of surface water quality results is presented in Table 2.7A-13 in TR Addendum 2.7-A.

Figure 2.7A-9 is a plan view that shows selected surface water locations throughout the Proposed Project area. As described in Section 3.4.1.1, the Proposed Project lies along the drainage divide between the Belle Fourche and Cheyenne River systems. Because of the project's location and the ephemeral nature of the alluvial channels in the Proposed Project, there is rarely any significant surface water, and the locations sampled are all artificial impoundments. The impoundments accumulate limited rainfall and snowmelt, plus CBM discharge water and water from stock wells.

Geochemical characterization of the site surface waters was conducted to:

- Characterize the surface water compositions throughout the Proposed Project area. This provides necessary background information and will facilitate subsequent comparisons with other waters during operations;
- Characterize the water composition of CBM related discharges to the surface environment in and near the Proposed Project area; and
- Compare the composition of AUC's anticipated lixiviant to CBM discharge water and surface waters from the previously characterized sources.

AUC collected the samples from the surface water sample locations on a quarterly basis. However, because many locations were dry during the sampling events the number of samples from each location has varied. For example, six sampling locations only had a single sample available due to the dry conditions. Eight of the sampling locations had just two samples taken while one other (SW 19) had three samples. Four quarterly samples were taken from four sample locations including SW 11, SW 16, SW 18, and SW 22. Two sampling locations, SW5 and SW 6, remained dry during all four quarterly sampling efforts.

The Piper diagram uses major ions only (Na+K, Ca, Mg, Cl^-, HCO_3^- + CO_3^{-2}, and SO_4^{-2}) and normalizes concentrations. The purpose of normalization is to show the relative concentrations of the analytes. The normalization also allows for the plotting of these compositions on triangular diagrams. Dilute waters and concentrated waters of similar cation/anion relative abundances will plot at the same locations in the diagram. In preparing a Piper diagram, the relative abundances of cations (as equivalent percentages) are plotted as single points in the left triangle; and the anions are similarly plotted in the right triangle. Because the concentrations are ultimately plotted as percentages of cations or anions on the two triangles, the use of equivalents or milliequivalents will produce the same final result.

The Piper diagram (Figure 2.7A-10 in TR Addendum 2.7-A) results for each sample were prepared using EnviroInsite (HydroAnalysis, 2012). The major ion compositions from the individual sample locations were averaged before plotting the results.

There are 63 Wyoming Pollutant Discharge Elimination System (WYPDES) permits within two miles of the Proposed Project area (Figure 2.7A-7). Nine of these permits are located within the Proposed Project area. All nine are operated by Williams Production RMT Company. These nine permits and other nearby WYPDES permits can be found in Table 2.7A-16 in TR Addendum 2.7-A. All permits are associated with either oil and gas production or CBM production. The associated outfall discharge points are also shown in Figure 2.7A-7 in Addendum 2.7-A. WYPDES effluent limitations and discharge concentrations for the facilities are shown in Table 2.7A-17 in Addendum 2.7-A.

Several of the surface water collection locations are close to, and often related to, coal bed methane (CBM) permitted discharge points, which are included on Figure 2.7A-9. The CBM discharge permit water quality data were in a different format than the quarterly samples collected specifically for this project and the last available reported discharge data were used for each parameter. These data were obtained from the publically available Wyoming Department of Environmental Quality CBM permitting program (WYPDES Coalbed Methane Permits). CBM discharge results are based on daily maximum values throughout the six month reporting period. Therefore, there is only a single composition for each location. Because of the nature of the reporting requirements the different parameters may actually represent different water samples or in some cases even different reporting periods. In many of the locations some parameters were not included in the summary data; sulfate is a good example of a parameter that was not consistently reported. Ten CBM discharge samples were originally selected for consideration. However, only three locations had sufficient data to allow for plotting of Piper Diagrams. Because of the nature of discharge permit water quality data, the compositions of the CBM water samples represent a composite of reports from several time periods. The three CBM waters did not report total dissolved solids concentrations (TDS); consequently those values were calculated based upon the major ion concentrations used for the samples. The calculated TDS values were approximately 500 mg/L for WY0048542_003, 650 mg/L for WY0048542_010 and 850 mg/L for WY0042340_010.

Figure 2.7A-10 in Addendum 2.7-A demonstrates that there are significant differences among the different surface water locations. For example, SW15 is extremely dilute and appears to have a composition similar to rainwater. Other dilute waters include SW7, SW9 and SW14.

On the other end of the spectrum, the CBM discharge waters are characterized by relatively high total dissolved solid (TDS) concentrations and are dominantly sodium bicarbonate waters. In spite of the issues related to the CBM discharge database, the three points plot in a small area on the Piper diagram, indicating that the CBM discharge waters are all similar to each other, all being derived from the same, continuous coal formation (Big George Coal of the Fort Union Formation). On Figure 2.7A-10 in Addendum 2.7-A, the three CBM water samples (WY0048542-003 and 010 and WY0042340-010) all plot in the bottom of the quadrilateral.

Several surface water samples compare well with the CBM discharges, indicating that their chemistry is strongly influenced by the CBM discharges. For example, SW11 appears to have the largest TDS concentration among the samples associated with the CBM discharges. When the TDS values from SW11 are compared to calculated TDS values for the CBM discharges it appears that the CBM waters have somewhat lower TDS values. It is possible that the TDS concentrations in these surface water locations reflect some evaporative concentration in the discharge pond. CBM waters are also characterized by very low sulfate concentrations. Sulfur in coal beds is present as sulfide, the reduced form, so the oxidized form of sulfate is not expected to be present. SW3 and SW11 show compositions similar to CBM discharge, SW22 also displays the sodium bicarbonate dominated composition but it is more dilute than the SW3 and SW11 samples. The sample from SW9 appears to be CBM type water that has undergone some dilution and possible interaction with minerals in the soil. The other potential end member composition is the SW19 sample which is dominantly calcium magnesium sulfate water. It has a cation composition in units of milliequivalents of 40 percent Ca, 40 percent Mg and 20 percent Na+K. The dominant anion is sulfate at over 90 percent of the anionic milliequivalents. The remaining three SW samples are difficult to classify, and the dilute nature of the SW7 and SW14 samples suggest mainly a precipitation (rain or snow) dominated source. The SW7 data was based upon two samples collected in March and June of 2011; the June sample shows a significant increase in alkalinity. The single sample from SW14 was collected in March; it is considered to be dilute and sulfate dominant. Sample SW18 has a high TDS and high sodium concentrations. It is dominantly a CBM discharge water, but the relative sulfate concentration appears to have increased.

Graphical analysis of the surface and CBM discharge waters in the vicinity of the Proposed Project area demonstrates that CBM waters have distinctive geochemical fingerprints related to their high sodium and bicarbonate concentrations. These compositions are apparent in some of the surface water sampling locations, but in other locations different compositions have been identified including dilute waters that appear to be derived from rain or snow melt. The use of these graphical methods provides a simple and effective means to characterize and classify the different surface waters present in the area. Water quality fingerprints also enable the rapid and verifiable determination of any potential contamination due to leaks or spills, and to the remediation of any such contamination.

3.4.2 Groundwater

This section describes regional and local hydrogeology, including hydrostratigraphy, groundwater flow patterns and hydraulic gradients, and aquifer parameters including site-specific pump testing results found in TR Addendum 2.7-D. In particular, information in this section provides hydrologic verification of the geologic confinement discussed in Section 2.6 of this TR. Further, data demonstrates that ISR operations can be conducted in the PZA without significant potential impacts to groundwater resources, both during production and restoration. Information on groundwater quality and local groundwater usage in the vicinity of the Proposed Project area is also presented in this section. Discussion is based on regional published literature, site-specific hydrologic data, as well as the more detailed geologic information presented in Section 3.3 of this ER.

3.4.2.1 Regional Hydrogeology

The Proposed Project is located in the south-central portion of the PRB, approximately 43 miles south of Gillette and 7.5 miles southwest of Wright, and approximately 30 miles east of the north-flowing Powder River. The basin is an asymmetrical, doubly plunging, down-warped synclinal structural feature defined by more steeply dipping western limb and shallower dipping eastern limb, with a north to northwesterly trending basin axis. The Proposed Project site is located approximately 15 to 20 miles east of the basin axis, where sediments have accumulated to depths of approximately 20,000 feet. The PRB lies within the Northern Great Plains Aquifer system that contains overlapping aquifers in the Lower Tertiary, Upper and Lower Cretaceous, and Upper and Lower Paleozoic strata (USGS, 1996). Figure 2.7B-1 illustrates the generalized column of hydrostratigraphic units of this aquifer system near the site. Table 2.7B-41 in Addendum 2.7-B summarizes the general transmissivity and general water yields within the Northern Great Plains Aquifer Systems. The following discussion focuses on the relatively shallower hydrostratigraphic units of the Upper Cretaceous aquifer system that include the Fox Hills and Lance Formation, and the Lower Tertiary aquifer system that includes the Fort Union and Wasatch Formations. Hydrostratigraphic units deeper than the Fox Hills that lie below the regional confining unit of the Lewis Shale (also referred to as the Pierre Shale) near the Proposed Project are generally too deep to economically develop for domestic water supplies or uranium recovery. These hydrostratigraphic units typically have elevated dissolved solids concentrations and therefore are not included in this discussion of regional hydrogeology with respect to the Proposed Project.

During Early Cretaceous time, thick sequences of shale were deposited and interfingered with marine sandstones. In the Late Cretaceous time, sea levels fell and shorelines regressed, depositing the Fox Hills Sandstone and continental shales, sandstones, and coals of the Lance Formation in a tropical, near sea-level environment. Basin deposition continued through the Early Tertiary time with Fort Union and Wasatch Formation deposition. During this time, the shape of the basin was established and the bounding margins had uplifted above the basin floor. Later in the Tertiary, there was regional uplift and more arid conditions as basin filling continued with deposition of sandstones, siltstones, and larger clast conglomerates near the mountains. Erosion of Precambrian metamorphic and igneous rocks to the southwest provided a source of sediments. Subsequent erosion has removed most all of these later Tertiary sediments, except in erosional remnants like the Pumpkin Buttes in the central portion of the PRB (Lowry et al., 1986).

The Eocene-age Wasatch Formation, which is the host for uranium mineralization at the Proposed Project, crops out at the surface at the Proposed Project site and in much of the central portion of the basin. The Oligocene-age White River Formation, which is observed cropping out along the basin margins to the south and in erosional remnants in areas such as the Pumpkin Buttes to the northwest, has been eroded from most locations in the central part of the basin. Quaternary-age alluvium deposits also are observed in some stream channel valleys, which provide a small groundwater supply source within the basin; but in general, groundwater in this unit are not extensively developed due to better water quality and higher yields are available in the underlying Wasatch to Fox Hills sequence (Rankl and Lowry, 1990). Lying unconformably below the Wasatch is the Paleocene-age Fort Union, which is included in the Lower Tertiary aquifer system in the PRB. The Lance Formation lies conformably below the Fort Union, and unconformably above the Fox Hills Sandstone, and these two units comprise the Upper Cretaceous aquifer system in the area.

Lower Tertiary aquifers of the Fort Union and Wasatch consist of semi-consolidated to consolidated sandstone beds that are interbedded with shale, mudstone, siltstone, lignite, and coal. The permeability of the lower Tertiary aquifers is variable and directly related to the thickness and continuity of sandstone beds that compose the aquifers. Some of the thick coal beds may yield groundwater, particularly if the coal is fractured or has been burned, forming typically higher permeability clinker zones.

Upper Cretaceous aquifers are widespread in the subsurface but generally contain groundwater of potable quality only where they crop out or short distances from the upland recharge areas at the basin margins. In the southern portion of the basin, these upper Cretaceous aquifers include the Lance Formation and underlying Fox Hills

Sandstone. Upper Cretaceous aquifers are composed of consolidated sandstone interbedded with shale, siltstone, and occasional lenticular beds of coal. Much of the available information related to the hydrology of the Lance and Fox Hills considers these two formations as a single hydrostratigraphic unit, as these formations are connected hydraulically on a regional scale. The Lewis Shale underlies the Fox Hills Sandstone and is a thick sequence of shale with minor interbedded sandstones that is a major regional confining unit (USGS, 1996). Available groundwater in the Lewis Shale is generally more highly mineralized and exhibits relatively poorer groundwater quality with depth.

Groundwater in the lower Tertiary aquifer generally moves northward and northeastward in the Wyoming portion of the PRB from the upland areas of recharge along the basin margins, to areas of groundwater flow that changes locally where there is discharge to larger surface streams. Groundwater in the Upper Cretaceous aquifers generally moves in a similar trend, to the north and northeast in Wyoming from areas of recharge (USGS, 1996).

Hydrostratigraphic units of interest in the southern PRB are shown on the stratigraphic column in Figure 2.7B-1. Discussion of regional characteristics of these units is provided below, in order of deepest to shallowest. It is noted that some of the available information on regional hydrologic properties and groundwater quality (presented in Section 3.4.2.10) considers the combined formations of the Upper Cretaceous sequence (Fox Hills and Lance) and of the Lower Tertiary sequence (Fort Union and Wasatch), or applies to the entire relatively shallow sequence of Fox Hills to the Wasatch, and are noted in these discussions:

- Lewis Shale (Late Cretaceous);
- Fox Hills Sandstone (Late Cretaceous);
- Lance Formation (Late Cretaceous);
- Fort Union Formation (Paleocene); and
- Wasatch Formation (Eocene).

<u>Lewis Shale</u>

The Lewis Shale (also regionally known as the Pierre Shale) is a late Cretaceous sequence of marine shales with interfingered sandstones that underlies the Fox Hills Sandstone and is approximately 900 feet thick near the Proposed Project (Fox & Higley, 1987). This unit is noted as a regional confining aquitard between the overlying Wasatch to Fox Hills sequence and underlying lower Cretaceous units. Hodson (1973) describes the unit as primarily shale containing sandy shale zones and lenticular fine-grained sandstones which thicken from approximately 200 feet in the northwest of the basin to almost 500 feet in the southwest. Most of the formation does not yield usable volumes of groundwater, but some sandy zones may yield as much as 10 gpm.

Fox Hills Sandstone

The Fox Hills Sandstone is the basal aquifer unit in the Lower Tertiary/Upper Cretaceous aquifer system. The Fox Hills is noted as fine- to medium-grained sandstone beds deposited during receding marine seas in barrier island, neritic, and marine environments. Sandstone is generally thin to massively bedded, weakly cemented, friable, lenticular, and interbedded with carbonaceous shale and siltstone. In the southwestern basin, the basal Fox Hills is a massive cliff-forming sandstone, while the upper part has increased shale interbeds. In the southern basin, the Fox Hills ranges from 400 to 500 feet in Niobrara County to 700 feet in Natrona County. The Fox Hills thins to the north with increasing shale content, and is noted to be 150 to 200 feet thick in Crook County. The Fox Hills is not mapped as a separate stratigraphic unit in the northwestern basin, but equivalent strata are included in the basal Lance Formation (Feathers, 1981).

Hodson (1973) notes that well yields as high as 200 gpm are found in the sandstone beds of the Fox Hills in the eastern part of the basin, and postulates maximum yields less than 100 gpm in the western basin. Several wells utilized for water flooding in Rozet (east of Gillette) produce approximately 200 gpm. The Fox Hills is also utilized for groundwater supply in the Hilight Field (general location is T45N, R71W) located in southeastern Campbell County (Feathers, 1981). Both of these industrial groundwater supply locations utilize wells completed across the Lance and Fox Hills sequence.

Feathers (1981) discusses properties of the Fox Hills in conjunction with the overlying Lance Formation, as these units are hydrologically connected throughout much of the basin. The Lance and Fox Hills interval is extensively developed in outcrop areas for relatively small yield domestic and stock wells, as well as industrial applications at Hilight and Rozet. Municipal water supply is provided from this sequence for the cities of Gillette, Glenrock, and Moorcroft (Feathers, 1981, and Hutson, et. al., 2004 for TR Table 2.7B-42). Edgerton and Midwest have historically utilized this interval for municipal water supply, but presently receive piped water from Casper due to higher dissolved solids in the Fox Hills.

Most hydrologic data are from shallow wells located near outcrops, which are primarily lower yield stock wells where single yield and drawdown results are generally reported. There is good potential for relatively low-yielding wells (i.e., 20 gpm) where upper Cretaceous sediments are near the surface. Larger volume industrial wells that perforate the entire Lance/Fox Hills interval can have yields up to 380 gpm (Feathers, 1981). Specific capacity values from these wells reported by Feathers (1981) average about 0.6 gpm per foot of drawdown (gpm/ft) and range from 0.1 to 2 gpm/ft. The high yield wells located in southeastern Campbell County average 323 gpm and have an average specific capacity of 0.3 gpm/ft. The range of reported transmissivities for the Lance/Fox Hills generally ranges from 100 to 2,000 gpd/ft (13 to 270 ft^2/d) (Feathers, 1981), and Lowry

(1972) reports a minimum transmissivity of about 250 gpd/ft (33 ft^2/d) for the entire aquifer system in southeastern Campbell County.

Regional potentiometric data from Hotchkiss and Levings (1985) are presented in a potentiometric contour map (Figure 2.7B-2) for the Lance and Fox Hills aquifer system. The potentiometric maps indicates a general northward regional groundwater flow direction, with a groundwater divide in southeastern Campbell County and subsequent groundwater flow towards the southeast, which is also noted by Feathers (1981). These aquifers principally discharge by subsurface, stratigraphically controlled underflow into Montana, as well as local discharge into topographically lower major drainages. Vertical leakage from the overlying Wasatch and Fort Union sequence is proposed by Lowry (1973), due to the heads observed in overlying strata that are several hundred feet higher in elevation. Core data for other ISR sites in Wyoming from confining mudstones suggest vertical hydraulic conductivities in the range of approximately 10^{-8} cm/s, which suggests vertical leakage potential is minimal. There is also limited localized recharge observed in some of the eastern outcrop areas.

Lance Formation

During the last seaward regression in the Late Cretaceous, continental deposits of the Lance Formation were deposited as interbedded, light yellow-grey, fine- to medium-grained, crossbedded, and lenticular sandstones, with grey carbonaceous shale, and siltstone, as well as thin coals. The contact with the underlying Fox Hills Sandstone is generally placed at the prominent change from massive sandstones of the Fox Hills, to the overlying shale and siltstone of the Lance Formation. Formation thickness varies from approximately 3,000 feet in Natrona County and the south-central basin, to 1,600 to 2,500 feet in Niobrara County, to less than 1,000 feet in Crook County in the northeastern basin (Feathers, 1981). On the west side of the basin, thickness decreases to the north, with an estimated 2,400 feet in southern Johnson County, to approximately 2,000 feet near Buffalo decreasing to about 600 feet into southern Montana (Hodson, 1973). In the Upper Cretaceous aquifer system, the Lance Formation represents the uppermost aquifer in the region that also includes the Fox Hills. The upper hydrologic boundary of the Lance/Fox Hills generally corresponds to the zone of lower permeabilities present in the finer-grained Lebo Shale Member of the Fort Union Formation (Feathers, 1981).

Hodson (1973) notes that well yields from the Lance Formation are generally less than 20 gpm, but yields of several hundred gpm may be possible from the entire section. Most wells drilled to the Lance Formation are located near outcrops and are utilized for domestic and stock usage. In much of the PRB, the Lance Formation is considered hydrologically connected to the Fox Hills Sandstone and characterized together as the Upper Cretaceous aquifer system. Excluding limited data from shallow outcrop wells that target the Lance Formation, much of the available hydrologic data are from the

Lance/Fox Hills sequence, previously summarized in the previous section on the Fox Hills Sandstone.

Fort Union Formation

The Paleocene Fort Union Formation is composed of continental deposits associated with Laramie uplift and basin filling. Thicknesses noted by Hodson (1973) are approximately 2,300 feet in the eastern basin, 2,900 feet in the southwest, and almost 3,500 feet in the northwest portion of the basin. The Fort Union is a heterogeneous unit of sandstones, interbedded shale, carbonaceous shale and coal. The formation thickens to the southwest and is conformably underlain by the Lance Formation and unconformably overlain by the Eocene-age Wasatch Formation. Outcrops of the Fort Union Formation encircle most of the basin and beds dip basinward. This formation is the major source of coal in the PRB and also hosts significant volumes of exploitable CBM reserves. Uranium deposits are hosted in coarse grained sandstone facies of the Fort Union Formation in the southern portion of the basin

In much of the basin, the Fort Union is divided into three members: the basal Tullock Member, the Lebo Shale, and the upper Tongue River Member. The Tullock Member lithology is similar to the Lance Formation deposited in a continental fluvial environment of fine-grained sandstone, sandy siltstone, shale, and coal. Tullock sands do not differ greatly from the Lance Formation sandstones except they are yellowish, thinner, and more lenticular, and contain no conglomeratic layers. Mapped thickness of the Tullock Member in the eastern basin is about 1,000 feet, as noted by Robinson et al. (1964), but thins to 500 feet at the Montana border. Brown (1993) indicates a maximum thickness of 370 feet in the northern basin and almost 1,500 feet in the southern basin. The Lebo Shale is approximately 250 feet in thickness and is comprised of finer-grained sequence of dark grey claystone and shale, with brown carbonaceous shale beds, and thin lenticular fine-grained sandstones, and with a noted absence of coal. The increased shale content of the Lebo Shale, which is apparent from geophysical logs, is noted as a partial hydrologic barrier in much of the basin (Feathers, 1981).

The upper Tongue River Member is about 800 feet thick in the northeastern part of the basin and thickens westward. It is composed of lighter-colored interbedded fine-grained sandstone, siltstone, sandy shale, and relatively significant coal deposits. There are seven to nine major minable coals in the Tongue River Member, but the Wyodak seam is the only one actively mined in the state. The Wyodak coal ranges from approximately 25 to 175 feet in thickness, and averages approximately 70 feet thick in the eastern basin. This unit outcrops along the eastern basin margin where extensive surface mining of this seam occurs. It is alternatively referred to as the Wyodak-Anderson and Anderson-Canyon coals. West of Gillette, the Wyodak separates into the Anderson and Canyon coal beds, and north of Gillette the Wyodak separates into the Upper and Lower Wyodak seams

(Lowry, 1986). Feathers (1981) notes that the Tongue River and Lebo Members are not differentiated in eastern basin outcrops south of T47N, and in the southern portion of the basin Sharp and Gibbons (1964) note two members of the Fort Union, characterized as lower fine-grained clayey sandstone with minor siltstone and coal and an upper member of clayey siltstone containing ironstone lenses and coals. Localized lenticular conglomeratic beds and coarser-grained sandstones are also noted in the middle Fort Union in the western portion of the basin (Whitcomb et al, 1966).

Most of the wells completed in the Fort Union for stock and domestic groundwater supply are generally completed across short intervals of single formations or completed into sand bodies at depths less than 500 feet, where yields of 20 gpm can be obtained with suitable water quality. The Fort Union also serves as a municipal water supply for the city of Wright, as well as supplementing the municipal supply for the city of Gillette. Hodson (1973) indicates maximum yields of up to 150 gpm in the Fort Union and indicates specific capacity values of 0.3 to 0.9 gpm/ft for several locations in the eastern half of the basin. Dissolved solids range from approximately 200 to more than 3,000 mg/L, but commonly range between 500 and 1,500 mg/L, and water type is primarily sodium bicarbonate and to lesser degree, sodium sulfate.

Feathers (1981) indicates that yields of 250 gpm can be found in wells of the Wasatch and Fort Union that perforate thick saturated sandstones, locally coarse sands, in zones of high secondary fracture permeability near basin margins or near clinker zones, and in areas with surface water hydrologic connections. Specific capacities are highly variable, ranging from 0.1 to 3 gpm/ft, with higher values of over one gpm/ft located in the western basin that are associated with coarser grained and conglomeratic aquifers. Extremely high values of 2,250 gpm/ft have been observed in the clinker aquifers near the basin margins. Permeability is lithology dependent and highly variable, as clinker is generally the most permeable, followed by coals, and then sandstones. Clinker permeabilities are several hundred gpd/ft^2 or higher (approximately 25 to 40 ft/d), coals can range between one to 100 gpd/ft^2 (approximately 0.1 to 13 ft/d); and while Fort Union sandstone data are sparse, it is likely in the range of 0.1 to 10 gpd/ft^2 (0.01 to 1.3 ft/d), similar to that observed in the Wasatch sands. Fort Union sands near Gillette have reported transmissivities of several thousand gpd/ft.

Much of the available data to characterize the Fort Union and Wasatch sequences are from shallow stock and municipal wells, and hydraulic head data from these cannot adequately define the potentiometric surface regionally, as there are often large head differences that are present with varying depths. Hotchkiss and Levings (1985) presents approximate potentiometric surface data for the three members of the Fort Union Formation: the Tullock, Lebo Shale, and Tongue River Members, which are presented in Figures 2.7B-3, 2.7B-4, and 2.7B-5 in TR Addendum 2.7-B, respectively. As can be seen in these potentiometric contour maps, the head in the Fort Union generally decreases with depth in these three formation members. General groundwater flow direction on a regional scale is to the north in the basal Tullock and overlying Lebo Shale. Potentiometric contours in the Tongue River are more highly variable and reflect localized discharge to the major alluvial valleys, such as the Powder, Little Powder, Tongue, and Belle Fourche Rivers.

Recharge to the Fort Union is primarily through infiltration at outcrops and through the highly permeable clinker zones at the basin margins, as well downward leakage from the overlying Wasatch, where present. Shallow groundwater circulation is generally topographically controlled under water table conditions and deeper strata exhibit stratigraphically controlled horizontal flow. Hydrogeologic conditions in the Fort Union can vary from water table conditions to fully confined between and within individual sandstone units. Regionally, groundwater discharge is to the north into Montana, but topographic valleys may also represent important discharge points.

<u>Wasatch Formation</u>

The Eocene-age Wasatch Formation, which contains the uranium mineralized sandstones at the Proposed Project, is composed of alternating beds of valley and channel-fill fine- to coarse-grained lenticular, sandstones, and interbedded shale and coal, with relatively coarser-grained deposits toward the southern part of the basin that are adjacent to the uplifted basin margins. The Wasatch is approximately 1,600 feet thick in southern Campbell County, although subsequent basin erosion since the middle Tertiary has removed approximately half of the original deposited material (Feathers, 1981). In the northwest basin near the Bighorn Mountains, the Wasatch is divided into two conglomeratic members, the Kingsbury and overlying Montcrief Members, which consist of as much as 2,000 feet of siltstone, sandstone, cobbles, and boulders which grade into finer-grained facies of the Wasatch several miles east of the mountains (Hodson, 1973). The contact with the overlying Fort Union Formation is unconformable and is noted by Anna (1996) at the top of the Roland-Anderson coal bed, which is a coal seam 50 to 100 feet thick that is areally extensive in the southern PRB. The Wasatch generally dips to the northwest at approximately one to two degrees and the sands that contain uranium mineralization are generally coarse, cross-bedded, arkosic sands deposited in a high-energy fluvial environment, with individual channel sand deposits possessing a general orientation to the north.

Hodson (1973) reports groundwater well yields of 10 to 50 gpm in the northern basin, generally increasing to the south with yields of 500 gpm or more possible in the southern portion of the basin. A well near Gillette in T50N R72W has a specific capacity of 4 gpm/ft, and wells in T44N R72W reported specific capacities ranging from 5 to 14 gpm/ft. Dissolved solids concentrations can range from 200 to greater than 8,000 mg/L in the Wasatch, but commonly are in the range of 500 to 1,500 mg/L. In general, the dominant Wasatch water types are sodium sulfate and sodium bicarbonate (Hodson, 1973).

As with the Fort Union Formation, much of the available hydrologic data are from shallow stock and domestic wells, and as hydraulic heads often vary with depth and between sandstones, hydraulic head data from these wells does not adequately define the potentiometric surface in the Wasatch.

Wasatch recharge is primarily through infiltration at outcrops and to a lesser degree surface infiltration, as the Wasatch is the dominant surficial geologic unit in the central portions of the PRB (Feathers, 1981). As with the Fort Union, shallow groundwater circulation is primarily topographically controlled, and at greater depths flow is horizontal and defined by stratigraphy. Groundwater discharge for the Wasatch primarily occurs in topographic alluvial valleys.

The Wasatch also contains many important coal bearing seams, which attain thicknesses of eight feet in the Tongue River Member. These coals are exploited targets for CBM in portions of the basin, but no Wasatch seams are currently being surface mined in the PRB (Lowry 1986). Stone and Snoeberger (1977) conducted hydrogeologic investigations on the Felix Coal seam approximately 15 miles south of Gillette and observed anisotropic permeabilities associated with cleat orientation in the Felix, with reported maximum and minimum permeabilities of 6.6 and 3.7 gpd/ft^2 (0.9 and 0.5 ft/d), respectively, at their study site. Additional site specific information on the hydrogeology of the Felix Coal at the Proposed Project is provided in the following section on site hydrogeology.

According to records from the Wyoming Oil and Gas Conservation Commission, indicates usage of the Felix for CBM (either as an individual seam or multiple permitted seams) occurs in two general areas. The eastern area is in the general vicinity of T47N-T53N and R73W-R75W (generally east of Gillette), and the western area is in the vicinity of T50N-T55N and R80W-R83W (generally near Buffalo and to the north). The closest permitted usage of the Felix seam for CBM to the Proposed Project is approximately 20 to 25 miles to the north. Outcrops of the Felix can be observed in roadcuts along Cosner Road, near the upper northwest corner of Section 35, T43N, R73W (see Figure 2.7B-6).

3.4.2.2 <u>Site Hydrogeology</u>

The Proposed Project area has a long history of hydrogeologic investigations beginning with hydrologic testing conducted by Union Pacific and Rocky Mountain Energy (RME) between 1978 and 1982. These data include geologic characterization and hydrologic pump testing (RME, 1982). Additional investigations by RME included a hydrogeologic integrity study to reveal the natural sealing of mudstones in exploratory boreholes, which is discussed in detail in Section 3.4.2.3. RME conducted extensive exploratory drilling and prepared a Class III UIC Permit to Mine Application and a Source Material License Application for the Reno Creek Project in 1993 and 1994. Energy Fuels Nuclear, Inc. (EFNI) also conducted additional hydrologic investigations in 1993 and 1994 that included multiple pump tests. These test data are of significant value in terms of hydrologic characterization at Reno Creek.

AUC LLC has been collecting lithologic, water level, water quality, and pump test data as part of its ongoing evaluations of hydrologic conditions at the Proposed Project during 2010 and 2011. AUC has conducted the most comprehensive hydrologic testing to date that includes multi-well and single-well pump testing at four well clusters in the Proposed Project area. These well clusters include the PZM1, PZM3, PZM4, and PZM5 well clusters. There are an additional two well clusters that have been installed at the PZM6 and PZM7 locations in the western and southwestern portion of the Proposed Project area for the purposes of baseline groundwater monitoring. Figure 2.7B-6 shows the locations of the current monitoring wells utilized in the site hydrologic evaluation. Table 2.7B-1 provides completion data for the current monitoring wells installed by AUC.

AUC's approach to hydrologic characterization is consistent with the requirements of NUREG 1569 and the objectives of these investigations were as follows:

- Evaluate the aquifer characteristics of transmissivity (T) and storativity (S) within the production zone aquifer (PZA) within the Proposed Project area;
- Demonstrate geological and hydrologic confinement of the PZA with respect to overlying aquifer and underlying aquifer (if present) within the Proposed Project area;
- Evaluate the presence or absence of hydrologic boundaries within the PZA within the Proposed Project area; and
- Evaluate the transmissivities of overlying aquifer and underlying aquifer (if present) within the Proposed Project area.

Section 3.4.2.3 describes the hydrostratigraphic units of interest at the Proposed Project area, which include a shallow water table unit (where present, includes SM prefix wells), the overlying aquifer (OM wells), the PZA, and the underlying unit (UM wells). The confining zones with respect to the PZA include the overlying aquitard (OA) and the underlying aquitard (UA). It is noted that based on the hydrologic characteristics of the shallow water table unit and underlying unit, these units do not meet the requirements of an aquifer, which is discussed in the following section.

Section 3.4.2.4 summarizes the Hydrogeologic Integrity Study conducted by RME to assess the potential for cross-aquifer flow through exploratory boreholes that were not properly abandoned. The results of this study indicate that the mudstones present above the PZA have naturally sealed and thus do not represent potential conduits to flow. Recent pump tests also support this conclusion.

Section 3.4.2.5 describes the potentiometric surfaces, groundwater flow direction and hydraulic gradients. A summary of aquifer testing activities is presented in Section 3.4.2.6 that includes a review of the historical pump testing and summarizes the pump testing conducted at the four well clusters PZM1, PZM3, PZM4, and PZM5.

The level of characterization of the hydrogeology within the Proposed Project area is substantial. The results of testing conducted by AUC in 2010 and 2011 indicate that the PZA is in hydraulic communication at well cluster testing locations and has been adequately characterized for the purposes of this license application. Additional hydrologic testing was also conducted on the water table (SM unit, where present), the overlying aquifer, and the underlying unit at the four well cluster locations. The results of testing indicate that overlying and underlying confinement with respect to the PZA is sufficient and no hydraulic responses were observed in the overlying aquifer or the underlying unit during any testing activities.

3.4.2.3 Hydrostratigraphic Units

A detailed discussion of stratigraphy within the proposed Reno Creek ISR Project is presented in Section 2.6 of the TR. The following summary provides the stratigraphic nomenclature and acronyms with descending depth utilized for the Proposed Project for the units of interest present in the Wasatch Formation.

- SM Unit: Shallow water table unit present in some locations. Based on geologic and hydrologic data, this unit does not meet the requirements of an aquifer in the Proposed Project area;
- Overlying Aquifer (OM wells): Overlying aquifer relative to the production zone. This aquifer also represents the uppermost aquifer observed in the Proposed Project area;
- OA Aquitard: Confining unit providing confinement between the production zone and overlying aquifer;
- PZA Aquifer: Production zone aquifer;
- UA Aquitard: Confining unit providing confinement between the production zone and underlying unit; and
- Underlying Unit (UM wells): Discontinuous underlying sand unit relative to the production zone. Based on geologic and hydrologic data, this unit does not meet the requirements of an aquifer in the Proposed Project area.

Typical geophysical logs depicting the units of interest throughout the Proposed Project area are presented in Figures 2.6A-7 through 2.6A-10 in TR Addendum 2.6-A. Water level data collected from the PZA aquifer since late 2010 as part of AUC's hydrologic investigations are presented in Table 2.7B-2 in TR Addendum 2.7-B. Water level data for the SM Unit, Overlying Aquifer, OA coal seams, and Underlying Unit are summarized in Tables 2.7B-3 through 2.7B-6 respectively. A description of each of the various aquifers/confining units is presented below.

SM Unit

In some locations of the Proposed Project area, a perched shallow water table unit was encountered. These locations include SM3, SM5, SM6, and SM7 and are shown in Figure 2.7B-6. Water level data is included in Table 2.7B-3 in TR Addendum 2.7-B. The SM unit is not continuous across the site. This sand is generally partially saturated, and approximately 10 to 20 feet thick, occurring between 40 and 80 feet below ground surface (ft bgs). Borings were also installed to this unit at the PZM1, PZM2, and PZM4 cluster areas, but no water was observed at these locations and no permanent well was installed.

Permeability of this perched water table unit is extremely low relative to the production zone. Table 2.7B-7 presents a summary of hydrologic testing conducted in this unit and is detailed further in Section 3.4.2.4. Specific capacity evaluations from the two locations where testing was conducted indicate values of 0.07 to 0.13 gallons per minute per foot (gpm/ft). Transmissivity values are also very low, between 0.3 ft^2/day and 0.014 ft^2/day. Calculated hydraulic conductivities range between 0.001 ft/day to 0.02 ft/day.

Based upon the extremely low well yields and hydraulic conductivities at wells completed in this perched water table unit, the SM unit does not meet the definition of an aquifer according to 10 CFR Part 40, Appendix A, which states:

> "*Aquifer means a geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.*"

Hydrologic data collected from the SM unit at two locations are presented in Sections 3.4.2.7.2 (at well SM3) and 3.4.2.7.4 (well SM5). The SM unit wells installed at clusters PZM1, PZM3, and PZM4 were observed to be dry. Based on the conclusion that the SM unit is not an aquifer, the overlying aquifer is the first observed and uppermost aquifer in the Proposed Project area.

Overlying Aquifer

The overlying aquifer appears continuous on a local scale within the PZM wellclusters, but specific units present in each of the well clusters do not correlate with each other over the greater distances across Proposed Project. Therefore, while it is true that a water bearing Overlying unit, exhibiting aquifer characteristics, is found in all areas across the site, based on geologic and potentiometric data, the Overlying Aquifer is not a single, discrete unit, but a series of aquifer-like units that do not correlate or connect to one another.

The overlying aquifer is partially saturated near the PZM1 cluster, and fully saturated at clusters PZM3, PZM4, and PZM5. At the PZM1 cluster, the overlying aquifer is approximately 60 feet thick, occurring at depths of approximately 155 to 215 feet bgs. At the PZM3 cluster, the overlying aquifer is approximately 20 feet thick at depths between 150 to 170 feet bgs. In the central portion of the Proposed Project area at the PZM4 cluster, the overlying aquifer is approximately 60 feet thick, occurring between depths of 125 to 185 feet bgs. And in the western PZM5 cluster, the overlying aquifer is substantially thinner (12 feet thick), occurring between depths of 70 to 82 feet bgs.

Table 2.7B-7 presents a summary of hydrologic testing conducted in the overlying aquifer, which is detailed further in Section 3.4.2.7. Based on testing, there is a wide range of permeability associated with this unit. Hydraulic conductivities calculated in the overlying aquifer at the PZM1, PZM4, and PZM5 clusters were 1.0 ft/day, 0.84 ft/day, and 3.3 ft/day, which is similar in scale to the conductivity of the PZA. The conductivity of the overlying aquifer at the PZM3 cluster and the two historical testing locations (see Figure 2.7B-7) were on the order of 0.03 to 0.05 ft/day.

The overlying aquifer is the uppermost aquifer observed within the Proposed Project area. A potentiometric surface map of this aquifer could not be constructed due to the discontinuous nature of this aquifer across the project area. A map of observed water level elevations in the overlying aquifer is presented in Figure 2.7B-8. Water level data is presented in Table 2.7B-4 TR Addendum 2.7-B.

Within the Proposed Project area, the overlying aquifer is considered the uppermost aquifer. Based on the depth to the top of the overlying aquifer, which ranges between approximately 70 and 155 ft bgs, and the observed sequence of finer grained silt and shale that overlies this aquifer, the overlying aquifer is considered isolated from the surface water drainages present in the Proposed Project area. As all surface drainages in the Proposed Project area are characterized as ephemeral, the lack of a perennial wetting front and the distance between ground surface and the top of the overlying aquifer (characterized primarily by shale and finer grained sediments) support this conclusion of isolation between surface water infiltration reaching the overlying aquifer.

OA Aquitard

The overlying OA aquitard is a laterally continuous sequence of clays and silts, including the Felix Coal seam. There is a minimum thickness of approximately 25 feet observed in the OA aquitard across the Proposed Project area. The Felix Coal is one or two laterally continuous marker beds lying in the lower portion of the OA aquitard. These coal seams are separated from the underlying PZA and overlying aquifer by continuous mudstone units present in varying thickness across the site. Over the eastern ¾ of the Proposed Project area, there are Upper and Lower Felix Coal seams, separated by at least five feet of mudstone. The Upper Felix Coal seam pinches out or climbs in the section in the western ¼ of the Proposed Project area (see cross sections included in Addendum 2.6-A), where there is only one seam of the Felix present. These coal seams range between five and 10 feet in thickness. Piezometers were installed in the Upper and Lower Felix coal seams at the PZM4 cluster to evaluate the hydrologic properties of these coal seams and determine whether these seams are aquifers. Based on the lack of yield in these wells, it was determined that these coal seams do not qualify as aquifers (additional details are presented in Section 3.4.2.7.3).

Total thickness of the OA aquitard is approximately 45 feet thick, 85 feet thick, 35 feet thick, and 100 feet thick at the PZM1, PZM3, PZM4 and PZM5 clusters, respectively. An isopach map of the OA unit is presented as Figure 2.6A-26 in Addendum 2.6-A and shows the lateral continuity of this unit across the Proposed Project area. Water level data is presented in Table 2.7B-5 in TR Addendum 2.7-B.

PZA Aquifer

The production zone aquifer (PZA) is a discrete and continuous aquifer across the Proposed Project area. The sand occurs between depths of approximately 260 to 380 ft bgs at the PZM1 cluster, 270 to 420 ft btgs at the PZM3 cluster, 220 to 380 ft bgs at PZM4 cluster, and 180 to 330 ft bgs at the PZM5 cluster. Based on the isopach map of the PZA across the site, thicknesses range between approximately 75 to 200 feet (Figure 2.6A-25 in Addendum 2.6-A).

Groundwater flow in the PZA is to the northeast and structural dip, as seen in the structural map at the bottom of the Felix Coal marker bed (Figure 2.6A-6 in Addendum 2.6-A), is to the northwest at approximately 35 to 50 feet per mile. Geologic confinement of the PZA by the overlying and underlying aquitards exists across the entire project area. Aquifer conditions transition from fully saturated in the western portion of the Proposed Project area to partially saturated conditions in the eastern project area, as shown by the approximate boundary line on Figure 2.7B-6. Based on available information to date, partially saturated conditions exist in approximately 30 percent of the Proposed Project area. At PZM1 and PZM3, the saturated thickness of the PZA is approximately 94 feet and 109 feet, and total sand thickness at these locations is approximately 125 feet and 165 feet. There is an unidentified mudstone unit that is present in some portions of the Proposed Project area that divides the PZA into upper and lower sand units. At the PZM4 cluster, there is a difference of approximately four to five feet in potentiometric elevation between the upper PZA and lower PZA. Further characterization of the impacts of this mudstone unit will be addressed in wellfield-scale hydrologic testing at a later date.

Uranium mineralization occurs most frequently in the lower portion of the PZA, or in the lower PZA where present. Sands in the PZA that host the uranium mineralization are commonly crossbedded, graded sequences fining upward from very coarse at the base to fine grained at the top. Additional lithologic discussion of this unit is presented in Section 3.3. Calculated transmissivities within the PZA range from approximately 20 ft^2/day to 1,428 ft^2/day and calculated hydraulic conductivities range between 0.3 ft/day and 13 ft/day (see Section 3.4.2.7). Water level data is presented in Table 2.7B-2 of TR Addendum 2.7-B.

<u>UA Aquitard</u>

The UA aquitard is a laterally continuous sequence of undifferentiated mudstones and clays, with discontinuous and often lenticular sandstones that is approximately 300 to 400 feet thick extending to the Badger Coal. Within the Proposed Project area, this aquitard includes the underlying unit, which is described below. The thickness of the UA aquitard above the underlying unit is approximately 60 feet, 35 feet, 35 feet, and 105 feet thick at well clusters PZM1, PZM3, PZM4, and PZM5. An isopach map of the UA aquitard is presented in Figure 2.6A-24 in Addendum 2.6-A a minimum thickness of approximately 10 feet is present across the Proposed Project area.

<u>Underlying Unit</u>

The underlying unit within the Proposed Project area is comprised of relatively ratty sandstones that are discontinuous and often lenticular. This underlying unit is not continuous or hydraulically connected across the project area, based on geologic data and potentiometric data. The underlying unit is generally 10 to 20 feet thick, occurring between depths of 415 to 480 feet bgs, and is fully saturated across the site (see cross-sections included as Figures 2.6A-12 to 2.6A-17. Water level data is presented in Table 2.7B-6.

Table 2.7B-7 summarizes the hydrologic testing conducted in the underlying unit and shows the relatively low permeability that is observed in this unit. Calculated conductivities are on the order of 0.005 to 0.02 ft/day, which is significantly less than in the PZA.

Based upon the extremely low well yields and hydraulic conductivities at wells completed in this underlying unit, this unit does not meet the definition of an aquifer according to 10 CFR Part 40, Appendix A, which states:

> "*Aquifer means a geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.*"

Single-well pump tests were conducted at the four well cluster locations in the UM-prefix wells completed in this underlying unit and are summarized in Section 3.4.2.7. These data support the conclusion that this underlying unit does not meet the definition of an aquifer within the Proposed Project area.

3.4.2.4 Hydrogeologic Integrity Study

The Reno Creek Project first began as an exploration prospect during 1967. The project moved toward the development phase after an ISR Pilot Plant was built in 1978, and successfully demonstrated that uranium in the PZA was amenable to carbonate solution recovery and subsequent groundwater restoration. Following the pilot plant demonstration, a UIC Class III feasibility report was completed in January 1982. The feasibility report noted that over 3,000 exploratory boreholes had been drilled during the previous 15 year history of the project, and most were drilled prior to abandonment and sealing regulations since this practice was not yet required by law. Before more capital would be committed toward the project, characterization of the natural self-sealing ability of the clays present within the borehole needed to be further evaluated.

3.4.2.4.1 Methodology

Rocky Mountain Energy (RME) conducted a series of hydrogeologic investigations within the Reno Creek Project area in 1982, in order to evaluate exploratory boreholes that were drilled prior to the enactment of well abandonment regulations and determine whether the boreholes have sealed themselves naturally and no longer represent potential locations for cross-aquifer groundwater flow. A portion of the summary and accompanying figures of the Hydrogeologic Integrity Study is included as TR Addendum 2.7-E. The evaluation focused primarily on the integrity of the overlying aquitard situated between the overlying aquifer and the production zone aquifer. RME performed these hydrogeologic investigations in areas referred to as the northern and southern mine block areas. It is important to note that the southern mine block area is located almost two miles south of the Proposed Project area in Section 33 of T43N R73W. The detailed investigations associated with the northern block were concentrated in areas that comprise the current Proposed Project area. In the northern block, investigations were performed in four different study areas. Figure 2.7B-7 presents the locations of historic boreholes, including the four different study areas that were investigated by RME. The four study areas that were investigated by RME correspond to the ore bodies located near the PZM1, PZM3 and PZM4 well cluster/pump test areas (Figure 2.7B-7).

As part of the hydrogeologic integrity testing, RME reentered 33 old exploration boreholes to evaluate for closure with respect to the swelling of mudstone and clay layers. Additionally, 24 new groundwater monitoring wells were installed, 18 of which were constructed for pumping and injection testing. Figure 2.7B-7 presents the locations of historical boreholes that were investigated by RME.

Existing boreholes were entered via an air rotary drill rig and drilling was advanced until an obstruction was encountered. These obstructions were sampled, when possible, using a coring barrel, in an effort to identify and determine the nature of the borehole obstruction. Previous site studies by Honea (1981) identified the clays associated with the Felix coal and overlying confining unit as the swelling type. Once the obstructions sealing the borehole were identified, an inflatable bottom hole packer was set just above the seal/obstruction, and water pressure was applied via the drill pipe. Pressure was increased to a maximum of 150 psi as measured at the surface, or until a drop in pressure was observed. Pressure was maintained or observed for approximately 30 minutes, and the packer was subsequently removed.

Bottom hole and straddle packer tests were conducted on 16 existing exploration boreholes at 39 intervals in what RME identified as the northern block. As mentioned earlier, the northern block generally corresponds to the current Proposed Project area. Additional packer testing was also conducted in 12 additional boreholes and 17 seal/obstruction intervals located within the southern block, which is located outside of the Proposed Project area. The age of the boreholes ranged from as recent as three to four years old, and as old as 10 years, at the time of the study.

3.4.2.4.2 Results

During borehole reentry investigations, mudstone obstructions were generally encountered at the mudstones above, between, and below the Felix Coal, within the unidentified mudstone present in middle portion of the PZA, and within a basal mudstone near the bottom of the PZA that separates a relatively less permeable sand within the PZA (identified as the #5 sand by RME).

In the northern block area of investigations (see Figure 2.7B-7), the mudstone overlying the Felix coal consistently held up to surface gauge hydrostatic pressures of 120 to 150 psi without bleeding off. Similar results were seen at slightly lower pressure in the mudstone separating the Upper and Lower Felix, and the mudstone below the Felix. The results of the packer testing indicated that the mudstone above the Felix consistently held up to surface gauge pressures of 120 to 150 psi, and the mudstones between and below the Felix withstood somewhat lower pressures. Regardless of location, packer testing of the basal PZA mudstone did not usually withstand much pressure and suggested that this mudstone provided minimal confinement between the upper ore sands and lower ore sand #5 (RME nomenclature). RME concluded that the sands of the PZA should be treated as one hydrologic unit.

Results of the pump and injection tests indicated that the production zone sand has good permeability and should is amenable to ISR recovery. Transmissivity values ranged from 149 to 555 ft^2/day; permeability values ranged from 0.9 to 4.1 ft/day; and storativity values ranged from 4.0×10^{-5} to 1.0×10^{-3}. No responses were observed in the overlying aquifer during any hydraulic testing activities. RME did not identify an underlying aquifer during their investigations.

The significance of the Hydrogeological Integrity Study conducted by RME demonstrates that the numerous exploratory boreholes do not provide a conduit to crossflow of groundwater between aquifer units, due to the natural sealing capacity of the swelling clays present in confining units with respect to the production zone sand. Recent pump testing conducted across the project area has also provided additional confirmation of the absence of open boreholes as hydraulic isolation of the overlying aquifer and underlying unit (which is not considered an aquifer) with respect to the production zone has been demonstrated.

In Section 3.4.2.7.2, an example of an improperly constructed and leaky well is presented that was discovered during pump testing at the PZM3 cluster (see Figure 2.7B-30). The significant drawdown response observed in the underlying unit (approximately three feet) illustrates a typical hydrograph at a well that is not completed properly. The underlying unit in this well essentially responds in the same manner as a well completed in the PZA pumping horizon.

3.4.2.5 <u>Potentiometric Surface, Groundwater Flow Direction and Hydraulic Gradient</u>

The hydrologic investigations at the Proposed Project included measurements of water levels completed in the production zone PZA aquifer, the shallow water table SM unit (where present), the overlying aquifer, and underlying unit to assess the potentiometric levels, and groundwater flow direction and hydraulic gradient in these aquifers. As previously mentioned, the SM unit and underlying unit do not meet the definition of an aquifer. Hydrologic data collected from these units is included in this document to support this conclusion. Additionally, two piezometers were installed at the PZM4 well cluster in the Upper and Lower Felix coal seams within the overlying OA confining zone. A summary of water level measurements in the PZA aquifer is provided in Table 2.7B-2. Summaries of water level data collected in the SM unit, overlying aquifer, OA confining unit, and underlying unit are presented in Tables 2.7B-3 through 2.7B-6, respectively. Vertical gradients between the water table unit (where present), overlying and PZA aquifers, and the underlying unit at the six well clusters are presented in Table 2.7B-8.

Potentiometric surfaces could not be constructed for the perched water table SM unit, overlying aquifer, and underlying unit due to the discontinuous nature of the sandstones that were identified and completed within these intervals. Figure 2.7B-8 presents the observed water level elevations at the seven OM-prefix wells from August 2011. Similarly, a potentiometric surface could not be constructed from water level data in the underlying unit due to discontinuity of sands below the PZA in the Proposed Project area. Figure 2.7B-9 presents water level elevations at the seven UM-prefix wells from August 2011.

Two potentiometric surface maps are presented for the production zone PZA aquifer. Figure 2.7B-10 presents the potentiometric surface as measured in October 1993 as part of historical hydrologic investigations conducted by ENFI. Figure 2.7B-11 presents the current potentiometric surface for the Proposed Project area from August 2011. The direction of groundwater flow in the PZA for both potentiometric surfaces is to the northeast. These two datasets are in good agreement and support the observed groundwater flow direction and gradients observed within the Proposed Project area. The horizontal hydraulic gradient from the 1993 potentiometric surface across the area of investigation is approximately 0.0027 ft/ft (14.4 ft/mile). The hydraulic gradient from 2011 in the southwestern portion of the Proposed Project area near the PZM5, PZM6 and PZM7 well clusters is approximately 0.0032 ft/ft (16.9 ft/mile) and is similar to the gradient in the northeastern portion of the Proposed Project area (approximately 0.0035 ft/ft [18.5 ft/mile]). The hydraulic gradient in the center of the project area is approximately 0.0017 ft/ft (9.0 ft/mile). This area of lower hydraulic gradient is likely related to the presence of thicker and more transmissive sands, which is supported by pump testing data (see Section 3.4.2.7).

At the PZM4 well cluster, the PZA aquifer is bifurcated by a mudstone present within the PZA that separates the upper and lower PZA at this location (see geophysical log in Figure 2.6-14). At PZM4, the mudstone is approximately 40 feet thick and is also present at wells PZM16 (approximately eight feet thick) and PZM15 (approximately 30 feet thick). The mudstone is not observed to the west at well PZM17 (see the A-A' cross section in Figure 2.6-6). At the PZM4 cluster, there is a head differential of approximately four feet between the higher head observed in the upper sand of the PZA (monitored in well PZM4) and the underlying lower PZA (monitored in well PZM4D). The potentiometric surface from 2011 in Figure 2.7B-9 utilizes the head in the lower PZA at well PZM4D. Based on the results of pump testing at the PZM4 cluster (presented in detail in Section 3.4.2.7), the area to the west near well PZM17 appears to represent an area of higher transmissivity, which may also be related to the relative flattening of the hydraulic gradient in this area.

Vertical gradients were calculated at the six well clusters where there is sufficient hydrologic data (PZM1, PZM3, PZM4, PZM5, PZM6, and PZM7) and are presented in Table 2.7B-8. Hydraulic head decreases with depth from the water table SM unit (where present) down to the underlying unit, and the downward hydraulic gradients are consistent at all locations. At the three locations where the SM unit was encountered (SM3, SM5, and SM6), the SM unit potentiometric elevation is approximately 66 feet, 3 feet, and 45 feet higher than the overlying aquifer potentiometric elevation, respectively. In the eastern portion of the project area at clusters PZM1 and PZM3, head in the overlying aquifer is approximately 110 feet and 165 feet higher than the underlying PZA aquifer, respectively. In the central portion of the project area at the PZM4 cluster, the overlying aquifer is 52 feet higher in head than the upper PZA. In the western half of the project area, the head in the overlying aquifer is approximately 91 feet, 79 feet, and 57 feet higher than the PZA aquifer at clusters PZM5, PZM6, and PZM7, respectively. Head in the underlying unit ranges between approximately 2 feet and 36 feet lower than the PZA at the six well clusters presented in Table 2.7B-8.

Water level hydrographs for the SM unit, overlying aquifer, PZA, and underlying unit are presented at the PZM5 cluster and shown in Figures 2.7B-12 through 2.7B-15, respectively. These hydrographs present approximately eight months of data, from February through September 2011 for the SM unit, overlying aquifer, and underlying unit. The PZA aquifer at well PZM5 has water level data over a 10 month period from December 2010 to September 2011.

3.4.2.6 Historical Pump Testing and Aquifer Properties

Pump testing in the Proposed Project area has been conducted in the past by previous operators between the years 1979 and 1994. These historical testing activities included multiple single-well tests as well as several multi-well observation well tests. The results of testing are presented in this section and summarized in Table 2.7B-9.

ENFI and Hydro-Engineering re-analyzed historical testing conducted by RME in 1979, 1981, and 1982, and conducted additional hydrologic testing in 1993 as part of the Class III UIC Permit to Mine Application and a Source Material License Application for the Reno Creek Project in 1993. The following presents a summary of these hydrologic results, which are also presented in Table 2.7B-9; Figure 2.7B-7 shows the locations of these investigations. These investigations reported in this document include:

- Five multi-well pump tests in the PZA and monitoring at a total of eleven PZA observation wells, one upper PZA well, and one overlying aquifer well;
- 16 single-well pump tests in the PZA at ten locations; and
- Three single-well pump tests in the overlying aquifer.

<u>OB-1 Test</u>

A multi-well pump test was conducted at pumping well OB-1, located approximately 2,000 feet northwest of the PZM1 well cluster (see Figure 2.7B-7). The PZA at this location is partially saturated and the net sand thickness is 115 feet. Well OB-1 was pumped at 16.8 gpm for 165 minutes, with a maximum observed drawdown in the pumping well of 14.8 feet. Observation wells P-1, I-1, and M-4 (not shown on Figure 2.7B-7) were monitoring during testing and evaluated for aquifer properties.

Calculated transmissivity from the pumping well OB-1 was 123 ft^2/day, and ranges between 138 to 225 ft^2/day in the observation wells. Specific yield values for the two observation wells were 2.4×10^{-2} and 4.7×10^{-2}. Based on 115 feet of sand in the PZA near this location, the calculated horizontal hydraulic conductivities range between 1.1 and 2.0 ft/day (Table 2.7B-9).

<u>P-10 Test</u>

A multi-well pump test was conducted in 1980 at pumping well P-10, located approximately 2,300 feet northwest of the PZM1 well cluster (Figure 2.7B-7). The PZA at this location is partially saturated and the net sand thickness is 113 feet. Well P-10 was pumped at an average rate of 18.9 gpm for 240 minutes, with a maximum observed drawdown of 7.6 feet. Observation wells I-12 and M-16 (not shown on figure) were monitoring during testing and evaluated for aquifer properties.

The calculated transmissivity for the pumping well was 254 ft^2/d from early time data as the straight line portion of the drawdown lasted approximately one minute before drawdown became essentially steady. Calculated transmissivities for wells I-12 and M-16 were 242 and 247 ft^2/d, respectively, and specific yield values of 6.9×10^{-2} and 6.0×10^{-2} were calculated from these wells, respectively. Based on 113 feet of sand thickness in the PZA, calculated horizontal conductivities range between 2.1 and 2.2 ft/day (Table 2.7B-9).

<u>RI-5 Tests</u>

Several historical pump tests were conducted at well RI-5 (located approximately 800 feet west of PZM1 cluster, see Figure 2.7B-7). The PZA at this location is partially saturated and net sand thickness is 96 feet. Testing conducted in 1982 included pumping

RI-5 at an average rate of 11.9 gpm for 360 minutes, and additional monitoring of the PZA observation well RI-22. Drawdown in the pumping well was approximately 13.6 feet at the end of testing. A second single-well test was conducted in 1982 at an average rate of 18.6 gpm for 120 minutes, resulting in approximately 30 feet of drawdown at pumping well RI-5. A third single-well test was conducted by ENFI in 1993 at RI-5 that consisted of pumping at an average rate of 6.7 gpm for 41 minutes, resulting in 5.3 feet of drawdown.

The calculated T from the pumping well RI-5 during the first test (11.9 gpm) was 75.4 ft^2/d utilizing early time data, and 298 ft^2/d utilizing later time data. The match of late time data appears more appropriate, as early time data includes withdrawal from casing storage. The calculated T from the RI-22 observation well at late time is 205 ft^2/d, with a specific yield value of 2.6×10^{-3}. Calculated T from the second single-well test at RI-5 was 174 ft^2/d from drawdown data and 203 ft^2/d from monitored recovery data. Calculated T from the third test from 1993 was 289 ft^2/day. The results of these tests at RI-5 indicate similar results, and calculated horizontal conductivities range between 1.8 and 3.1 ft/day (Table 2.7B-9).

RI-28 Test

A multi-well pump test was conducted in 1982 at RI-28, which is located approximately 700 feet southeast of the PZM4 well (Figure 2.7B-7). The PZA at this location is fully saturated and has a net sand thickness of 164 feet. Well RI-28 was pumped at an average rate of 30.3 gpm for 2,580 minutes (1.8 days), resulting in a maximum drawdown of 53 feet. Water levels in PZA at well RI-34 (not shown in Figure 2.7B-7), which is located 77 feet from the pumping well, were also monitored.

Calculated T from drawdown data in RI-5 was 207 ft^2/d, and the same value was calculated from the recovery data. Calculated T in the RI-34 observation well was 217 ft^2/d from drawdown data, and 206 ft^2/d from recovery data. Storativity calculated from RI-34 was 1.3×10^{-4}. Calculated horizontal conductivities for all analyses were 1.3 ft/day (Table 2.7B-9).

RI-1 Tests

Two single-well pump tests were conducted in 1982 at RI-1, which is located approximately one mile southwest of PZM4 (Figure 2.7B-7). The PZA at this location is fully saturated and has a net sand thickness of 169 feet. In the first test, RI-1 was pumped at a constant rate of 44.8 gpm for 100 minutes, resulting in 23 feet of drawdown. The second test at RI-1 was pumped at a constant rate of 25 gpm for approximately 2,500 minutes, resulting in approximately 18 feet of maximum drawdown. A third single-well test was conducted in 1993 by ENFI, as well RI-1 was pumped at 3.8 gpm for 51 minutes.

Calculated T values shown in Table 2.7B-9 compare well; calculated T from drawdown data in the first test was 868 ft^2/d and 813 ft^2/d from the recovery data. Calculated T from drawdown data in the second test was 802 ft^2/d and 828 ft^2/d from recovery data. Calculated T from the 1993 test was slightly lower at 639 ft^2/d. Calculated horizontal conductivities for all analyses range from 3.8 to 5.1 ft/day (Table 2.7B-9).

RI-2 Test

A single-well test was conducted in 1982 at RI-2, which is located approximately 1,300 feet southwest of the PZM4 well (Figure 2.7B-7). The PZA at this location is fully saturated and has a net sand thickness is 121 feet. Well RI-2 was pumped at a constant rate of 41.2 gpm for 100 minutes, resulting in 39 feet of drawdown. Recovery monitoring was also conducted. A single-well test was also conducted in 1993 by ENFI at this location, pumping at a rate of 3.5 gpm for 46 minutes.

Calculated T from drawdown data was 189 ft^2/d, and T from the recovery data was calculated to be slightly lower at 156 ft^2/day. Calculated T from the 1993 test from drawdown data was 156 ft^2/d. Calculated horizontal conductivities are 1.3 ft/day to 1.6 ft/day from drawdown data and 1.3 ft/day from recovery data (Table 2.7B-9).

RI-3 Test

Two single-well pump tests were conducted in 1978 and 1982 at well RI-3, which is located approximately 3,600 feet northeast of well PZM4 (Figure 2.7B-7). A third single-well test was also conducted in 1993. The PZA at this location is fully saturated and has a net sand thickness is 154 feet. Well RI-3 was pumped at a constant rate of 34.7 gpm for 100 minutes for the first test conducted in 1978, resulting in 24 feet of drawdown. In 1982, the well was pumped at an average rate of 24.8 gpm for 360 minutes, resulting in 19 feet of drawdown. In the 1993 test, the well was pumped at an average rate of 7.6 gpm for 52 minutes.

Calculated T values for the first test from drawdown and recovery data were 451 ft^2/day and 459 ft^2/day, respectively. Calculated T values from the second test from drawdown and recovery data were 468 ft^2/day and 588 ft^2/day, respectively. Calculated T from drawdown data for the third test was 497 ft^2/d. Calculated hydraulic conductivities range between 2.9 and 3.8 ft/day (Table 2.7B-9).

RI-4 Test

A single-well test was conducted in 1982 at well RI-4, which is located approximately 4,300 feet northwest of PZM1 (see Figure 2.7B-7). The PZA at this location was indicated to be saturated, with a net sand thickness of 124 feet. The well was pumped at an average rate of 22.2 gpm for 100 minutes, resulting in 50 feet of drawdown. A second single-well test was conducted in 1993 and the well was pumped at an average rate of 8.0 gpm for 180 minutes.

Calculated T values from drawdown and recovery data were 72 ft^2/day and 75 ft^2/day, respectively, for the first test. Calculated T of the second test was 156 ft^2/day. Hydraulic conductivities were calculated at approximately 0.6 ft/day for the first test and 1.3 ft/day for the second test (Table 2.7B-9).

RI-6 Test

A single-well test was conducted in 1982 at well RI-6, located approximately 2,000 feet northeast of well PZM3 (Figure 2.7B-7). The PZA at this location is partially saturated, with a sand thickness of 67 feet. The well was pumped at an average rate of 15.9 gpm for 141 minutes. A second single-well test was conducted in 1993 and the well was pumped at a rate of 5.7 gpm for 38 minutes.
Calculated T values from drawdown and recovery data of the first test were 105 ft^2/d and 110 ft^2/d, respectively. Calculated T from drawdown data of the second test was 109 ft^2/d. Hydraulic conductivities were calculated at approximately 1.6 ft/day (Table 2.7B-9).

RI-7 Test

A single-well test was conducted in 1982 at well RI-7, located approximately 2,500 feet southeast of the PZM3 well (Figure 2.7B-7). The PZA at this location is partially saturated, with a sand thickness of 56 feet. The well was pumped at an average rate of 16.6 gpm for 110 minutes.

Calculated T values from drawdown and recovery data were 185 ft^2/d and 124 ft^2/d, respectively. Hydraulic conductivities were calculated at 3.3 ft/day and 2.2 ft/day from the drawdown and recovery analysis, respectively (Table 2.7B-9).

RI-28 Test

A single-well test was conducted in 1982 at well RI-28, located approximately 700 feet southeast of well PZM4 (Figure 2.7B-7). The PZA at this location is fully saturated with a sand thickness of 164 feet. The well was pumped at an average rate of 30.3 gpm for approximately 2,580 minutes.

Calculated T values from drawdown and recovery data were 176 ft^2/d and 175 ft^2/d, respectively. Hydraulic conductivities were calculated at approximately 1.1 ft/day (Table 2.7B-9).

RI-42C

A single-well test was conducted in 1993 by ENFI at well RI-42C, which is located approximately 2,000 feet east of well PZM3 (Figure 2.7B-7). The PZA at this location is partially saturated with a sand thickness of 74 feet. The well was pumped at a rate of 20 gpm for 241 minutes, resulting in a drawdown of approximately 27 feet.

The calculated T value from drawdown was 504 ft^2/d. Hydraulic conductivity at this location is approximately 6.8 ft/day (Table 2.7B-9).

RI-43C

A single-well test was conducted in 1993 by ENFI at well RI-43C, which is located approximately 2,500 feet east-southeast of well PZM4 (Figure 2.7B-7). The PZA at this location was noted as fully saturated at a lower permeability unit at the top of the sand, and static water level was approximately 80 feet above this unit. The well was pumped at a rate of 20 gpm for 411 minutes, resulting in a drawdown of approximately 67 feet.

The calculated T value from the drawdown data from this test was 203 ft^2/day. Hydraulic conductivity at this location is approximately 2.3 ft/day (Table 2.7B-9).

MP-9 Multi-Well Test

ENFI conducted a multi-well pump test within the lower portion of the production zone sand at pumping well MP-9, which is located approximately 1,400 feet east-northeast of well PZM4. (Figure 2.7B-7) The PZA is fully saturated and sand thickness at this location is 103 feet. In addition to the pumping well, four additional wells (MP-2, RI-46, RI-45, RI-47) in the lower sand were monitored during testing which were located approximately 90 feet west, 105 feet north, 175 feet west, and 217 feet north from the pumping well, respectively. Additional monitoring was conducted at a single well (MO-2) in the upper portion of the PZA and at a single well (MU-2) in the overlying aquifer at this location. Well MP-9 was pumped at an average rate of 15.5 gpm for 24 hours, resulting in 40 feet of drawdown. Drawdowns in observation wells MP-2, RI-46, RI-45, and RI-47 were 21 feet, 19 feet, 18 feet, and 12 feet.

The potentiometric level in the upper sand of the PZA at this location was approximately seven feet higher than the level in the lower sand, while the overlying aquifer well indicates the potentiometric level in the overlying aquifer is approximately 70 feet higher than the lower sand of the PZM. Pumping from the lower sand of the PZA from well MP-9 produced no response in the PZA upper sand at well MO-2 (located 50 feet from the pumping well), and no response in the overlying aquifer at well MU-2 (located 100 feet from the pumping well).

Calculated transmissivities are presented in Table 2.7B-9 and the Theis, Cooper-Jacob straight-line, and Theis recovery evaluated data show good agreement, ranging between 45 ft^2/d to 62 ft^2/d, with hydraulic conductivities ranging between 0.4 ft/day and 0.6 ft/day. The average transmissivity at this location is approximately 50 ft^2/d. Storativity values at this location are range between 5.5×10^{-5} to 2.2×10^{-4}.

RI-15U – Overlying Aquifer

Two single-well tests were conducted in 1993 at well RI-15U, which is completed in the overlying aquifer at this location. Well RI-15U is located approximately 1,200 feet east of the PZM3 well (Figure 2.7B-7). The first test results indicate an interruption in pumping and a pumping rate (3.8 gpm) that was too high for the well, as water level data are indicative of wellbore storage. The second test was conducted at one gpm for 26 minutes, resulting in approximately 17.5 feet of drawdown.

Calculated T values from drawdown data were significantly less than values seen in the PZA at this location. The calculated T value from the second test was 1.4 ft^2/d. Based on the log from this well, sand thickness is approximately 30 feet. Hydraulic conductivity at this location was calculated at approximately 0.05 ft/day (Table 2.7B-9).

RI-24U – Overlying Aquifer

A single-well pump test was conducted at well RI-24U, which is completed in the overlying aquifer and located approximately 4,300 feet northwest of PZM1 (Figure 2.7B-7). The well was pumped at an average rate of 1.5 gpm for 77 minutes, resulting in approximately 59 feet of drawdown.

Calculated transmissivity from the drawdown data was extremely low at 0.2 ft^2d. Based on the log at this location, the sand quality is relatively poor and thin, with approximately 8 feet or less of sand. The calculated hydraulic conductivity in this sand is approximately 0.03 ft/day (Table 2.7B-9).

RI-30U – Overlying Aquifer

A single-well pump test was conducted in the overlying aquifer well RI-30U, located approximately 700 feet southeast of well PZM4 (Figure 2.7B-7). The well was pumped at a rate of 4.3 gpm for 20 minutes, resulting in 2.9 feet of drawdown.

Calculated T from drawdown data was 164 ft^2/d. Based on a sand thickness of 61 feet, the calculated hydraulic conductivity at this location is approximately 2.7 ft/day (Table 2.7B-9).

3.4.2.7 Recent Pump Testing and Aquifer Properties

AUC has conducted four multi-well pump tests in 2010 and 2011 at four well cluster locations, PZM1, PZM3, PZM4, and PZM5. Based on the results of testing, both the water table SM unit and underlying unit below the PZA do not meet the definition of an aquifer. Data from these units are included in this section to support this conclusion. The following summarizes the wells tested and monitored during these activities:

- Four multi-well pump tests were conducted in the PZA; a total of 20 wells monitored in the PZA; aquifer properties determined for 14 wells in the PZA;
- A total of two SM unit wells, four overlying aquifer wells, and five underlying unit wells monitored during PZA multi-well tests; and
- Single-well pump tests conducted in the SM unit (two), overlying aquifer (four), and underlying unit (four) to determine aquifer properties.

These pump tests represent the most complete hydrologic characterization completed to date at the Proposed Project and provide more than sufficient characterization for the purposes of this license application. Hydrostratigraphic diagrams at the four well clusters are presented in Figures 2.7B-16 through 2.7B-19. Aquifer characteristics of transmissivity (T) and storativity (S) were evaluated for the PZA at the four cluster locations. Additionally, single-well pump testing was conducted in the overlying SM unit, overlying aquifer, and the underlying unit to determine transmissivity of these units. Hydraulic isolation of the PZA with respect to the overlying aquifer and underlying unit has been demonstrated at all four well cluster locations, as no drawdown responses were observed. Addendum 2.7-D presents the full detailed reports related to the well cluster hydrologic investigations.

It is noted that due to surface discharge concerns of water quality from the ore bodies, the pumping wells at the four well cluster locations were be located outside of the ore bodies.

3.4.2.7.1 PZM1 Well Cluster Pump Testing

The PZM1 well cluster is located in the NW ¼ of Section 27, T43N, R73W (see Figure 2.7B-6). Multi-well pump testing of the PZA aquifer was conducted during December 2010 and single-well tests of the overlying aquifer and underlying unit were conducted during October 2011. Testing was conducted to evaluate hydrologic characteristics of the PZA, overlying aquifer, and the underlying unit, and demonstrate isolation of the PZA with respect to the adjacent overlying aquifer and underlying unit. A detailed report of these testing activities is provided in the PZM1 data package, included as Addendum 2.7-D. The results of testing indicate that the PZA at this location is hydraulically connected at the monitoring locations, and no drawdown responses were observed in the overlying aquifer or underlying unit, demonstrating that there is sufficient confinement at this location for the purposes of ISR operations.

A hydrostratigraphic diagram for the PZM1 well cluster integrating geophysical log data and water level data is presented in Figure 2.7B-16. The PZA at the PZM-1 well is partially saturated but geologically confined by a relatively thick mudstone and occurs between depths of 256 and 385 feet bgs, with mineralization occurring in the lower half of the aquifer (see Figure 2.6A-10 for the type log near the PZM1 cluster). Depth to water at PZM1 is approximately 292 feet below top of casing (feet btoc), resulting in a saturated sand thickness of approximately 94 feet. Total sand thickness at this location is 128 feet.

The overlying aquifer at this location is approximately 50 to 60 feet thick, occurring between 156 to 215 feet bgs at the PZM1 well, and completed between 191 ft and 211 feet at well OM1. The overlying OA confining unit at the well cluster is between 35 and 53 feet thick, and observed at depths of 215 to 256 feet bgs at the PZM1 pumping well. The underlying unit is 17 feet thick at well UM1 and occurs at depths between 432 and 449 ft bgs, and the underlying UA aquitard is a mudstone approximately 49 feet thick, at depths of 383 to 432 feet bgs at UM1.

For the multi-well pump test conducted at PZM1, three PZA observation wells were monitored, PZM9, PZM8, and PZM10. These wells are located 58, 81, and 235 feet from the pumping well, respectively. Water levels in the overlying OM1 well and the underlying UM1 well were also monitored to demonstrate hydraulic isolation between the PZA and the overlying aquifer and underlying unit.

Two relatively short term single-well tests were conducted in wells OM1 and UM1 to evaluate aquifer characteristics in the overlying aquifer and the underlying unit. The following summary details the results of testing at this location.

PZM1 Multi-Well Pump Test

Pumping well PZM1 was pumped at an average rate of 8.9 gpm for 2,595 minutes (1.8 days). Total drawdown observed in the pumping well was 46.8 feet; drawdown observed in wells PZM9, PZM8, and PZM10 were 1.4 feet, 1.6 feet, and 0.5 feet, respectively, and summarized in Table 2.7B-10. Figure 2.7B-20 shows the relative water levels of the three PZA observation wells versus the PZM1 pumping well. All data presented have been corrected for barometric pressure (BP) fluctuations. The PZA aquifer at this location is highly efficient with respect to barometric pressure. Barometric efficiency (BE) is 0.81 at PZM8 and between 0.93 and 0.96 at the remaining PZA wells. Thus at PZM8, the aquifer will fluctuate at a level of 81 percent of the equivalent fluctuation in BP. Additional details on the BE evaluation is provided in the pump test data report for the PZM1 pump test, provided in Addendum 2.7-D.

Figure 2.7B-21 shows a closeup view of water level data in the PZA at early time, as the water level in the well nears the level of maximum drawdown in less than 30 minutes. The drawdown observed in the pumping well is not reflective of the water levels calculated outside of the well completion, as the pumping well is only approximately 10 percent efficient. Based on a Theis prediction of drawdown at a distance of one foot from the well, the predicted drawdown is only 4.6 feet (compared to 46.8 feet drawdown in the pumping well). Additional details of the well efficiency evaluation are presented in Addendum 2.7-D.

It is noted that the drawdown observed does not correspond directly to distance in the observation wells, as greater drawdown is observed in well PZM8 (1.6 feet drawdown; 81 feet from pumping well) versus PZM9 (1.4 feet; 58 feet from pumping well). It is possible that the non-uniform distribution of drawdown is related to depositional heterogeneities present at depth (e.g., sand quality and/or thickness variations), but will be characterized further at a later date during wellfield-scale hydrologic testing.

No drawdown response was observed in the overlying OM1 and underlying UM1 wells, as seen in Figures 2.7B-22 and 2.7B-23, respectively. Hydraulic isolation of the PZA aquifer with respect to the overlying aquifer and underlying unit has thus been demonstrated in the vicinity of PZM1.

Aquifer characteristics of transmissivity (T) and storativity (S) were evaluated in the PZA aquifer and are summarized in Table 2.7B-11. Drawdown data at the observation wells were analyzed by the Theis (1935) method, correcting drawdown data for the partially saturated sand present at this location. A correction for drawdown in a partially saturated aquifer was applied to the drawdown data analyzed, commonly referred to as a Jacob correction. Corrected drawdown (s') for partially saturated conditions is defined by the following relationship between observed drawdown (s) and saturated aquifer thickness (B):

$s' = s^2/2B$ (Kruseman and de Ridder, 1990)

The recovery data were analyzed according to the straight-line Theis (1935) analysis on the observation wells and the pumping well. Table 2.7B-11 summarizes the results of analysis.

Transmissivity (T) results from drawdown data in the observation wells PZM9, PZM8, and PZM10 were 427 ft^2/d, 559 ft^2/d, and 694 ft^2/d. Theis recovery analysis of T for the pumping well PZM1 was calculated to be 389 ft^2/d, and T ranged between 454 ft^2/d to 758 ft^2/d for the three observation wells from recovery data (Table 2.7B-11). Calculated storativity values for the three observation wells ranged between 6.0×10^{-4} to 5.0×10^{-3}. Calculated hydraulic conductivities (based on 94 foot saturated thickness at the pumping well) ranged from 4.5 to 7.4 ft/day from drawdown data, and from 4.1 to 7.6 ft/day from recovery data.

<u>Single-Well Overlying Aquifer Pump Test</u>

A single-well test was conducted in the overlying aquifer at well OM1 on October 5, 2011 and water levels in the pumping well were monitored. The well was pumped at an average rate of 3.3 gpm for 75 minutes, resulting in 19.3 feet of drawdown. A hydrograph of the pump test water level data is presented in Figure 2.7B-24.

Recovery data were evaluated according to Theis (1935) and transmissivity was determined by a straight-line fit, the results of which are summarized in Table 2.7B-11. A T value of 39 ft^2/day was calculated in the aquifer at this location, which indicates that the hydraulic conductivity (K) in the overlying aquifer is approximately one ft/day.

<u>Single-Well Underlying Unit Pump Test</u>

A single-well test was conducted in the underlying unit at well UM1 on October 24, 2011. The well was pumped at an average rate of 6.1 gpm for 12 minutes, resulting in approximately 98 feet of drawdown. Pumping was stopped as water levels approached the level of the pump in the well. Based on the hydrograph of water level during testing presented in Figure 2.7B-25, it appears that much of the water removed during the short test was from wellbore storage. Water levels in the well were also very slow to recovery, only reaching within three feet of the initial static water level after a period of more than two days.

Recovery data were analyzed by a straight-line fit according to Theis (1935), the results of which are presented in Table 2.7B-11. A T value of 0.1 ft^2/d was calculated at the underlying unit at this location. Hydraulic conductivity based on 17 feet of saturated thickness is approximately 0.01 ft/day. Based on the lack of sustainable yield, very slow recovery, and very low transmissivity calculated at UM1, the underlying unit does not meet the definition of an aquifer at this location.

PZM1 Pump Test Summary

Pump testing was conducted in the partially saturated PZA at well PZM1. A drawdown response of 0.5 ft was measured in an observation well 235 feet from the pumping well. No responses were observed in the overlying aquifer and underlying unit, indicating that the PZA in this area is isolated from these adjacent intervals.

Average transmissivity of the PZA at the PZM1 cluster is approximately 560 ft^2/day from drawdown data and 588 ft^2/day from the recovery data analysis. Hydraulic conductivities average approximately 6.0 to 6.3 ft/day. Storativity values range between 6 x 10^{-4} to 5.0 x 10^{-3} (see Addendum 2.7-D for detailed report). Historical testing near the PZM1 cluster was conducted at well RI-5 (see Figure 2.7B-7, located 800 feet east of PZM1), which is summarized in Table 2.7B-9. Transmissivity values from these historical tests are approximately half the values seen at the PZM1 cluster, which may indicate relatively less transmissive sands to the west.

3.4.2.7.2 PZM3 Well Cluster Pump Testing

The PZM3 well cluster is located in the NE ¼, Section 33, T43N, R73W (see Figure 2.7B-6). A multi-well pump test was conducted in the PZA aquifer during October 18 – 21, 2011. Single-well tests of the SM unit, overlying aquifer, and underlying unit were conducted during October 2011. Testing was conducted to evaluate the hydrologic characteristics of the PZA, SM unit, overlying aquifer, and underlying unit, and to demonstrate isolation of the PZA with respect to these adjacent intervals. A more detailed report of these hydrologic investigations is provided in the PZM3 data package, included as Addendum 2.7-D. The results of testing indicate that the PZA at this location is hydraulically connected at the monitoring locations, and no drawdown responses were observed in the overlying aquifer or underlying unit, demonstrating that there is sufficient confinement at this location for the purposes of ISR operations.

A hydrostratigraphic diagram for the PZM3 well cluster integrating geophysical log data and water level data is presented in Figure 2.7B-17. The PZA at the PZM3 well cluster is partially saturated but geologically confined by the predominantly mudstone OA aquitard. A type-log for this area is presented in Figure 2.6A-4 in Addendum 2.6-A, and shows that the PZA is found between depths of approximately 255 feet to 425 feet, with mineralization occurring in the upper and middle portions of the PZM. Depth to water at

PZM3 is approximately 302 feet btoc, resulting in a saturated sand thickness of approximately 109 feet.

The overlying aquifer at this location is saturated and approximately 10 feet thick, occurring between depths of approximately 150 to 160 feet bgs at well OM3, with a confining head of approximately 13 feet. The overlying OA aquitard is approximately 85 feet thick. The underlying unit is approximately 14 feet thick at well UM1, occurring at depths of 460 to 474 feet bgs, with a confining head of approximately 146 feet.

For the multi-well pump test conducted at PZM3, three additional PZA observation well were monitored, PZM11, PZM12, and PZM13. These wells are located 52 feet, 102 feet, and 199 feet from the pumping well, respectively. Water levels in the overlying SM3 and OM3 wells and in the underlying UM3R wells were also monitored during testing to demonstrate hydraulic isolation between the PZA and adjacent units.

Short-term single-well pump tests were conducted in wells SM3, OM3, and UM3R to evaluate transmissivity in the water table SM unit and overlying aquifer and underlying unit. The following summary details the results of testing at the PZM3 well cluster.

PZM3 Multi-Well Pump Test

Pumping well PZM3 was pumped at an average rate of 9.9 gpm for 4,149 minutes (2.88 days). Total drawdown observed in the pumping well was 32.1 feet; drawdowns observed in wells PZM11, PZM12, and PZM13 were 3.1 feet, 1.5 feet, and 0.7 feet, respectively, and are summarized in Table 2.7B-12. Figure 2.7B-26 shows the relative water levels of the three observation wells versus the PZM3 pumping well. All data presented have been corrected for barometric pressure (BP) fluctuations. The PZA aquifer at this location is highly efficient with respect to BP. Barometric efficiency (BE) ranges between 0.82 and 0.87 for the wells monitored during testing. Additional details on the BE evaluation are provided in the pump test data report for the PZM3 pump test, provided in Addendum 2.7-D.

Figure 2.7B-27 shows a closeup view of water level data in the PZA at early time, as the water level in the well nears the level of maximum drawdown in approximately five minutes. The drawdown observed in the pumping well (32.1 feet) is not reflective of the water levels calculated outside of the well completion, as the pumping well is only approximately 10.5 percent efficient. Based on a Theis prediction of drawdown at a distance of one foot from the well, the predicted drawdown is only 4.2 feet for the duration of the test. Additional details of the well efficiency evaluation are presented in Addendum 2.7-D.

No drawdown response was observed in the overlying SM3 and OM3 well, as seen in the water level data presented in Figures 2.7B-28 and 2.7B-29. Water level data from well UM3R from the underlying unit is presented in Figure 2.7B-30 and shows an overall water level decline in the well, but no apparent decline related to pumping in the PZM. The steady decline in water level in this well possibly reflects the impacts of well development by airlifting and shows that the well had yet to reach equilibrium and static water level until approximately October 24, whereupon the water level in the well leveled out at approximately 315.7 ft btoc.

Aquifer characteristics of transmissivity (T) and storativity were evaluated in the PZA aquifer and are summarized in Table 2.7B-13. Drawdown data at the observation wells were analyzed by a Theis (1935) curve match, applying the Jacob correction (previously described in Section 3.4.2.7.1) for the partially saturated PZA aquifer. Straight-line analysis by the Cooper-Jacob method, and correcting drawdown for a partially saturated aquifer, were also evaluated from the PZA observation well drawdown data. Recovery data in the pumping well and observation wells were analyzed according to the straight-line Theis (1935) analysis.

Calculated T results from the Theis drawdown data for wells PZM11, PZM12, and PZM13 were 587 ft^2/day, 830 ft^2/day, and 1327 ft^2/day, respectively, and calculated storativity values were 1.0 x 10^{-5}, 2.0 x 10^{-4}, and 8.3 x 10^{-4}, respectively. Calculated T values from the straight-line Cooper-Jacob analysis for these three observation wells were 535 ft^2/day, 841 ft^2/day, and 1428 ft^2/day, respectively. The calculated S values from these analyses were 2.7 x 10^{-5}, 1.9 x 10^{-4}, and 6.2 x 10^{-4}, respectively (see Addendum 2.7-D for analyses). A comparison of results from the Theis and Cooper-Jacob analytical methods indicate similar values for T and S at each observation well. Recovery data were analyzed for the pumping well and T was calculated at 588 ft^2/day. Transmissivity from recovery data for well PZM11 was slightly higher than calculated from the drawdown data, at 748 ft^2/day. Calculated T from recovery for wells PZM12 and PZM13 was slightly lower at 748 ft^2/day and 1131 ft^2/day, respectively. Calculated hydraulic conductivity for the PZM3 pumping well and observation wells PZM11, PZM12, and PZM13 was 5.4 ft/day, between 4.9 and 6.9 ft/day, and between 6.9 and 7.7 ft/day, respectively.

A comparison to historical pump testing can be evaluated at locations RI-6 and RI-42C (see Figure 2.7B-7), the results of which are summarized in Table 2.7B-9. RI-6, which is located approximately 2,000 feet northeast of PZM3 and within the identified ore body, had a reported T value of between 105 and 109 ft^2/day and a hydraulic conductivity of approximately 1.6 ft/day. The lower T found at this location within the ore body is not unexpected, as ore generally accumulates in the less permeable channel sands. Historical well RI-42C, located approximately 2,000 feet east of PZM3, has a reported transmissivity of 504 ft^2/day and conductivity of 6.8 ft/day, which is similar in scale to the results of testing at the PZM3 cluster.

Single-Well SM Pump Test

A single-well test was conducted in the water table SM unit at well SM3 on September 27, 2011 and water levels in the pumping well were monitored. The well was pumped at an average rate of 0.6 gpm for 19 minutes until water reached below the pump intake, resulting in a drawdown of approximately 8.4 feet. A hydrograph of the pump test water level data is presented in Figure 2.7B-31. Based on this hydrograph, most of the withdrawn water came from wellbore storage, and water level had only recovered to within 4.3 feet of initial static water level after approximately 2.85 days.

Recovery data were evaluated by a straight-line fit according to Theis (1935) to evaluate transmissivity. Transmissivity was calculated to be 0.014 ft^2/day and a calculated hydraulic conductivity of approximately 0.002 ft/day (Table 2.7B-13) in the SM unit at this location. Based on these data, and the lack of sustainable yield in this well, the SM unit does not meet the definition of an aquifer at this location.

Single-Well Overlying Aquifer Pump Test

A single-well test was conducted in the overlying aquifer at well OM3 on September 27, 2011 and water levels in the pumping well were monitored. The well was pumped an average rate of 2.6 gpm for 28 minutes, resulting in approximately 23.7 feet of drawdown. A hydrograph of pump test water level data is presented in Figure 2.7B-32.

Transmissivity by a straight-line fit of recovery data according to Theis was calculated to be 0.049 ft^2/day (Table 2.7B-13). Hydraulic conductivity in the overlying aquifer at this location is approximately 0.005 ft/day.

Single-Well Underlying Unit Pump Test

A single-well test was conducted in the underlying unit at well UM3R on November 4, 2011 and water levels in the pumping well were monitored. The well was pumped an average of 1.9 gpm for 27 minutes, resulting in approximately 104 feet of drawdown. A hydrograph of the pump test water level data is presented in Figure 2.7B-33. Based on this hydrograph, most of the withdrawn water is from wellbore storage. Recovery in this well after just over 3 days was only within approximately one foot of the initial static water level.

Calculated transmissivity of the recovery data according to Theis is 0.074 ft^2/day. Hydraulic conductivity in the underlying unit at this location is approximately 0.005

ft/day (Table 2.7B-13). Based on these data and lack of sustainable yield observed at this well, the underlying unit does not meet the definition of an aquifer at this location.

Well Completion Problems at Well UM3

The initially installed underlying UM3 well was discovered to be in communication with the PZA during a step-rate test conducted in well PZM3 on September 14, 2011. Figure 2.7B-34 illustrates the water level response in well UM3 (located 31 feet from the pumping well) and the response in observation well PZM11 (located 52 feet from the pumping well) versus the water level in the PZM3 pumping well. The scale of drawdown during testing is similar in the responses observed at the PZM11 well and the UM3 well (approximately three feet), which indicates that well UM3 was directly connected to the PZM. This figure is illustrative of a typical response expected resulting from faulty well completion.

Based on field reports by AUC, it was concluded that well UM3 was irreparably damaged during well completion. After the UM3 well casing was cemented and allowed to cure, underreaming was conducted. During the underreaming operations, two blades were severely bent while reaming a four to five feet thick hard carbonate layer immediately above the underlying unit. After completion of the underreaming, the damaged underreaming blades could not be retracted into the bit. Withdrawal of the bit resulted in pressure on the inside of the well casing and caused casing distortion and left continuous grooves inside the well casing, which were visible at the surface. The well was completed, but as the results of the step test conducted at PZM3 show, the intended underlying unit completion interval was compromised by the lack of casing integrity and direct communication with the PZA and underlying unit resulted. Based on this data, the well was plugged and abandoned, and replacement well UM3R was successfully installed to the underlying unit.

It is noted that this response shows what direct communication between adjacent aquifers looks like and has not been seen anywhere else in the project area during any hydrologic investigations.

PZM3 Pump Test Summary

Pump testing was conducted in the partially saturated PZA at well PZM3. A drawdown response was measured at 0.7 feet in an observation well 199 feet from the pumping well. No responses were observed in the overlying aquifer and underlying unit, indicating the PZA in this area is isolated from these adjacent intervals.

Average transmissivity in the PZA at the PZM3 well cluster is approximately 924 ft^2/day from drawdown data and 804 ft^2/day from recovery data analysis. Hydraulic conductivities average approximately 7.4 to 8.4 ft/day. Storativity values range between 1.0 x 10^{-5} and 8.3 x 10^{-4} (see Addendum 2.7-D for analyses). Historical testing near the PZM3 cluster was conducted at wells RI-6, RI-7, and RI-42C (see Figure 2.7B-7) which are generally located within the ore body in this vicinity east and northeast of PZM3. Transmissivity values were less than those calculated at the PZM3 cluster, ranging from approximately 105 to 504 ft^2/day.

3.4.2.7.3 PZM4 Well Cluster Pump Testing

The PZM4 well cluster is located in the SW ¼ of Section 29, T43N, R74W (see Figure 2.7B-6). Multi-well pump testing of the PZA aquifer was conducted in well PZM4D during August 2011, and single-well tests of the overlying aquifer and underlying unit were conducted during September and October 2011. Testing was conducted to evaluate the hydrologic characteristics of the PZA, overlying aquifer, and underlying unit, and to demonstrate isolation of the PZA with respect to these adjacent intervals. A more detailed report of these testing activities is provided in the PZM4 data package, included as Addendum 2.7-D. The results of testing indicate that no drawdown responses were observed in the overlying aquifer or underlying unit, demonstrating that there is sufficient confinement at this location for the purposes of ISR operations.

A hydrostratigraphic diagram for the PZM4 well cluster integrating geophysical log data and water level data is presented in Figure 2.7B-18. The PZA at the PZM4 well cluster is fully saturated and bifurcated by an internal mudstone unit that separates the PZA into upper and lower sand units. Based on potentiometric data in the upper PZA at well PZM4, hydraulic head in the upper PZA is approximately five feet higher than that observed in the lower PZM. Pumping for this test was conducted in the lower PZA at pumping well PZM4D. The upper PZA, as depicted on the geophysical log in Figure 2.6A-8 in Addendum 2.6-A, is approximately 40 feet thick, from depths of 220 to 260 feet bgs. The mudstone unit observed in this well cluster is approximately 40 feet thick, observed between depths of 260 to 300 feet bgs (Figure 2.6A-8). The lower PZA is approximately 80 feet thick from this log, extending to a depth of approximately 380 feet bgs.

The overlying aquifer at this location is approximately 75 feet thick at well OM4, occurring between depths of approximately 95 to 170 feet bgs. Depth to water in the overlying aquifer is approximately 93 feet bgs at this location, and thus the aquifer is partially saturated. The overlying OA aquitard is approximately 35 feet thick, extending to the top of the upper PZM. The underlying unit at well UM4 is approximately 17 feet thick, separated from the lower PZA by approximately 35 feet of the underlying UA aquitard.

For the multi-well pump test conducted at well PZM4D, two additional wells completed in the lower PZA (PZM16 and PZM15) were monitored during testing. Well PZM4, completed in the upper PZA and located 57 feet from the pumping well, was also monitored during testing. Wells PZM17 and PZM14, located approximately 2,800 feet southwest and 6,200 feet northeast of the PZM4D pumping well, respectively, were also monitored during testing. It is noted that the PZA at well PZM17 appears continuous and the mudstone unit observed at the pumping well is not present. At well PZM14, the completion zone appears to correspond to the upper portion of the PZA, but the lateral continuity of the unidentified mudstone that bifurcates the PZA has not been established at distance from the PZM4 cluster.

Water levels in the overlying aquifer at well OM4 and water levels in the underlying unit at well UM4 were monitored during testing to demonstrate hydraulic isolation between the PZA and these aquifer units. Piezometers OAM4S, completed in the upper Felix Coal portion of the OA aquitard, and OAM4D, completed in the lower Felix Coal, were also monitored during testing.

Two short-term single-well tests were conducted in wells OM4 and UM4 in the overlying aquifer and underlying unit, respectively. The following summary details the results of the multi-well and single-well testing conducted at this location.

<u>PZM4D Multi-Well Pump Test</u>

During the pump test conducted in pumping well PZM4D between August 9 and August 16, 2011, there was an issue with the pump at approximately 8,375 minutes into the test (5.82 days, on August 15, 2011). This is visible on the hydrograph of showing water level data from the pumping well in Figure 2.7B-35. Based on water level data, there was a dramatic drop in pumping rate for approximately two hours, and based on the data available from monitoring the pumping rate, it was estimated that the pump slowed down to approximately 6 gpm during this pumping problem. It does not appear that the pump shut off, but no explanation is possible to characterize this problem based on the available field data. The pump test was conducted for a total of 10,050 minutes (6.98 days) until the pump was shut off, and the average pumping rate over this interval is approximately 14.1 gpm. Drawdown data from testing was analyzed for all data up to 8,375 minutes utilizing a pumping rate of 17.6 gpm. The pumping rate utilized for analysis of recovery data was 14.1 gpm.

Total drawdown observed in the pumping well PZM4D was 119.2 feet at the time of test shut-in; drawdowns observed in wells PZM16, PZM15, and PZM17 were 1.2 feet, 4.5 feet, and 0.3 feet, respectively (Table 2.7B-14). Figures 2.7B-35 through 2.7B-38 show the relative water levels of observation wells PZM16, PZM15, PZM17, and PZM14, respectively, versus water level in the pumping well. Figure 2.7B-39 presents water level data in the upper PZA at PZM4 versus water level data in the pumping well PZM4D.

No response was observed in well PZM14, located almost 6,200 feet northeast of the pumping well. All data analyzed and presented has been corrected for barometric pressure fluctuations. The barometric efficiency (BE) of the PZA aquifer ranged between 0.46 to 0.58 at wells PZM16, PZM17, and PZM15. The BE calculated to the northeast at well PZM14 was slightly higher at 0.78. Additional details of the BE evaluation are provided in the pump test data report for the PZM4D pump test, provided in Addendum 2.7-D.

It is noted that the drawdown does not correspond directly with distance in the observation wells (Table 2.7B-14), as the drawdown observed in well PZM15 (approximately 1,800 feet east of PZM4D) was 4.5 feet, but only 1.2 feet in well PZM16 (located approximately 1,300 feet south of PZM4D). Drawdown observed in the upper PZA at well PZM4 (located 57 feet from the pump wells) was only 0.6 feet, indicating that the upper PZA at this location is not in direct hydraulic communication with the lower PZA (which is also supported by potentiometric data and the approximate five feet difference between head in the upper and lower PZM).

No drawdown response was observed in the overlying OM4 well, as seen in Figure 2.7B-40. Piezometers OA4S and OA4D, completed in the two Felix Coal seams in the OA aquitard, also did not show a drawdown response to pumping (Figure 2.7B-41). There is an apparent rise in water level that is coincident with pumping that is likely related to the "Noordbergum effect" or "reverse water-level fluctuation" previously described in Section 3.4.2.7.1. This phenomena is not related to any hydraulic connection of aquifers. No drawdown response was observed in the underlying UM4 well, as seen in Figure 2.7B-42, and this well also exhibited what appears to be a "Noordbergum effect" response (water levels have been observed to rise or fall in response to changing pore pressure) as there was an approximate drop in water level of 0.2 feet that corresponds to the start of pumping, and a similar rise that was coincident with the end of pumping.

Aquifer characteristics of transmissivity (T) and storativity (S) were evaluated in the PZA aquifer and are summarized in Table 2.7B-15. Drawdown data (up to 8,375 minutes, before pump problems) were analyzed according to Theis for wells PZM16 and PZM15. Recovery data were analyzed for the PZM4D pumping well and observation wells. Transmissivity results from the drawdown data at well PZM16 was 229 ft^2/day and a calculated storativity of 8.7 x 10^{-4}. At well PZM15, T from drawdown was 57 ft^2/day, and a calculated S value of 1.3 x 10^{-4} (see Addendum 2.7-D for analyses). Transmissivity evaluated from recovery data was in good agreement with the drawdown data, 286 ft^2/day at PZM16 and 63 ft^2/day at PZM15. Transmissivity from recovery data in the pumping well was 31 ft^2/day, approximately half that observed at PZM15 and significantly less than at PZM16. A definitive analysis of PZM17 could not be conducted due to the later time data (due to pump problems), but the data suggest that the transmissivity in this well is even higher than at well PZM16.

Based on the observed drawdowns and calculated transmissivities, it appears that the PZA is more conductive to the south of pumping well PZM4D (at well PZM16) versus data to the east at well PZM15. The drawdown at PZM16 is almost four times less than that observed at PZM15, even though PZM16 is closer to the pumping well, and transmissivity at PZM16 is approximately four times greater than at PZM15. Preliminary results at PZM17 to the southwest also suggest a more transmissive PZA in this location. The increase in T observed west of PZM4D is likely a function of increasing sand thickness where the bifurcation of the PZA by a mudstone pinches out. The mudstone in the PZA at PZM4 area was not observed in PZM17.

Single-Well Overlying Aquifer Pump Test

A single-well pump test was conducted on September 29, 2011 in the overlying aquifer at well OM4. The well was pumped at an average rate of 3.5 gpm for 95 minutes and subsequently pumped at an average rate of 3.8 gpm for 94 minutes, for a total of 189 minutes, resulting in 100.5 feet of drawdown. A hydrograph of water level data from well OM4 is presented in Figure 2.7B-43.

Recovery data were analyzed by a straight-line fit according to Theis (1935) that accounts for the variable pumping rate in the well, the results of which are presented in Table 2.7B-15. A transmissivity value of 262 ft^2/day was calculated from the data. Calculated hydraulic conductivity based on 82 feet of saturated thickness is approximately 3.2 ft/day.

Single-Well Underlying Unit Pump Test

A single-well pump test was conducted in the underlying unit at well UM4 on October 14, 2011. The well was pumped at an average rate of 6.1 gpm for 23 minutes, resulting in 188 feet of drawdown. A hydrograph of the water level data is presented in Figure 2.7B-44. Based on this hydrograph, most of the withdrawn water is from wellbore storage.

Recovery data were analyzed by a straight-line Theis fit, the results of which are presented in Table 2.7B-15. Calculated transmissivity in the well was determined to be 0.22 ft^2/day, and based on a saturated thickness of 17 feet, hydraulic conductivity was calculated to be 0.013 ft/day. Based on these data and the lack of sustainable yield observed in this well, the underlying unit does not meet the definition of an aquifer at this location.

Felix Coal Piezometers Yield

Piezometers were installed in the Upper and Lower Felix Coal seams (wells OA4S and OA4D, respectively) to evaluate the characteristics in the Felix within the overlying OA aquitard. During development of these wells, the Upper and Lower Felix coal seams yielded less than 0.25 gpm and 1.0 gpm, respectively, and went dry. Based on this, the Upper and Lower Felix Coals are not considered aquifers because:

- The definition of an aquifer per NRC, 10 CFR Part 40 Appendix A, states: "*Aquifer means a geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs*"; and
- The definition of an aquifer per Wyoming DEQ-LQD Guideline 8 Hydrology Coal and Non-Coal states: "*A zone, stratum, or group of strata that stores and transmits water in sufficient quantities for a specific use*".

Based on the lack of sustainable yield in these coal seams, the Felix Coal is not considered an aquifer at the Proposed Project area.

PZM4D Pump Test Summary

Pump testing was conducted in the fully saturated lower portion of the PZA at well PZM4D. Drawdown responses were not radially symmetrical with respect to distance from the pumping well and based on transmissivity evaluations, it is apparent that the PZA is more conductive to the south and southwest in relation to the pumping well. No responses were observed in the overlying aquifer and underlying unit, indicating that the PZA in this area is isolated from these adjacent intervals.

Transmissivity at the pumping well was approximately 31 ft^2/day, slightly higher to the east at well PZM15 (between 57 ft^2/day and 63 ft^2/day), and significantly higher to the south at well PZM16 (between 229 ft^2/day and 286 ft^2/day). Hydraulic conductivities at these three locations ranged between 0.3 and 2.9 ft/day. Calculated storativity values were between 8.7×10^{-4} and 1.3×10^{-4} (see Addendum 2.7-D for analyses). Historical testing near the PZM4 well cluster was conducted at nearby several locations, including RI-28 to the south of PZM4D, RI-1 and RI-2 to the southwest of PZM4D, and MP-09 east of PZM4D (see Figure 2.7B-7, and Table 2.7B-9 for the results summary). Transmissivity at the RI-28 area was between 176 ft^2/day to 217 ft^2/day, which is consistent with the increased T seen at well PZM16. Calculated T at RI-2 (approximately 1,300 feet southwest of PZM4D) ranged between 156 ft^2/day to 189 ft^2/day, and was between 639 ft^2/day and 868 ft^2/day at RI-1 (located approximately one mile southwest of PZM4D). At the MP-09 location east of PZM4D, reported transmissivities ranged between 45 ft^2/day and 62 ft^2/day, which are consistent with the results observed at PZM15.

3.4.2.7.4 PZM5 Well Cluster Pump Testing

The PZM5 well cluster is located in the SW ¼ of Section 36, T43N, R74W (see Figure 2.7B-6). Multi-well pump testing of the PZA was conducted between February 16-24, 2011, and single-well tests of the shallow water table SM unit, overlying aquifer, and underlying unit were conducted in September and October 2011. Testing was conducted to evaluate the hydrologic characteristics of the PZA, SM unit, overlying aquifer, and underlying unit, and demonstrate isolation of the PZA with respect to these adjacent intervals. A more detailed report of these testing activities is provided in the PZM5 data package, included as Addendum 2.7-D. The results of testing indicate that the PZA at this location is hydraulically connected at the PZA monitoring locations, and no drawdown responses were observed in the SM unit, overlying aquifer, or underlying unit, indicating sufficient confinement of the PZA at this location (see Table 2.7B-16).

A hydrostratigraphic diagram for the PZM5 well cluster integrating geophysical log data and water level data is presented in Figure 2.7B-19. The PZA at the PZM5 cluster is fully saturated and occurs between depths of approximately 185 to 330 ft bgs, as seen in the geophysical type log for the area in Figure 2.6A-7, with mineralization present near the middle of the PZM. Depth to water at PZM5 is approximately 129 ft btoc, resulting in approximately 58 feet of confining head at the pumping well. The unidentified mudstone is present at this location (between depths of approximately 250 to 260 ft on Figure 2.6A-7), resulting in a net sand thickness of approximately 132 feet in the pumping well. The PZM5 pumping well is completed across the entire PZA interval, with the screen placed across the lower sand of the PZA and sanded up to the top of the PZM. Observation wells PZM20 and PZM19 (located 499 feet and 1,048 feet north of PZM5, respectively) are completed with 20 foot screen intervals in the lower sand of the PZM. Well PZM18 is located 2,085 feet north of PZM5 and is completed in the upper sand of the PZM. Well PZM6 (2,085 feet northwest of PZM5) is completed in the lower sand of the PZA, but based on the log for this well, the upper sand is not present at well PZM6. The BLM All Night Creek well ANCVSS, located 4,025 feet west of PZM5, was also monitored and is also completed at depths that correspond to the lower sand of the PZM.

Based on the potentiometric surface presented in Figure 2.7B-9, there does not appear to be an observable head differential between the upper and lower sands of the PZM. This is seen by the consistency of hydraulic gradient observed in the general direction of groundwater flow between wells PZM20 and PZM18. Additional characterization of the potentiometry and confining nature of the unidentified mudstone in this vicinity will be conducted at a later date upon initiation of wellfield-scale hydrologic testing.

The water table SM unit is encountered at depths of approximately 30 to 50 feet, with a saturated thickness of 14 feet. The overlying aquifer is approximately 12 feet thick from 70 to 82 feet at well OM1, with a confining head of approximately 35 feet. The overlying

OA confining zone is approximately 100 feet thick, as seen in the type log in Figure 2.6-14. The underlying unit is approximately 18 feet thick at well UM1, and isolated from the PZA by the underlying UA aquitard which is approximately 105 feet thick.

For the multi-well pump test at PZM5, five PZA observation wells were monitored during testing, located between 499 and 4,026 feet from the pumping well (see Table 2.7B-16). Water levels in the water table SM unit, overlying aquifer, and underlying unit were also monitored to demonstrate hydraulic isolation between the PZA and adjacent aquifer units.

Single-well pump tests were conducted in wells SM1, OM1, and UM1 to evaluate the aquifer characteristics in the overlying aquifer and underlying unit. The following summary presents the details of testing at the PZM5 cluster.

<u>PZM5 Multi-Well Pump Test</u>

The pump test at PZM5 was initially started on February 7, but was aborted on February 10 due to sub-zero freezing conditions which affected the pump. Water levels were allowed to recover for approximately seven days to static conditions prior to the initiation of the pump test. Pumping well PZM5 was pumped at an average rate of 10 gpm for 11,393 minutes (7.91 days) from February 16-24. Total drawdown observed in the pumping well was 102.1 feet; drawdowns observed in observation wells PZM20, PZM19, PZM18, PZM6, and BLM ANCVSS were 11.7 feet, 4.3 feet, 0.8 feet, 0.9 feet, and 0.2 feet, respectively, and are summarized in Table 2.7B-16. Figures 2.7B-45 and 2.7B-46 shows the relative water levels of these observation wells versus the pumping well. All data presented have been corrected for BP fluctuations. The barometric efficiency (BE) of the PZA aquifer at this location varies between 0 (no apparent trend in pumping well PZM5) to between 0.05 and 0.57 at the PZA observation wells. Additional details regarding the BE evaluation is provided in the pump test data report for the PZM5 pump test, provided in Addendum 2.7-D.

No drawdown response was observed in the water table SM unit, the overlying aquifer, or the underlying unit, indicating that the PZA is isolated hydraulically from these aquifers at this location. Hydrographs of the SM1, OM1, and UM1 wells with respect to water level data in the PZM5 pumping well are presented in Figures 2.7B-47 to 2.7B-50, respectively. The hydrograph response in wells SM1 and OM1 show an apparent rise in water level that is coincident with pumping in PZM5. It is speculated that this is phenomenon is related to the "Noordbergum effect" or "reverse water-level fluctuation" that occurs in layered confined aquifer systems (Hsieh, 1996). Conventional groundwater theory does not account for this effect, and is explained by poroelastic theory. Poroelastic theory considers that "drawing down and aquifer produces time-dependent volumetric contraction and, hence, induced increases in pore pressure in the aquifer, adjacent confining layers, and adjacent aquifers" (Wang, 2000). This observed water level increase is not due to hydraulic communication between the PZA and the overlying aquifer and SM unit.

In order to account for the completion interval of the PZM5 pumping well, which is completed across the entire PZA, an estimated flow was apportioned for the lower sand of the PZM. This was necessary to complete analysis of observation wells PZM20 and PZM19, both of which are completed in the lower PZM. The flow in the lower PZA was estimated at seven gpm (of the total 10 gpm that was pumped) based on the curve match provided by Theis drawdown analysis.

Aquifer characteristics of transmissivity (T) and storativity (S) were evaluated in the pumping well and two closest observation wells PZM20 and PZM19 and are summarized in Table 2.7B-17. Based on the drawdown observed in these two observation wells, it was determined that the drawdown data matches a leaky confined model, as the change in drawdown at later time decreased. Based on geologic information during drilling, it was observed that in the area west of PZM5, the PZA is coarser grained and gravel deposits were noted. It is postulated that at later time, a higher transmissive portion of the aquifer (i.e., more permeable sand) is encountered, thus decreasing the rate of drawdown with time for these observation wells. A Theis curve match was attempted on the data, but a defensible match could not be made to account for the late time data. The Hantush-Jacob analytical method (1954), which assumes a leaky confined aquifer with no aquitard storage, was utilized on the drawdown and this solution provided a good match for mid- to late-time data. A Cooper-Jacob straight-line match was also evaluated on the drawdown data at well PZM20. A straight-line Theis recovery analysis was conducted on the recovery data at the pumping well and PZM20 and PZM19.

Based on the recovery analysis of data at the pumping well PZM5, a transmissivity value of 61.8 ft^2/day was calculated. Based on a sand thickness of 132 feet at this location, the calculated hydraulic conductivity is 0.5 ft/day. For well PZM20, transmissivity from the leaky solution for drawdown is 20.2 ft^2day, the straight-line analysis transmissivity is 26.7 ft^2/day, and the recovery data analysis indicates a transmissivity value of 31.0 ft^2/day. Based on a sand thickness of 47 feet at this well, hydraulic conductivity is between 0.4 and 0.7 ft/day from these analyses. At well PZM19, transmissivity from the leaky solution for drawdown is 26.0 ft^2/day and 47.0 ft^2/day from the recovery analysis. Based on the sand thickness of 56 feet at this well, hydraulic conductivity at PZM19 is between 0.5 ft/day and 0.8 ft/day. Calculated storativity values for the two observations wells range between 6.5×10^{-5} and 1.1×10^{-4} (see Addendum 2.7-D for analyses).

Single-Well SM Pump Test

A single-well pump test was conducted in the water table SM unit on October 4, 2011 and water levels in the pumping well were monitored. The well was pumped at an average rate of 1.7 gpm for nine minutes. A hydrograph of water level data is presented in Figure 2.7B-51. The rapid decline in water level indicates that most of the water removed was from wellbore storage and therefore the water level recovery data were utilized for transmissivity determination.

Transmissivity was determined by a straight-line fit to recovery data according to Theis, the results of which are summarized in Table 2.7B-17. A T value of 0.26 ft^2/day was determined for the SM unit at this location, and hydraulic conductivity was calculated at 0.019 ft/day. Based on these data and the lack of sustainable yield observed at this well, the SM unit does not meet the definition of an aquifer at this location.

Single-Well Overlying Aquifer Pump Test

A single-well pump test was conducted in the overlying aquifer on September 30, 2011 and water levels in the pumping well were monitored. The well was pumped at an average rate of 3.3 gpm for 135 minutes, resulting in 22.7 feet of drawdown. A hydrograph of water level data is presented in Figure 2.7B-52.

Transmissivity was determined by a straight-line fit to recovery data according to Theis, the results of which are summarized in Table 2.7B-17. A T value of 39.1 ft^2/day was determined and hydraulic conductivity is approximately 3.3 ft/day.

Single-well Underlying Unit Pump Test

A single-well pump test was conducted in the underlying unit on October 18, 2011. The well was pumped at an average rate of 4.3 gpm for 27 minutes. A hydrograph of water level data from well UM1 is presented in Figure 2.7B-53. The rapid decline in water level indicates most of the water withdrawn was from wellbore storage.

Transmissivity was determined by a straight-line fit to recovery data, the results of which are summarized in Table 2.7B-17. A T value of 0.44 ft^2day was determined and hydraulic conductivity in the underlying unit at this location is approximately 0.024 ft/day. Based on these data and the lack of sustainable yield observed in this well, the underlying unit does not meet the definition of an aquifer at this location.

PZM5 Pump Test Summary

Pump testing was conducted in the fully saturated PZA aquifer at well PZM5. Drawdown was observed to a distance greater than 4,000 feet in the PZA aquifer. No responses to pumping were observed in the SM unit, overlying aquifer, or underlying unit, indicating that the PZA in this area is isolated from adjacent aquifers.

Transmissivity in the entire PZA at well PZM5 was approximately 62 ft^2/day. Transmissivity in the lower PZA was approximately 25 ft^2/day from drawdown data and between 31 ft^2/day and 47 ft^2/day from recovery analysis. Hydraulic conductivities from all analyses range between 0.4 and 0.8 ft/day. Storativity values were between 6.5×10^{-5} and 1.1×10^{-4} (see Addendum 2.7-D for analyses).

3.4.2.7.5 Hydrologic Testing Summary and Conclusions

Based on testing conducted by AUC at the Proposed Project area, the following presents a general summary of results that impact the proposed ISR operations.

- The PZA is a discrete and continuous aquifer and is geologically confined across the entire project area;
- The PZA is fully saturated in the western portion of the project and transitions to partially saturated conditions in the eastern third of the site;
- Hydrologic testing completed at four separate locations across the project area provides substantial characterization of the PZA necessary for this license application;
- Calculated transmissivities were found to vary across the site, between 20 ft^2/day to 1,428 ft^2/day; calculated hydraulic conductivities range between 0.3 ft/day and 13 ft/day;
- No drawdown responses were observed during any pump testing in the overlying aquifer and underlying unit, indicating that there is adequate confinement of the PZA for the purposes of ISR operations;
- Based on the results of testing, no hydrologic boundaries were detected in the PZA;
- Transmissivities were evaluated at multiple locations in the water table SM unit, overlying aquifer, and underlying unit. In general, these units have significantly lower transmissivities in relation to the PZA. These units are discontinuous across the project area;
- Based on the lack of sustainable well yields and extremely low values of transmissivity evaluated in the two pump tests conducted in the perched water

table SM unit and the four tests conducted in the underlying unit, these intervals do not meet the definition of an aquifer;

- As discussed in Section 3.1.6 of the TR, AUC anticipates monitoring the wells completed in the SM unit and underlying unit for a limited time. No additional wells will be installed in these units in the future, unless they meet the definition of an aquifer; and
- In addition, a site-wide groundwater model based on the hydrologic data collected within the Proposed Project area is presented in Section 4.4.2, and is included as TR Addendum 2.7-C.

3.4.2.8 Powder River Basin CBM Groundwater Study

The Wyoming Geological Survey, in cooperation with the U.S. Bureau of Land Management (BLM), presents a hydrologic study by Clarey (2009) that utilizes data from a basin-wide monitoring well network from 1999 to 2006 to evaluate drawdown in the mined coal seam and adjacent sandstone aquifers. The following discussion is provided to address the potential competing interests of CBM in the area and in-situ uranium production in the Wasatch Formation at the Proposed Project. Results of the study in this vicinity indicate that while there is significant drawdown in the Big George coal seam from local CBM production, drawdown in the adjacent sandstone intervals is an order of magnitude or less than the drawdown observed in the coal seam, and decreases as depths become shallower.

One of the most complete data sets is from the All Night Creek monitor well cluster, which is located in the SW ¼ of Section 36 of T43N, R 74W. This well cluster is located approximately 4,000 feet west of the PZM-5 well cluster (see Figure 2.7B-6). In addition to the monitored Big George coal seam, four sandstone aquifers overlying the Big George have also been monitored for this study. The coal seam is screened from depths of 984 to 1,051 feet below ground surface (feet bgs), the overlying sand above this is screened from depths of 840 to 860 feet bgs (well name ANCS), the next overlying sand is screened from depths of 580 to 640 feet bgs (well ANCSS), the next overlying sand from 350 to 420 feet (well ANCVSS) and the next overlying sand from 200 to 240 feet bgs (well ANCVVSS). The ANCVSS well is completed in the equivalent PZA aquifer of the Proposed Project from 350 to 420 feet bgs, and the ANCVVSS is completed across the overlying aquifer. Figure 2.7B-54 presents a schematic diagram of the completion intervals at this location from a well log run through casing at the ANCSS well, with a comparison to the well log from the RC006 strat hole at the PZM6 well cluster (approximately 2,000 feet east-northeast of the ANCVSS well). It is apparent from the gamma ray spikes indicating mineralization that the sand interval of the ANCVSS well is equivalent to the PZA aquifer.

The results of water level monitoring at the All Night Creek well cluster location indicates that while the maximum drawdown in the coal seam is over 600 feet, there is minimal to no observable drawdown seen in the overlying sand aquifers. Hydrographs of the ANCC (Big George coal) well is presented in Figure 2.7B-55. Figure 2.7B-56 shows water level data in the ANCS and ANCSS wells, which represents the two sandstone aquifers above the Big George. Figure 2.7B-55 shows water level data from the ANCVSS and ANCVVSS wells, which correspond to the PZA and overlying aquifers, respectively. Over 600 feet of drawdown is observed in the Big George coal and only approximately seven to eight feet of water level decline is observed in the ANCS (Deep Sand) well. In the next overlying sandstone (ANCSS), water level declined approximately four to five feet over a period of approximately 10 years (Figure 2.7B-54). As seen in Figure 2.7B-57, there is no observable water level decline in the ANCVSS well (PZA aquifer equivalent) or the shallowest ANCVVSS well (Overlying aquifer equivalent) over a period of approximately nine years.

As the stratigraphic section of the lower Wasatch Formation and upper Fort Union is a complex and heterogeneous system of stratified fluvial deposits, the propagation of drawdown away from the coal seam (if even observed at all) is dampened with vertical distance away from the coal seam through multiple sequences of sand and shale. This behavior is observed near the Proposed Project, and these data indicate that there will be no expected hydraulic communication that will be observed between in-situ uranium production and the underlying groundwater withdrawals associated with CBM development.

3.4.2.9 <u>Groundwater Use</u>

An inventory of groundwater wells within a two mile radius of the Proposed Project area boundary was conducted based on information available from the Wyoming State Engineer's Office (SEO). Table 2.7B-18 summarizes the groundwater wells appropriated for stock, domestic, miscellaneous, and industrial usage. The locations of these wells are shown on Figure 2.7B-58. Table 2.7B-19 summarizes the groundwater wells that are appropriated for coalbed methane (CBM) usage, and the locations of these wells are shown on Figure 2.7B-59. The details and locations of all groundwater wells presented are based on data obtained from the SEO and are a composite of data collected from the Old Water Rights Database (http://seo.state.wy.us/wrdb/index.aspx) on 04/1/2011, a shape file obtained from (ftp://seoftp.wyo.gov/geolibrary_data) on 09/13/2010, and the new e-Permit System (https://seoweb.wyo.gov/e-Permit) on 03/10/2011.

There are 49 identified groundwater wells (non-CBM usage) within two miles of the Proposed Project area indicated as stock, domestic, miscellaneous, and industrial wells (Table 2.7B-18). Based on available depth information on completion intervals from the SEO databases and reviewing available online well record documents, a determination of the aquifer completion zone was made, if possible. This determination was based on the available geologic information within the Proposed Project area on aquifer depths and structural configuration and extrapolated to distance outside of the Proposed Project area if possible.

There are 15 groundwater wells within the Proposed Project area that are noted on Table 2.7B-18. Six of these wells indicate that the water right has been cancelled. Of the nine wells with existing water rights, eight wells are appropriated for stock watering usage. The Taffner #1 well (located in Section 1, 42N, R74W) is the only domestic supply well in the Proposed Project area and is completed to the PZA at this location. AUC will acquire the Taffner property prior to construction and it will not thereafter be used as a residence. The domestic water well located at the Taffner residence will be plugged in accordance with all WDEQ Rules and Regulations and will not be used for consumption once construction begins.

Of the eight stock wells with existing water rights, one is completed to a sandstone interval below the Badger Coal, three are completed in the PZA, and four are completed in the overlying aquifer.

Of the 69 identified non-CBM groundwater wells within three miles of the project area, 56 aquifer determinations were made based on available depth information. Twenty-five of these wells were identified as being completed in the overlying aquifer or above, 23 wells were identified as likely PZA completions, and eight wells were identified as likely having been completed below the PZA.

A discussion regarding the assessment of potential impacts from ISR operations and restoration operations on local groundwater can be found in Sections 4.4.2.1 through 4.4.2.5 of this ER.

There are 324 wells identified as CBM usage or CBM and stock usage within two miles of the Proposed Project area. Based on the available information in the area, the target coal seam for CBM is the Big George Coal within the Fort Union Formation. Reported total depths (when provided) range between 1,424 feet and 631 feet, averaging approximately 1,000 feet (Table 2.7B-19). It is noted that the Big George at the All Night Creek well cluster (see Section 3.4.2.8 on hydrologic impacts of CBM in the project area) is observed between depths of 984 to 1,051 feet. A summary table of all groundwater use can be viewed in Table 2.7B-20 in Addendum 2.7-B.

3.4.2.10 Groundwater Quality

Information related to regional groundwater quality is based upon published literature for the PRB area, related to the aquifers comprising Upper Cretaceous aquifer system and the

Lower Tertiary aquifer system. Specific site baseline water quality is based upon the baseline groundwater monitoring program initiated by AUC to collect data required for the WDEQ Permit to Mine as well as the NRC License Application for the Proposed Project.

3.4.2.10.1 Regional Groundwater Quality

Much of the available information on regional water quality is from the relatively shallow Upper Cretaceous and Tertiary formations where sufficient stock and domestic supply can be obtained in most areas of the basin from wells less than 500 feet deep. The following discussion of general water quality is based upon the relatively shallow waters of these formations. In general, wells and springs in the basin utilized primarily for stock water and less domestic supply show consistent total dissolved solids (TDS) concentrations of less than 500 mg/L (Lowry, 1986). Regional analysis of these wells does not include wells determined to be too high in dissolved solids and does not include deeper oil-field related data, and thus is biased toward the higher quality waters with lower dissolved solids.

In general, the length of flow time or flow path from recharge to discharge areas is the dominant factor affecting TDS concentrations in most aquifers. Table 2.7B-21 reports water sampling from the Upper Cretaceous and Lower Tertiary aquifer systems in the Powder River and shows relatively little differences in dissolved solids in the aquifers from the Fox Hills, Lance Formation, Fort Union Formation, and Wasatch Formation. Chemical quality of groundwater is also controlled by the solubility of aquifer rocks and minerals, reactions that occur along groundwater flow paths, the pH and temperature of the water, pressure, and to a lesser degree the length of contact time of the water (Lowry, 1986). The dominant reactions controlling water quality in these aquifers is cation-exchange softening and sulfate reduction. Cation-exchange is a reaction where calcium and magnesium ions are exchanged for sodium from solids such as clay, resulting in softer water. Sulfate reduction occurs due to the presence of organic material to form bicarbonate and sulfide.

Concentrations of manganese and iron in area groundwater samples commonly exceed the National Secondary Drinking Water Regulations standards of 50 and 300 micrograms per liter (ug/L), respectively, which is not an issue for stock watering (Lowry, 1986). Lowry (1986) notes that trace metals concentrations are generally low because these constituents tend to react with sulfide to form relatively insoluble precipitates at natural occurring pH levels. It is noted that concentrations of selenium exceeded the Maximum Contaminant Level (MCL) of 10 ug/L in four of 159 samples tested, and exceeded the MCL for lead (50 ug/L) in six of 165 samples (Lowry, 1986). Single exceedances were reported from available samples for each of the following constituents, including arsenic, barium, and cadmium.

Lance and Fox Hills Water Quality

There are few water quality data in the central portion of the PRB for the Lance/Fox Hills interval. Near the outcrop, there is little difference observed in water quality or major ion concentrations between the waters of the Fox Hills Sandstone and the overlying Lance Formation. Feathers (1981) notes outcrop waters of the Lance and Fox Hills typically have TDS concentrations from 350 to 3,500 mg/L, and having variable major ion composition. Central basin waters typically contain 1,000 to 3,500 mg/L TDS and are typically sodium bicarbonate-sulfate in composition. Feathers (1981) notes that local lithologic variations likely control observed anion composition due to the dissolution of carbonate, gypsum, or pyrite, and cation exchange favors the replacement of sodium for calcium and magnesium. Oil and gas data from the USGS Produced Waters Database and from Wyoming Oil and Gas Conservation Commission (WOGCC) data indicate TDS values for the Lance Formation that range from approximately 1,400 to 2,400 mg/L and from approximately 1,000 to 3,700 mg/L for the Fox Hills.

Rankl and Lowry (1990) describe water quality in the entire Wasatch to Fox Hills sequence. Water from deep wells is soft (sodium plus potassium exceeds calcium plus magnesium) and contain carbonate as well as bicarbonate, with some containing large concentrations of sulfate, while some contain very little. The dominant reaction mechanism controlling water quality is cation exchange and sulfate reduction. Riffenberg (1925) indicated that there is a relationship between water hardness and depth, as water from 100-125 feet is generally soft, and all water below 125 feet is soft. Rankl and Lowry (1990) show a relationship with depth that indicates a decrease in calcium, magnesium, and sulfate and an increase in bicarbonate to a depth of approximately 500 feet. Deeper than 500 feet, the concentration of dissolved solids is relatively uniform. Rankl and Lowry indicate the general decreasing trend in total dissolved solids to a depth of about 500 feet “has not been explained.”

Wasatch/FU Water Quality

The Wasatch and Fort Union hydrostratigraphic unit consists of 3,000 feet or more of highly variable lenticular fine-grained sandstones, shales, claystones, and coals. Lithologic variability and the discontinuous and lenticular nature of the sandstones results in a highly variable water quality composition over relatively short distances (Feathers, 1981). Feathers (1981) notes dissolved solids concentrations ranging from 250 to 6,000 mg/L and that there is little correlation between well depth and dissolved solids concentration. Relatively shallow wells in this aquifer show a wide variation in major ion composition, showing either mixed cation concentrations or sodium enrichment (Feathers, 1981). In general, waters less than 500 mg/L dissolved solids are enriched in bicarbonate, while the more saline waters are more enriched with sodium. The major ions concentrations versus well depth (Feathers, 1981) shows an increase in sodium which is attributed to cation exchange of sodium for dissolved calcium or magnesium.

3.4.2.10.2 Proposed Reno Creek Project Groundwater Quality

Water Quality Sampling

AUC installed a large number of ground water monitoring wells to characterize the regional ground water chemistry. The chemical characterization reflects the hydrology and geology within the Proposed Project area. Present within the Proposed Project are two aquifers, the Production Zone and the Overlying Aquifers. The Production Zone is continuous and hydraulically connected across the site. The Overlying Aquifer is the uppermost aquifer within the Proposed Project area and appears continuous on a local scale, but does not correlate with greater distances across the entire Proposed Project site based on geologic and potentiometric data. In addition, there are two units that do not qualify as aquifers due to low yields and transmissivities, which include the shallow water table unit (SM-designated wells) and the deeper underlying unit (UM-designated wells). AUC did, however, install the following monitoring wells in all four units in order to characterize hydrologic and water quality conditions:

- Production Zone Aquifer: 21 wells (designated PZM);
- Overlying Aquifer: 7 wells (designated OM);
- Underlying Unit: 7 wells (designated UM); and
- Surficial (Shallow) Water Table Unit: 4 wells (designated SM; borings were installed and observed to be dry at 3 additional locations).

Water Quality Analysis

Per NUREG 1569 and WDEQ LQD Chapter 11, the objectives of the groundwater characterization required to permit ISR operations included:

- Evaluating the occurrence of groundwater with respect to depth, location and seasonal fluctuations in hydraulic gradient and flow and water quality;
- Determining the dominant water types;
- Assessing potential impacts from non-ISR operations (e.g., CBM production); and
- Assessing how ISR production potentially could impact other water users.

An evaluation of groundwater quality is an important part of the overall groundwater characterization. This evaluation included (a) a general groundwater evaluation (e.g., inorganic concentrations and groupings), (b) review of water quality by formation, and (c) the significance of key indicators to understanding the shallow groundwater system. A summary of groundwater quality results is presented in Tables 2.7B-22 through 2.7B-40 in TR Addendum 2.7-B.

Proposed Project Aquifers

Because of the large number of ground water samples, several Piper Diagrams were prepared. The Piper diagram uses major ions only (Na+K, Ca, Mg, Cl^-, HCO_3^- + CO_3^{-2}, and SO_4^{-2}) and normalizes concentrations. The purpose of normalization is to show the relative concentrations of the analytes. The normalization also allows for the plotting of these compositions on triangular diagrams. Dilute waters and concentrated waters of similar cation/anion relative abundances will plot at the same locations in the diagram. In preparing a Piper diagram, the relative abundances of cations (as equivalent percentages) are plotted as single points in the left triangle; and the anions are similarly plotted in the right triangle. Because the concentrations are ultimately plotted as percentages of cations or anions on the two triangles, the use of equivalents or milliequivalents will produce the same final result. Figure 2.7B-60 in Addendum 2.7-B shows the Piper diagram for ground water samples from within the Production Zone (PZ). These 15 locations plot in a small area within the red circle. The waters are sulfate dominant and sulfate ranges from about 65 percent to 95 percent when calculated as milliequivalents, with lesser amounts of bicarbonate and chloride percentages less than 5 percent. For the cations, sodium plus potassium represents approximately 50 percent to slightly more than 70 percent of the cation milliequivalents. The similarity of these compositions reflects a continuous and uniform aquifer in the PZA as described in Section 3.4.2.2.

The consistent composition of these waters is related to the geochemical processes responsible for the formation of the ore bodies in the Production Zone. Oxygen bearing ground water reacts with dispersed uranium minerals and causes the uranium to dissolve, the solution continues to migrate and it will react with minerals such as pyrite. The oxidation of pyrite produces the sulfate that is the dominant anion in these waters. Eventually, the available oxygen in these waters is consumed and uranium along with other redox sensitive minerals will precipitate at this boundary. Uranium precipitates as uraninite (UO_2), which is insoluble under anoxic conditions. These redox boundaries can be quite abrupt and result in the precipitation of these minerals over a short distance. Some zonation in the ore body is typically noted, and this may be reflected in differences in the dissolved concentrations of uranium and other trace metals. These differences have been occasionally noted in some samples, but in most cases uranium and trace metal concentrations are consistently low, with most locations within the production zone displaying concentrations less than 0.10 mg/L of U. At this time it is assumed that the concentrations noted in PZM10 (with an average U concentration of 0.47 mg/L) and PZM16 (average U concentration of 0.30 mg/L) reflect some of these redox related processes.

Figure 2.7B-61 in Addendum 2.7-B compares the Overlying Aquifer water samples (designated OM) with the PZ aquifer water samples. For simplicity all but one of the PZ data points have been removed, but the red circle has been retained. PZM3 was selected to represent the PZ waters because it plots near the center of the red circle. The TDS circle (dark brown) has been retained for that point to facilitate comparisons with the OM data points. The OM samples show the greatest variability among the ground water samples at the site. Several samples, specifically OM3, OM2 and OM6 have greater proportions of bicarbonate and more sodium than the PZM samples. Two samples (OM5 and OM7) are similar to the PZM waters and they plot within the red circle. Finally, OM1 and OM4 appear to have greater proportions of calcium than the PZM samples. The variability among the OM samples is likely to be related to the discontinuous nature of this aquifer across the site. OM4 has the greatest proportion of calcium and it appears that the Overlying aquifer in this region is thick and continuous. OM1 is also within a thick aquifer, but it appears to be slightly less continuous. Sodium dominant waters include the OM2 and OM3 samples. Those samples, particularly OM3 appear to be associated more with the aquitard zones rather than the more permeable aquifers. The OM2 sample may be related to a thin aquifer. These samples have lower TDS concentrations than some of the other OM water samples. Using the OM4 and OM3 as “end members”, we can attempt to explain the remaining three samples (OM5, OM6 and OM7). These three samples tend to be associated with the aquitard interval rather than the aquifer. The simplest explanation for the variability among the OM samples is that the samples do not represent one large and continuous formation, which conclusions correlates to the geologic and potentiometric data across the project area that indicates discontinuity within the overlying aquifer.

The variability of the water levels between the OM screened interval and the corresponding PZM well are significant. Using water level data presented by Petrotek (note Table 2.7B-8). The differences in water level (depth) between the OM and PZM levels were calculated. The variability suggests that the OM screened intervals probably represent different water table elevations. There is no evidence to suggest that the OM water elevation represents any type of consistent head. Therefore, at least some of the upper level waters appear to be distinct perched zones reflecting small localized zones.

<u>Proposed Project Water Bearing Non-Aquifer Units</u>

Figure 2.7B-62 is a Piper diagram that presents the shallow SM unit water samples and the underlying unit (designated UM) samples. Several things should be noted. The blue oval represents a range of samples that include all the underlying (UM series) water samples. The oval also would contain several of the overlying aquifer series (e.g., OM3, OM2 and OM6) water samples. Although there is a significant variation in the anion makeup of the waters contained in this oval, the primary cation signature is sodium plus potassium (Na+K). The UM samples are also characterized by more relative chloride

than the PZM waters. This may be a reflection of their more dilute nature. The underlying unit is not classified as an aquifer and is discontinuous and lenticular across the site and is included within the underlying aquitard that is predominantly a mudstone with limited thin and discontinuous sand zones. Although UM5 and UM1 are similar to the composition of the CBM waters, these two UM samples have much lower TDS concentrations. The other samples UM2, UM4, UM6 and UM7 are more similar to the PZM compositions.

Geochemical variability for the SM series of samples is most readily apparent in differences in the divalent cations mainly calcium, but the SM3 and SM5 samples also have a greater proportion of Mg than all others except the OM4 sample. The SM5 sample also has the greatest sulfate and corresponding TDS concentrations among the recently collected samples.

Figure 2.7B-63 is a stiff diagram showing a cross section with numerous water samples collected from the well clusters and from some individual wells. The Stiff diagrams use four sets of parameters. For the cations the parameters are, from top to bottom, Na+K, Ca, Mg and Fe. For the anions chloride, bicarbonate plus carbonate, sulfate and fluoride are displayed. Because milliequivalents are employed the area represented by the cations should be similar to the area represented by the anions. Because individual coal bed methane discharge permits have different reporting requirements, iron and fluoride were not included in the surface water Stiff diagrams.

The consistent compositional fingerprint of the PZM wells is apparent. The more dilute nature of the underlying wells is also readily apparent. Finally, the tendency for the shallow water table unit and overlying aquifer well samples to contain a greater proportion of divalent cations (Ca^{+2} and Mg^{+2}) is also apparent.

Historical Groundwater Data

Additional ground water samples collected in 1979 through 1982, as well as additional ground water samples collected in 1993, were also included in the overall evaluation (Figure 2.7B-64). There is limited supporting information available with these results, e.g., confirmation of formation screen depths and intervals, and therefore the results should be used mainly to confirm the previously discussed observations. No assessment of the quality of these data was available, nor are original laboratory reports. Thus the data should be viewed somewhat cautiously. In support of the historical data: (1) most of these locations were sampled numerous times and (2) results from these locations appear to be consistent with respect to sampling events and locations, and (3) the results are representative of the PZ aquifer.

Figure 2.7B-65 is a Piper diagram of the historical samples. Total dissolved solid concentrations were not available for these samples and so the TDS circles are not plotted on the figure. The overall compositions are consistent with the recently collected samples. Several samples plot within or close to the circle originally assigned to the recent PZ well samples. The sample from RI14, although not within the circle is close enough to demonstrate that the well belongs with the other production zone wells.

Historical wells identified with a U (Upper) correspond to the overlying aquifer described previously. Several of these locations, specifically RI25U, RI30U, and RI38U display similar characteristics to some of the recently collected OM samples. The sample from RI2, although assigned to the production zone, contained very low levels of uranium and radium and so it may represent the overlying aquifer. The historical data support the overall conclusions noted in the discussion based upon the recently collected data.

Summary of Groundwater Geochemical Characteristics

Ground waters from the project area have distinctive geochemical characteristics that can be used to identify different aquifers and units. The waters from the PZM aquifer display a consistent composition with sodium and sulfate as the dominant ions. The underlying unit (UM) tends to have greater amounts of sodium and more variation between sulfate and bicarbonate plus carbonate. Waters from overlying (OM) aquifer and the shallow (SM) unit often have more calcium than the PZM waters, although there is a large degree of variation. The variation in the upper units is related to the discontinuous nature of the more permeable "aquifers" and the abundance of low permeability mudstones.

Comparison of CBM Discharge Waters with Lixiviant

The Piper diagram evaluation described previously showed that there are significant differences between the Production Zone waters and CBM type waters. However, it is expected that the leaching solutions (lixiviants) used in the ISR operation will have greater total bicarbonate and sodium concentrations and the resultant lixiviant compositions will tend to move down the Piper diagram quadrilateral in the direction of CBM waters. Geochemical modeling using PHREEQC (Parkhurst and Appelo, 1999) was used to estimate an expected range of lixiviant compositions. To prepare this solution, compositions from 12 PZM water samples were mixed using PHREEQC to prepare an average compositions identified in Table 2.7A-18 in TR Addendum 2.7-A as PZM Mixture. These samples represented the four quarterly samples from 10 wells (PZM-2, 6, 7, 8, 10, 14, 15, 16, 17 and 18).

Lixiviant A was prepared assuming a total bicarbonate concentration of approximately 800 mg/L. In the preparation of this solution, 0.01125 moles of $NaHCO_3$ were added to the PZM Mixture. Bicarbonate increased by about 669 mg/L and sodium concentrations increased by about 260 mg/L. Addition of the $NaHCO_3$ also causes a slight decrease in the pH.

For Lixiviant B, 0.0167 moles per liter of $NaHCO_3$ were added to the average composition of the PZM water. This resulted in an increase of nearly 400 mg/L in sodium, and an increase in bicarbonate of approximately 1000 mg/L. Carbonate also increase slightly, some of the increase is offset by the decrease in pH. These two solutions represent compositions prior to injection into the production zone. Consequently, the uranium concentration reflects a pre-mining condition. Identification of a solution that had contacted ore would be facilitated by an elevated uranium concentration typically on the order of 50 to 250 mg/L (Krumhansi et al., 2009). In this regard, the design head grade concentration for the Proposed Project ranges from 40-200 mg/L.

As shown on Figure 2.7B-66, both solutions have sufficient sulfate to plot near the middle of the Piper diagram quadrilateral. The high initial sulfate concentrations in the PZM waters provide a simple and direct method to discriminate between ISR lixiviant and CBM discharge waters. Preparation of Piper diagrams is not necessarily required to identify these waters. But the Piper provides a simple demonstration of the relative differences in these waters.

Another characteristic that can discriminate CBM discharge waters with ISR produced waters is the difference in barium concentrations. The mineral barite ($BaSO_4$) is considered to be insoluble in most ground waters that contain sulfate concentrations above about 50 mg/L. Because of the low sulfate concentrations in the coal bed ground waters, barium cannot precipitate as barite. Therefore, barium concentrations are elevated in CBM discharge waters. For 203 total barium analyses collected from January 2001 through January 2007, as reported in the three-mile buffer data compilation the average concentration of barium (total) was 0.66 mg/L, with a maximum concentration of 1.2 mg/L and a minimum of 0.1 mg/L. An additional 86 total recoverable barium analyses, collected from 2006 to 2011, had an average of 0.530 mg/L, a maximum of 0.894 mg/L and a minimum of 0.124 mg/L. Among 121 dissolved barium analyses representing the various sample levels and surface waters, only one ground water sample was reported to be above 0.1 mg/L; the concentration was 0.2 mg/L from OM-6. A concentration of 0.2 mg/L was also noted in SW3, which is associated with the WY0048526 006 CBM discharge. The lowest values were from PZM-6 at 0.02 mg/L (two samples). All of the remaining samples had values of 0.1 mg/L, this value was also the reporting limit and the majority of these samples (approximately 94 of the 121 samples) were flagged as less than the reporting limit.

CBM wells are also higher in iron; the elevated iron concentrations are also related to the reducing (low Eh) environment. Under Low Eh conditions the more soluble ferrous form of iron is stable. Examination of 256 CBM water samples produced an average dissolved iron concentration of 0.378 mg/L, nearly twice the PZM average. Unfortunately, this parameter is generally not conserved in surface waters because upon exposure to the atmosphere the ferrous iron will oxidize to ferric iron and precipitate as amorphous ferric hydroxide (ferrihydrite). Manganese also demonstrates similar redox behavior, so it is not a reliable indicator if these waters are retained in surface discharge ponds for any period of time.

In summary, two different constituents have been selected as parameters that can be employed to discriminate between ISR derived lixiviants, and CBM discharge waters. Sulfate is the dominant anion in the PZM waters, which will provide the starting solution for the lixiviant, and even with addition of $NaHCO_3$ the sulfate concentration will provide a simple and direct means to discriminate between ISR lixiviants and CBM discharge waters. A secondary parameter to discriminate between these two waters is based upon the elevated barium concentrations present in the low sulfate CBM discharge waters

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3.5 Ecological Resources

3.5.1 Introduction

This section describes the existing ecological resources within the proposed Reno Creek Project (Proposed Project) area. The analysis consists of a review of documents, databases, and reports in conjunction with field surveys. Further discussions regarding ecological resources can be found in:

- Addenda 3.5-A through 3.5-I of this ER;
- Section 4.5 of this ER (Potential Ecological Resource Impacts);
- Section 6.5 of this ER (Mitigation for Potential Ecological Resources Impacts);
- Section 7.3 of this ER (Ecological Monitoring);
- Section 8.4.2 of this ER (Long-Term Costs of Habitat Disturbance);
- Section 2.8 of the TR (Ecological Resources);
- Section 5.7.7 of the TR (Airborne Effluent/Environmental Monitoring Programs);
- Section 6.2 of the TR (Plans and Schedules for Reclaiming Disturbed Lands); and
- Sections 7.1.7 and 7.2.7 of the TR (Potential Ecological Impacts).

Ecological studies including baseline flora and fauna data were conducted to fulfill the objectives specified in USNRC NUREG-1569, *Standard Review Plan for In Situ Leach Uranium Extraction License Applications.* Ecological surveys were also conducted in accordance with applicable WDEQ-LQD, WGFD, and USFWS established guidelines. These agencies were consulted accordingly during development of survey plans to ensure adequate objectives, methodologies, and survey techniques were utilized.

Vegetation and wetland surveys were conducted by BKS Environmental Associates, Inc. (BKS) of Gillette, Wyoming during the fall of 2010 and the summer of 2011. Initial wildlife surveys were conducted by ICF International (ICF) of Gillette during the spring of 2008 and 2010. Due to access restrictions, the wildlife surveys were limited in coverage in those years. Ultimately, full coverage was obtained and the baseline surveys were completed in their entirety for the complete survey area during spring and summer 2011.

3.5.2 Regional Setting

The Proposed Project area is within the Northwestern Great Plains (Level III) ecoregion within the PRB (Level IV) ecoregion (Chapman et al. 2004). Elevation within the Proposed Project area ranges from approximately 5,041 to 5,296 feet above mean sea level. Topography within the Proposed Project area is primarily level to gently rolling, though numerous prominent ephemeral drainages dissect the site and is influenced by previous disturbance from county roads, oil and gas development, and reservoirs. Similar terrain characterizes unearthed lands surrounding the Proposed Project area.

Vegetation within the PRB is generally described as mixed grass prairie dominated by rhizomatous wheatgrasses, various bunchgrasses, and shrubs. The Proposed Project area is comprised primarily of sagebrush shrubland and upland grassland. Interspersed among these major vegetation communities, within and along the ephemeral drainages, are less abundant vegetation types of breaks grassland and meadow grassland. Trees within the Proposed Project area were limited in number and extent.

The majority of the area is drained by Spring Creek-Antelope Creek, Upper Porcupine Creek-Antelope Creek, and Belle Fourche River-All Night Creek. All natural flow within the region is categorized as ephemeral. Stock tanks and reservoirs are scattered throughout the Proposed Project area; however, these features usually contained very little if any water late in the growing season.

The Proposed Project area is located entirely on private lands, except for Section 36, T43N, R74W which is managed by the State of Wyoming. Livestock grazing has been the principal land use in the region for many years, although conventional oil and gas production has also had a long-term presence in the area. More recently, Coal Bed-Methane (CBM) activities, and their associated infrastructure, have become prominent across the landscape both within and surrounding the Proposed Project area.

3.5.3 Climate

As noted in NUREG-1910 (GEIS Section 1.4.3), the Proposed Project is located in the Wyoming East Uranium Region. The Proposed Project area features a semi-arid or steppe climate. The region is characterized seasonally by cold harsh winters, hot dry summers, relatively warm moist springs and cool autumns. Temperature extremes range from roughly -25° F in the winter to 100° F in the summer. The "last freeze" occurs during late May and the "first freeze" mid-to-late September.

Yearly precipitation totals are typically near 10 inches. The region is prone to severe thunderstorm events throughout the spring and early summer months and much of the precipitation is attributed to these events. In a typical year, the area will see four or five severe thunderstorm events (as defined by the National Weather Service criteria) and 40 to 50 thunderstorm days. Autumn stratiform rain events also contribute to precipitation totals, but to a lesser degree than those before mentioned. Snow frequents the region throughout winter months (40-50 in/year), but provides much less moisture than rain events.

Wyoming is windy and ranks first in the United States with an annual average speed of 12.9 mph (NUREG-1910, GEIS Section 3.3.6.1). Nearly five percent of the time, hourly wind speed averages exceed 25 mph. In the general vicinity of the Proposed Project, the predominant wind direction is west/southwest with the wind blowing out of that direction 25 percent of the time. A north/northwest secondary mode is also present. Surface wind speeds are relatively high all year-round, with hourly averages 11-15 mph. Higher average wind speeds are encountered during the winter months while summer months experience lower average wind speeds. A detailed description of and presentation of climatologic data is presented in Section 3.6 of this report.

3.5.4 Terrestrial Ecology

3.5.4.1 Vegetation

As discussed in Section 3.5.2, the Proposed Project area is within the Northwestern Great Plains and PRB ecoregions, and is generally classified as mixed grass prairie (Chapman, et al. 2004). The elevation within the Proposed Project area ranges from approximately 5,041 to 5,296 feet above mean sea level. Topography is primarily level to gently rolling, though numerous prominent ephemeral drainages dissect the Proposed Project area.

3.5.4.1.1 Vegetation Survey Methodology

All sampling procedures were designed according to the WDEQ-LQD Rules and Regulations for Non-Coal Permitting, Guideline 2 (November 1997), and the methodology approved by the WDEQ (May 2011).

This guidance, whose usage is described in detail below, is deemed acceptable in accordance with NRC approval of the Uranerz Energy Inc. license for the Nichols/Hank Ranch facility which utilized the same guidance. Habitat and species surveys for U.S. Fish and Wildlife Service (USFWS) threatened, endangered, and candidate plant species were conducted during the appropriate period based on phenology and in accordance with current survey protocols (USFWS 1995, BLM 2004, USFWS 2010). Noxious weeds were inventoried in conjunction with all vegetation sampling and survey activities.

Mapping

Four plant communities were identified within the Proposed Project area: Big Sagebrush Shrubland, Meadow Grassland, Upland Grassland, and Breaks Grassland. Plant communities were mapped using USDA 2009 National Agricultural Imagery Program (NAIP) true color ortho aerial imagery and verified through field surveys. Disturbed areas within the Proposed Project area were also identified and mapped, based on the scale of the available mapping.

Using WDEQ guidelines, all areas within a 0.5 mile vegetation review area within the Proposed Project area were mapped based on review of NAIP true color ortho aerial imagery and known expression of the NAIP true color ortho aerial imagery within the Proposed Project area. Field verification of the plant communities within the 0.5 mile review area was not necessary. The 0.5 mile vegetation review area was approved by the NRC in the Moore Ranch project license application.

Transect Origin Selection

A computerized systematic grid (using ArcGIS) was used to randomly locate sample points within each plant community. These computer generated random locations were then uploaded to a hand-held Garmin© Global Positioning System (GPS) unit for actual location in the field. Sample points were sampled in numerical order until minimum sample size and sample adequacy was attained.

Cover Data

A sample size of 20, 50-meter point-intercept cover transects were sampled within the Big Sagebrush Shrubland, Meadow Grassland, Upland Grassland, and Breaks Grassland plant communities for a total of 80, 50-meter point-intercept cover transects within the Proposed Project area.

Each 50-meter point-intercept cover transect represented a single sample point within the given plant community. Percent cover measurements were taken from point-intercepts at one meter intervals along each 50-meter point-intercept cover transects using a laser point device. Point-intercept cover transects that exceeded the boundaries of the sampled plant community were redirected back into the plant community being sampled, at a 90 degree angle from the original transect direction at the point of intercept. In instances where a 90 degree angle of reflection did not place the transect within the sampled plant community, a 45 degree angle of reflection was used. Each point-intercept represented two percent of the cover measurements.

Percent cover measurements record “first-hit” point-intercepts by live foliar vegetation species, litter, rock, or bare ground. Multiple hits on vegetation were recorded, but used only for the purpose of constructing a plant species list for each plant community. Acreage and percent total area for each plant community is shown on Table 3.5-1.

Total Vegetation Cover

Vegetation cover data was recorded by species using first hit point-intercept data. All first-hit point intercepts of living vegetation and growth, produced during the current growing season, were counted toward total vegetation cover. Percent vegetation cover is the vertical projection of the general outline of plants to the ground surface. Total vegetation cover measurements were expressed in absolute percentages for each sample point. Relative cover values for percent species cover were also calculated. Total vegetation cover percentages do not include lichen and moss cover. Cover summaries for each plant community are located in Addendum 3.5-A.

Total Ground Cover

Total ground cover data was recorded by live vegetation, litter, rock, or bare ground. Litter included all non-living organic material that is recognizable, including manure. Rock fragments were recorded when equal to or greater than two centimeters in size (i.e., sheet flow, minimum non-erodible particle size). Total ground cover measurements were expressed in absolute percentages for each sample point. Total ground cover equals the sum of cover values for percent vegetation, percent litter, percent rock, and percent lichen. Refer to Table 3.5-2 for absoulute cover values for each plant community in the Proposed Project area.

Species Diversity and Composition

Species diversity was determined by noting all plant species observed or sampled within a two meter wide belt transect centered over the 50-meter point-intercept cover transects for a 100-meter-squared species diversity belt transect. The number of species diversity belt transects equaled the number of 50-meter point-intercept cover transect for a given plant community (i.e., 20 100-meter squared belt transects were sampled in the Big Sagebrush Shrubland, Meadow Grassland, Upland Grassland, and Breaks Grassland plant communities). A list of plant species encountered during 2011 quantitative vegetation sampling is located in Addendum 3.5-B. The species list includes plant species sampled in cover transects, as well as, plant species observed along the belt transects. Plant species were compiled by lifeform and plant community. Scientific nomenclature follows the Rocky Mountain Vascular Plants of Wyoming (Dorn, 3rd Edition).

Shrub Density

Although shrub density sampling is not required for non-coal projects, this data was collected in conjunction with the cover sampling. All full, half, and sub-shrubs were counted within the same 100-meter-squared belt transect utilized to calculate species diversity described in the previous section. The number of belt transects equaled the number of 50-meter point intercept cover transects for a given plant community. Summarization of shrub density data is located in Addendum 3.5-C.

Sample Adequacy

Statistical evaluations were made on the total perennial plant cover, total vegetation cover and total ground cover data for each of the vegetation types surveyed. The sample adequacy formula outlined in WDEQ-LQD Guideline 2 was utilized to determine the minimum required size of the sample population. The formula calculated that 20 samples be taken in all plant communities and all plant communities met sample adequacy. Refer to Table 3.5-3 for a summary of sample adequacy calculations.

Extended Reference Area

The Extended Reference Area (EXREFA) is a native land unit used to evaluate revegetation success on portions of the same native plant community that is potentially affected by ISR operations. For the Proposed Project area, ISR operations will potentially affect the four plant communities: Big Sagebrush Shrubland, Meadow Grassland, Upland Grassland, and Breaks Grassland. All areas of these plant communities not affected by ISR activities will serve as the EXREFA. The EXREFA will be as large as practical, at least two acres, considering land ownership patterns and land management history. Addendum 3.5-D and Addendum 3.5-E contain photos of the vegetation and a map of plant communities within the Proposed Project area, respectively.

3.5.4.1.2 Vegetation Survey Results

3.5.4.1.2.1 Big Sagebrush Shrubland

Cover

The Big Sagebrush Shrubland plant community comprised approximately 4,729 of the 6,057 acres of the Proposed Project area (78 percent). Twenty point-intercept cover transects were sampled for this community. Absolute total vegetation cover was 62.40 percent. Absolute bare soil and litter/rock percentages were 12.40 and 22.20, respectively. Absolute total ground cover was 87.60 percent. Big sagebrush (*Artemisia tridentata*) provided the highest relative vegetation cover at 30.93 percent, while blue grama (*Bouteloua gracilis*) provided the next highest relative vegetation cover at 9.29 percent.

Species Diversity and Composition

Fifteen lifeforms and 62 plant species were observed within the Big Sagebrush Shrubland plant community. Native full shrubs were the dominant lifeform with 31.25 percent relative cover, followed by native cool season perennial grasses which accounted for 26.76 percent of the relative cover. Native perennial forbs, native warm season perennial grasses, and native grasslikes accounted for 11.05 percent, 9.29 percent, and 8.49 percent of the relative cover, respectively. Introduced perennial grasses, introduced annual grasses, introduced annual forbs, native half and sub-shrubs, introduced perennial forbs, introduced biennial forbs, and native annual forbs each accounted for less than 5 percent of the relative cover. Big sagebrush was the dominant native shrub; other full, half, and sub-shrubs present included: sticky-leaved rabbitbrush (*Chrysothamnus viscidiflorus*), rubber rabbitbrush (*Ericameria nauseosa*), fringed sagewort (*Artemisia frigida*), birdfoot sagebrush (*Artemisia pedatifida*), and Gardner saltbush (*Atriplex gardneri*). Cool season perennial grasses were dominated by western wheatgrass (*Elymus smithii*) and green needlegrass (*Nassella viridula*). Blue grama was the only warm season perennial grass present and threadleaf sedge (*Carex filifolia*) was the dominant native grasslike. Annual grasses were dominated by Japanese brome (*Bromus japonicus*) and cheatgrass (*Bromus tectorum*). Crested wheatgrass (*Agropyron cristatum*) was the dominant introduced perennial grass. American vetch (*Vicia americana*) and Hoods phlox (*Phlox hoodii*) were the dominant perennial forbs. Desert alyssum (*Alyssum desertorum*) was the dominant annual forb. Lichens and plains pricklypear (*Opuntia polyacantha*) were also present.

Refer to Table 3.5-4 for a summary of relative cover values and Addendum 3.5-A for a complete cover summary.

3.5.4.1.2.2 Meadow Grassland

Cover

The Meadow Grassland plant community comprised approximately 484 of the 6,057 acres of the Proposed Project area (8 percent). Twenty point-intercept cover transects were sampled for this community. Absolute total vegetation cover was 68.00 percent. Absolute bare soil and litter/rock percentages were 4.30 percent and 27.10 percent, respectively. Absolute total ground cover was 95.70 percent. Western wheatgrass provided the highest relative vegetation cover at 44.41 percent, while cheatgrass provided the next highest relative vegetation cover at 15.74 percent.

Species Diversity and Composition

Fourteen lifeforms and 59 plant species were observed within the Meadow Grassland plant community. Native cool season perennial grasses were the dominant lifeform with

51.17 percent of the relative cover, followed by introduced annual grasses which accounted for 15.89 percent of the relative cover. Introduced perennial grasses and native perennial forbs accounted for 8.96 percent and 7.50 percent of the relative cover, respectively. Native full, half, and sub-shrubs accounted for 2.36 percent of the relative cover. Introduced annual forbs, introduced perennial forbs, native warm season perennial grasses, native grasslikes, and native annual forbs each accounted for less than five percent of the relative cover. Western wheatgrass was the dominant native cool season perennial grass and cheatgrass was the dominant introduced annual grass. Introduced perennial grasses present included crested wheatgrass, smooth brome (*Bromus inermis*), and Kentucky bluegrass (*Poa pratensis*). Prairie sandreed (*Calamovilfa longifolia*) was the dominant warm season perennial grass and common spikerush (*Eleocharis palustris*) was the dominant native grasslike. American vetch and western yarrow (*Achillea millefolium*) were the dominant perennial forbs. Desert alyssum was the dominant annual forb. Shrub species present included big sagebrush, silver sagebrush (*Artemisia cana*), Louisiana sagewort, and winterfat (*Krascheninnikovia lanata*). Lichens were also present.

3.5.4.1.2.3 Upland Grassland

Cover

The Upland Grassland plant community comprised approximately 480 of the 6,057 acres of the Proposed Project area (7.93 percent). Twenty point-intercept cover transects were sampled for this community. Absolute total vegetation cover was 57.10 percent. Absolute bare soil and litter/rock percentages were 9.50 percent and 31.50 percent, respectively. Absolute total ground cover was 90.50 percent. Crested wheatgrass provided the highest relative vegetation cover at 35.03 percent, while western wheatgrass provided the next highest relative vegetation cover at 12.08 percent.

Species Diversity and Composition

Fourteen lifeforms and 49 plant species were observed within the Upland Grassland plant community. Introduced perennial grasses were the dominant lifeform with 38.36 percent of the relative cover, followed by native cool season perennial grasses which accounted for 21.71 percent of the relative cover. Introduced annual grasses and native grasslike species accounted for 10.15 percent and 8.41 percent of the relative cover, respectively. Native warm season perennial grasses accounted for 7.36 percent of the relative cover and native perennial forbs accounted for 5.97 percent of the relative cover. Native full, half, and sub-shrubs accounted for 3.51 percent of the relative cover. Introduced annual forbs, introduced perennial forbs, native annual grasses, native annual forbs, and introduced biennial forbs each accounted for less than five percent of the relative cover. Crested wheatgrass was the dominant introduced perennial grass and western wheatgrass was the dominant native cool season perennial grass. Blue grama was the dominant native warm season perennial grasses and threadleaf sedge was the dominant native grasslike. Annual grasses included Japanese brome, cheatgrass, and sixweeks fescue (*Vulpia octoflora*). American vetch, Hood's phlox, and spoonleaf milkvetch (*Astragalus spatulatus*) were the dominant perennial forbs. Dominant annual forbs included littleseed falseflax (*Camelina microcarpa*) and bluebur stickseed (*Lappula redowskii*). Native full, half, and sub-shrubs included big sagebrush, fringed sagewort, Louisiana sagewort (*Artemisia ludoviciana*), birdfoot sagebrush, and Gardner saltbush. Lichens and plains pricklypear were also present.

3.5.4.1.2.4 Breaks Grassland

Cover

The Breaks Grassland plant community comprised approximately 80 of the 6,057 acres of the Proposed Project area (1.3 percent). Twenty point intercept cover transects were sampled for this community. Absolute total vegetation cover was 57.50 percent. Absolute bare soil and litter/rock percentages were 20.10 and 20.20 percent, respectively. Absolute total ground cover was 79.90 percent. Western wheatgrass provided the highest relative vegetation cover at 19.30 percent, while threadleaf sedge provided the next highest relative vegetation cover at 13.04 percent.

Species Diversity and Composition

Fourteen lifeforms and 57 plant species were observed within the Breaks Grassland. Native cool season perennial grasses were the dominant lifeform with 42.42 percent of the relative cover, followed by native grasslikes which accounted for with 13.04 percent of the relative cover. Native perennial forbs and native full, half, and sub-shrubs accounted for 12.70 percent and 12.16 percent of the relative cover, respectively. Introduced annual grasses accounted for 8.34 percent of the relative cover.

Native warm season perennial grasses, introduced perennial grasses, introduced annual forbs, introduced perennial forbs, and introduced biennial forbs each accounted for less than five percent of the relative cover. Dominant native cool season perennial grasses were western wheatgrass and green needlegrass. Threadleaf sedge was the dominant grasslike. Cheatgrass was the dominant annual grass and blue grama was the dominant warm season perennial grass. Crested wheatgrass and Kentucky bluegrass were the dominant introduced perennial grasses. American vetch, spoonleaf milkvetch, and Hoods phlox were the dominant perennial forbs. Desert alyssum was the dominant annual forb. Native full, half, and sub-shrubs present included silver sagebrush, big sagebrush, rubber rabbitbrush, fringed sagewort, Louisiana sagewort, birdfoot sagebrush, Gardner saltbush, and winterfat. Lichens and plains pricklypear were also present.

3.5.4.1.3 Noxious Weeds

Surveys for Wyoming State Designated Noxious Weeds (Wyoming Weed and Pest Council 2010a) and Campbell County Declared Weeds (Wyoming Weed and Pest Council 2010b) were conducted in conjunction with baseline vegetation mapping and sampling, and threatened and endangered plant species surveys. Occurrences of these species were scattered and isolated throughout the Proposed Project area; locations are depicted in Addendum 3.5-E

Three Wyoming State Designated Noxious Weed species were located within the Proposed Project area: Canada thistle (*Cirsium arvense*), field bindweed (*Convolvulus arvensis*), and Russian olive (*Elaeagnus angustifolia*). Isolated individuals or small populations, of Canada thistle, were located at eight survey locations. Isolated individuals of field bindweed and Russian olive were located at one survey location. No Campbell County Declared Weeds were located within the Proposed Project area. Although, cheatgrass and Japanese brome were located at almost all baseline vegetation sample locations density of these invasive annual grasses was not sufficient enough to preclude native plant species occurrence.

3.5.4.1.4 Trees

Trees within the Proposed Project area were limited in number and extent. Plains cottonwood (*Populus deltoids*) and Russian olive (*Elaeagnus angustifolia*) occurred in a small stand near the reservoir in the NWNW Quarter, Section 5, T42N R73W.

3.5.4.1.5 Summary of Vegetation Surveys

The proposed 6,057 acre project area consists of four vegetation communities: Big Sagebrush Shrubland, Upland Grassland, Meadow Grassland, and Breaks Grassland. Big Sagebrush Shrubland accounts for 78.08 percent, Meadow Grassland accounts for 8 percent, Upland Grassland accounts for 7.93 percent, and Breaks Grassland accounts for 1.33 percent of the Proposed Project area. Total vegetation cover ranged from 57.10 percent to 68.00 percent. Total ground cover ranged from 79.90 percent to 95.70 percent. Species diversity ranged from 49 to 62 plant species, with a total of 93 species observed within the Proposed Project area. Dominant shrub species included big sagebrush, fringed sagewort, and birdfoot sagebrush. Western wheatgrass, green needlegrass, crested wheatgrass, and blue grama were the dominant perennial grasses. Threadleaf sedge was the dominant grasslike. Dominant perennial forbs included American vetch, Hoods phlox, and spoonleaf milkvetch. No threatened or endangered plant species habitat or individuals were encountered within the Proposed Project area. Canada thistle, field bindweed, and Russian olive were the only Wyoming State Designated Noxious Weed species observed within the Proposed Project area. Occurrences of these species were scattered and isolated throughout the Proposed Project area.

3.5.4.2 Wetlands

Projects that discharge dredge or fill material into Waters of the U.S. (WoUS), including special aquatic sites and jurisdictional wetlands, require accurate identification of wetland boundaries for the Section 404 of the Clean Water Act (CWA) permitting process. Through the Section 404 permitting process, the USACE can authorize dredge or fill activities by issuance of a standard individual permit, nationwide permit, or regional permit. The USACE makes the determination on what type of permit is needed. Construction, operation, or reclamation activities that cause disturbance or impacts to jurisdictional wetlands within the Proposed Project area will likely be performed in accordance with an appropriate Nationwide Permit (NWP). Possible applicable NWPs include:

- NWP 44 (non-coal mining activites) requires a Pre-constrcution Notification (PCN) for all activities;
- NWP 12 (utility line activities) requires a PCN for an area where a Section 10 Permit is required, discharges that result in the loss of >1/10 acre; and
- NWP 14 (linear transportation projects) which requires a PCN for 0.5 acre in nontidal waters and 0.33 acre in tidal waters.

3.5.4.2.1 Wetland Survey Methodology

Wetland surveys were conducted in accordance with the NRC approved, Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region (Version 2.0). All OWUS were also assessed in conjunction with the wetland surveys. The routine wetland delineation approach with onsite inspection was utilized, and the survey was conducted by pedestrian reconnaissance and orthophotography maps. Identification of potential wetlands was based on visual assessment of vegetation and hydrology indicators, as well as, intrusive soil sampling to determine the presence of wetland criteria indicators. USACE Wetland Determination Data Forms-Great Plains Region (Version 2.0), were utilized for each observation point. Hydrology and soils were evaluated whenever a plant community met hydrophytic vegetation parameters based on the Dominance Test and Prevalence Index (as defined by the USACE Great Plains Regional Supplement), or whenever indicators suggested the potential presence of a seasonal wetland under normal circumstances.

Natural Resources Conservation Service (NRCS) soil mapping for Campbell County, Wyoming, and BKS baseline soil mapping for the Proposed Project area were reviewed for general soils information.

Potential WoUS and OWUS were initially identified via review of area maps to include the following:

- United States Fish and Wildlife Service NWI mapping.

No flow data, stream gauge information or historical information of flow was available for the Proposed Project area.

Wetland indicator categories were identified for each dominant plant species noted through use of the National List of Vascular Plant Species that Occur in Wetlands, 1988 National Summary. Region 4 (North Plains) indicator categories were utilized for the Proposed Project area. Wetland species identified are listed in Addendum 3.5-F.

Field sample locations and resulting wetland boundaries were recorded with a hand-held Garmin GPSmap 60Cx Global Positioning System (GPS) unit and a Garmin III Plus GPS unit in NAD 1983 UTM Zone 13.

3.5.4.2.2 Wetland Survey Results

The Proposed Project area is generally characterized as a Big Sagebrush Shrubland with pockets of Upland Grassland and Breaks Grassland, with inclusions of several drainages. The drainage basins are dominated by the Meadow Grassland plant community and occupy approximately 484acres of the Proposed Project area. The dominate plant species witin this community are *Elymus smithii* (Western wheatgrass), *Bromus inermis* (smooth brome), *Bromus tectorum* (cheatgrass brome), and *Poa pratensis* (Kentucky bluegrass). The wetland indicator statuses of these plants are UPL (upland), FACU (facultative upland), UPL, and NI, respectively. Refer to Section 3.5.3.1.2.2 for more details regarding the plant communities and species found within the Meadow Grassland plant community.

Relatively abrupt upland/wetland transition areas occurred, and were a result of changes in topography occurring along drainage channels. Coal bed natural gas (CBM) outfalls, windmills, and livestock watering tanks, were found within the project area, and were all located along or within a drainage.

Soils information for the project area was obtained from NRCS Web Soil Survey for southern Campbell County, Wyoming, (2006) and from BKS baseline soil mapping (BKS 2011). The soil map units found within the main drainages and tributaries located in the Proposed Project area were Ulm Clay Loam and Forkwood Loam. Refer to ER Section 3.3.4 for more information on site soils.

Both soil map units are found on the Wyoming Hydric Soils List for southern Campbell County. The map units are typically found in depressional areas or playas. These soils are described as soils that are frequently ponded for long duration or very long duration during the growing season (NRCS 2011).

The majority of the wetlands were found along and within existing drainage bottoms; however, these wetlands were generally not continuous along the entire length of the drainages. Classifications of the wetlands along the drainages were primarily Palustrine Emergent (PEM) OWUS. The sum wetland and OWUS, acres identified within the project area, totals 42.31 acres. These acres are comprised of PEM stream channel, Palustrine Aquatic Bed (PAB) stream channel and isolated ponds, PEM isolated ponds, and Palustrine Unconsolidated Bottom (PUB) isolated ponds and OWUS. See Addendum 3.5-F for a summary of wetland areas within the Proposed Project area.

3.5.4.2.3 Wetland Survey Conclusions

Windmills, livestock watering tanks and CBM outfalls were observed within the Proposed Project area. Some outfalls and watering tanks had no water present while others were presently releasing water into the drainages where they were located. The release of water from the outfalls and watering tanks has influenced the presence or absence of wetland parameters within these drainages. In drainages where water is still being released, the wetland characteristics are actively present. Where water has ceased being released, the wetland paramters are receding, particularlity wetland hydrology and hydrophytic vegetation causing upland vegetation encroachment.

The headwaters of the Belle Fourche River are located within the Proposed Project area. The Belle Fourche River can be characterized as an ephemeral channel with isolated pockets of wetlands. Historic NWI mapping states that the Belle Fourche River and the majority of its tributaries are classified as PEM wetlands that are continueous within their channels. While PEM wetlands are present within the Belle Fourche and its tributaries, they are not continuous and are usually isolated by upland swales or by manmade berms created within the channel.

3.5.4.2.4 Wetland Delineation and Jurisdictional Determination

AUC met with the USACE, Omaha District in Cheyenne, Wyoming in April 2010 to discuss survey methods used to complete the aquatic resources inventory for the Proposed Project. During the meeting USACE stated that a formal wetland delineation for the entire Proposed Project area would not be necessary at this time. This level of analysis is only necessary in areas where Department of the Army authorization is actually required thus deferring the delineation requirement until site plans are developed in sufficient detail to identify specific locations where aquatic resources would be affected. The USACE verification letter will be provided to NRC and WDEQ/LQD when available.

The wetland report is included in Addendum 3.4-F and was deemed acceptable for planning purposes by the USACE. A letter from the USACE in response to the April 2012 meeting is provided in Addendum 3.5-G.

3.5.4.3 Wildlife

3.5.4.3.1 Introduction

ICF initially conducted wildlife baseline investigations in the Proposed Project area and extended survey area during 2008 and 2010. However, due to the timing of the project and limited ground access in those years, wildlife baseline surveys were repeated in their entirety for the complete survey area during spring 2011.

The objective of the survey was to collect both quantitative and qualitative data on vertebrate occurrence, abundance, diversity, and general habitat affinity in the Proposed Project area including identification of habitats that could support T&E species and other high value or unusual wildlife habitats. Wildlife surveys were expanded to include the project area and a one-mile perimeter around it (hereafter, wildlife review area). Prior to field work, the WGFD and USFWS were contacted to determine whether any special species or habitats were known to occur in the vicinity and the type of surveys that would be required for the baseline inventory. Additionally, other existing federal databases (e.g., BLM) were obtained for the wildlife review area and all existing data was reviewed prior to beginning field surveys.

To date, specific surveys have been conducted for nesting raptors, upland game bird leks, mountain plovers (*Charadrius montanus*), and prairie dog (*Cynomys* spp.) colonies. In addition, during all visits, biologists watched for all T&E species or other species of concern (e.g., swift fox [*Vulpes velox*]) and habitats that could support them. A list of all observed WGFD species of greatest conservation need (SGCN) and USFWS Migratory Bird Species of Management Concern in Wyoming (non-coal) was maintained during every site visit, as well as a list of all other vertebrate species encountered during each survey. Maps illustrating big game range delineations in the wildlife review area were generated, as requested by the WGFD, but no big game surveys were required for this project.

According to the guidance in NUREG-1569 (Section 2.8.3 Acceptance Criteria), the characterization of the site ecology is acceptable if inventories of terrestrial species are compiled by the applicant based on reports or databases of state or federal agencies. The survey types and methods used for the Proposed Project were in compliance with applicable sections of WDEQ-LQD Non-coal Chapters 2, 3, and 11; WDEQ-LQD Guidelines 4 and 5; and the Draft In-Situ Mining Permit Application Requirements Handbook (March 2007 update). The suite of baseline wildlife surveys was approved by the WGFD (letter dated April 7, 2008 with an updated letter provided June 14, 2010). The USFWS Ecological Services Office (ESO) in Cheyenne, Wyoming, has not typically provided project-specific guidance in recent years, but instead refers project applicants to the list of T&E species for each Wyoming county, as posted on their website. The wildlife survey requirements for the project were based on the nature of the expected disturbance and the presence of or potential for unique, critical, or previously unsampled wildlife habitats in or near the Proposed Project area. The survey requirements were also in keeping with those applied to baseline studies completed at other ISR properties on private surface in Wyoming in recent years.

The wildlife baseline review area, methods, and results for the Proposed Project are described below, with information presented by animal group.

3.5.4.3.2 General Setting

The Proposed Project is located approximately 8 miles southwest of Wright in Campbell County, Wyoming. Annual precipitation in the vicinity is approximately 10 inches, approximately 75 percent of which falls from April through September. Topography within the Proposed Project area and surrounding perimeter is primarily level to gently rolling, with more varied relief along the Belle Fourche River in the western portion of the Proposed Project area. Elevation within the overall Proposed Project wildlife review area ranges from approximately 5,041 feet above sea level along the Belle Fourche River to 5,296 feet in the southernmost hills.

The Proposed Project site is located within three drainage basins: Spring Creek-Antelope Creek, Upper Porcupine Creek-Antelope Creek, and the Belle Fourche River-All Night Creek. Numerous ephemeral drainages are also present in the area. Several stock tanks and reservoirs occur in the project area, though many were dry during the baseline survey period.

The majority of the Proposed Project site is privately owned, with scattered sections managed by the State of Wyoming. Traditionally, this semi-arid rangeland has been used for year-round livestock grazing (cattle and horses) and some dryland hay production. Other current land uses in the area include occupied residences and energy development (including both conventional oil and CBM. The area is bisected by several improved roads including Highway 387 and Clarkelen, Turnercrest, and Cosner County Roads.

3.5.4.3.3 Methods

The baseline wildlife surveys followed standard survey requirements and protocols used by the WGFD and USFWS, as well as the permitting guidelines issued by the WDEQ-LQD. Procedures and schedules recommended in the Handbook of Biological Techniques (WGFD 1982) were reviewed prior to the surveys. Biologists used binoculars and spotting scopes to make observations. Standard field guides and references (Stebbins 1966, Baxter and Stone 1985, Clark and Stromberg 1987, Peterson 1990, Stokes and Stokes 1996, and Cerovski et. al. 2004) were used to identify animals and their sign. Those resources, as well as the USFWS Migratory Bird Species of Management Concern (non-coal) and the WGFD SGCN lists were used to generate a potential species list for the area. Species' habitat requirements and availability were considered when the Proposed Project species list was developed.

3.5.4.3.3.1 Habitat Assessment

For the purposes of the wildlife baseline surveys, habitats within the Proposed Project area were assessed in the field and classified using broad categories (e.g., grassland, sagebrush, etc.). The Proposed Project area also was evaluated for the presence of any unusual or high value wildlife habitat features. Detailed vegetative data, including maps and photographs, were collected during the baseline vegetation assessment (see Section 3.5.3.1).

3.5.4.3.3.2 Raptors

The raptor survey area included the Proposed Project area and the one-mile review area. As described above, biologists reviewed current federal agency databases for previously known raptor nests prior to entering the field. Searches for additional nest sites were conducted on the following dates:

- July 1, 2008;
- June 4 and 16, 2010; and
- April 11, May 2 and 16, June 3, and July 11, 2011.

Raptor use of the survey area was documented through both comprehensive nest searches and monitoring, and opportunistic observations.

During all field work, guidelines recommended by Grier and Fyfe (1987) were followed to prevent nest abandonment, damage to eggs, or injury to young. Nests were located by slowly driving throughout the survey area and frequently stopping to examine typical nesting habitat. Creek banks and rough breaks were searched on foot. While in the field, biologists also continually watched for adult raptors. Areas with individuals or pairs that were seen repeatedly were thoroughly searched for nests.

Nest locations were obtained using hand-held Garmin® Global Positioning System (GPS) receivers and were recorded in Universal Transverse Mercator (UTM) coordinates (Zone 13N, NAD83). Nest locations were then plotted on topographic maps. The status (active, inactive, gone, etc.) and condition of all nests and production of young were recorded.

3.5.4.3.3.3 Upland Game Birds

Two aerial surveys for greater sage-grouse (*Centrocercus urophasianus*) and sharp-tailed grouse (*Tympanuchus phasianellus*) leks were conducted in spring 2008, and three aerial surveys were conducted in both spring 2010 and 2011. Those surveys took place on the following dates:

- April 12 and 28, 2008;
- April 12, 19, and 29, 2010; and
- April 1, 12, and 28, 2011.

All surveys followed WGFD-approved protocols, and were conducted between 30 minutes before and one hour after sunrise by two biologists and a pilot in a Cessna 172 or 172XP, flying at 80 to 100 miles per hour and 100 to 300 feet above ground level. During all surveys, all known leks within four miles of the Proposed Project area were checked, and north-south transects spaced at 0.62 mile (one km) intervals within one mile of the Proposed Project area were searched for new leks. All lek searches were conducted during favorable weather conditions (i.e. no precipitation, calm to light winds). Following current WGFD recommendations, the four-mile lek review area from the Proposed Project area was used for lek monitoring because it generally covers the range females are known to nest beyond the lek where they were bred.

In 2011, ground-based lek counts were also conducted for the known leks within four miles of the project area where landowner access was granted (Porcupine Creek and Spring Creek leks). Those surveys took place on April 11 and May 2, 2011 between 30 minutes before and one hour after sunrise. The known leks were checked, and suitable nearby habitats were also searched (by scanning and listening) from a vehicle on existing roads and trails.

Upland game bird use of the survey area was also tracked through opportunistic observations of birds and their sign while conducting other surveys. All upland game bird sightings were recorded, including the number of birds, sex and age (when possible), location (UTM and quarter-quarter section), habitat, and activity

3.5.4.3.3.4 Sensitive, Threatened, and Endangered Species

The USFWS ESO in Cheyenne, Wyoming, maintains the *Non-coal Mine List of 77 Migratory Bird Species of Management Concern in Wyoming* (USFWS 2002). In addition, the State of Wyoming has identified 279 species of greatest conservation need, including 54 mammals, 60 birds, 26 reptiles, 12 amphibians, 40 fishes, 19 crustaceans, and 68 mollusks (WGFD 2005). Both lists remained current through 2011, and were obtained and reviewed prior to commencing field surveys.

Surveys for mountain plovers were conducted throughout all suitable habitats on the following dates:

- June 4 and 16, 2010; and
- May 2 and 16, and June 3, 2011.

Those surveys were conducted in accordance with the USFWS March 2002 Mountain Plover Survey Guidelines, by scanning all appropriate habitats from a vehicle on existing roads and trails.

Biologists watched for all T&E species and other sensitive species and habitats that could support them while conducting all aerial and ground surveys. All sightings were recorded, including notes on number of individuals, sex and age (when possible), location, habitat, and activity.

3.5.4.3.3.5 Other Animals

No quantitative surveys for big game, lagomorphs (e.g., jackrabbits [*Lepus* spp.] and cottontails [*Sylvilagus* spp.]), breeding birds, waterfowl, small mammals, mammalian predators, furbearers, reptiles, amphibians, or fish were required or conducted specifically for the Proposed Project wildlife baseline survey. However, all sightings of non-targeted animals within the project area and one mile perimeter were recorded, and a species list maintained, during baseline surveys (2008, 2010, and 2011) to document comprehensive wildlife use of the survey area. As requested by the WGFD, big game range maps were used to determine which range delineations overlapped the survey area for future reclamation efforts.

Although the WGFD requested specific surveys for swift fox, the USFWS and WGFD do not currently have a required survey protocol for this species. The letters requesting the survey can be found in Addendum 3.5-H. Biologists were vigilant for this species during all surveys, carefully scanned all appropriate habitats, and inspected any large burrows encountered for fresh signs of use (tracks, scat, or prey remains) by swift fox.

Biologists also searched for black-tailed prairie dog (*Cynomys ludovicianus*) colonies during all baseline surveys in 2008, 2010, and 2011.

3.5.4.3.4 Results

3.5.4.3.4.1 Habitat Assessment

Three major wildlife habitat types were classified within the Proposed Project area. Those habitats correspond with plant communities defined during the vegetation baseline study (Table 3.5-1). For the purposes of the wildlife discussion, the Breaks Grassland was considered a part of the Upland Grassland community. Therefore, the Proposed Project area was comprised of three habitat types: Big Sagebrush Shrubland (78.1 percent), Breaks/Upland Grassland (9.2 percent), and Meadow Grassland (8.0 percent). Other habitat types, such as disturbed lands (county roads and existing ranch or CBM operations), were present to varied extents, and are not considered a "wildlife habitat" for this discussion. A distribution map and detailed descriptions of the composition and extent of all vegetative communities are provided in Section 3.5.3.1.

Big Sagebrush Shrubland

Big Sagebrush Shrubland is the most common habitat type within the project area. This community was present throughout the area, with taller and denser sagebrush plants occurring in the eastern half of the project area. The sagebrush shrubland habitats are characterized by rolling upland terrain with native and non-native grasses interspersed with sparse to moderately dense sagebrush cover. Wyoming big sagebrush is the most visually prominent vegetation in this habitat type, but native perennial cool-season grasses such as western wheatgrass and green needlegrass, and other native and non-native cool- and warm-season grass species were also prevalent. Other shrub and sub-shrub species present in this habitat type include rabbitbrush, fringed sagewort, and birdfoot sagebrush.

Numerous wildlife species specialize in utilizing sagebrush shrubland habitat (i.e., sagebrush obligates). Additionally, other generalist species may utilize them for foraging or hunting and/or refuge, while moving through the landscape. As a result, sagebrush habitats could support several species of big game (e.g., pronghorn [*Antelocarpa* *americana*] and mule deer [*Odocoileus hemionus*]), lagomorphs and other medium-sized mammals like the badger (*Taxidea taxus*), small mammals (e.g. mice and voles), and several sagebrush obligate avian species such as the sage thrasher (*Oreoscoptes montanus*), sage-grouse, and Brewer's sparrow (*Spizella breweri*).

Upland Grassland

The Upland Grassland habitat type is scattered throughout the Proposed Project area, with the largest expanses located along the higher elevations in the south, adjacent to Highway 387. This habitat is characterized by level to rolling terrain with limited shrub cover. Upland grasslands are comprised of both native and non-native cool- and warm-season grasses including crested wheatgrass, western wheatgrass, and blue grama. The forb component is comprised of annual, biennial, and perennial species such as American vetch and Hood's phlox. Shurbs and sub-shrubs such as big sagebrush and fringed sagewort have a limited presence in this habitat type.

Grassland vegetation communities tend to support a lower diversity and abundance of wildlife species because they are less complex relative to other habitats (e.g., shrublands and woodlands) and may even be comprised of non-native plant species or less overall vegetative diversity. Natural disturbance (e.g., fire) and maturation of this habitat are key factors in determining their current value to wildlife species. Nevertheless, composition and the availability of adjacent habitats can produce grasslands that support both specialist and generalist species for a variety of activities (e.g., nesting, foraging, and refuge). Small mammals such as mice and voles, as well as their predators (e.g., coyotes, foxes, hawks, and harriers) are common in grassland habitats. Other mammals such as deer and pronghorn can be found foraging or resting in this habitat. Other avian species that utilize grasslands include several species of sparrows, larks, and shrikes. Several species of snakes and other reptiles are also typically found in grassland habitats.

Meadow Grassland

Meadow Grassland habitat occurs along the creeks and drainages throughout the project area, and the areas adjacent to them. Forbs, grasses, and some mesic vegetation species compose this habitat, but adjacent upland shrubland and grassland species are often included in these plant communities.

The wildlife value of these habitats is similar to that discussed in the Upland Grassland section, above.

3.5.4.3.4.2 Raptors

Prior to the 2011 breeding season, a search of all available agency raptor databases indicated three known nests in the Proposed Project area and an additional 10 nests within the one-mile review area (BLM 2010). All but one of the nests are ferruginous hawk (*Buteo regalis*) ground nests situated on creek banks, hilltops, and rock outcrops throughout the area. The location, status, and condition of all nests are detailed in Table 3.5-5 and mapped in Figure 3.5-1.

Only some of the nests were accessible during the 2008 and 2010 ground surveys; thus, the condition and status of several of the nests included in Table 3.5-5 were not known until spring 2011. Only one nest was active in 2011. That nest was located in a cottonwood tree and was used successfully by red-tailed hawks (*Buteo jamaicensis*) in 2008, but was destroyed and gone from the tree by 2010. In 2011, the nest was rebuilt by red-tailed hawks, as they were seen tending the nest on May 16. However, the nest was empty on all subsequent visits, suggesting that the nesting attempt failed. No other nests were active or showed any signs of raptor activity during 2011.

No nesting activity from ferruginous hawks has been recorded in the area for the last several years. The nests surveyed during the baseline period were in dilapidated condition and showed no signs of recent activity. Individual ferruginous hawks have been observed occasionally during the baseline surveys while soaring and foraging over the general area, but no defensive or territorial behaviors have been observed.

Aside from the active red-tailed hawk nest and the aforementioned ferruginous hawk observation, other incidental raptor sightings within the survey area include golden eagles (*Aquila chrysaetos*), Swainson's hawks (*Buteo swainsoni*), and northern harriers (*Circus cyaneus*). Golden eagles are unlikely to nest in the survey area due to a lack of suitable nesting substrate (large trees, cliffs, etc.). One Swainson's hawk nest has been recorded just beyond one mile of the project area; however, the lack of trees within the Reno Creek wildlife survey area greatly limits the potential for this species to nest in the area. Northern harriers are likely to be nesting in the dense grassland habitats within the project area; however, no nests were located. Because northern harrier nests are placed on the ground and often concealed by dense vegetation, their nests are seldom found. Despite additional vigilance for burrowing owls (*Athene cunicularia*), this species was not observed, and suitable habitat (i.e., prairie dog colonies) was not present in the survey area.

The final rule delisting the bald eagle *(Haliaeetus leucocephalus)* was published in the Federal Register on July 9, 2007 (USFWS 2007). Delisting became effective 30 days after publication of this rule, on August 8, 2007. However, this species will continue to be protected under both the Bald and Golden Eagle Protection Act and the Migratory

Bird Treaty Act. The bald eagle is considered a winter resident and an uncommon breeder in portions of Campbell County, Wyoming (Cerovski et al. 2004). Due to the paucity of trees within the survey area, nesting and winter roosting habitat for this species is extremely limited. Furthermore, the available prey base for bald eagles in the area is limited and consists primarily of lagomorphs, prairie dogs, and sporadic carrion (wildlife and livestock). The area does not support a large big game herd, though some groups may winter in the area. Although these resources could provide a marginal year-round food supply, no consistent or significant food sources exist within the survey area that would attract or sustain large numbers of bald eagles.

3.5.4.3.4.3 Upland Game Birds

<u>Sage-grouse</u>

The Proposed Project area does not overlap with any of the core or connectivity areas for sage-grouse as designated by the State of Wyoming (Wyoming EO 2011-5). The closest core area ("Thunder Basin") is over 20 miles to the east. According to current WGFD records (WGFD 2010a), no known sage-grouse leks are present within the Proposed Project area, but three sage-grouse leks (160 Acre, Porcupine Creek, and Spring Creek) exist within four miles (Table 3.5-6 and Figure 3.5-1). All three leks are classified as "occupied" in the WGFD database, meaning that they have been active during at least one strutting season within the prior 10 years (WGFD 2010b).

The Porcupine Creek and Spring Creek leks were first documented in 2005, while the 160 Acre lek was discovered in 2006. Grouse numbers at the leks were relatively steady between 2005 and 2008 until a sharp decline in 2009 and 2010 (Table 3.5-7). The decline coincided with the natural cyclic pattern exhibited in sage-grouse with the most recent periodic low occurring in 2009. However, it is also worth noting that small numbers of grouse are more difficult to detect during aerial surveys, which was the primary survey method during most of the baseline period. Peak counts of 12 and one displaying male(s) were observed during ground counts conducted at the Porcupine Creek and Spring Creek leks, respectively, in 2011. The Porcupine Creek lek site had also shifted approximately 0.27 mile to the north of the originally listed WGFD location (Figure 3.5-1) that year. On one of the counts at the Porcupine Creek lek, 12 females were also present. On two occasions, a single male was observed displaying at the Spring Creek lek, while three female grouse were also present at the lek on one of those dates.

No new leks were identified within one mile of the project area during surveys in spring 2008, 2010, or 2011. On June 3, 2011, one female sage-grouse was observed foraging in moderately dense sagebrush-grassland in SWSW Section 23, T43N R73W (approximately 0.8 miles southwest of the Porcupine Creek lek). No other sage-grouse or sign thereof were observed within the Proposed Project survey area during the baseline surveys.

Habitats within most of the survey area have limited potential to support sage-grouse throughout the year. Sagebrush stands are relatively sparse, with the only patches of moderately tall and dense sagebrush noted in the east, primarily south of Highway 387 and north of the Cosner County Road in portions of Sections 26-28, 33, and 34 T43N R73W. This same general area (the eastern one-third of the survey area) is also designated by the WGFD as a Crucial Habitat Priority Area for the sagebrush/mixed grassland habitats (WGFD 2009). This means that the WGFD has identified the area to have significant biological and ecological value, and the department will concentrate habitat protection and management activities in those areas. Sagebrush habitats within that area could provide adequate nesting and wintering habitat for sage-grouse, and the moist drainages in the area could also provide adequate brood-rearing and late summer habitat. Otherwise, habitats throughout the remainder of the survey area primarily consisted of grassland or sparse sagebrush (less than five percent canopy cover), which are not likely to be utilized by sage-grouse during any portion of the year.

Sharp-tailed Grouse

The most recent WGFD records (WGFD 2004) do not reveal any sharp-tailed grouse leks near the Proposed Project area, as the nearest known lek is located greater than 30 miles to the north. Habitats within the survey area are only marginally suitable for this species during most of the year. The mosaic of sagebrush-grasslands could provide habitat from April through October. However, cottonwood trees and berry-producing shrubs (e.g., snowberry [*Symphoricarpos* spp.] and chokecherry [*Prunus virginiana*]), which provide winter forage for sharp-tailed grouse, were very limited or absent from the survey area.

Other Upland Game Birds

The mourning dove (*Zenaida macroura*) was the only other upland game bird that was observed in or near the Proposed Project survey area during the baseline surveys. Mourning doves were most often recorded flying from tree windbreaks at occupied ranches or in individual trees located throughout the survey area. The gray partridge (*Perdix perdix*) could potentially occur in the survey area, but the species was not documented during the baseline surveys.

3.5.4.3.4.4 Sensitive Species

Mountain Plover

On June 29, 2010, the USFWS reinstated its 2002 proposed rule to list the mountain plover as threatened under the Endangered Species Act (ESA). After a thorough review of all available information, the USFWS announced its decision to withdraw the proposed listing on May 12, 2011 (USFWS 2011a). However, the mountain plover remains on multiple federal agency sensitive species lists (e.g., BLM and USFWS), as well as the WGFD list of Species of Concern.

Despite thorough searching in the limited appropriate habitats within the survey area, no mountain plovers were observed during baseline surveys in 2008, 2010, or 2011. Mountain plovers are typically associated with sparse, short grassland habitats and are often found within or in close proximity to prairie dog colonies. As described below, no active prairie dog colonies exist within the wildlife survey area.

Other Sensitive Species

The non-coal list of 77 migratory bird species considered by the USFWS to be of current management concern in Wyoming and their occurrence in the Proposed Project survey area are included in Table 3.5I-1 in Addendum 3.5-I. A general species list for all potential and observed species documented during the Reno Creek baseline surveys is also included as Table 3.5I-2 in Addendum 3.5-I, which further indicates all species that are included in the WGFD SGCN list.

Migratory Bird Species of Management Concern in Wyoming (non-coal)

Twelve USFWS avian species of concern were recorded within the Proposed Project survey area during baseline surveys in 2008, 2010, and 2011. Six of those 12 species are categorized as Level I, which indicates a need for conservation action (i.e., having a monitoring and mitigation plan): the greater sage-grouse, McCown's longspur (*Rhyncophanes mccownii*), ferruginous hawk, Brewer's sparrow, Wilson's phalarope (*Phalaropus tricolor*), and Swainson's hawk. The remaining six species are considered Level II, for which continued monitoring is recommended: the lark bunting (*Calamospiza melanocorys*), sage thrasher, grasshopper sparrow (*Ammodramus savannarum*), loggerhead shrike (*Lanius ludovicianus*), vesper sparrow (*Pooecetes gramineus*), and lark sparrow (*Chondestes grammacus*).

Wyoming Game and Fish Department, Species of Greatest Conservation Need

The State of Wyoming has identified 279 SGCN, including 54 mammals, 60 birds, 26 reptiles, 12 amphibians, 40 fishes, 19 crustaceans, and 68 mollusks (WGFD 2005). Of the 192 vertebrate species included in the list, ICF biologists have documented 10 of those species during the baseline surveys in 2008, 2010, and 2011. Those include the greater sage-grouse, ferruginous hawk, Swainson's hawk, boreal chorus frog (*Pseudacris triseriata*), Brewer's sparrow, grasshopper sparrow, lark bunting, McCown's longspur, northern pintail (*Anas acuta*), and sage thrasher within appropriate habitats in the survey area as shown in Table 3.5I-2 in Addendum 3.5-I.

The remaining species of concern have not been documented in the Proposed Project survey area. Although they could migrate through the area, range and habitat considerations such as the lack of coniferous woodlands, limited riparian corridors, and large persistent bodies of water make it unlikely that most of those species would occur in the immediate vicinity.

3.5.4.3.4.5 Other Animals

Big Game

Pronghorn and mule deer were the only two big game species observed within the Proposed Project survey area. Both species were observed throughout the baseline survey period, though pronghorn were more prevalent. Only these two big game species have WGFD range delineations that overlap the Proposed Project survey area; however, no crucial big game habitat or migration corridors are recognized by the WGFD in this area. Crucial range is defined as any particular seasonal range or habitat component that has been documented as the determining factor in a population's ability to maintain and reproduce itself at a certain level (WGFD 2006).

The WGFD has classified the project area as both yearlong (40 percent of total acreage) and winter/yearlong (60 percent) pronghorn range as shown in Figure 3.5-1. This means that a population or a portion of a pronghorn population makes general use of this habitat on a year-round basis, but may also increase in abundance during the winter months as individuals immigrate into the area from other surrounding ranges. The Proposed Project area spans two WGFD pronghorn Herd Units: the Pumpkin Buttes area to the north of Wyoming Highway 387, and the North Converse Unit south of the highway. The WGFD estimated the 2006 post-season pronghorn populations in those two hunt areas to be approximately 36,500 and 32,300 individuals, respectively; both considerably above the WGFD objective (WGFD 2006).

Mule deer are not abundant in the survey area, with most individuals recorded in eroded draws and bottomland habitats. The WGFD has classified the entire project area as yearlong mule deer range. As with pronghorn, the Proposed Project spans the Pumpkin Buttes and North Converse mule deer Herd Units. The WGFD estimated the 2006 post-season pronghorn populations to be approximately 12,350 and 9,700 animals, respectively, with WGFD herd objectives of 11,000 and 9,100, for each of the respective units (WGFD 2006). No crucial mule deer ranges or migration corridors occur within several miles of the Proposed Project area.

The WGFD does not consider the general area to be within the "use range" of any other big game species (e.g., white-tailed deer [*Odocoileus virginianus*], moose [*Alces alces*], or elk [*Cervus elaphus*]). Sightings of those species in the vicinity are extremely rare or may not occur at all.

Small and Medium-sized Mammals

No standardized surveys targeting small mammals, lagomorphs, mammalian predators, or furbearers were required or conducted specifically for the Proposed Project wildlife baseline. However, incidental species observed during baseline surveys include: the badger, cottontail, white-tailed jackrabbit (*Lepus townsendii*), and muskrat (*Ondatra zibethicus*). A single badger was observed in the grass along Spring Creek in Section 3, T42N R73W. Both cottontails and white-tailed jackrabbits were observed resting and foraging in sagebrush-grassland habitats throughout the area. Muskrats were observed in ponds in NE NE Section 4, T42N R73W and NE NE Section 11, T42N R74W.

Although not directly observed, it is probable that several species of small mammals (voles, ground squirrels, and mice) exist in the area. Although WGFD databases indicate a few historical black-tailed prairie dog colonies within the northern and southern extents of the one mile review area, those colonies were inactive in 2011 with no signs of recent activity (e.g., scat, diggings, or maintained burrows).

The swift fox was removed from the ESA Candidate List in 2001, in part due to the conservation efforts of several western states (USFWS 2001). The WGFD classifies it as a SGCN species because population status and trends are largely unknown. Despite thorough searching in all appropriate habitats within the survey area, no swift fox, dens, or sign thereof were observed during the baseline surveys.

Although the black-footed ferret (*Mustela nigripes*) is listed as federally endangered under the ESA throughout portions of its range, it is no longer considered a federally listed species for Campbell County, Wyoming (USFWS 2010). Additionally, the USFWS issued a block clearance for this species in all black-tailed prairie dog colonies throughout Wyoming in early 2004 (USFWS 2004). Consequently, ferret surveys are no longer required or recommended in those colonies statewide.

Waterfowl and Shorebirds

No standardized surveys were targeted for waterfowl, wading bird, or shorebirds, but common species recorded in the survey area include the mallard (*Anas platyrhynchos*), northern pintail, American wigeon (*A. americana*), northern shoveler (*A. clypeata*), green-winged teal (*A. crecca*), eared grebe (*Podiceps nigricollis*), killdeer (*Charadrius vociferous*), and Wilson's phalarope. These wetland birds were observed in the limited ponds and reservoirs throughout the Proposed Project survey area, particularly those along the Belle Fourche River and Spring Creek.

Reptiles and Amphibians

No standardized surveys targeting reptiles or amphibians were required or conducted specifically for the Proposed Project wildlife baseline. Potential habitat for aquatic reptiles and amphibians is relatively limited within the Proposed Project area and occurs primarily in ephemeral habitat associated with small, scattered stock ponds or drainages in the area. However, suitable habitat for snakes and other terrestrial reptiles does exist within the rocky outcrops, especially along the Belle Fourche River drainage. The only amphibian encountered in the survey area during the surveys was the boreal chorus frog, which was heard calling in several of the reservoirs throughout the Proposed Project area. A single short-horned lizard (*Phrynosoma douglassi*) was the only reptile observed. It was observed in sagebrush-grassland uplands within the Proposed Project area.

3.5.4.3.5 Conclusions

The Proposed Project survey area supports an array of common wildlife species, despite the relatively limited variety of habitat types and the presence of existing disturbances within the area.

Likewise, the habitats present within the Proposed Project area and survey area are common in central Wyoming. The survey area is dominated by sagebrush shrubland; however, for wildlife utility, the sagebrush habitats are somewhat limited in extent and marginal in quality within most of the survey area. Moderately dense sagebrush stands are largely confined to the eastern third of the area (the area south of Highway 387 and north of Cosner Road). Those areas are likely to support sagebrush obligate species such as the greater sage-grouse and Brewer's sparrow during portions of the year. Lowland grassland (i.e., bottomland) and tree habitats, which often support considerable wildlife diversity, are extremely limited within the Proposed Project area. The natural drainages within the survey area do not have persistent flow. However, CBM-enhanced reservoirs and some stock ponds provide a few reliable water sources throughout the year. No occupied prairie dog colonies are present within the survey area.

A total of 13 raptor nests are known to exist within the survey area, and three of those are located within the Proposed Project area boundary. Twelve of the 13 nests are ground nests built by ferruginous hawks; however, no nesting activity from ferruginous hawks has been recorded in the area for several years. Most of the nests were in dilapidated condition and showed no signs of recent activity. One nest was active in 2008 and 2011, and was occupied by red-tailed hawks in both years.

Three occupied sage-grouse leks (160 Acre, Porcupine Creek, and Spring Creek) exist within four miles of the Proposed Project area. Grouse numbers at the leks were low in 2009 and 2010, but surveys in 2011 indicated that both the Porcupine Creek and Spring Creek leks were active. No new leks were identified during the baseline surveys. Habitats within most of the survey area have limited potential to support sage-grouse throughout the year. Sagebrush stands are relatively sparse, with the only patches of moderately tall and dense sagebrush noted in the east, primarily south of Highway 387 and north of the Cosner County Road. While the project does not overlap with any core or connectivity areas for sage-grouse as designated by the State of Wyoming, the eastern one-third of the area has been designated as a Crucial Habitat Priority Area by the WGFD.

A total of 10 WGFD SGCN and 12 USFWS species of management concern were documented in the survey area during the baseline survey period. All of those species are common to sagebrush-grassland habitats of the region, either seasonally or year-round. No perennial streams or sizeable reservoirs occur in the survey area. The only waterfowl, shorebird, and wetland-associated species observed during baseline surveys to date are common and widespread, and generally associated with small or ephemeral water sources. Likewise, the reptile and amphibian species that were observed are known to be relatively common in the area. The pronghorn and mule deer were the only big game species documented in the survey area during the baseline survey period; those and other mammalian species observed during surveys to date are also common to the region.

The Proposed Project survey area currently experiences various levels of regular human disturbance, depending on the time of year. The area is bisected by several improved roads including Highway 387 and Clarkelen, Turnercrest, and Cosner County Roads. Additional disturbances in the area include active ranching and livestock grazing (cattle and horses), existing oil and CBM activity, and occupied residences.

As described above, the Proposed Project survey area supports an array of common wildlife species, despite the relatively limited variety of habitat types and the presence of existing disturbances within the area. Given the physical and faunal characteristics of the area described above, no significant impacts to wildlife or their habitats are anticipated from ISR operations and reclamation of the Proposed Project area. Development will result in short-term habitat loss for some species, but careful reclamation efforts should allow for their eventual recovery. Analyses of anticipated impacts to wildlife species are discussed in detail in Section 4.5.2.3 (Wildlife and Fisheries) of this ER.

3.5.4.4 Threatened, Endangered, or Candidate Species

The USFWS has identified three federally listed species potentially occurring in Campbell County that require monitoring for project development. Those include two plant species, the Ute ladies'-tresses (*Spiranthes diluvialis*) (threatened) and blowout penstemon (*Penstemon haydenii*) (endangered), and one vertebrate species, the greater sage-grouse (candidate) (USFWS 2010).

Other than a single female sage-grouse that was documented in 2011, no threatened, endangered, candidate, or proposed wildlife species have been documented in the Proposed Project survey area during surveys in 2008, 2010, and 2011, and available data sets do not indicate the occurrence of any T&E species in the survey area. Therefore, no T&E species and habitat exist at the site.

3.5.4.4.1 Blowout Penstemon

Blowout penstemon (*Penstemon haydenii*), a member of the snapdragon family, was federally listed as an endangered plant species in 1987, but was not added to the list of threatened and endangered plant species for Campbell County until 2008 (USFWS 2008). Blowout penstemon is a pioneer species of sand dunes and sandy aprons at the base of mountains and ridges. Blowout penstemon populations occur on sparsely vegetated sandy blowouts or dunes of 60 to 120 feet tall on steep slopes at elevations between 5,800 to 7,500 feet. Plant communities are in the early stages of development, and are typically composed of blowout grass (*Redfieldia flexuosa*), lemon scufpea (*Psoralidium lanceolatum*), and thickspike wheatgrass (*Elymus lanceolatus*) or Indian ricegrass (*Achnatherum hymenoides*). Wind and gravity prevent the shifting blowouts or dunes from becoming fully stabilized and overgrown.

The three documented blowout penstemon populations, in Wyoming, are comprised of several thousand individuals, and are located in the northeastern corner of the Great Divide Basin in Carbon County, near the Ferris and Seminoe Mountains (Heidel et al. 2007). These populations are restricted to two habitat types: steep, northwest-facing slopes of active sand dunes with less than five percent vegetative cover; and north-facing sandy slopes, on the lee side of active blowouts, with 25 percent to 40 percent vegetative cover (USFWS 2008).

Habitat suitability for blowout penstemon, within the Proposed Project area, was evaluated based on the presence of the following characteristics: eolian sand deposits or sand deposits greater than three feet in depth, fine sandy textured soils absent of rocks and coarse fragments, wind or gravity erosion versus water erosion, slopes greater than 25 percent, slope elevation changes of 60 to 120 feet, vegetation cover of less than 40 percent, and associated plant species. Based on Natural Resources Conservation Service

(NRCS) soil data and baseline soil sampling, soils derived from eolian sources were present within the Proposed Project area. However, where eolian sands were present, sand dunes or blowouts were not present. Slopes, erosion type, elevation changes, vegetation cover, and associated species were not present or not present in sufficient combination to provide suitable habitat. No individuals or populations of blowout penstemon were found during field surveys, and based on the lack of suitable habitat characteristics; local habitat was confirmed unsuitable for blowout penstemon.

3.5.4.4.2 Ute Ladies'-Tresses

Ute ladies'-tresses (*Spiranthes diluvialis*), a member of the orchid family, was federally listed as a threatened plant species in 1992. Ute-ladies'-tresses is endemic to moist soils near springs, lakes, or perennial streams. Most occurrences are in alluvial substrates along riparian edges, gravel bars, old oxbows, and moist to wet meadows in the floodplains of perennial streams. Moisture in the rooting zone typically provided by a high ground water table, through the growing season and into late summer or early autumn is required. This species is intolerant of deep shade, strongly alkaline or clay soils, and cannot compete with aggressive rhizomatous species (USFWS 1995). In Wyoming, Ute ladies'-tresses typically occur on eastern plains in moist valley bottoms with groundwater fed perennial rivers or streams. Soils, within these areas, are derived from river deposits, are well drained, and remain moist through the growing season. The hydrology is stable, dissolved minerals and clay content are low, and calcium concentrations are high, in comparision to similar areas without Ute ladies-tresses populations. Vegetation is relatively short, but dense and dominated by redtop (*Agrostis stolonifera*) and switchgrass (*Panicum virgatum*) (Heidel et al. 2008). Documented Ute ladies'-tresses populations, in Wyoming, are located in Goshen, Converse, Niobrara, and Laramie counties in the Horse, Antelope, and Niobrara Headwaters watersheds (Fertig 2005).

Habitat suitability for Ute ladies'-tresses, within the Proposed Project area, was evaluated based on the presence of the following characteristics: late season perennial water source, associated vegetation species, sandy or loamy textured soils, gradual transitions between uplands and water body or drainages, vegetation density between 75 percent and 90 percent, vegetation height less than 18 inches, non-alkaline soils. Based on field evaluations during the appropriate timeframe, late season perennial water sources were present within the Proposed Project area. However, where late season perennial water sources were present, associated vegetation species, appropriate soil textures, gradual transitions, vegetation cover and density, and non-alkaline soils were not present or not present in sufficient combination to provide suitable habitat. No individuals or populations of Ute ladies'-tresses were found during field surveys, and based on the lack of suitable habitat characteristics, local habitat was confirmed unsuitable for Ute ladies'-tresses.

3.5.4.4.3 Greater Sage-Grouse

On March 5, 2010, the USFWS issued a decision that the greater sage-grouse was warranted for listing under the ESA, but that listing was precluded by higher priority species. As a result, the sage-grouse is currently considered a candidate species under the ESA, and will undergo an annual review of its status to determine if a change in that decision is warranted. No core or connectivity areas for sage-grouse have been designated by the State of Wyoming in the Proposed Project area or the four mile revew area (Wyoming EO 2011-5). The closest core area ("Thunder Basin") is over 20 miles to the east. Survey methods, results, and potential habitat for sage-grouse in the Proposed Project area were thoroughly discussed in the preceding *Upland Game Birds* sections of this report.

Table 3.5-1: Acreage and Percent of Total Area for Each Plant Community

Plant Community	**Project Area**		**0.5 Mile Vegetation Review Area**	
	Acres	% of Area	Acres	% of Area
Big Sagebrush Shrubland	4,729.27	78.07	4,595.60	78.59
Meadow Grassland	484.06	7.99	495.34	8.47
Upland Grassland	480.23	7.93	407.06	6.96
Breaks Grassland	80.41	1.33	142.8	2.44
Disturbed	279.14	4.61	203.97	3.49
Water	4.31	0.07	3.11	0.05
Total	6,057.42		5,847.88	**100.00**

Table 3.5-2: Summary of 2011 Absolute Cover Values for the Proposed Project Area

Plant Community	Mean Absolute (%)	
	Total Vegetation Cover	Total Ground Cover
Big Sagebrush Shrubland	62.4	87.6
Meadow Grassland	68	95.7
Upland Grassland	57.1	90.5
Breaks Grassland	57.5	79.9

Table 3.5-3: Summary of Sample Adequacy Calculations for Percent Vegetation Cover for the Proposed Project Area

Plant Community & Vegetation Parameter	Mean (%)	Standard Deviation	Computed Sample Adequacy Sample Size	Actual Sample Number	Computed Z-Value	Confidence Level Achieved
Big Sagebrush Shrubland						
Total Vegetation Cover	62.4	8.8	6.52	20	2.24	98.75
Total Ground Cover	87.6	8.32	2.96	20	3.33	99.96
Meadow Grassland						
Total Vegetation Cover	68	14.1	14.08	20	1.53	93.7
Total Ground Cover	95.7	4.36	0.68	20	6.94	100
Upland Grassland						
Total Vegetation Cover	57.1	11.42	13.1	20	1.58	94.29
Total Ground Cover	90.5	7.92	2.51	20	3.61	99.99
Breaks Grassland						
Total Vegetation Cover	57.5	11.22	12.47	20	1.62	94.74
Total Ground Cover	79.9	13.32	9.11	20	1.9	97.13

Table 3.5-4: Summary of Mean Vegetation Cover Data, by Lifeform, for the Proposed Reno Creek Project Area

Lifeform	Big Sagebrush Shrubland		Meadow Grassland		Upland Grassland		Breaks Grassland	
	Absolute Mean	Relative Mean	Absolute Mean	Relative Mean	Absolute Mean	Relative Mean	Absolute Mean	Relative Mean
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Native Annual Grasses	0	0	0	0	0.3	0.53	0	0
Introduced Annual Grasses	2.2	3.52	10.8	15.89	5.8	10.15	4.8	8.34
Total Annual Grasses	**2.2**	**3.52**	**10.8**	**15.89**	**6.1**	**10.68**	**4.8**	**8.34**
Native Cool Season Perennial Grasses	16.7	26.76	34.8	51.17	12.4	21.71	24.4	42.42
Native Warm Season Perennial Grasses	5.8	9.29	1	1.47	4.2	7.36	3.1	5.39
Introduced Perennial Grasses	2.7	4.33	6.1	8.96	21.9	38.36	1.7	2.96
Native Grasslikes	5.3	8.49	0.9	1.33	4.8	8.41	7.5	13.04
Total Perennial Grasses	**30.5**	**48.87**	**42.8**	**62.93**	**43.3**	**75.84**	**36.7**	**63.81**
Native Annual Forbs	0.1	0.16	0.8	1.18	0.2	0.35	0	0
Introduced Annual Forbs	1.4	2.24	3.9	5.73	1.3	2.28	1.1	1.92
Introduced Biennial Forbs	0.2	0.32	0	0	0.1	0.18	0.2	0.34
Total Annual/Biennial Forbs	**1.7**	**2.72**	**4.7**	**6.91**	**1.6**	**2.81**	**1.3**	**2.26**
Native Perennial Forbs	6.9	11.05	5.2	7.65	3.4	5.97	7.3	12.7
Introduced Perennial Forbs	0.6	0.96	2.9	4.26	0.7	1.23	0.4	0.7
Total Perennial Forbs	**7.5**	**12.01**	**8.1**	**11.91**	**4.1**	**7.2**	**7.7**	**13.4**
Native Perennial Shrubs	19.5	31.25	1.4	2.06	1.8	3.15	6.3	10.95
Native Perennial Sub-Shrubs	1	1.6	0.2	0.3	0.2	0.36	0.7	1.21
Total Shrubs	**20.5**	**32.85**	**1.6**	**2.36**	**2**	**3.51**	**7**	**12.16**
Lichen	3	—	0.6	—	1.9	—	2.2	—

Table 3.5-5: Raptor Nest Locations, Status, and Productivity within One Mile of the Proposed Reno Creek Project from 2008 through 2011

Map ID[1]	Species[2]	Substrate[3]	UTM NAD83, Zone 13N	¼-¼ Section	Nest Status & Productivity[4]			
					2008	2009	2010	2011
1 *(2398)*	FEHA	GHS	449928E, 4838726N	NW SW 15, T43N:R73W	U	U	U	I
2 *-799*	FEHA	GHS	449676E, 4838602N	NW SW 15, T43N:R73W	U	U	U	Nest Gone
3 *(2396)*	FEHA	GHS	449606E, 4838433N	NE SE 16, T43N:R73W	U	U	U	I
4 (762)	FEHA	GHS	446778E, 4836877N	NW SW 20, T43N:R73W	U	U	U	I
5	FEHA	GHS	445477E, 4835787N	SE NW 30, T43N:R73W	I	U	U	I
6*	FEHA	GHS	445940E, 4834941N	SW SE 30, T43N:R73W	I	U	I	I
7*	FEHA	GHS	445472E, 4833932N	SE NW 31, T43N:R73W	I	U	I	I
8	FEHA	CKB	443056E, 4833074N	NE NE 2, T42N:R74W	I	U	I	I
9 *(2565)**	RTHA	CTL	446744E, 4833015N	NW NW 5, T42N:R73W	A,2+,2	U	Nest Gone	A,0,0
10	FEHA	CKB	443821E, 4832824N	NE NW 1, T42N:R74W	I	U	I	I
11 *(2566)*	FEHA	GHS	446660E, 4831407N	NW NW 8, T42N:R73W	U	U	U	I
12 *(2564)*	FEHA	GHS	445901E, 4830491N	NW SE 7, T42N:R73W	U	U	U	I
13 *(2579)*	FEHA	GHS	444476E, 4829970N	SE SE 12, T42N:R74W	I	I	U	Nest Gone

Note: the first three nests listed are located just outside the one mile review area

[1] BLM ID numbers in parentheses were obtained from the BLM raptor nest database (BLM 2010). Nests without a BLM ID number are not included in the BLM database.

[2] FEHA: Ferriginous Hawk; RTHA: Red Tailed Hawk

[3] GHS= ground/hillside; CKB=creekbank; CTL=cottonwood (live)

4 Nest status informationobtained from both ICF records and the BLM raptor nest database A=active; I=inactive; U=unknown; Nest Gone=nest is destroyed and no longer present or conditions have deteriorated due to natural events and the nest is no longer discernible. X, #, #=Status number of young hatched; number of young fledged.

* Denotes nests within the Proposed Project area

Table 3.5-6: Sage-Grouse Leks within 4.0 miles of the Proposed Reno Creek Project.

Lek Name	UTM X (UTM NAD83, Zone 13N)	UTM Y	¼ ¼ Section, T(N):R(W)	Proximity to Proposed Project Area
160 Acre	451,064	4,828,885	NE SE 15, 42:73	3.0 miles southeast
Porcupine Creek*	452,497	4,837,418	SW NE 23, 43:73	1.2 miles east
Spring Creek	454,712	4,831,604	SW SW 6, 42:72	3.2 miles east

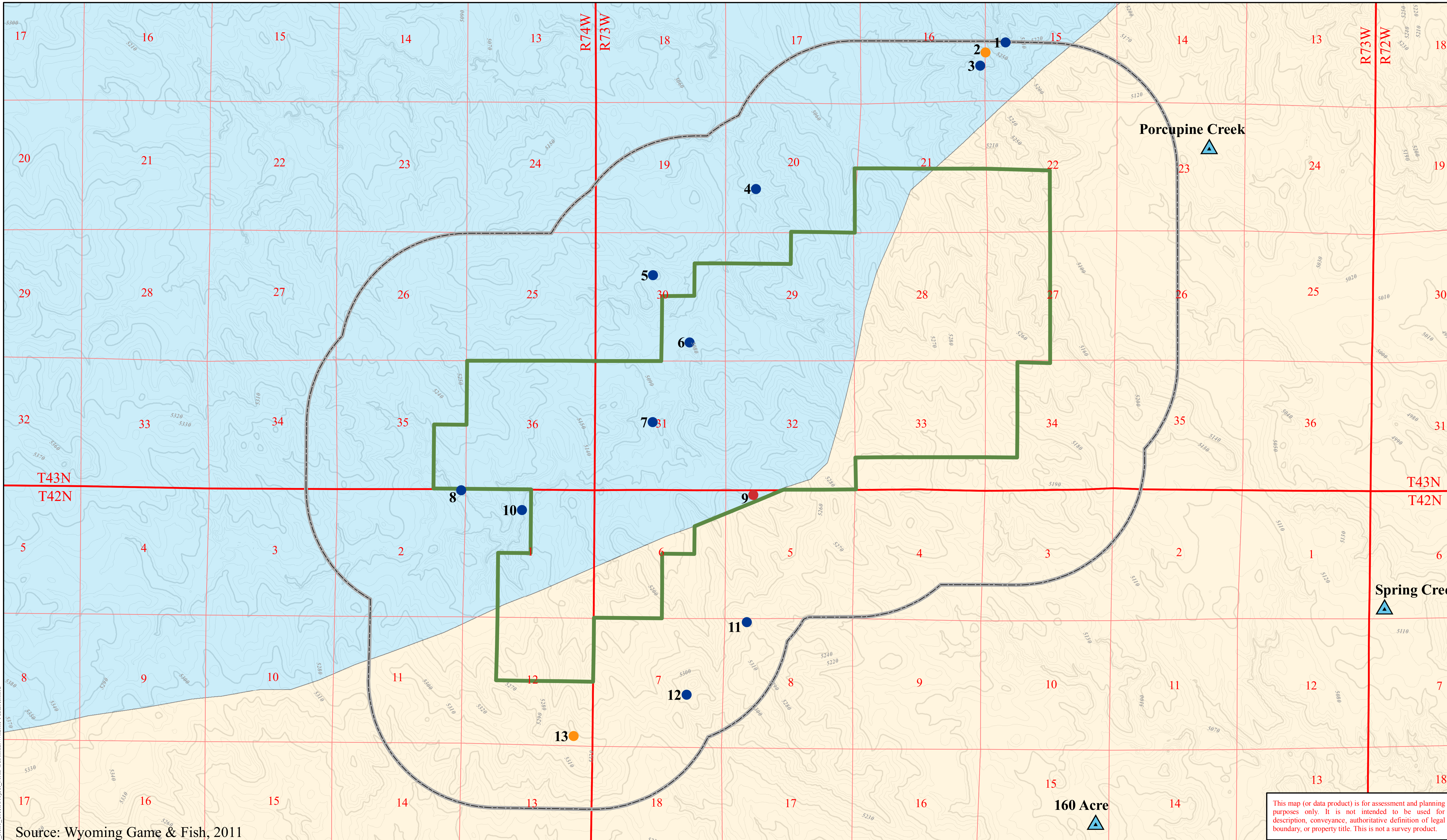
* The Porcupine Creek lek location listed and shown on Figure 3.5-1 represents the site where males were seen displaying in 2011, (approximately 0.27 mile north of listed WGFD lek location).

Table 3.5-7: Peak male Counts[1] at Sage-Grouse Leks (2005 through 2011).

<table>
<tr><th>Year</th><th>160 Acre</th><th>Porcupine Creek</th><th>Spring Creek</th></tr>
<tr><td>2005</td><td>---</td><td>12</td><td>18</td></tr>
<tr><td rowspan="2">2006</td><td rowspan="2">10</td><td>24</td><td rowspan="2">16</td></tr>
<tr><td>---</td></tr>
<tr><td>2007</td><td>20</td><td>---</td><td>12</td></tr>
<tr><td>2008</td><td>19</td><td>34</td><td>10</td></tr>
<tr><td>2009</td><td>0</td><td>11</td><td>3</td></tr>
<tr><td>2010</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>2011</td><td>0</td><td>12</td><td>1</td></tr>
</table>

[1] Peak male counts obtained from ICF records and WGFD databases; not all leks were monitored in all years.

--- = Lek was not discovered or monitored in the given year.



PROPOSED RENO CREEK PROJECT
CAMPBELL COUNTY, WY
PREPARED FOR AUC LLC
LAKEWOOD, CO

ICF INTERNATIONAL
TREC, Inc.
Engineering & Environmental Management

Legend
Proposed Reno Creek Project Boundary
One Mile Wildlife Survey Area
Sage-grouse Leks (within Four Miles)

Pronghorn Habitat Range
Winter/Yearlong
Yearlong

Raptor Nest Sites 2011 Status
Active
Inactive
Gone

0 0.25 0.5 1 Miles
Contour Interval = 10 feet
1:44,000

N S E W

DRAWN BY: JM (ICF)
CHECKED BY: RHK (TREC)
APPROVED BY: JEY (TREC)

Wildlife Features

REV #	DESCRIPTION	BY	DATE
0	Draft	JM	09/29/11
1	Revised Draft for Review	RHK	10/14/11
2	Final	RHK	12/07/11

FIGURE 3.5-1

Path: O:\WY_Projects\2010-100_AUC_Reno_Creek\Project_MXD\Submittal\Wildlife Features.mxd

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3.6 Meteorology, Climatology and Air Quality

3.6.1 Introduction

This section summarizes the general climate of the region and local meteorological characteristics of the area where the Proposed Project is located. In particular, this section demonstrates that the one year of on-site meteorological data is clearly representative of long term conditions. Comparable and/or more detailed discussions can be found in:

- Section 4.6 of this ER (Potential Air Quality Impacts);
- Section 5.4 of this ER (Cumulative Impacts);
- Section 6.6 of this ER (Mitigation Measures);
- Section 2.5 of the TR (Climatology);
- Addendum 2.5A of the TR contains the Meteorological System Audit Report; and
- Sections 7.1.4 and 7.2.4 of the TR (Environmental Effects).

The Proposed Project is located in a semi-arid or steppe climate. The region is characterized seasonally by cold harsh winters, hot dry summers, relatively warm moist springs and cool autumns. Though summer nights are normally cool, the daytime temperatures can be quite high. Conversely, there can be rapid changes during the spring, autumn and winter when frequent variations of cold-to-mild or mild-to-cold can occur.

As noted in NUREG-1910 (GEIS Section 3.3.6), the region's relatively cool temperatures are a result of Wyoming's elevation. Temperature extremes range from roughly -25° F in the winter to 100° F in the summer. Typically, the "last freeze" occurs during late May and the "first freeze" mid-to-late September.

Yearly precipitation totals are typically near 13 inches. The region is prone to severe thunderstorm events throughout the spring and early summer months and much of the precipitation is attributed to these events. In a typical year, the area will see four or five severe thunderstorm events (as defined by the National Weather Service criteria) and 40 to 50 thunderstorm days. Autumn stratiform rain events also contribute to precipitation totals, but to a lesser degree than those before mentioned. Snow frequents the region throughout winter months (40 to 50 in/year), but provides much less moisture than rain events.

Windy conditions are fairly common to the area. Nearly five percent of the time hourly wind speed averages exceed 25 mph. The predominant wind directions are west and west/southwest with the wind blowing out of that those directions over 25 percent of the time. A north/northwest secondary mode is also present. Surface wind speeds are relatively high all year-round, with hourly averages from 11 to 15 mph. Higher average wind speeds are encountered during the winter months while summer months experience lower average wind speeds.

A regional overview is presented first. This section includes a discussion of the maximum and minimum temperature, relative humidity, annual precipitation including snowfall estimates, evaporation rates, and a brief wind speed and direction summary. For purposes of the regional analysis, meteorological data were acquired through the Western Regional Climate Center (WRCC, 2011) for 20 COOP and ASOS stations operated by the National Weather Service (NWS). These include Casper Airport (AP), Douglas, Gillette AP, Glenrock, Kaycee, Lance Creek, Midwest, Reno, and others. In addition, Glenrock Coal Mine and Antelope Coal Mine meteorological data have been obtained through the Air Science division of Inter-Mountain Laboratories (IML Air Science) located in Sheridan Wyoming. The latter two mentioned sites are operated in compliance with regulations set forth by the Wyoming Air Quality Division (AQD) for air quality monitoring. IML Air Science has maintained the sites for several decades. Table 3.6-1 provides the station identification, coordinates, and period of operation for each site used in the regional analysis.

Figure 3.6-1 shows the 22 sites in relation to the project boundary. As can be seen in the figure, Antelope and Glenrock are the closest available sites with wind data. The closest NWS operated station which continuously records all weather parameters are the Casper AP and Gillette AP sites, roughly equidistant from the Proposed Project. The 22 sites in Table 3.6-1 have been analyzed collectively to provide a regional climatic temperature and precipitation analysis of the Proposed Project area. Only the Casper AP, Gillette AP, Glenrock Mine and Antelope Mine sites were analyzed for the regional wind characteristics. The NWS sites were used for snowfall analysis as neither mine site records snowfall data.

The site specific analysis follows the regional analysis. For the site-specific analysis, baseline meteorological information for the Proposed Project was collected from the Reno Creek meteorological station by IML Air Science and subsequently reported to AUC. The baseline monitoring period was approximately one year. Meteorological parameters monitored at the proposed site include wind speed, wind direction, ambient temperature, relative humidity, precipitation, barometric pressure, solar radiation and pan evaporation. An in-depth wind analysis includes wind speed and wind direction statistics, annual and seasonal wind roses, joint frequency distributions to characterize the wind data for the site by stability class, and wind speed frequency distributions. These data are summarized on a monthly, seasonal and annual basis. The seasons are classified in calendar quarters as follows; January-March for winter, April-June for spring, July-September for summer, and October-December for fall. No site specific general climate data are included as this is addressed in the regional evaluation.

The Antelope Coal Mine was analyzed in the site specific analysis due to its proximity to the proposed site and to its similar topography. Antelope Mine is located approximately 20 miles southeast of the Proposed Project site. The Antelope Mine site, like the Proposed Project area, extends from the eastern slope of a ridge downward into a drainage. Both sites are characterized by mildly rolling hills covered with grass and sparse shrubs.

The Antelope Mine and Glenrock Mine meteorological stations were also proposed to the NRC for use in meteorological studies for the Allemand-Ross Project by High Plains Uranium, Inc. (HPU) in August of 2006. Since that time, HPU was acquired by Energy Metals Corporation and subsequently by Uranium One. In a letter from the NRC to HPU dated September 14, 2006, the NRC states that the meteorological stations at the Antelope and Glenrock mines meet the standards identified in NRC Regulatory Guide 3.63, *Onsite Meteorological Measurement Program for Uranium Recovery Programs-Data Acquisition and Reporting,* and can be recognized as "standard installations" per NUREG-1569. Therefore, data from these stations may be used along with NWS Station Data. As described above, the Antelope Mine meteorological station is closer to the Proposed Project than the nearest NWS station and lies in very similar terrain. As a result, AUC believes that weather conditions at the Antelope station generally resemble conditions at the Proposed Project site. Moreover, data from the baseline monitoring year at Antelope are shown in this report to be typical of the last 25 years at that site. By its similarities to the Proposed Project, Antelope serves the purpose of demonstrating that the baseline monitoring year should be typical of the long term at the Proposed Project as well.

The nearest mountain ranges to this area are:

- the Bighorn Mountains, approximately 60-miles west from the Proposed Project site and 80 miles northwest from Antelope Mine;
- the Black Hills, approximately 100 miles east from Antelope Mine and 75 miles east from the Proposed Project site; and
- the northern Laramie Range, approximately 80 miles south of Proposed Project site and 80 miles southwest of Antelope Mine.

Due to these large distances, neither the Antelope site nor the Proposed Project site experiences significant weather effects from the three mountain ranges. Also, there are no major bodies of water affecting the meteorology of these two sites. The Antelope site is several hundred feet lower in elevation than Proposed Project. Both, however, are situated on the southeasterly side of the hydrologic divide with a similar vertical relationship to the divide.

Because of the extensive surface coal mining that has developed over the last 30 years, the PRB air shed is one of the most heavily monitored in the country. Coal production in the PRB grew from a few million tons in 1973 to over 400 million tons in 2010. The Clean Air Act and the Surface Mining Control and Reclamation Act of the 1970's prompted a parallel growth in ambient air quality monitoring throughout the PRB. This has led to over 100 particulate monitoring samplers and more than 20 meteorological monitoring towers, all configured to support air quality permitting, compliance and research objectives.

The monitoring programs at these sites meet the Wyoming Department of Environmental Quality requirements for land and air quality permit compliance. Methods used in collecting and validating these data adhere to EPA's "On-Site Meteorological Program Guidance for Regulatory Modeling Applications." Hourly average values for various parameters are generated by field instruments and recorded by continuous data loggers, all operated and maintained by IML Air Science. Data recovery has typically exceeded 95 percent. Depending on the mine, meteorological parameters logged include wind speed, wind direction, sigma theta, ambient temperature, barometric pressure, solar radiation and precipitation. All hourly data are downloaded to IML Air Science's relational database. The database software provides for quality assurance, invalidation of suspect or erroneous data, and various forms of data presentation.

3.6.2 Regional Overview

3.6.2.1 Temperature

According to NUREG-1910 (GEIS Section 1.4.3), the Proposed Project is located in the Wyoming East Uranium Region. The Proposed Project area features a semi-arid or steppe climate. Temperature extremes range from roughly -25° F in the winter to 100° F in the summer. The "last freeze" occurs during late May and the "first freeze" mid-to-late September. The annual average temperature for the region is 46° F. The graph in Figure 3.6-2 shows monthly average temperatures for the two mine sites, the Gillette AP site and the Casper AP site. The graph exhibits very little difference between the four sites. July shows the highest average monthly temperatures followed by August. January and December record the lowest average temperatures for the year. Table 3.6-2 compares the monthly temperature statistics for three of the four sites. The slight differences in average temperatures could be attributed to the small changes in elevation between the stations. Antelope Mine has the highest average temperature and the lowest elevation of the three while Casper has the lowest average temperature and is the highest in elevation.

Large diurnal temperature variations are found in the region due in large part to its altitude and low humidity. Figure 3.6-3 shows this variation for Antelope Mine. Peak daily temperatures generally occur during late afternoon. Diurnal changes in temperature are typically 25° F during the summer with maximum temperature variations of 30 to 40° F observed during extremely dry periods. Less daily variation is observed during the cooler portions of the year as fall and winter have variations averaging about 15° F. The lesser variation in daily temperature can be attributed to the more stable environment the region is exposed to during the fall and winter months. Stable periods have much lower mixing heights and accompanying lapse rates allowing for less temperature variation.

The region is characterized seasonally by cold harsh winters, hot dry summers, relatively warm moist springs and cool autumns. The Proposed Project region has annual average maximum temperatures of 58.5° F and average minimum temperatures of 33.6° F. July has the highest maximum temperatures with averages near 90° F while the lowest minimum temperatures are observed in January with averages near 10° F. Interpolated annual average minimum and maximum temperatures are shown in Figures 3.6-4 and 3.6-5, respectively.

3.6.2.2 Cooling, Heating, and Growing Degree Days

The graphs shown in Figure 3.6-6 show the average monthly cooling, heating, and growing degree days for Casper. The data are assumed to be indicative of the region as the other meteorological parameters for the various sites track very closely. The heating and cooling degree days are included to show deviation of the average daily temperature from a predefined base temperature. For heating and cooling degree days, 55° F has been selected as the base temperature. The number of heating degree days is computed by taking the average of the high and low temperature occurring that day and subtracting it from the base temperature. The calculation for computing growing and cooling degree days is the same, except that the base temperature is subtracted from the average of the high and low temperature for the day. Also, the base temperature used for growing degree days is 50° F. Negative values are disregarded for all calculations.

As expected, the heating degree days and cooling degree days are inversely proportional and the numbers of growing and cooling degree days are directly correlated. The maximum number of heating degree days occurs in January, 980 degree days, which coincides with January having the lowest minimum average temperature. Conversely, July registers the most cooling degree days with 492, which also corresponds to July having the highest maximum average temperature.

3.6.2.3 Relative Humidity

The Casper and Gillette airports provide relative humidity data for this analysis. The graph shown in Figure 3.6-7 presents data taken from the National Climatological Data

Center (NCDC, 2011). The graph shows monthly average relative humidity (percent) for the two sites. It can be seen here that July through September is the "driest" period of the year. Figure 3.6-7 also shows the winter months of December through February are the "wettest" portions of the year. This seasonal contrast is largely an artifact of ambient temperatures. Relative humidity is a temperature based calculation which shows the fraction of moisture present divided by the amount of moisture for saturated air at that temperature. The dew point is the temperature at which the existing moisture in the air would reach saturation, and below which moisture would begin to condense. Warm air will hold more moisture than cool air; thus, for a given mass of moisture in the atmosphere, relative humidity will increase as the air cools.

This phenomenon also explains much of the diurnal fluctuation in relative humidity observed in the region. Relative humidity maximums occur more frequently in early morning when temperatures are lowest, while minimums typically occur during the late afternoon when temperatures are highest. Figure 3.6-8 illustrates this pattern for the Gillette AP Site. Average annual readings are 70 percent and 43 percent for mornings and afternoons, respectively. Diurnal changes in relative humidity are compounded by seasonal variations. Mean monthly afternoon values at Gillette range from 24 percent in August to 62 percent in December while morning mean values range from 66 percent in August to 77 percent in May. Table 3.6-3 shows monthly average, average monthly maximum and average monthly minimum relative humidity values recorded for Casper and Gillette.

3.6.2.4 Precipitation

The region is characterized by generally dry conditions. On average, the region experiences only 40 to 60 days with measurable (>0.01 in) precipitation (WRCC, 2011). The Proposed Project region has an annual average precipitation ranging from 11 to 15 inches. Spring and early summer (May-July) thunderstorms produce roughly 45 percent of the precipitation. May is typically the wettest month of the year; all stations average more than two inches during this month. Winter months average the least, with most of the precipitation occurring as snow. January is the driest month of the year as values are generally one half inch or less. December through February typically account for only 10 percent of the yearly totals. A secondary minimum is also evident during August as warm air during the summer months promotes extremely stable conditions. Little precipitation occurs during this time as convective activity is limited. Severe weather does arise throughout the region, but is limited to four to five severe events per year. These severe events are generally split between hail and damaging wind events. Tornadoes can occur but on rare occasions, with less than one tornado per county per year (Martner, 1986). Figure 3.6-9 shows monthly average precipitation for the Gillette AP and Antelope Mine sites. Figure 3.6-11 interpolates annual averages across the region.

Major snowstorms (more than six in/day) are also frequent the region. The region surrounding Casper experiences one to two of these major snowstorms per year. Casper AP has the highest annual snowfall of all the regional sites considered, with an average of nearly 78 inches. This value is in sharp contrast to Lance Creek and Reno, which receive on average less than 30 inches of snow per year. Casper's high snowfall can attributed to its proximity to Casper Mountain. The city is located at the base of the northern slopes of the mountains and is influenced by snow events which occur as a result of orographic lifting. Figure 3.6-10 indicates that substantial monthly averages (more than three in/month) occur for over half the year and "measurable" averages (greater than one in/month) for at least 2/3 of the year. Figure 3.6-12 interpolates the regional average snowfall amounts based on those NWS stations with snow data available. The project region as a whole averages about 40 inches. This value agrees well with the Wyoming Climate Atlas (Martner, 1986) which lists averages for southwestern Campbell County at 40 to 50 inches.

3.6.2.5 Wind Patterns

Wyoming is windy and ranks first in the United States with an annual average speed of 12.9 mph (NUREG-1910, p.3.3-37). The Casper AP site averaged 12.8 mph for the 50+ years included in its climate database. The wind patterns throughout the region show very little variability. Strong southwesterly winds dominate the Casper area. More than 40 percent of the time the wind direction in Casper is from the southwest to west sectors and accompanying wind speeds are generally fairly high with averages greater than 12 mph nearly 65 percent of the time (Figure 3.6-13). Nearly five percent of the time, hourly wind speed averages exceed 25 mph. Winds at the Antelope Mine follow a similar pattern, although the dominant winds are shifted slightly to the westerly and west-southwesterly directions (Figure 3.6-14). At the Glenrock Mine this pattern is concentrated in the west-southwesterly direction (Figure 3.6-15), with the highest average wind speeds in the region.

Figure 3.6-16 shows mean monthly wind speeds at the four regional sites with available wind data. July has the lowest wind speeds, ranging from nine to 12 mph. January has the highest wind speeds, ranging from 11 to over 18 mph. Table 3.6-4 shows the monthly average wind speeds and peak gusts for Gillette AP, Antelope and Glenrock (NWS wind speeds at sites such as Gillette AP are recorded to the nearest mph). High wind events are a regular event as gust data from both Antelope and Glenrock show every month recording wind gusts greater than 40 mph.

3.6.3 Site Specific Analysis

On 10/06/2010 a 10 meter meteorological station (Figure 3.6-46) was installed within the Proposed Project area and is currently gathering site specific meteorological data. The Reno Creek meteorological station is located at N 43^{o} 34' 14.4'', W 105^{o} 49' 42.4'' (Figure 3.6-45). Parameters recorded at this station include wind speed, wind direction, ambient temperature, relative humidity, barometric pressure, solar radiation, precipitation and pan evaporation. Table 3.6-5 lists the instruments deployed at this site and the associated instrument specifications. While the Reno Creek meteorological station continues to collect hourly data, the baseline monitoring period for purposes of this study ran from October 6, 2010 to October 3, 2011. Figure 3.6-17 summarizes the on-site baseline monitoring results. Data recovery for all parameters ranged from 97 percent to 99 percent. Semiannual meteorological station audit records are presented in Appendix A of this document. AUC also conducted an analysis to demonstrate that the data from the on-site station for the baseline year is substantially representative of long term meteorological conditions, and that the MILDOS and other modeling are therefore appropriate and meaningful estimates of potential environmental effects.

The Antelope Coal Mine meteorological station was used as a reference for this site specific analysis due to its proximity to the proposed site and to its similar topography. Antelope Mine is located approximately 20 miles southeast of the Proposed Project site. While not intended to be strictly representative of Reno Creek, its proximity and similar topography qualify it as generally representative of the weather patterns in the project area. The Antelope Mine site, like the Proposed Project area, extends from the eastern slope of a ridge downward into drainage. Both sites are characterized by mildly rolling hills covered with grass, sagebrush and very sparse woody coverage.

3.6.3.1 Temperature

The average site temperature during the baseline monitoring year was 44.2 °F with temperatures for each site experiencing a maximum up to 95.9° F and minimum falling down to -25.1° F (Table 3.6-6). Monthly temperatures averaged 22.5° F in January and 71.5° in August. Temperatures at Antelope Mine during the same baseline period were very similar, as illustrated in Figure 3.6-18.

Figure 3.6-19 shows significant diurnal temperature variations at Reno Creek for each of the four seasons. Differences between daytime maximum and nighttime minimum temperatures were highest in the summer, at 27º F. The average diurnal temperature swing during the winter months averaged 11º F.

3.6.3.2 Relative Humidity

As with the regional analysis, relative humidity (RH) at the Proposed Project exhibited a strong inverse correlation with temperature. The highest RH values averaged from 68 percent on early summer mornings to 87 percent during early winter mornings (Figure 3.6-20). The lowest RH values averaged from 24 percent on summer afternoons to 57 percent on winter afternoons. This is typical of the entire region, where relative humidity maximums occur more frequently in early morning when temperatures are lowest, while minimums typically occur during the late afternoon. These diurnal changes are superimposed upon seasonal variations, which also depend on ambient temperatures.

3.6.3.3 Precipitation

Precipitation at Reno Creek during the baseline year totaled 13.4 inches. Precipitation records show a pronounced peak in May of 2011, when the area received over five inches of rain. With the exception of May and June, all other months recorded less than an inch of precipitation. Figure 3.6-21 shows monthly precipitation totals for both the Reno Creek and Antelope Mine sites for the baseline monitoring year. As with ambient temperatures, precipitation totals were very similar at the two sites.

3.6.3.4 Evaporation

To prevent instrument freeze-up, the Reno Creek pan evaporation gauge was only operated from April to October of 2011. Total pan evaporation during these seven months was approximately 48 inches. This is consistent with the Wyoming Climate Atlas, which shows 47 inches total for the same months at Gillette (Martner, 1986). Projecting these values over a full 12 months based on cold-weather evaporation rates at Casper, yields an annual evaporation for the project site of roughly 60 inches per year. Figure 3.6-22 shows the measured pan evaporation for Reno Creek, Casper and Gillette by month. Reno Creek data reflect only the baseline monitoring year. July of 2011 was unusually cool and moist in this region, resulting in uncharacteristically low evaporation. Typically, most evaporation occurs during the months of June through September with an average monthly rate of nearly 10 inches. This is the result of high temperatures, low humidity and relatively consistent winds. During the winter, less evaporation occurs because of low temperatures, periods of stable air, and low solar radiation.

3.6.3.5 Wind Patterns

Figures 3.6-23 shows the monthly average wind speeds at the Proposed Project and Antelope Mine monitoring sites. The patterns are remarkably similar, except that wind speeds at the Proposed Project area average nearly two mph higher than Antelope. This may be attributed to the slightly higher elevation and greater exposure of the Reno Creek met station. Both sites show maximum average wind speeds in February and minimum speeds in September.

Figure 3.6-24 presents the wind rose for the baseline monitoring year at the Proposed Project. Winds are predominantly from the west-southwest and southwest, with secondary modes from the northwest/north-northwest and southeast directions. Figures 3.6-25 through 3.6-28 show the quarterly wind roses for the Proposed Project. High pressure located over the southwestern United States causes the strong west/southwesterly winds which dominate the winter months and are also prominent in the fall. Spring and summer exhibit the greatest variability in wind direction. The secondary modes are a result of the synoptic scale transition period that occurs during this time. Low pressure regions develop on the lee side of the Rockies bringing southeast/easterly winds during development. As the low pressure systems form and move off with the general atmospheric flow, winds switch to a north-northwesterly direction.

Figure 3.6-29 summarizes the wind speed statistics at the Reno Creek meteorological station, as a function of wind direction. The highest average wind speeds of 16 to 17 mph occur from the southwest, west-southwest, and north-northwest directions. Winds from the east, east-northeast and northeast average less than 10 mph. Diurnal variations in wind speed are not pronounced, but in all but the summer season they show a maximum during the early to mid-afternoon hours (Figure 3.6-30). The average wind speed for the on-site meteorological station during the baseline monitoring year was 13.5 mph. The median speed was approximately 11.5 mph as indicated in the wind speed frequency distribution in Figure 3.6-31. This figure also shows two modes, at 6 and 10 mph.

The Joint Frequency Distributions (JFDs) for the Proposed Project, on-site monitoring station are provided in Tables 3.6-7 through 3.6-11. The first two tables present the JFD’s for the entire baseline monitoring period. The remaining tables present quarterly JFD’s for the same site. Each JFD shows the frequencies of average wind speed for each direction based on stability class. Stability class A represents the least stable, or most turbulent atmospheric conditions and stability class F represents the most stable conditions. Stability classes A, B, and C are shown in the first of each pair of tables, while classes D, E, and F are shown in the second table of each pair.

Atmospheric stability can be classified by one of several available methods. The Reno Creek monitoring station records hourly average standard deviation of horizontal wind speed (sigma theta), which provides the basis for one of these methods. Another method allows the use of solar radiation and vertical temperature gradient (SRDT). However, since this temperature gradient was not measured at the Proposed Project, only a hybrid between the sigma theta method and the SRDT method is possible. The hybrid method would employ solar radiation during the daytime and sigma theta during the nighttime hours. Figure 3.6-32 compares the results obtained from these two methods, which are similar. For simplicity and consistency, the sigma theta method was chosen for characterizing atmospheric stability at the Proposed Project. As demonstrated in Figure 3.6-32, stability class D accounts for roughly 70 percent of all of the hourly averages recorded during the baseline year. This is typical of eastern Wyoming. Stability class D represents near neutral to slightly unstable conditions. The light winds which accompany stable environments can be seen by stability class F, which accounts for less than three percent of the hourly averages.

3.6.3.6 Average Inversion and Mixing Layer Heights

Mixing height is the height of the atmosphere above the ground that is well mixed due either to mechanical turbulence or convective turbulence. The air layer above this height is stable. Higher mixing heights are associated with greater dispersion, all other parameters being the same. Stable periods have much lower mixing heights and accompanying lapse rates allowing for less temperature variation. The MILDOS-AREA model uses mixing height, along with other wind parameters, to predict pollutant dispersion. Unstable air leads to more dispersion, which leads to lower predicted impacts on ambient air quality. The default mixing height used by MILDOS-AREA is 100 meters, a very conservative value given that typical mixing heights exceed 1,000 meters.

The nearest upper-air data available from the National Weather Service are from Rapid City, South Dakota, approximately 150 miles east-northeast of the project area. Average mixing heights were derived from the AERMOD calculations used for dispersion modeling, based on hourly data obtained from the National Weather Service stations in Rapid City (upper air). The AERMOD calculation is based on a combination of mechanically and convectively driven boundary layer processes. The results of these calculations are provided for morning and afternoon in Table 3.6-12. The annual average mixing height is 1,110 meters, with morning mixing heights averaging 333 meters and afternoon mixing heights averaging 1,547 meters.

The Air Quality Division of the Wyoming Department of Environmental Quality (WDEQ-AQD) has provided statewide mixing heights to be used in dispersion modeling with the Industrial Source Complex (ISC3) model. These are based on the methods of Holzworth (1972) as applied to Lander, located in central Wyoming. For modeling purposes, the annual average mixing heights are assigned according to stability class as follows:

Class A	3,450 meters
Class B	2,300 meters
Class C	2,300 meters
Class D	2,300 meters
Class E	10,000 meters
Class F	10,000 meters

Stability classes E and F are given an arbitrarily high number to indicate the absence of a distinct boundary in the upper atmosphere. Based on the predominance of stability class D, data obtained from the NWS in Rapid City produce roughly half the mixing height used by WDEQ-AQD. The default MILDOS model mixing height is set at 100 meters, far more conservative than either of these sources.

3.6.3.7 Bodies of Water and Special Terrain Features

There are no major bodies of water affecting the meteorology of the Proposed Project site. The area is characterized by small, ephemeral streams and sparse stock ponds. The nearest perennial stream is the Powder River, approximately 25 miles west of the Proposed Project site. There are no major lakes within a 50 mile radius of the Proposed Project.

The nearest mountain ranges to this area are:

- Bighorn Mountains, approximately 60 miles west from the Proposed Project site and 80 miles northwest from Antelope Mine;
- Black Hills, approximately 100 miles east from Antelope Mine and 75 miles east from the Proposed Project site; and
- Northern Laramie Range, approximately 80 miles south of Proposed Project site and 80 miles southwest of Antelope Mine.

Due to these large distances, neither the Antelope site nor the Proposed Project site experiences significant wind channeling or shielding from any of the three mountain ranges.

3.6.3.8 Demonstration That the Baseline Year Represents Long Term

The Proposed Project is situated in central Wyoming. The baseline meteorological monitoring period extended approximately one year, from October 6, 2010 through October 3, 2011. To demonstrate that this baseline year is representative of the longer term wind and temperature conditions, the Antelope Mine meteorological monitoring site was analyzed. This site is approximately 20 miles southeast from the Proposed Project site. The closest NWS operated station which continuously records all weather parameters is the Gillette Airport, some 50 miles to the north. Among the weather stations in this region, the Antelope Mine is the closest to Reno Creek station. It also has similar topography and elevation. It was therefore selected as most representative of the proposed Reno Creek Project area meteorology. Available hourly data from Antelope span from 1986 to 2011 and therefore represent the last 25 years. These data were collected in accordance with EPA's On-Site Meteorological Program Guidance for Regulatory Modeling Applications (EPA, 2000). All meteorological instruments at the Antelope station meet or exceed NRC guidelines. Audit records for this station are presented in Appendix A to this document.

Figure 3.6-33 shows wind roses for Antelope. The wind rose on the left reflects 25 years of monitoring, while the one on the right reflects the baseline monitoring period only. It can be seen that wind speeds and directions are very similar between the 25 year and one year monitoring periods.

In order to quantify this similarity, it is useful to isolate wind speed and wind direction variables and correlate short-term and long-term frequency distributions. IML Air Science has developed a statistical methodology for assessing the degree to which the distributions of wind speed class and wind direction frequencies from baseline monitoring at a particular location represent the long-term distributions at that same location.

For the joint frequency wind distribution used in the MILDOS-AREA model, wind speeds are divided into six classifications ranging from mild (zero to three mph) to strong (> 24 mph) as illustrated in Tables 3.6-7 through 3.6-11. Figure 3.6-34 compares the frequency of occurrence of each of the six classifications during the one-year and 25-year periods. The percent of the time the wind speed falls within each of the six wind speed classes shown, is also quite similar for the two monitoring periods.

Likewise, wind directions are divided into 16 categories corresponding to the compass directions illustrated in the wind roses and in Figure 3.6-35. The percent of the time that winds occur in each of the six wind speed categories can be calculated to produce a wind speed frequency distribution. The percent of the time that winds blow from each of the sixteen directions can be calculated to produce a wind direction frequency distribution. For each parameter, the one-year and 25-year distributions can then be compared. Linear regression analysis provides a useful tool to assess the degree of correlation between short and long-term distributions.

Figure 3.6-36 presents this correlation for the wind speed distributions at Antelope. Each point represents one of the six wind speed classes. The "x" coordinate corresponds to the percent of the one-year period during which the wind speed fell in a given class, while the "y" coordinate corresponds to the percent of the 25-year period during which the wind speed fell in that same class. The regression line (red) in Figure 3.6-36 represents the least-squares fit to the six data points. The corresponding R^2 value of 0.99 implies very strong linear correlation between short and long-term wind speed classifications.

A similar analysis can be performed for wind direction frequencies. Figure 3.6-37 presents this correlation, again for the Antelope site. Each point represents one of the sixteen wind direction categories. The x coordinate corresponds to the percent of the one-year period during which the wind blew from a given direction, while the y coordinate corresponds to the percent of the 25-year period during which the wind blew from that same direction. The regression line (red) in Figure 3.6-37 represents the least-squares fit to the sixteen data points. The corresponding R^2 value of 0.96 implies very strong linear correlation between short and long-term wind direction classifications.

Figures 3.6-36 and 3.6-37 offer conclusive evidence that monitored wind conditions during the 2010-2011 baseline monitoring year adequately represent wind conditions over the last 25 years at the Antelope site. Since the one-year wind data serve as reliable predictors of the long-term wind conditions at Antelope, and since the proposed Reno Creek Project site experiences similar regional weather patterns, it is proposed here that the one-year baseline monitoring at the Proposed Project represents long-term wind conditions at that site.

A case has been made that Antelope Mine is representative of regional wind conditions and is exposed to the same general climate patterns as the proposed Reno Creek Project. The spatial correlation between these two sites, however, is not as strong as the temporal correlation demonstrated at the Antelope site. Figure 3.6-38 shows the wind speed distributions to be fairly similar between these two sites during the baseline year. Figure 3.6-39 shows the wind direction distributions to be somewhat similar between these two sites during the baseline year. Figure 3.6-40, however, shows the wind direction correlation to be much weaker than that shown in Figure 3.6-37. An R^2 value of 0.51 indicates only slight correlation.

This trend of weak spatial correlations and strong temporal correlations can be observed throughout the region. Variations in wind patterns from year to year rely on synoptic weather systems, which tend to deviate only mildly. On the other hand, wind variations from one location to another tend to be more pronounced, driven by localized effects such as elevation, surrounding topography, ground cover, etc.

The method used to correlate short and long-term wind speeds and directions can also be applied to monthly average temperatures. Figure 3.6-41 graphs these averages for the Antelope Mine site, demonstrating rough equivalence between the baseline monitoring year and the 25-year average. Figure 3.6-42 presents a linear regression analysis between short and long-term monthly average temperatures. An R^2 value of over 0.97 indicates strong correlation between the two time frames. Since the one-year temperature data serve as reliable predictors of the long-term temperatures at Antelope, and since the Proposed Project site experiences similar regional weather patterns, it is proposed here that the one-year baseline monitoring represents long-term temperatures at the proposed Reno Creek Project.

As a point of interest, average ambient temperatures tend to be less dependent on localized effects than wind conditions. Figure 3.6-43 graphs monthly average temperatures for the Proposed Project site and the Antelope Mine site during the baseline monitoring year. Since these sites have comparable elevations and topographic features and are only 20 miles apart, average temperatures between the two sites are quite similar. Figure 3.6-44 presents a linear correlation between monthly average temperatures at the Proposed Project and Antelope during the baseline monitoring year. An R^2 value of 0.99 represents nearly perfect correlation between the two sites. Unlike wind conditions, then, temperatures at Antelope are highly representative of temperatures at the Proposed Project.

A case has already been made that short-term wind speed and direction statistics closely represent long-term wind statistics at Antelope, and that its proximity and geographic similarity to the Proposed Project warrant a similar conclusion for that site. The same case has been made for temperature statistics. It has been further demonstrated that in the project vicinity temperatures correlate spatially as well as temporally. Since the spatial correlation is even stronger, it may be inferred that long-term temperatures at Antelope provide a better predictor of long-term temperatures at the Proposed Project than do baseline-year temperatures at the proposed Reno Creek Project. This distinction is mostly academic, as temporal and spatial correlations of monthly average temperatures both yield high R^2 values.

3.6.4 Air Quality

The Proposed Project is located in and adjacent to counties that are designated as attainment with EPA National Ambient Air Quality Standards (NAAQS) for all criteria pollutants. The nearest and only designated nonattainment areas in Wyoming are the city of Sheridan, in Sheridan County and the Upper Green River Basin Area in Lincoln, Sublette, and Sweetwater Counties (EPA, 2012). The city of Sheridan is approximately 102 miles northwest of the Proposed Project, The Upper Green River Basin is over 200 miles southwest. The terrain within the region where the proposed site is located, combined with windy conditions can potentially provide good conditions for dispersion of air pollutants (BLM, 2003). The nearest residence to the Proposed Project in each compass sector are listed in ER Table 3.1-3. Potential air emissions for the Proposed Project are described in Section 4.6.

As discussed in GEIS Section 3.3.6.2, the EPA has established air quality standards to promote and sustain healthy living conditions. These standards, known as NAAQS, address six pollutants EPA refers to as criteria pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (N02), particulate matter (PM_{10} and $PM_{2.5}$), ozone (0_3), and sulfur dioxide ($S0_2$). EPA revised the NAAQS standards after the preparation of the GEIS. This includes a new rolling 3-month average standard for lead at 0.15 $\mu g/m^3$ and a new 1-hour nitrogen dioxide standard at 100 parts per billion. WDEQ adopted the EPA NAAQS, as summarized in the GEIS (NRC, 2009, Table 3.2-8). States may develop standards that are stricter than, or that supplement, the NAAQS. Wyoming has a more restrictive standard for sulfur dioxide (annual at *60* $\mu g/m^3$ and 24-hour at 260 $\mu g/m^3$*)* and supplemental standards for particulate matter (annual PM_{10} at 50 $\mu g/m^3$ and 24 hour $PM_{2.5}$ at 35 $\mu g/m^3$*)* (WDEQ, 2012). The principal nonradiological emissions from activities at the Proposed Project include diesel combustion engine emissions and fugitive road dust (particulate matter) described in Section 4.6.

Particulate matter (PM) refers to particles found in the air. Some particles are large enough to be seen as dust, soot, or smoke, while others are too small to be visible. As noted previously, NAAQS for PM_{10} and $PM_{2.5}$ limit the allowable concentration of PM particles to smaller than 10 and 2.5 µm. Emissions from highway and nonroad construction vehicles comprise approximately 28 percent of total PM_{10} and $PM_{2.5}$ emissions. The largest source of PM includes fugitive dust from paved and unpaved roads, agricultural and forestry activities, wind erosion, wildfires, and managed burning.

The WDEQ Air Quality Division analyzes measurements from 26 stations located throughout Wyoming to ensure ambient air quality is maintained, in accordance with NAAQS. The results are synthesized into the Wyoming Ambient Air Monitoring Annual Network Plan (WDEQ, 2009). The baseline air quality conditions of the Proposed Project were determined by evaluating data from several monitoring stations in the region to provide a reasonable representation of the air pollutant levels that could be expected to occur at the site. Additionally, meteorological station information from Reno Creek was obtaining as site specific baseline data. Furthermore, the GEIS reported that all areas within the Wyoming East Uranium Milling Region were classified as being in attainment for NAAQS (NRC, 2009).

As discussed in GEIS Section 3.3.6.2, of the Prevention of Significant Deterioration (PSD) requirements identify maximum allowable increases in concentrations for particulate matter, $S0_2$, and NO_2 for areas designated as attainment. There are several different classes of PSD areas, with Class I areas having the most stringent requirements. GEIS Table 3.4-9 identifies the Class I areas in Wyoming, South Dakota, Montana, and Nebraska. GEIS Figures 3.2-16 and 3.4-20 map the locations of Class I areas. Wind Cave National Park, the closest Class I area to the Proposed Project, is located approximately

113 miles to the east of the Proposed Project. Cloud Peak Wilderness Area, the closest Class II area to the Proposed Project, is located approximately 105 miles to the northwest of the Proposed Project.

Table 3.6-1: Meteorological Stations Included in Climate Analysis

Name	Agency	Lat	Long	Elev (ft)	Years Operation	Wind Spd	Wind Dir	Temp	Precip	Evap	RH	Snow
Casper AP	NWS	42.91	-106.47	5338	1948-2005	X	X	X	X	X	X	X
Douglas	NWS	42.74	-105.39	4820	1909-2005	X	X	X	X	X	X	X
Dull Center	NWS	43.41	-104.96	4420	1926-2005			X	X			
Glenrock 5 ESE	NWS	42.83	-105.79	4950	1941-2005			X	X			X
Kaycee	NWS	43.71	-106.64	4660	1900-2005			X	X			
Lance Creek 3 WNW	NWS	43.05	-104.70	4340	1962-1984			X	X			
Midwest	NWS	43.42	-106.27	4820	1939-2005			X	X			
Newcastle	NWS	43.87	-104.21	4314	1952-2005			X	X			X
Reno	NWS	43.47	-105.54	5080	1963-1983			X	X			
Torrington	NWS	42.49	-104.15	4859	1994-2005			X	X			X
Reno Creek Met	NRC	43.68	-105.52	5080	2010-2011	X	X	X	X	X	X	
Gillette AP	NWS	44.34	-105.54	4354	1902-2009	X	X	X	X	X	X	X
Devils Tower	NWS	44.58	-104.71	3862	1959-2009			X	X			
Weston	NWS	44.64	-105.30	3530	1951-2009			X	X			X
Moorcroft	NWS	44.27	-104.95	4262	1903-2009			X	X			X
Gillette ESE	NWS	44.26	-105.49	4640	1931-2009			X	X			
Echeta	NWS	44.47	-105.91	4000	1949-2009			X	X			X
Leiter	NWS	44.84	-106.29	4160	1945-2009			X	X			
Hulett	NWS	44.70	-104.60	3758	1945-2010			X	X			X
Sundance	NWS	44.41	-104.35	4200	1945-2010			X	X			X
Antelope Coal Mine	EPA	43.50	-105.32	4675	1986-2011	X	X	X	X			
Glenrock Coal Mine	EPA	43.06	-105.84	5674	1996-2010	X	X	X	X			

Sources: National Climatic Data Center, 2011; IML Air Science, 2011 NAD 83

Table 3.6-2: Monthly Temperature Statistics for Region

MONTH	Average Temperature (°F)			Average Daily Minimum Temperature (°F)			Average Daily Maximum Temperature (°F)		
	Antelope Coal	Glenrock Coal	Casper AP	Antelope Coal	Glenrock Coal	Casper AP	Antelope Coal	Glenrock Coal	Casper AP
Jan	25.2	26.9	23.4	15.9	17.8	13.0	35.5	32.2	33.7
Feb	25.9	27.2	27.1	17.1	19.5	16.4	37.1	34.1	37.8
Mar	33.5	34.6	33.7	24.3	24.4	21.6	45.9	42.3	45.8
Apr	43.4	44.1	42.7	32.2	32.7	29.3	54.2	50.1	56.1
May	53.3	53.1	52.5	41.6	42.1	38.3	63.5	61.0	66.7
Jun	63.1	63.2	62.7	50.8	50.5	46.9	74.9	71.4	78.6
Jul	73.8	74.5	70.9	58.0	60.0	54.1	84.5	82.0	87.7
Aug	70.3	70.4	69.2	56.6	57.7	52.5	83.5	78.9	85.8
Sep	59.3	60	58.4	45.5	48.5	42.4	72.4	68.2	74.4
Oct	44.3	45.2	46.5	33.8	36.5	32.5	58.0	54.2	60.5
Nov	35.5	36.9	33.4	24.3	27.0	22.2	44.4	42.4	44.6
Dec	24.3	26.1	25	15.7	17.6	14.9	35.3	30.9	35.2
Year-Round	46.0	46.9	46.5	34.6	36.2	32.0	57.4	54.0	58.9

Table 3.6-3: Monthly and Relative Humidity Statistics for Region

MONTH	Average Relative Humidity (%)		Average Daily Minimum Relative Humidity (%)		Average Daily Maximum Relative Humidity (%)	
	Casper AP	Gillette AP	Casper AP	Gillette AP	Casper AP	Gillette AP
Jan	64.4	61.4	51.3	46.2	78.2	78.7
Feb	62.7	64.5	47.5	44.1	78.0	82.0
Mar	57.1	61.2	34.4	34.4	79.7	81.8
Apr	59.8	60.8	32.7	38.2	86.8	84.1
May	62.0	62.5	36.8	36.0	88.1	87.7
Jun	55.8	59.2	26.6	33.5	87.5	86.7
Jul	46.5	46.7	19.1	22.5	76.8	76.7
Aug	37.0	47.9	16.0	21.8	68.5	78.1
Sep	39.3	49.7	16.3	26.1	69.2	76.5
Oct	60.2	63.2	33.9	35.5	81.8	83.8
Nov	55.3	56.8	33.9	36.4	75.5	80.1
Dec	68.2	64.3	54.4	46.6	81.3	78.8
Year-Round	55.7	58.2	33.6	35.1	79.3	81.3

Table 3.6-4: Monthly Wind Speed Statistics for Region

MONTH	Average Wind Speed (mph)			Maximum Wind Speed (mph)		
	Antelope Mine	Glenrock Mine	Gillette AP	Antelope Mine	Glenrock Mine	Gillette AP
Jan	12.5	17.5	12.4	50.6	59.4	46.0
Feb	11.5	16.3	10.7	44.0	57.6	48.0
Mar	11.8	15.6	11.6	50.7	53.4	43.0
Apr	11.7	14.9	11.5	45.1	51.8	35.0
May	11.2	13.8	10.7	46.3	55.6	39.0
Jun	10.2	13.3	9.0	42.5	45.2	38.0
Jul	9.3	11.7	8.8	41.7	41.4	32.0
Aug	9.1	12.1	9.1	47.3	45.2	33.0
Sep	9.1	12.9	9.8	41.6	50.6	33.0
Oct	10.2	14.6	10.4	42.6	52.7	38.0
Nov	11.9	16.2	11.1	41.9	55.3	41.0
Dec	12.8	18.4	11.1	51.7	55.4	36.0
Year-Round	10.9	14.8	10.5	45.5	52.0	48.0

Table 3.6-5: Proposed Project Meteorological Station Instrument Specifications

Parameter	Instrument	Range	Accuracy	Threshold	Instrument Height
Wind Speed	RM Young 05305 Wind Monitor AQ	0 to 112 mph	±0.4 mph or 1% of reading	0.9 mph	10 meters
Wind Direction	RM Young 05305 Wind Monitor AQ	0 to 360º	±3º	1.0 mph	10 meters
Temperature	Fenwal 107 Temperature Probe	-35º to 50º C	±0.2º C @ 0 - 60º C, ±0.4º C @ -35º C	-- º C	2 meters
Relative Humidity	Vaisalla HMP50-L15 Temp and RH Probe	0 to 98%	±3% at 20 º C	--	2 meters
Barometric Pressure	Campbell Scientific CS-106 BP sensor	500-1100 millibars	±0.3 mb at 20 º C	--	2 meters
Precipitation	Hydrologic Services TB3/0.01P Tipping Bucket Rain Gauge	Temp: -20ºto 50º C	±0.5% @ 0.5 in/hr rate	--	1 meter
Evaporation	Novalynx 255-100 Evaporation Gauge	0 to 944"	0.25%	--	1 meter
Evaporation Pan Temperature Gauge	Fenwal 107 Temperature Probe	-35º to 50º C	±0.2º C @ 0 - 60º C, ±0.4º C @ -35º C	--	1 meter
Solar Radiation	LI-COR LI200X Solar Radiation Sensor	0 to 3000 watts/m^2	± 5%	--	1 meter
Data Logger	Campbell Scientific CR1000 Data Logger	--	--	--	--

Table 3.6-6: Proposed Project Monthly Temperature Statistics

Month	Average Temperature (°F)	Minimum Temperature (°F)	Maximum Temperature (°F)
Jan	22.5	-19.9	43.5
Feb	20.1	-25.1	50.0
Mar	34.3	4.2	59.6
Apr	38.5	17.1	72.6
May	45.2	25.3	71.7
Jun	59.5	39.1	89.7
Jul	72.2	50.6	95.9
Aug	71.5	48.8	95.3
Sep	60.7	35.9	86.7
Oct	49.9	26.1	86.4
Nov	30.3	-12.1	71.3
Dec	25.9	-7.6	48.7
Year-Round	44.2	15.2	72.6

Table 3.6-7: Proposed Project Baseline Year Joint Frequency Distribution

Stability Class	Wind Direction	Wind Speed (mph) - Annual Average						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
A	N	0.000346	0.001384					0.001730
	NNE	0.000461	0.000807					0.001269
	NE	0.000461	0.000692					0.001153
	ENE	0.000461	0.000923					0.001384
	E	0.000231	0.001269					0.001499
	ESE	0.000461	0.001153					0.001615
	SE	0.000807	0.001269					0.002076
	SSE	0.000692	0.002537					0.003230
	S	0.000231	0.002076					0.002307
	SSW	0.000461	0.000923					0.001384
	SW	0.000807	0.002422					0.003230
	WSW	0.000807	0.001730					0.002537
	W	0.000346	0.001499					0.001845
	WNW	0.000577	0.001384					0.001961
	NW	0.000346	0.003114					0.003460
	NNW	0.000231	0.003230					0.003460
B	N	0.000231	0.000923	0.000115				0.001269
	NNE		0.000807	0.000115				0.000923
	NE	0.000115	0.000577	0.000115				0.000807
	ENE	0.000231	0.000461	0.000346				0.001038
	E	0.000231	0.000577					0.000807
	ESE	0.000115	0.000692					0.000807
	SE	0.000346	0.002191					0.002537
	SSE		0.002422	0.000231				0.002653
	S		0.001961	0.000231				0.002191
	SSW		0.001499	0.000115				0.001615
	SW	0.000115	0.001384					0.001499
	WSW	0.000115	0.001845	0.000577				0.002537
	W	0.000115	0.002422	0.000115				0.002653
	WNW	0.000346	0.002422	0.000231				0.002999
	NW	0.000115	0.002884	0.000231				0.003230
	NNW	0.000115	0.001730	0.000577				0.002422
C	N	0.000115	0.000461	0.003460				0.004037
	NNE		0.000577	0.001153				0.001730
	NE		0.000461	0.001615				0.002076
	ENE	0.000115	0.000461	0.000461				0.001038
	E	0.000231	0.000692	0.001153				0.002076
	ESE	0.000346	0.000692	0.001153				0.002191
	SE		0.001730	0.001845				0.003576
	SSE	0.000115	0.001384	0.003345				0.004844
	S		0.000461	0.001961				0.002422
	SSW		0.000692	0.002884				0.003576
	SW		0.000692	0.004037				0.004729
	WSW	0.000231	0.000923	0.004498				0.005652
	W	0.000115	0.000461	0.005306				0.005882
	WNW	0.000461	0.001269	0.004844				0.006574
	NW		0.001153	0.004844				0.005998
	NNW		0.001038	0.005652				0.006690

Table 3.6-7: Proposed Project Baseline Year Joint Frequency Distribution (cont.)

Stability Class	Wind Direction	Wind Speed (mph) - Annual Average						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
D	N	0.000231	0.002191	0.011880	0.009343	0.002884	0.000115	0.026644
	NNE	0.000231	0.001961	0.008304	0.005998	0.000231		0.016724
	NE	0.000115	0.001384	0.005536	0.001499	0.000115		0.008651
	ENE	0.000115	0.002307	0.003230	0.001269	0.000115		0.007036
	E	0.000346	0.003460	0.005767	0.003460	0.000346		0.013379
	ESE	0.000346	0.006805	0.019377	0.012457	0.003691	0.000807	0.043483
	SE	0.000115	0.007151	0.025721	0.020761	0.004037	0.001615	0.059400
	SSE	0.000231	0.005075	0.014533	0.010035	0.000231	0.000115	0.030219
	S		0.003114	0.010381	0.007958	0.000577	0.000115	0.022145
	SSW	0.000115	0.001961	0.008766	0.008881	0.002076	0.000346	0.022145
	SW	0.000923	0.003691	0.022376	0.049481	0.022261	0.011303	0.110035
	WSW	0.001730	0.009573	0.025836	0.044637	0.027105	0.011880	0.120761
	W	0.001845	0.012687	0.016494	0.013495	0.004037	0.001845	0.050404
	WNW	0.001961	0.012457	0.014648	0.012803	0.003576	0.001038	0.046482
	NW	0.000923	0.009112	0.018454	0.024567	0.010727	0.003691	0.067474
	NNW	0.000461	0.005190	0.016378	0.025836	0.016840	0.005536	0.070242
E	N	0.000346	0.001038	0.000461				0.001845
	NNE	0.000231	0.001384	0.002422				0.004037
	NE	0.000577	0.002076	0.002422				0.005075
	ENE	0.000231	0.002191	0.001153				0.003576
	E	0.000115	0.004268	0.001845				0.006228
	ESE		0.005536	0.006920				0.012457
	SE		0.003922	0.006805				0.010727
	SSE	0.000231	0.002422	0.001961				0.004614
	S	0.000577	0.002076	0.002653				0.005306
	SSW		0.001615	0.001961				0.003576
	SW	0.000461	0.003345	0.005536				0.009343
	WSW	0.001153	0.007843	0.006920				0.015917
	W	0.000923	0.010842	0.003230				0.014994
	WNW	0.001615	0.008651	0.005767				0.016032
	NW	0.000807	0.007843	0.004498				0.013149
	NNW	0.000231	0.003691	0.003922				0.007843
F	N	0.000577	0.000692					0.001269
	NNE	0.000692	0.000231					0.000923
	NE	0.000577	0.000577					0.001153
	ENE	0.000577	0.000346					0.000923
	E	0.000807	0.000231					0.001038
	ESE	0.000692	0.000346					0.001038
	SE	0.000577	0.000923					0.001499
	SSE	0.000692	0.000461					0.001153
	S	0.000923	0.001269					0.002191
	SSW	0.000577	0.001153					0.001730
	SW	0.000692	0.000461					0.001153
	WSW	0.000692	0.000923					0.001615
	W	0.001269	0.000807					0.002076
	WNW	0.001499	0.001153					0.002653
	NW	0.000692	0.001038					0.001730
	NNW	0.000461	0.000231					0.000692

Table 3.6-8: Proposed Project 1st Quarter Joint Frequency Distribution

Stability Class	Wind Direction	Wind Speed (mph) - Winter < 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	Row Total
A	N							
	NNE		0.000926					0.000926
	NE							
	ENE	0.000463	0.000926					0.001389
	E	0.000463	0.000926					0.001389
	ESE	0.000926	0.000463					0.001389
	SE	0.000463	0.000463					0.000926
	SSE		0.000926					0.000926
	S		0.000926					0.000926
	SSW							
	SW	0.000463	0.000463					0.000926
	WSW	0.000926						0.000926
	W							
	WNW	0.000463	0.000463					0.000926
	NW		0.001389					0.001389
	NNW		0.001852					0.001852
B	N							
	NNE		0.001389					0.001389
	NE		0.000463					0.000463
	ENE							
	E	0.000463	0.000463					0.000926
	ESE		0.000463					0.000463
	SE	0.000463	0.000463					0.000926
	SSE		0.000926					0.000926
	S			0.000463				0.000463
	SSW							
	SW	0.000463						0.000463
	WSW			0.000463				0.000463
	W		0.001389					0.001389
	WNW		0.000926					0.000926
	NW		0.000926					0.000926
	NNW		0.000926					0.000926
C	N	0.000463	0.000463					0.000926
	NNE			0.000463				0.000463
	NE							
	ENE							
	E	0.000463	0.000463					0.000926
	ESE	0.000463	0.000463					0.000926
	SE		0.003241	0.000926				0.004167
	SSE		0.000463	0.000463				0.000926
	S		0.000463	0.000463				0.000926
	SSW			0.001389				0.001389
	SW		0.000463	0.000926				0.001389
	WSW	0.000463	0.000463	0.000926				0.001852
	W			0.003241				0.003241
	WNW	0.000463	0.001389	0.001852				0.003704
	NW		0.000463	0.001852				0.002315
	NNW		0.000926	0.001852				0.002778

Table 3.6-8: Proposed Project 1st Quarter Joint Frequency Distribution (cont.)

Stability Class	Wind Direction	Wind Speed (mph) - Winter						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
D	N		0.003704	0.014815	0.006944	0.001389	0.000463	0.027315
	NNE	0.000926	0.001852	0.005093	0.003704			0.011574
	NE	0.000463	0.000463	0.003704	0.001852			0.006481
	ENE			0.002315				0.002315
	E	0.000463	0.001852	0.006019	0.001852			0.010185
	ESE		0.004167	0.018056	0.009259	0.001389		0.032870
	SE	0.000463	0.005556	0.020370	0.016667	0.001852		0.044907
	SSE		0.002315	0.011574	0.003704			0.017593
	S		0.003241	0.007870	0.006019			0.017130
	SSW	0.000463	0.002778	0.007407	0.006481	0.000463	0.000463	0.018056
	SW	0.000926	0.002778	0.030556	0.085185	0.040278	0.017593	0.177315
	WSW	0.002315	0.007870	0.037963	0.074537	0.061574	0.023148	0.207407
	W	0.001852	0.007870	0.023148	0.013426	0.004630	0.002778	0.053704
	WNW	0.001852	0.008796	0.017593	0.017593	0.005556	0.000926	0.052315
	NW	0.000926	0.009259	0.018981	0.032870	0.008796	0.000926	0.071759
	NNW		0.006944	0.019907	0.024537	0.012500	0.002315	0.066204
E	N		0.001389	0.000926				0.002315
	NNE		0.000926	0.001389				0.002315
	NE	0.000463	0.001852	0.001389				0.003704
	ENE		0.000926	0.000463				0.001389
	E	0.000463	0.001389	0.000926				0.002778
	ESE		0.003704	0.005093				0.008796
	SE		0.004630	0.002778				0.007407
	SSE		0.001389	0.001389				0.002778
	S	0.000926	0.003241	0.001852				0.006019
	SSW		0.001852	0.002315				0.004167
	SW		0.003241	0.003704				0.006944
	WSW	0.001389	0.004630	0.009259				0.015278
	W	0.000463	0.004630	0.003704				0.008796
	WNW	0.001852	0.008333	0.006019				0.016204
	NW	0.000926	0.006944	0.007407				0.015278
	NNW		0.002315	0.003241				0.005556
F	N	0.000463	0.000463					0.000926
	NNE	0.000926						0.000926
	NE	0.001389						0.001389
	ENE	0.000463						0.000463
	E	0.002315						0.002315
	ESE	0.000463						0.000463
	SE	0.001852	0.001852					0.003704
	SSE	0.000463	0.000463					0.000926
	S							
	SSW	0.001389						0.001389
	SW		0.000463					0.000463
	WSW	0.000926	0.000463					0.001389
	W	0.001852	0.000926					0.002778
	WNW	0.003241	0.000926					0.004167
	NW	0.000926	0.000463					0.001389
	NNW							

Table 3.6-9: Proposed Project 2nd Quarter Joint Frequency Distribution

Stability Class	Wind Direction	Wind Speed (mph) - Spring						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
A	N	0.000917	0.000917					0.001834
	NNE	0.000459	0.000459					0.000917
	NE	0.001376						0.001376
	ENE	0.001376	0.001376					0.002751
	E		0.000459					0.000459
	ESE		0.000917					0.000917
	SE	0.000917	0.000917					0.001834
	SSE		0.001834					0.001834
	S		0.001834					0.001834
	SSW		0.001376					0.001376
	SW	0.000917	0.000917					0.001834
	WSW		0.000459					0.000459
	W		0.001376					0.001376
	WNW	0.000917	0.000917					0.001834
	NW		0.003210					0.003210
	NNW	0.000459	0.001376					0.001834
B	N	0.000459	0.000917					0.001376
	NNE		0.000459	0.000459				0.000917
	NE		0.000917					0.000917
	ENE		0.000459					0.000459
	E		0.000917					0.000917
	ESE							
	SE		0.003668					0.003668
	SSE		0.002751	0.000917				0.003668
	S		0.001834	0.000459				0.002293
	SSW		0.001376					0.001376
	SW		0.001376					0.001376
	WSW	0.000459	0.000917					0.001376
	W		0.003210					0.003210
	WNW		0.001376					0.001376
	NW		0.004585					0.004585
	NNW	0.000459	0.002293	0.000459				0.003210
C	N		0.000459	0.004585				0.005044
	NNE		0.001376	0.001376				0.002751
	NE		0.000917	0.002293				0.003210
	ENE		0.000917	0.000917				0.001834
	E		0.000459	0.001834				0.002293
	ESE		0.000917	0.002293				0.003210
	SE			0.002293				0.002293
	SSE		0.000917	0.004127				0.005044
	S		0.000917	0.004127				0.005044
	SSW		0.001376	0.003210				0.004585
	SW		0.000459	0.005961				0.006419
	WSW		0.000917	0.005502				0.006419
	W		0.000459	0.005044				0.005502
	WNW		0.000917	0.006419				0.007336
	NW		0.000459	0.005961				0.006419
	NNW		0.001376	0.006419				0.007795

Table 3.6-9: Proposed Project 2nd Quarter Joint Frequency Distribution (cont.)

Stability Class	Wind Direction	Wind Speed (mph) - Spring						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
D	N	0.000459	0.001376	0.021550	0.015131	0.001834		0.040348
	NNE		0.001834	0.013755	0.011463			0.027052
	NE		0.002751	0.011463	0.000917			0.015131
	ENE		0.002751	0.003668	0.003210			0.009629
	E		0.005502	0.004585	0.009629	0.000459		0.020174
	ESE		0.004585	0.016048	0.015589	0.007795	0.003210	0.047226
	SE		0.005044	0.025218	0.033012	0.012838	0.006419	0.082531
	SSE		0.004127	0.016048	0.008253			0.028427
	S		0.001834	0.008712	0.005502	0.000459		0.016506
	SSW		0.000917	0.005961	0.004585	0.001834		0.013297
	SW	0.000917	0.001376	0.013297	0.030261	0.019257	0.007336	0.072444
	WSW	0.001376	0.009170	0.019257	0.027052	0.011921	0.012838	0.081614
	W	0.001376	0.012838	0.014672	0.017423	0.007795	0.004585	0.058689
	WNW	0.002293	0.013297	0.012380	0.012838	0.005502	0.003210	0.049519
	NW	0.000917	0.011463	0.018340	0.031637	0.013297	0.009170	0.084823
	NNW	0.000459	0.006419	0.022925	0.040807	0.019716	0.007336	0.097662
E	N	0.000459	0.001376					0.001834
	NNE		0.001376	0.001376				0.002751
	NE		0.000917	0.003668				0.004585
	ENE		0.001834	0.001834				0.003668
	E		0.004585	0.000459				0.005044
	ESE		0.008712	0.005502				0.014214
	SE		0.001376	0.002751				0.004127
	SSE		0.002751	0.002293				0.005044
	S		0.000917	0.001834				0.002751
	SSW		0.000459	0.000459				0.000917
	SW		0.003210	0.004585				0.007795
	WSW	0.001834	0.004585	0.004127				0.010546
	W	0.001376	0.005961	0.001834				0.009170
	WNW	0.001834	0.005502	0.004585				0.011921
	NW		0.005502	0.004127				0.009629
	NNW		0.005961	0.006878				0.012838
F	N	0.000459	0.000459					0.000917
	NNE	0.000459	0.000459					0.000917
	NE	0.000459	0.000459					0.000917
	ENE							
	E							
	ESE	0.000459	0.000917					0.001376
	SE		0.000459					0.000459
	SSE	0.000459	0.000459					0.000917
	S	0.000917	0.000917					0.001834
	SSW		0.000917					0.000917
	SW	0.000917						0.000917
	WSW	0.000917						0.000917
	W	0.001376	0.000917					0.002293
	WNW	0.000917	0.000459					0.001376
	NW	0.000459	0.001376					0.001834
	NNW	0.000459	0.000459					0.000917

Table 3.6-10: Proposed Project 3rd Quarter Joint Frequency Distribution

Stability Class	Wind Direction	Wind Speed (mph) - Summer < 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	Row Total
A	N		0.004076					0.004076
	NNE	0.001359	0.001812					0.003170
	NE		0.002264					0.002264
	ENE		0.001359					0.001359
	E	0.000453	0.002717					0.003170
	ESE	0.000453	0.002264					0.002717
	SE	0.001812	0.003170					0.004982
	SSE	0.001812	0.006341					0.008152
	S		0.004076					0.004076
	SSW	0.001359	0.001812					0.003170
	SW	0.001359	0.004529					0.005888
	WSW	0.001812	0.004076					0.005888
	W	0.000906	0.004529					0.005435
	WNW	0.000906	0.002717					0.003623
	NW	0.000906	0.007246					0.008152
	NNW	0.000453	0.009058					0.009511
B	N		0.002264	0.000453				0.002717
	NNE		0.001359					0.001359
	NE		0.000906	0.000453				0.001359
	ENE		0.001359	0.001359				0.002717
	E		0.000453					0.000453
	ESE	0.000453	0.001812					0.002264
	SE	0.000453	0.004076					0.004529
	SSE		0.004982					0.004982
	S		0.002717					0.002717
	SSW		0.004076	0.000453				0.004529
	SW		0.001812					0.001812
	WSW		0.003623	0.001812				0.005435
	W		0.004076					0.004076
	WNW		0.006341	0.000906				0.007246
	NW	0.000453	0.004982	0.000906				0.006341
	NNW		0.003170	0.001812				0.004982
C	N		0.000453	0.009058				0.009511
	NNE		0.000453	0.002717				0.003170
	NE		0.000906	0.003623				0.004529
	ENE		0.000906	0.000906				0.001812
	E	0.000453	0.000453	0.002717				0.003623
	ESE	0.000453		0.000906				0.001359
	SE		0.001812	0.003170				0.004982
	SSE		0.002717	0.007699				0.010417
	S		0.000453	0.002264				0.002717
	SSW		0.000906	0.004529				0.005435
	SW		0.001812	0.008152				0.009964
	WSW		0.000453	0.010870				0.011322
	W	0.000453	0.000453	0.011775				0.012681
	WNW	0.000453	0.000453	0.009511				0.010417
	NW		0.000906	0.009964				0.010870
	NNW		0.000906	0.011322				0.012228

Table 3.6-10: Proposed Project 3rd Quarter Joint Frequency Distribution (cont.)

Stability Class	Wind Direction	Wind Speed (mph) - Summer						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
D	N		0.002264	0.009058	0.011322	0.003623		0.026268
	NNE		0.001359	0.012681	0.007246	0.000906		0.022192
	NE		0.002264	0.006793	0.003170	0.000453		0.012681
	ENE	0.000453	0.005435	0.006793	0.001812	0.000453		0.014946
	E		0.004076	0.009964	0.001812	0.000906		0.016757
	ESE	0.000906	0.010870	0.030797	0.019475	0.001812		0.063859
	SE		0.009058	0.038496	0.024004			0.071558
	SSE		0.006793	0.018569	0.020380	0.000453		0.046196
	S		0.002717	0.011322	0.011322	0.000453		0.025815
	SSW		0.000906	0.010417	0.009964	0.000906	0.000453	0.022645
	SW	0.001812	0.002264	0.016304	0.021739	0.005888		0.048007
	WSW	0.001359	0.004076	0.017210	0.024909	0.008152		0.055707
	W	0.002264	0.010870	0.014493	0.013134	0.001812		0.042572
	WNW	0.001359	0.010870	0.009511	0.008152	0.000453		0.030344
	NW	0.000906	0.005435	0.011322	0.007246	0.004076		0.028986
	NNW	0.000453	0.002264	0.012681	0.015399	0.005435	0.001812	0.038043
E	N		0.000906	0.000906				0.001812
	NNE	0.000906	0.001359	0.005888				0.008152
	NE	0.000453	0.004529	0.003623				0.008605
	ENE	0.000906	0.004076	0.001812				0.006793
	E		0.009964	0.004982				0.014946
	ESE		0.005888	0.014946				0.020833
	SE		0.004076	0.011322				0.015399
	SSE	0.000453	0.000906	0.001359				0.002717
	S	0.000453	0.002264	0.002717				0.005435
	SSW		0.002264	0.003623				0.005888
	SW	0.000906	0.000906	0.002717				0.004529
	WSW		0.008605	0.004982				0.013587
	W	0.001359	0.014946	0.002264				0.018569
	WNW	0.000453	0.007246	0.003623				0.011322
	NW	0.000906	0.007699	0.002264				0.010870
	NNW	0.000453	0.002717	0.002264				0.005435
F	N	0.000906	0.001812					0.002717
	NNE	0.000453	0.000453					0.000906
	NE		0.001812					0.001812
	ENE	0.001359	0.001359					0.002717
	E	0.000453	0.000906					0.001359
	ESE	0.000906	0.000453					0.001359
	SE	0.000453	0.000906					0.001359
	SSE	0.001359						0.001359
	S	0.000906	0.002717					0.003623
	SSW	0.000453	0.002264					0.002717
	SW	0.000906	0.000906					0.001812
	WSW		0.002264					0.002264
	W	0.000453						0.000453
	WNW	0.001359	0.001359					0.002717
	NW	0.000453	0.001812					0.002264
	NNW	0.000453	0.000453					0.000906

Table 3.6-11: Proposed Project 4th Quarter Joint Frequency Distribution

Stability Class	Wind Direction	Wind Speed (mph) - Fall						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
A	N	0.000486	0.000486					0.000971
	NNE							
	NE	0.000486	0.000486					0.000971
	ENE							
	E		0.000486					0.000486
	ESE	0.000486	0.000486					0.000971
	SE							
	SSE	0.000971	0.000971					0.001943
	S	0.000971	0.001457					0.002428
	SSW		0.000486					0.000486
	SW	0.000486	0.003400					0.003885
	WSW	0.000486	0.002428					0.002914
	W	0.000486						0.000486
	WNW		0.001457					0.001457
	NW	0.000486	0.000486					0.000971
	NNW		0.000486					0.000486
B	N	0.000486	0.000486					0.000971
	NNE							
	NE	0.000486						0.000486
	ENE	0.000971						0.000971
	E	0.000486	0.000486					0.000971
	ESE		0.000486					0.000486
	SE	0.000486	0.000486					0.000971
	SSE		0.000971					0.000971
	S		0.003400					0.003400
	SSW		0.000486					0.000486
	SW		0.002428					0.002428
	WSW		0.002914					0.002914
	W	0.000486	0.000971	0.000486				0.001943
	WNW	0.000971	0.000971					0.001943
	NW		0.000971					0.000971
	NNW		0.000486					0.000486
C	N		0.000486					0.000486
	NNE		0.000486					0.000486
	NE			0.000486				0.000486
	ENE	0.000486						0.000486
	E		0.001457					0.001457
	ESE	0.000486	0.001457	0.001457				0.003400
	SE		0.001943	0.000971				0.002914
	SSE	0.000486	0.001457	0.000971				0.002914
	S							
	SSW		0.000486	0.000971				0.001457
	SW			0.000971				0.000971
	WSW	0.000486	0.001943	0.000486				0.002914
	W		0.000971	0.000971				0.001943
	WNW	0.000971	0.002428	0.001457				0.004857
	NW		0.002914	0.001457				0.004371
	NNW		0.000971	0.002914				0.003885

Table 3.6-11: Proposed Project 4th Quarter Joint Frequency Distribution (cont.)

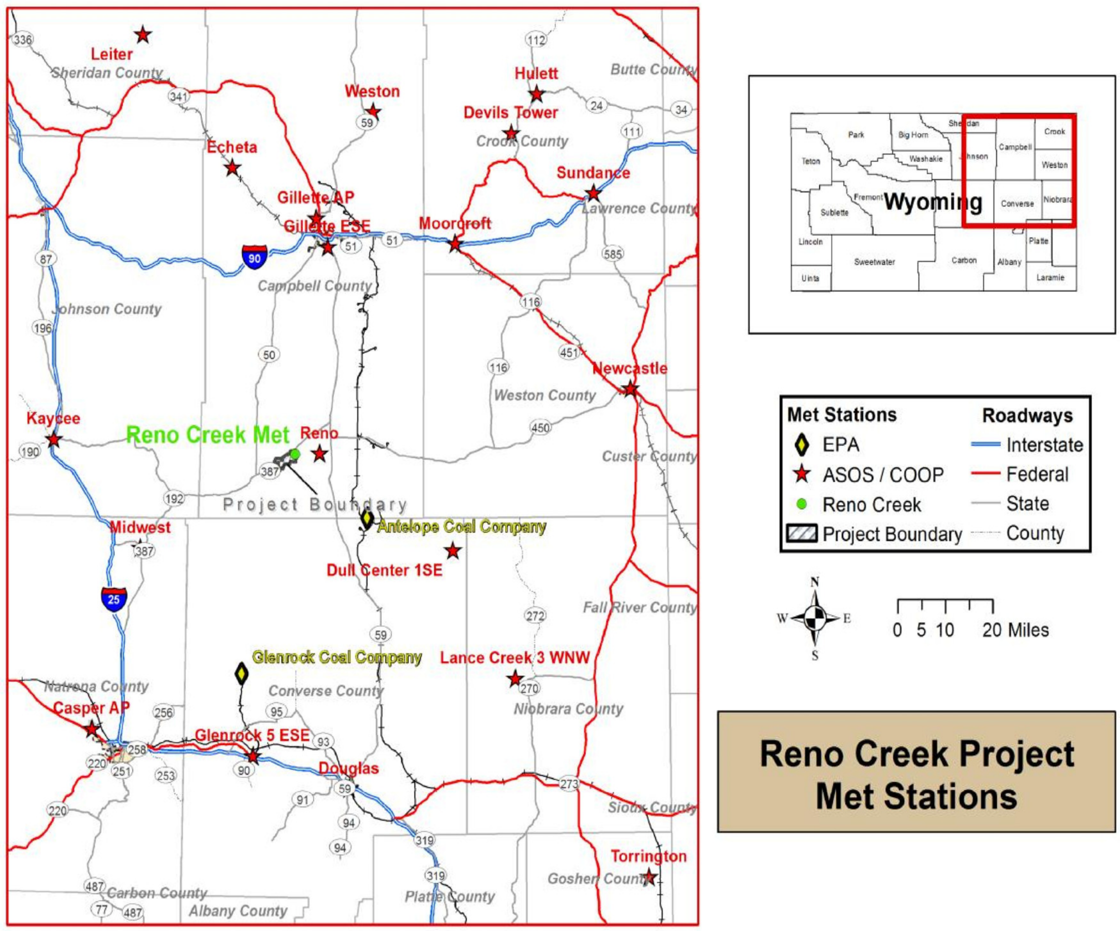
Stability Class	Wind Direction	Wind Speed (mph) - Fall						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
D	N	0.000486	0.001457	0.001943	0.003885	0.004857		0.012627
	NNE		0.002914	0.001457	0.001457			0.005828
	NE							
	ENE		0.000971					0.000971
	E	0.000971	0.002428	0.002428	0.000486			0.006314
	ESE	0.000486	0.007771	0.012627	0.005342	0.003885		0.030112
	SE		0.009228	0.018456	0.008742	0.001457		0.037882
	SSE	0.000971	0.007285	0.010685	0.006799	0.000486	0.000486	0.026712
	S		0.004857	0.012142	0.009228	0.001457	0.000486	0.028169
	SSW		0.003400	0.010685	0.014570	0.005342	0.000486	0.034483
	SW		0.008742	0.028655	0.061195	0.024769	0.021370	0.144730
	WSW	0.001943	0.016999	0.029626	0.050024	0.027683	0.012142	0.138417
	W	0.001943	0.018456	0.014085	0.010199	0.001943		0.046625
	WNW	0.002428	0.016999	0.019427	0.013113	0.002914		0.054881
	NW	0.000971	0.010685	0.025741	0.027683	0.017484	0.004857	0.087421
	NNW	0.000971	0.005342	0.010199	0.023312	0.031083	0.011170	0.082079
E	N	0.000971	0.000486					0.001457
	NNE		0.001943	0.000971				0.002914
	NE	0.001457	0.000971	0.000971				0.003400
	ENE		0.001943	0.000486				0.002428
	E		0.000971	0.000971				0.001943
	ESE		0.003885	0.001943				0.005828
	SE		0.005828	0.010685				0.016513
	SSE	0.000486	0.004857	0.002914				0.008256
	S	0.000971	0.001943	0.003885				0.006799
	SSW		0.001943	0.000971				0.002914
	SW	0.000971	0.006314	0.010685				0.017970
	WSW	0.001457	0.014085	0.009713				0.025255
	W	0.000486	0.017970	0.005342				0.023798
	WNW	0.002428	0.014085	0.009228				0.025741
	NW	0.001457	0.011170	0.003885				0.016513
	NNW	0.000486	0.003885	0.003400				0.007771
F	N	0.000486						0.036053
	NNE	0.000486						0.030110
	NE	0.000486						0.019538
	ENE	0.000486						0.009591
	E	0.000486						0.011140
	ESE	0.000971						0.011165
	SE		0.000486					0.009100
	SSE	0.000486	0.000971					0.017032
	S	0.001943	0.001457					0.014060
	SSW	0.000486	0.001457					0.011682
	SW	0.000971	0.000486					0.012097
	WSW	0.000971	0.000971					0.011656
	W	0.001457	0.001457					0.013519
	WNW	0.000486	0.001943					0.018945
	NW	0.000486	0.000486					0.021865
	NNW	0.000971						0.041199

Table 3.6-12: Upper Atmosphere Characteristics at Rapid City, South Dakota

Time Period (Filtered)	Average Mixing / Inversion Height
Morning (2 am – 6 am)	333 meters (1,093 ft)
Afternoon (12 pm – 4 pm)	1,547 meters (5, 075 ft)

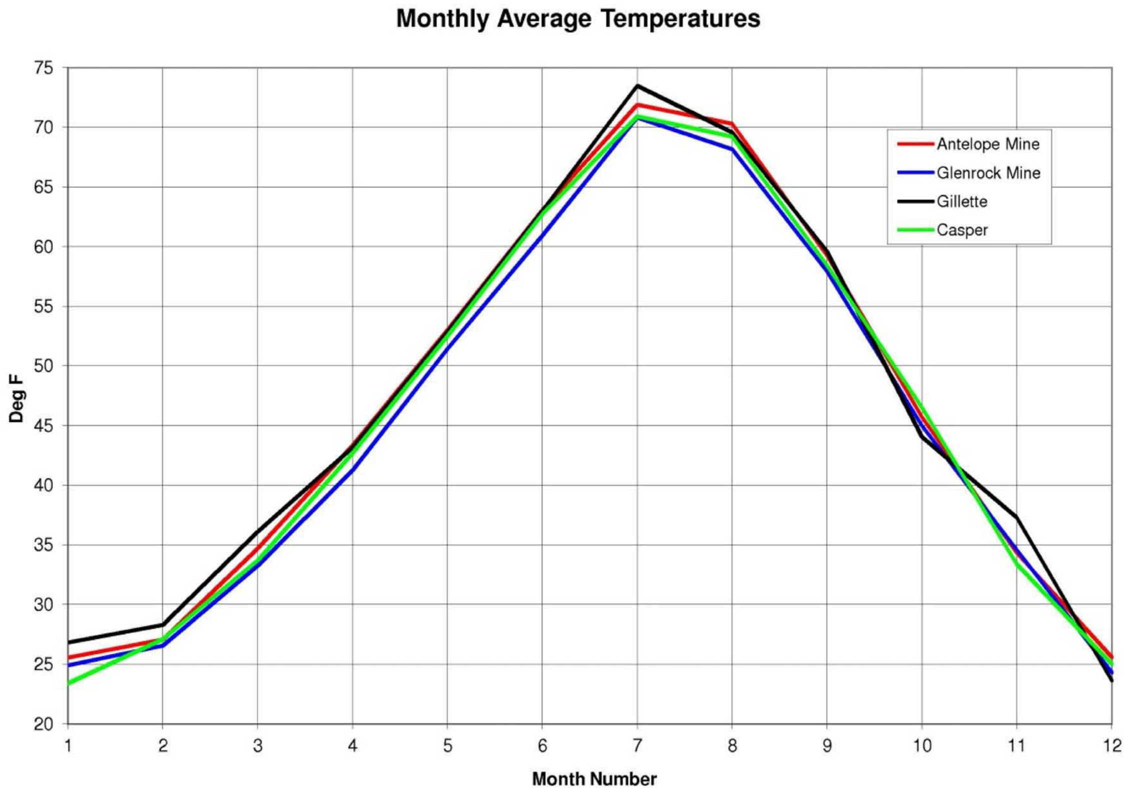
Source: IML computation based on data from National Climate Data Center, 2011

Figure 3.6-1: NWS and Coal Mine Meteorological Stations



Source: National Climatic Data Center, 2011
Period: (varies by monitoring location – see Table 2.5-1)

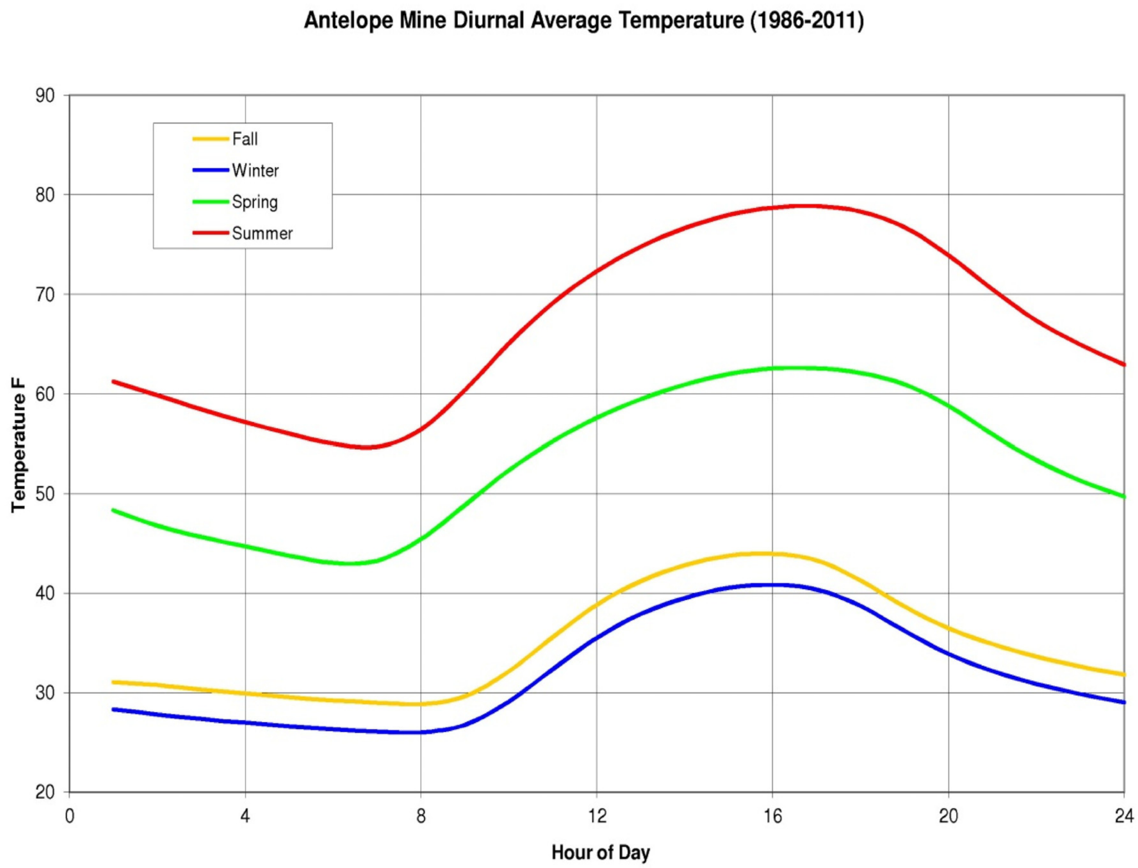
Figure 3.6-2: Regional Average Monthly Temperatures



Sources: National Climatic Data Center, 2011; IML Air Science meteorological database, 2011

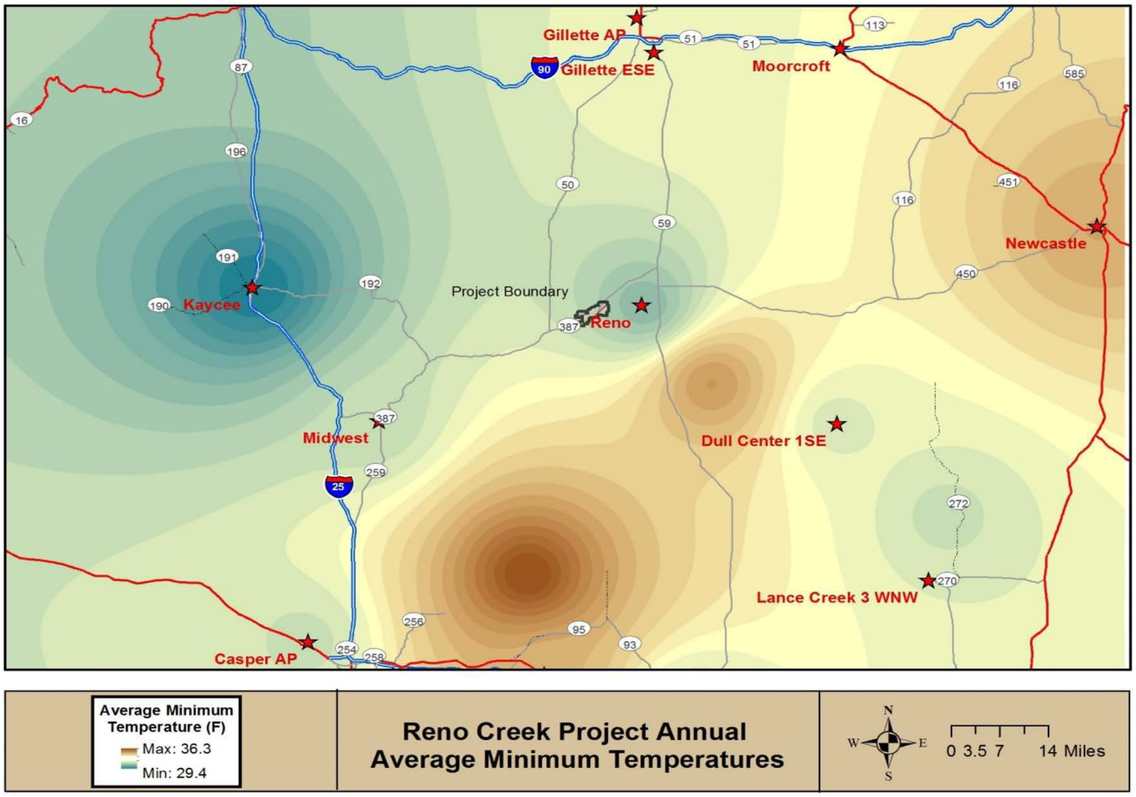
Period: (varies by monitoring location)

Figure 3.6-3: Antelope Mine Monthly Diurnal Temperature Variations



Source: IML Air Science meteorological database, 2011
Period: 1986-2011

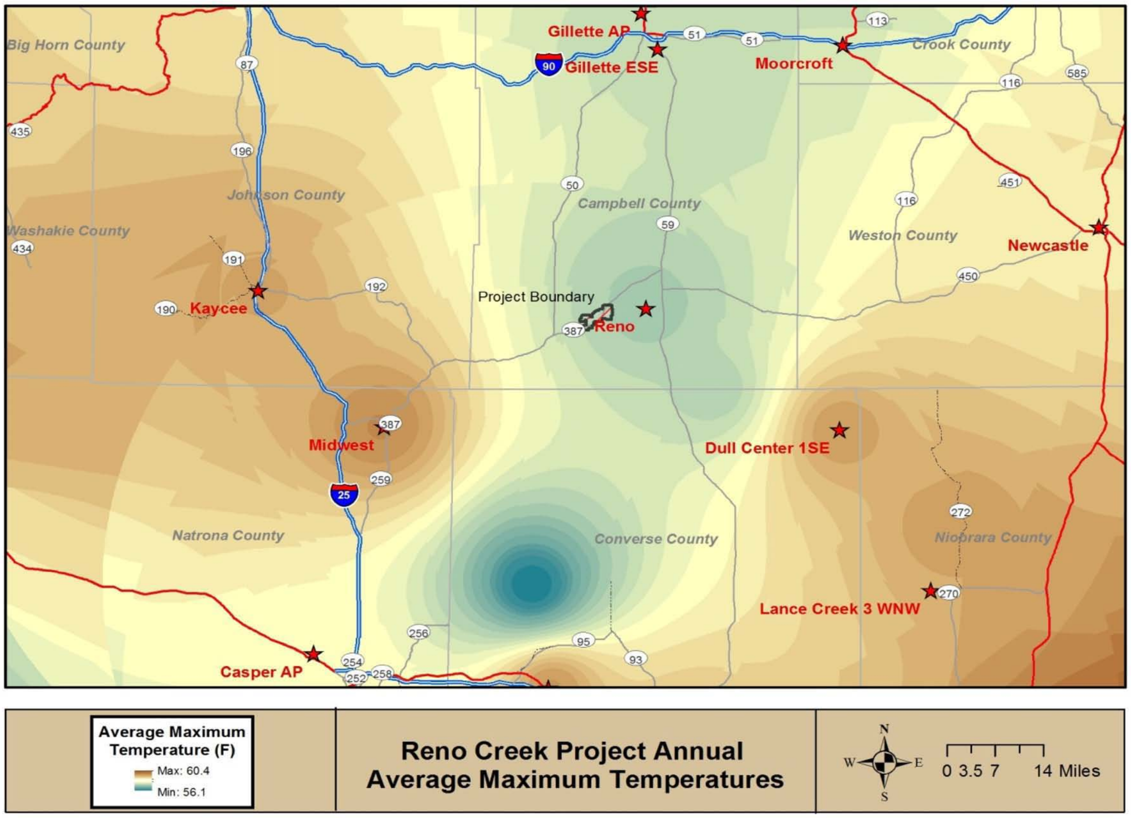
Figure 3.6-4: Regional Annual Average Minimum Temperatures



Source: National Climatic Data Center, 2011

Period: (varies by monitoring location – see Table 2.5-1)

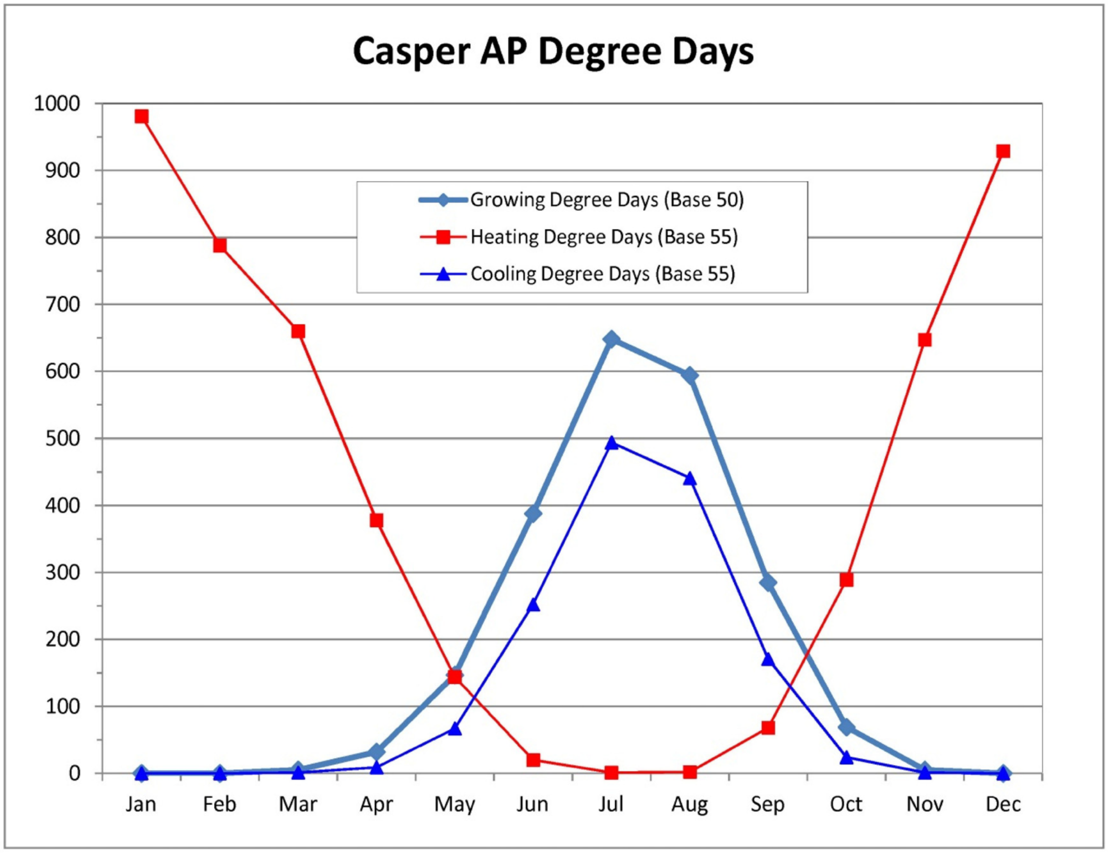
Figure 3.6-5: Regional Annual Average Maximum Temperatures



Source: National Climatic Data Center, 2011

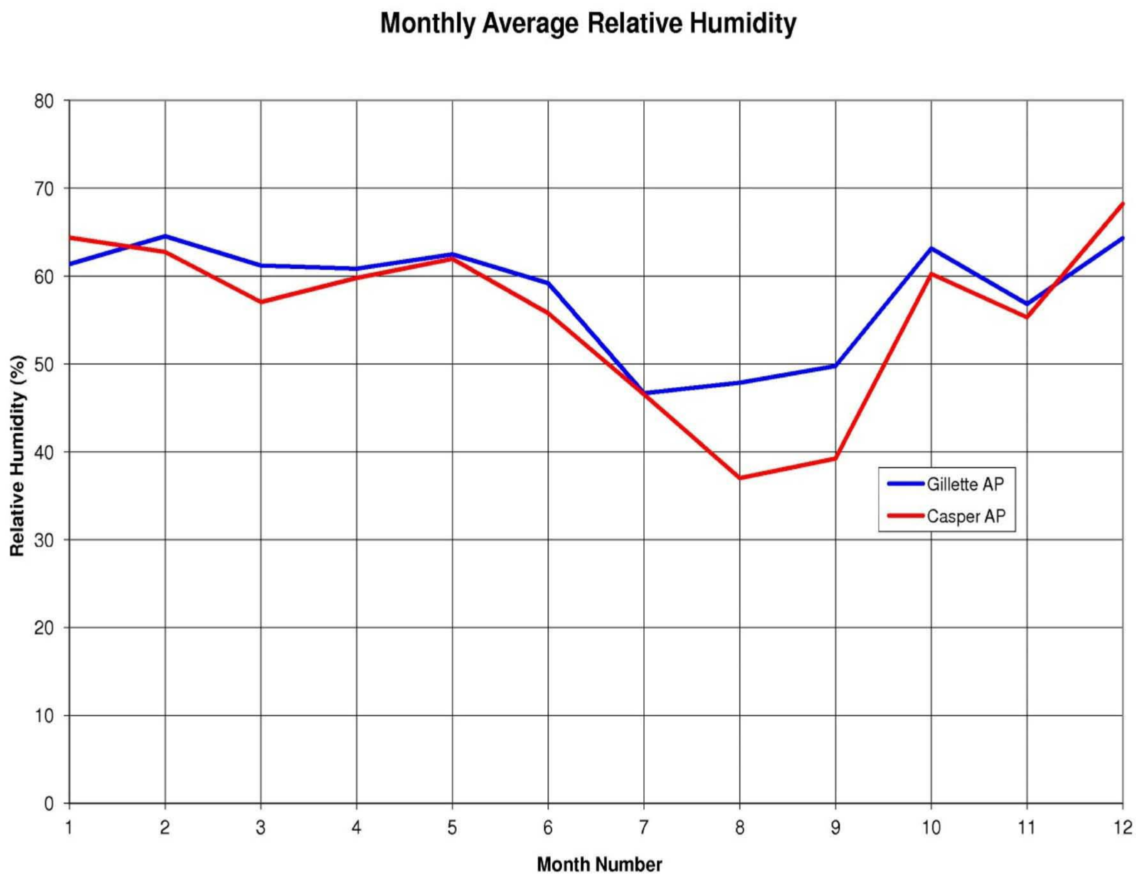
Period: (varies by monitoring location – see Table 2.5-1)

Figure 3.6-6: Casper Airport Degree Days



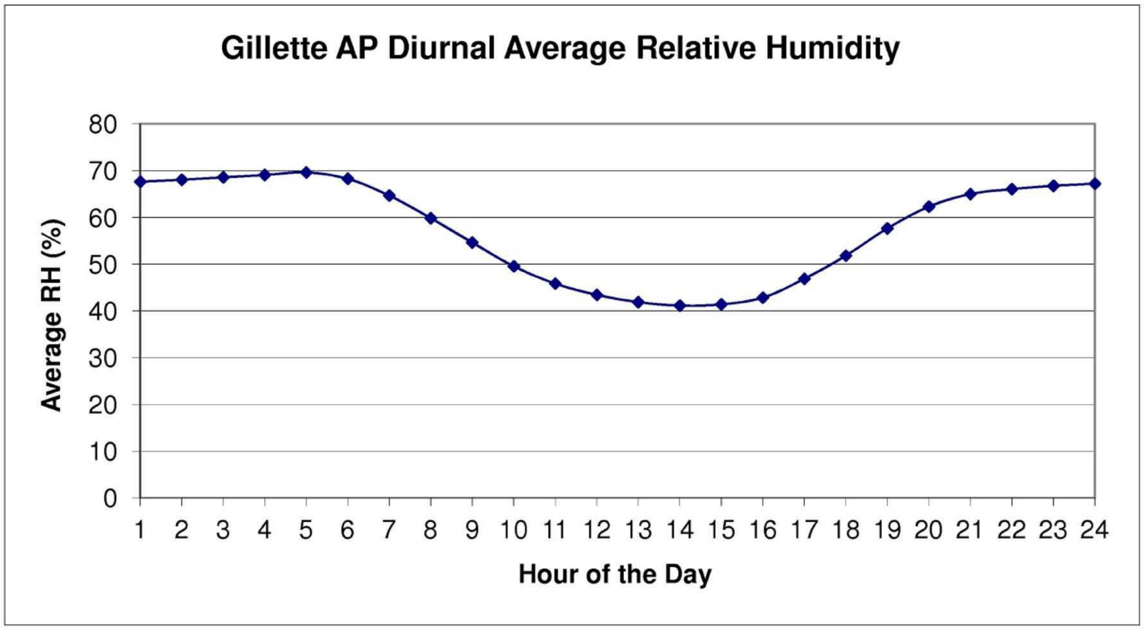
Source: National Climatic Data Center, 2011
Period: 1948-2010

Figure 3.6-7: Mean Monthly Relative Humidity for Gillette and Casper



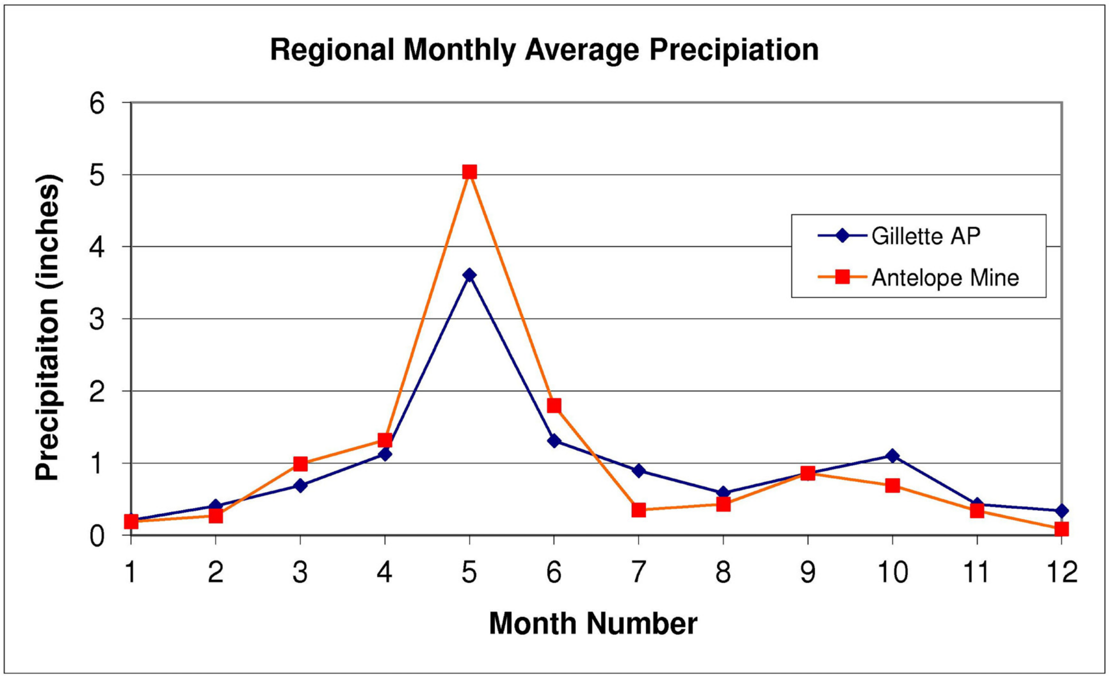
Source: National Climatic Data Center, 2011
Period: (varies by monitoring location)

Figure 3.6-8: Diurnal Average Relative Humidity for Gillette AP



Source: National Climatic Data Center, 2011
Period: 2005-2009

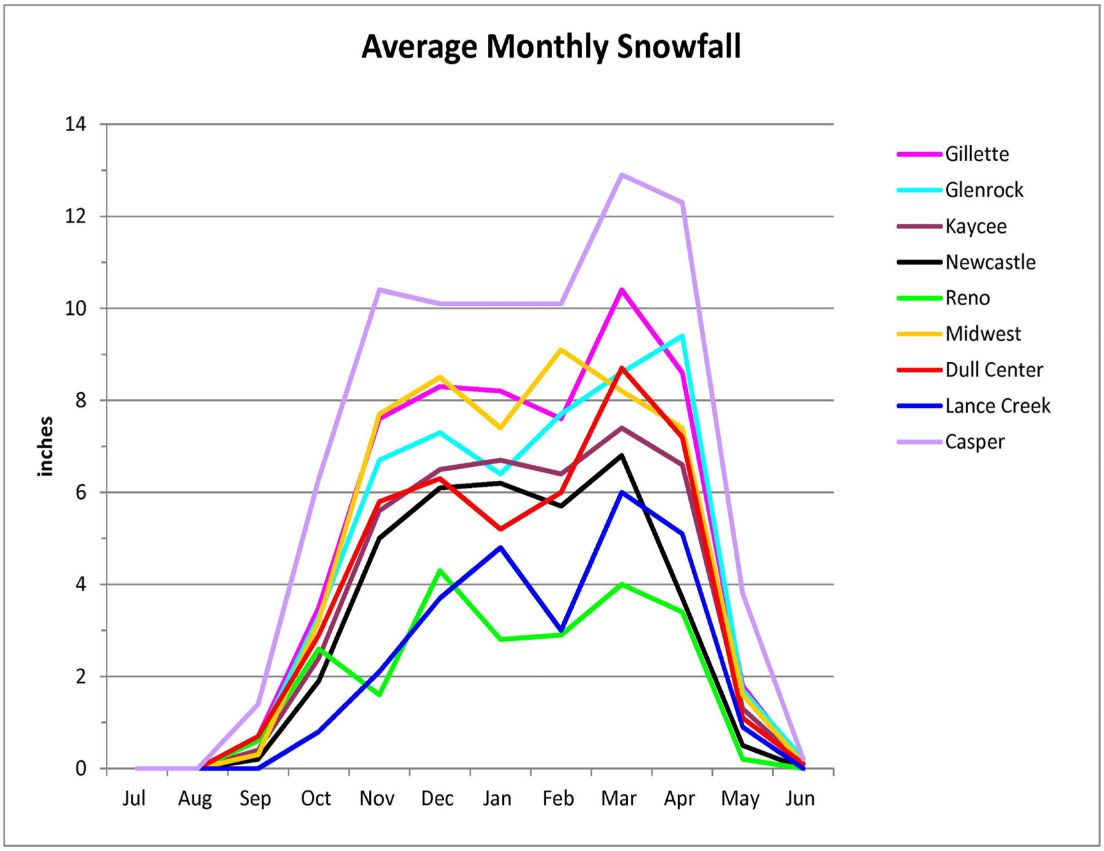
Figure 3.6-9: Regional Monthly Average Precipitation



Sources: National Climatic Data Center, 2011; IML Air Science meteorological database, 2011

Period: (varies by monitoring location)

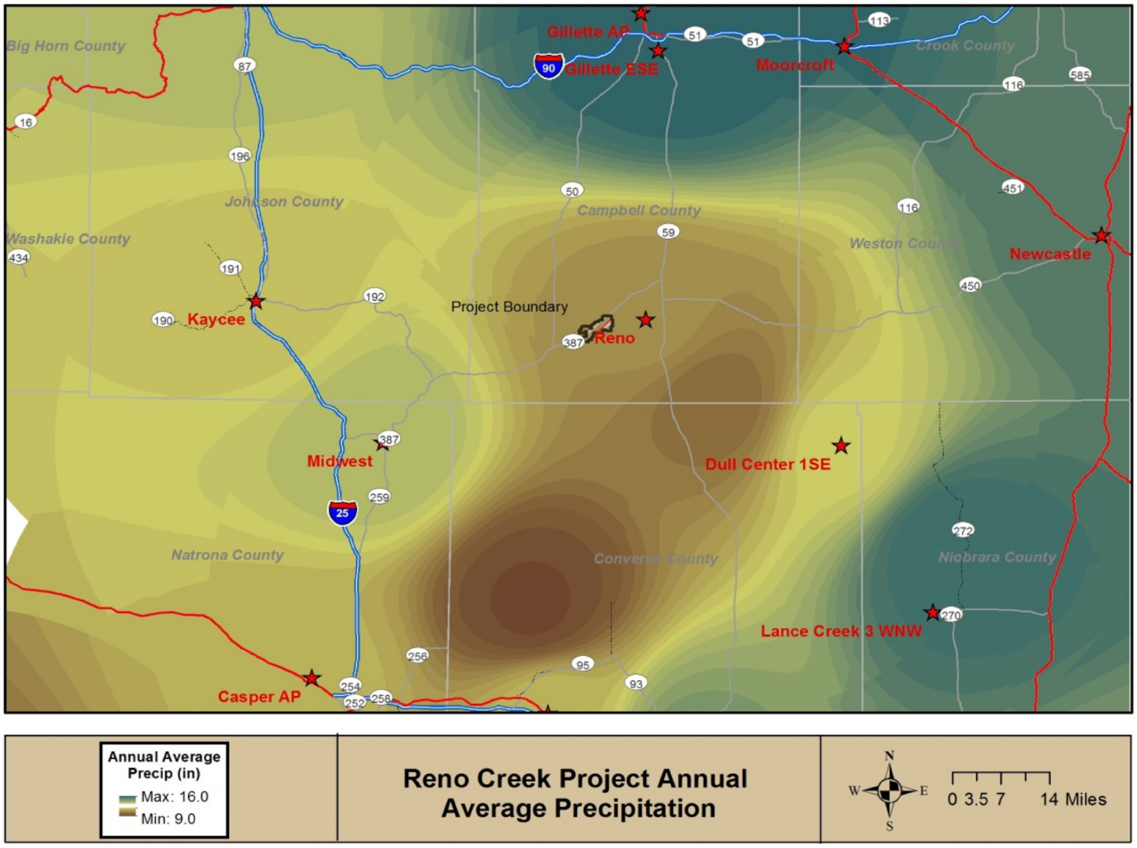
Figure 3.6-10: NWS Station Monthly Snowfall Averages



Source: National Climatic Data Center, 2011

Period: (varies by monitoring location – see Table 2.5-1)

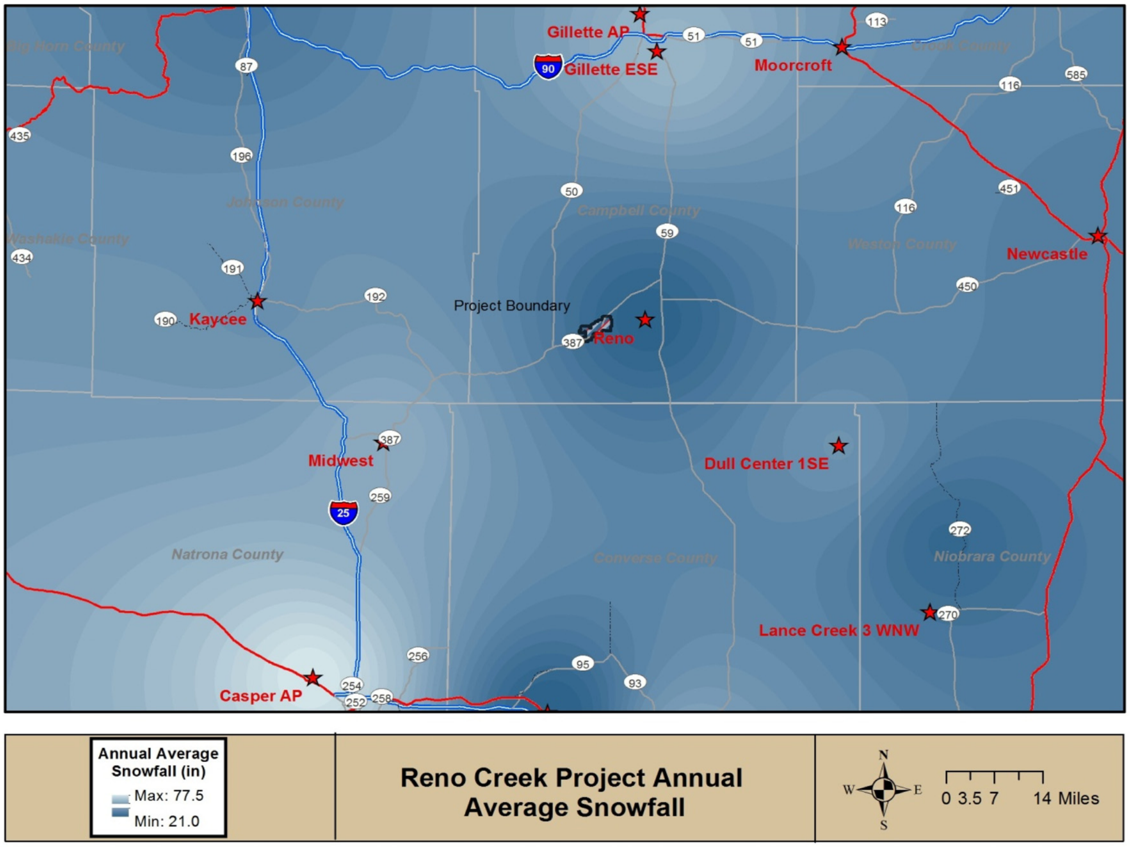
Figure 3.6-11: Regional Annual Average Precipitation



Source: National Climatic Data Center, 2011

Period: (varies by monitoring location – see Table 2.5-1)

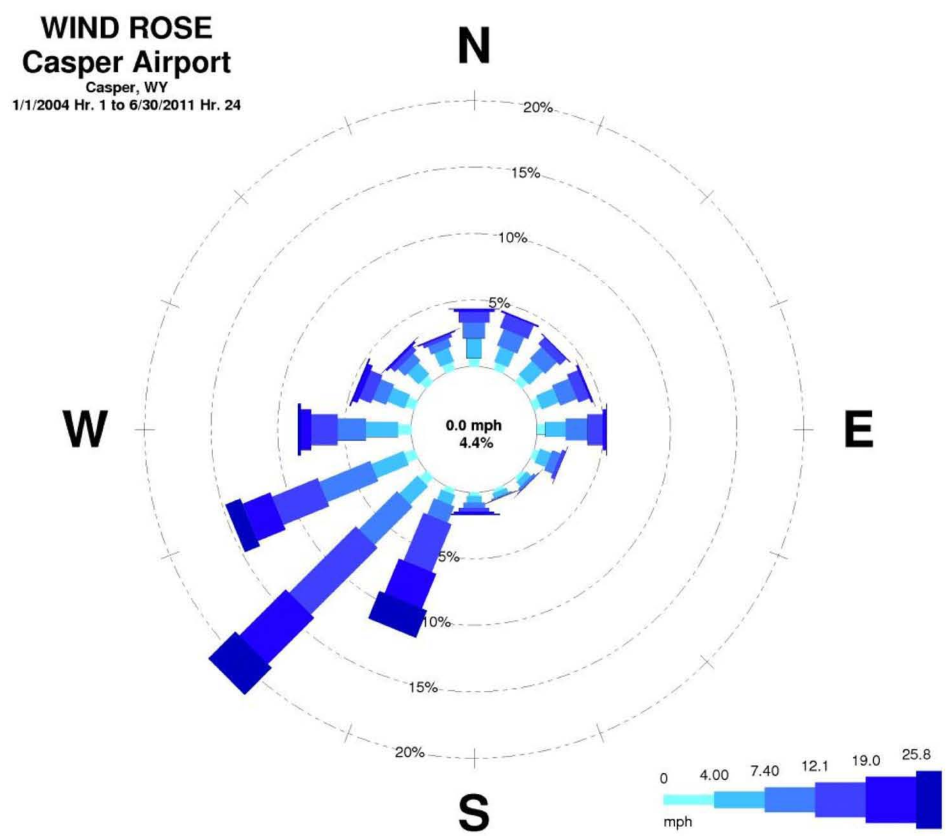
Figure 3.6-12: Regional Annual Average Snowfall



Source: National Climatic Data Center, 2011

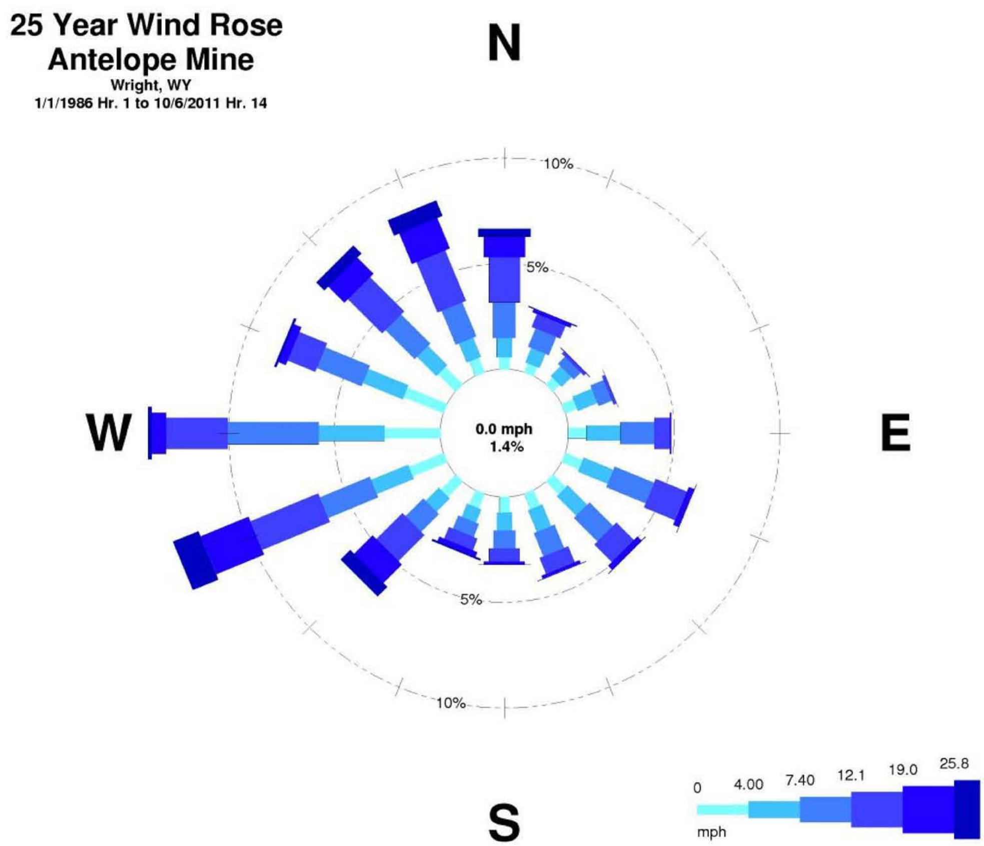
Period: (varies by monitoring location – see Table 2.5-1)

Figure 3.6-13: Casper Airport 8-Year Wind Rose



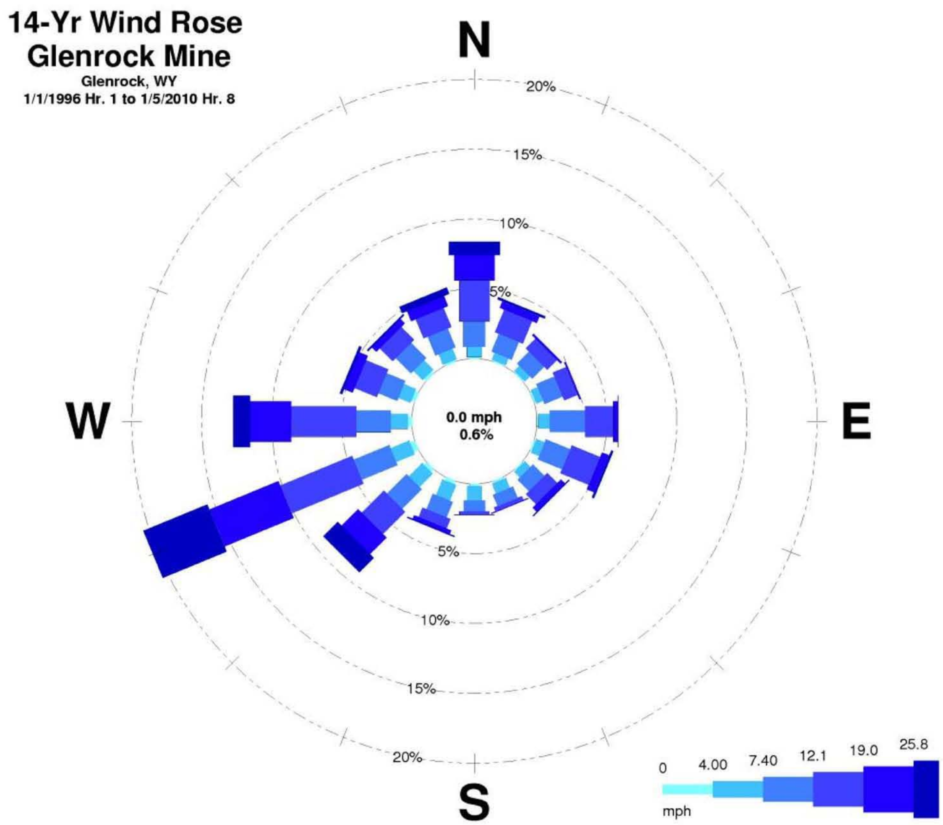
Source: National Climatic Data Center, 2011
Period: 2004-2011

Figure 3.6-14: Antelope Mine 25-Year Wind Rose



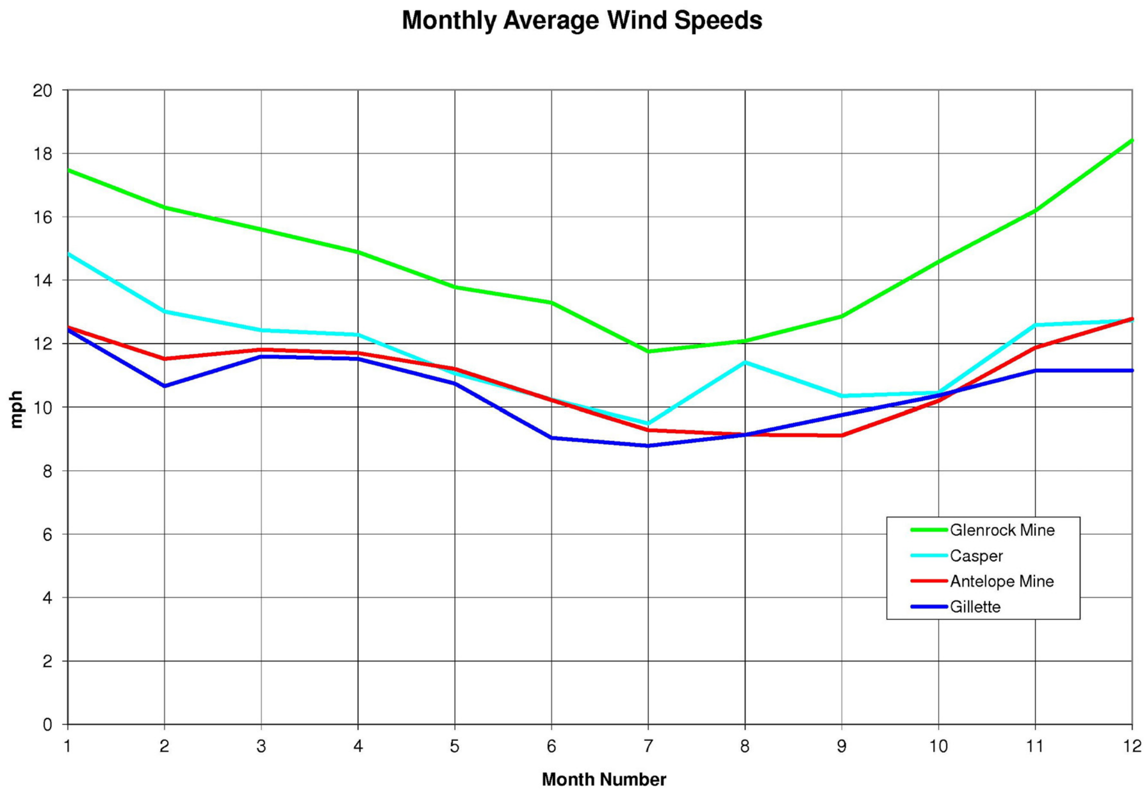
Source: IML Air Science meteorological database
Period: 1986-2011

Figure 3.6-15: Glenrock Mine 14-Year Wind Rose



Source: IML Air Science meteorological database
Period: 1996-2010

Figure 3.6-16: Regional Wind Speeds by Month



Sources: National Climatic Data Center, 2011; IML Air Science meteorological database, 2011
Period: (varies by monitoring location)

Figure 3.6-17: Reno Creek Project 1-Year Meteorological Summary

Reno Creek

Meteorological Data Summary

10/6/2010 - 10/3/2011

Hourly Data

	Average/Total	Max	Min
Wind Speed (mph)	13.5	42.0	1.1
Sigma-Theta (°)	10.5	73.7	0.4
Temperature (F)	44.3	95.9	-25.1
Relative Humidity (%)	63.5	100.0	8.0
Precipitation (in)	13.39	0.30	
Bar. Pressure (in Hg)	24.7	25.3	23.9
Solar Radiation (w/m^2)	176.1	1,008.0	

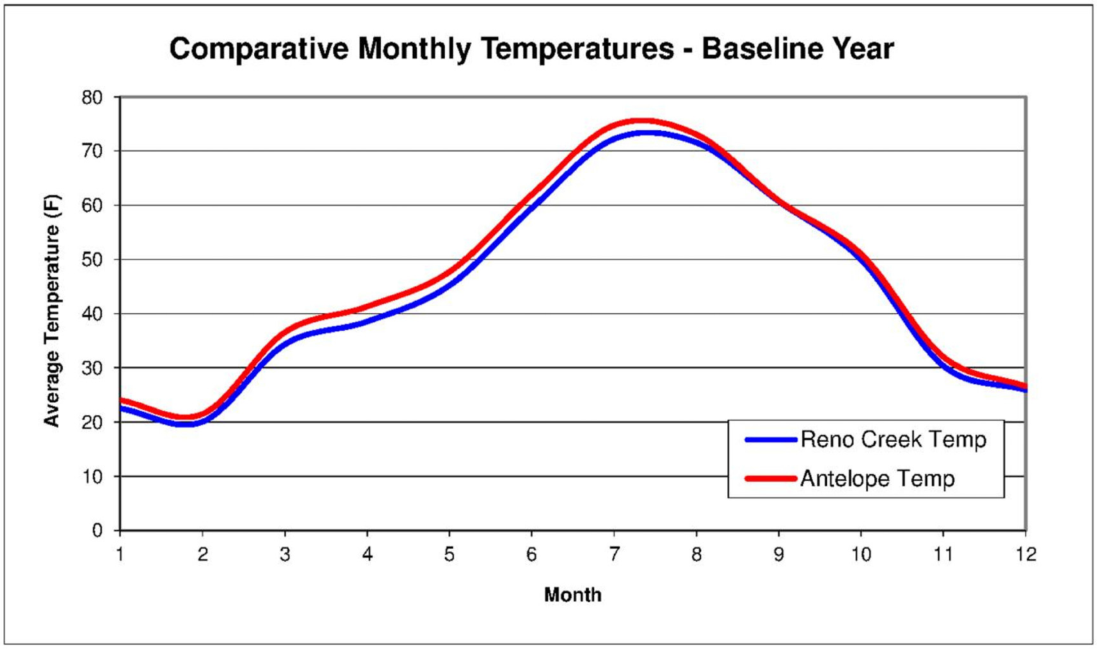
Predominant wind direction was from the WSW sector, accounting for 14.9% of the possible winds

Data Recovery

Parameter	Possible (hours)	Reported (hours)	Recovery
Wind Speed	8683	8670	99.85%
Wind Direction	8683	8670	99.85%
Sigma-Theta	8683	8670	99.85%
Temperature	8683	8670	99.85%
Relative Humidity	8683	8414	96.90%
Precipitation	8683	8670	99.85%
Bar. Pressure	8683	8412	96.88%
Solar Radiation	8683	8414	96.90%

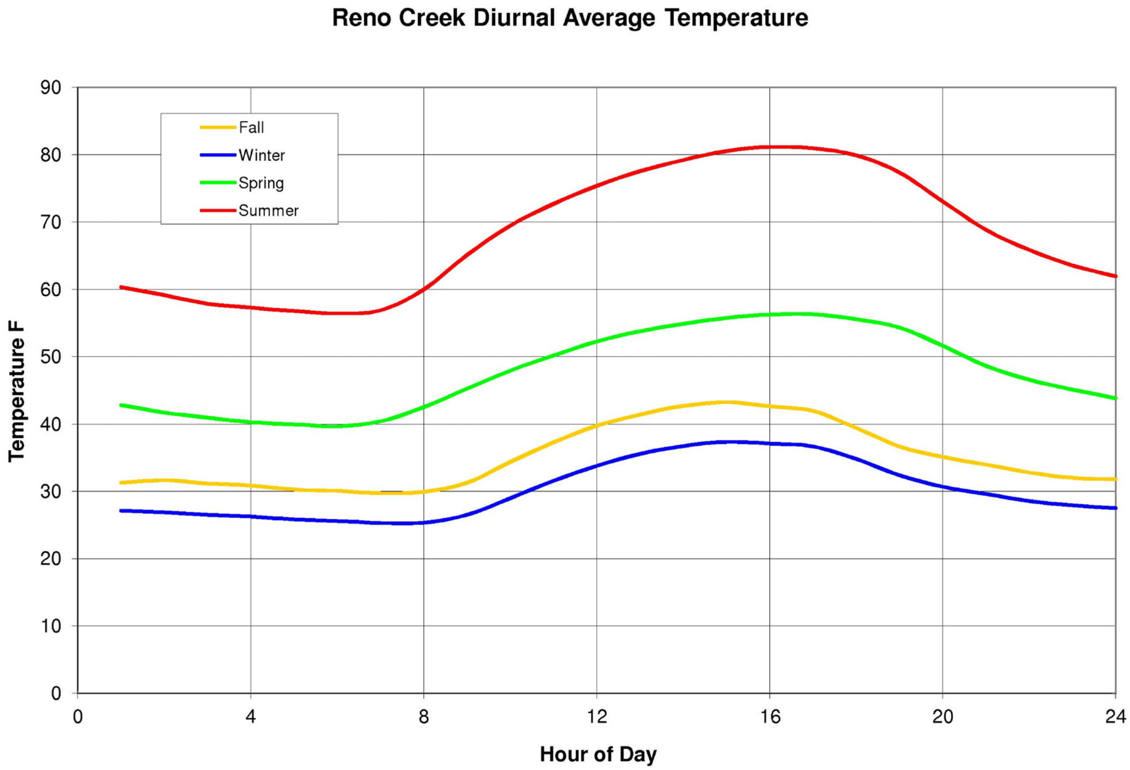
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year

Figure 3.6-18: Reno Creek vs. Antelope Monthly Average Temperatures



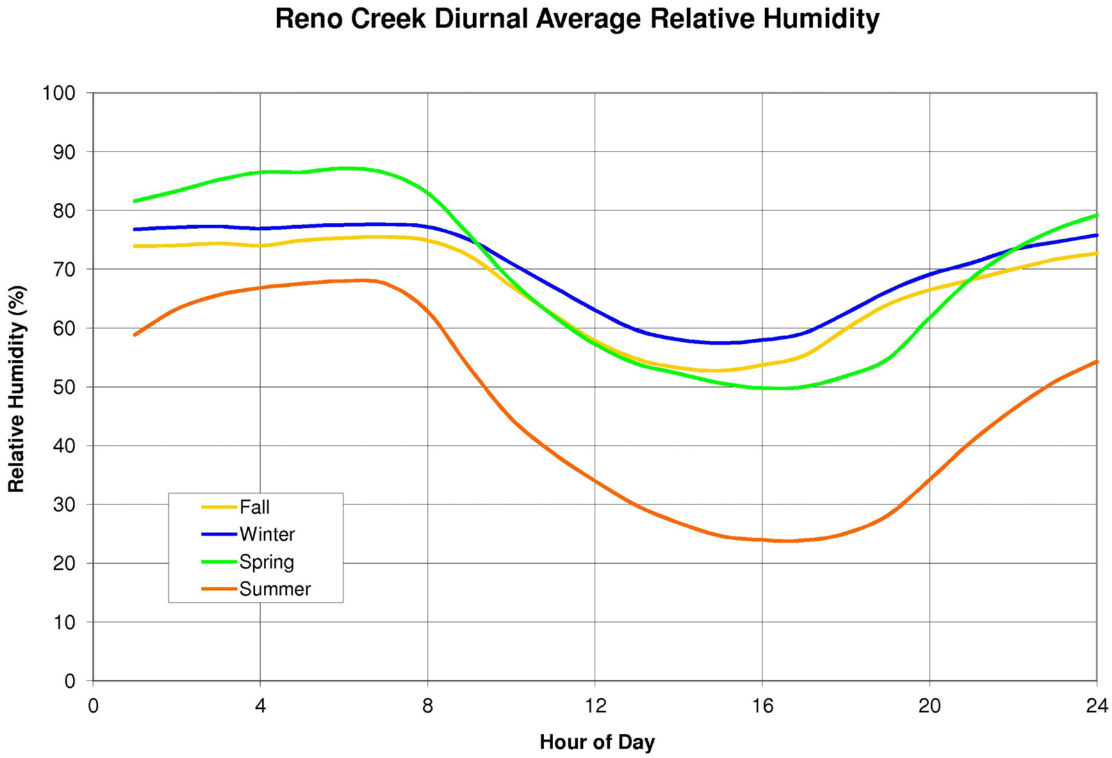
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year

Figure 3.6-19: Proposed Project Diurnal Average Temperatures



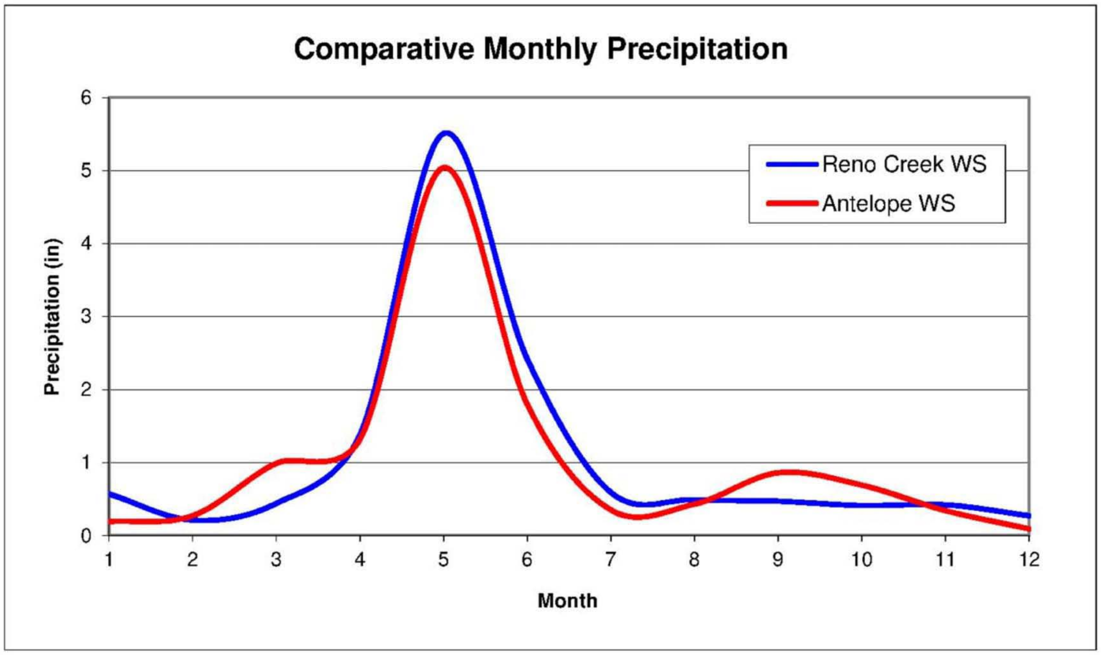
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year, 2010-2011

Figure 3.6-20: Proposed Project Diurnal Average Relative Humidity



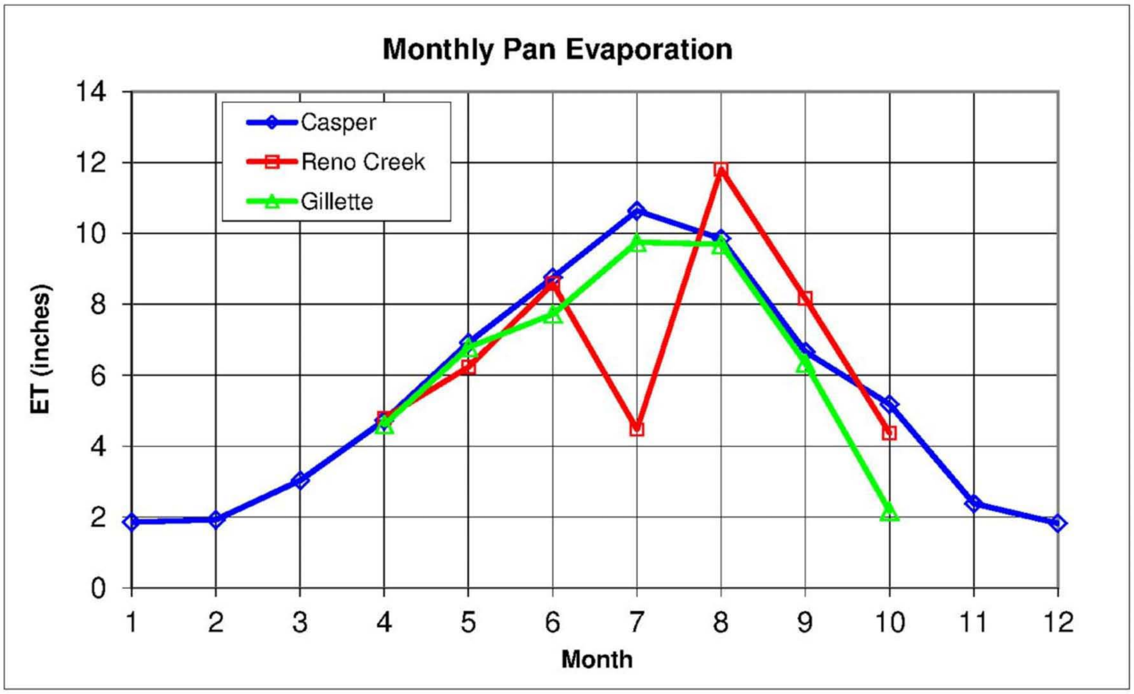
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year, 2010-2011

Figure 3.6-21: Proposed Project vs. Antelope Monthly Precipitation



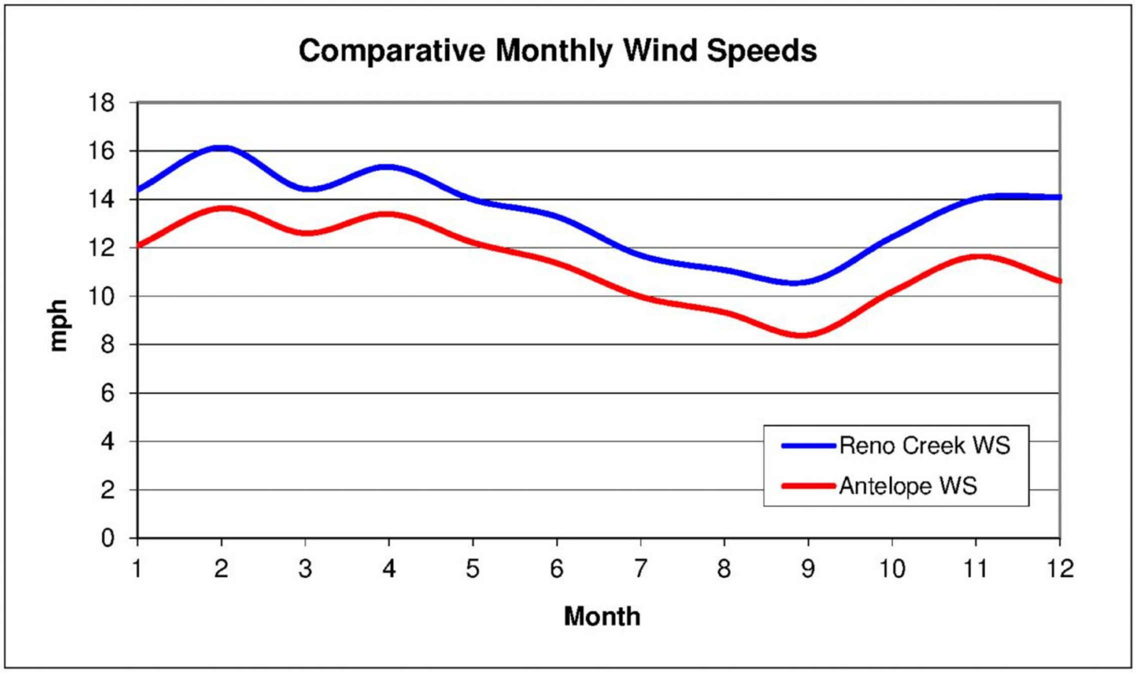
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year

Figure 3.6-22: Proposed Project Monthly Evaporation



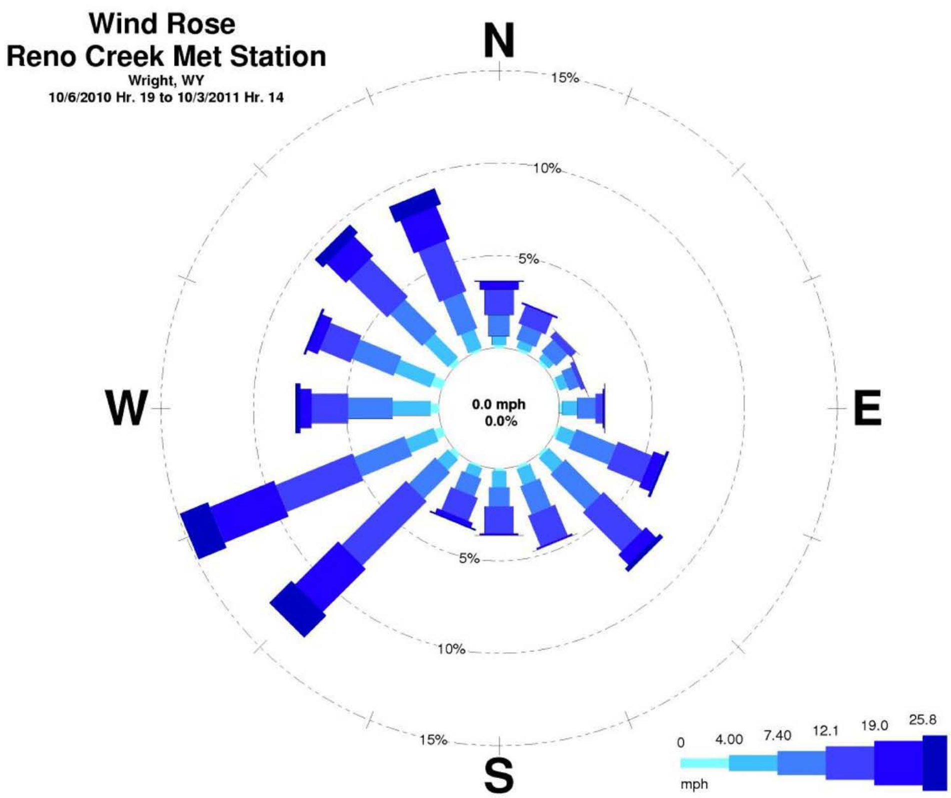
Source: IML Air Science calculations and meteorological database, 2011

Figure 3.6-23: Reno Creek Project vs. Antelope Monthly Average Wind Speeds



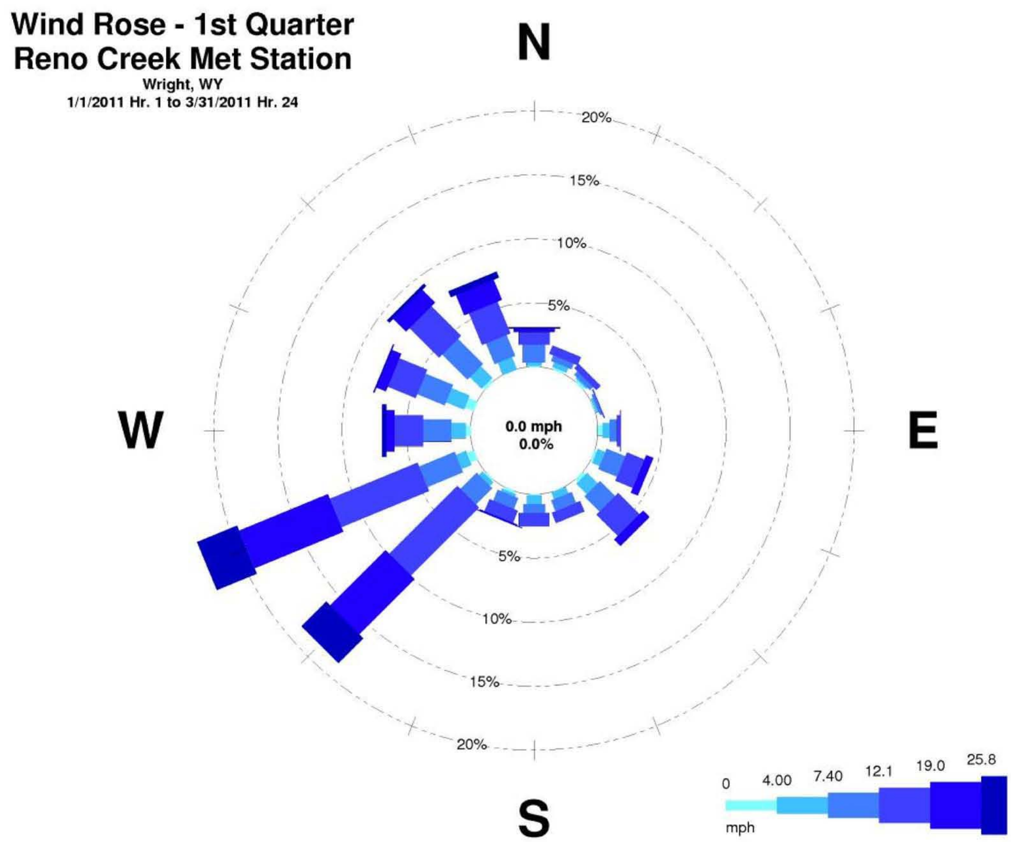
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year

Figure 3.6-24: Reno Creek Project Windrose



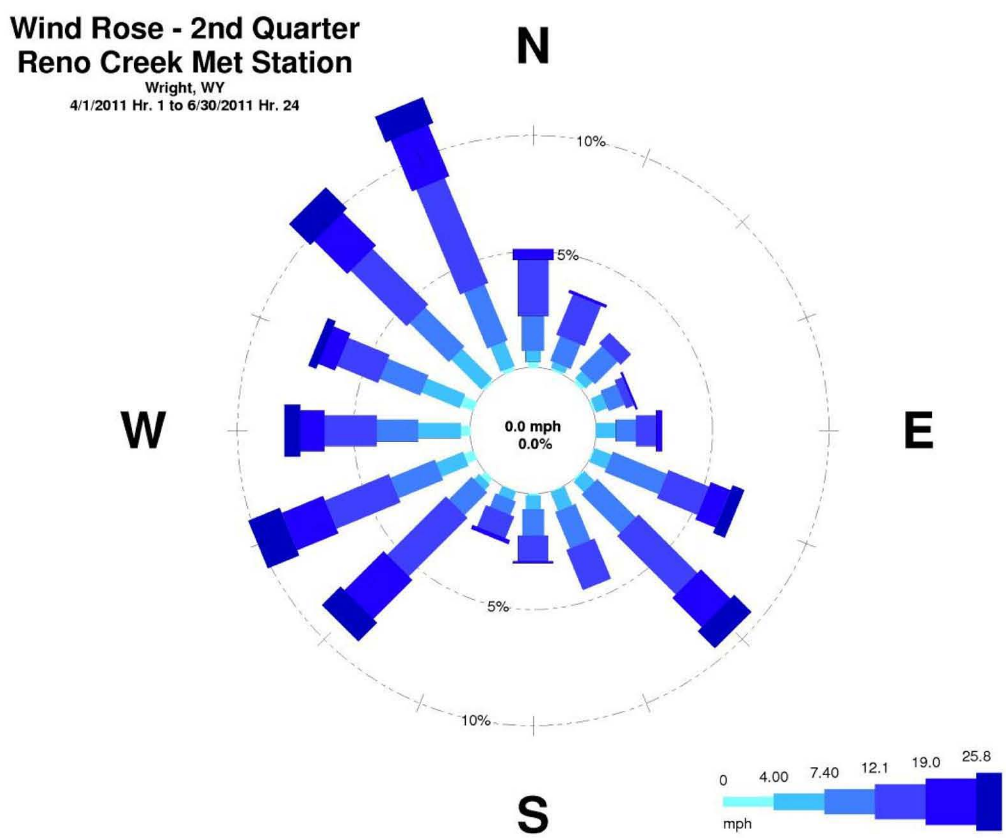
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year

Figure 3.6-25: Proposed Project Wind Rose: 1st Quarter



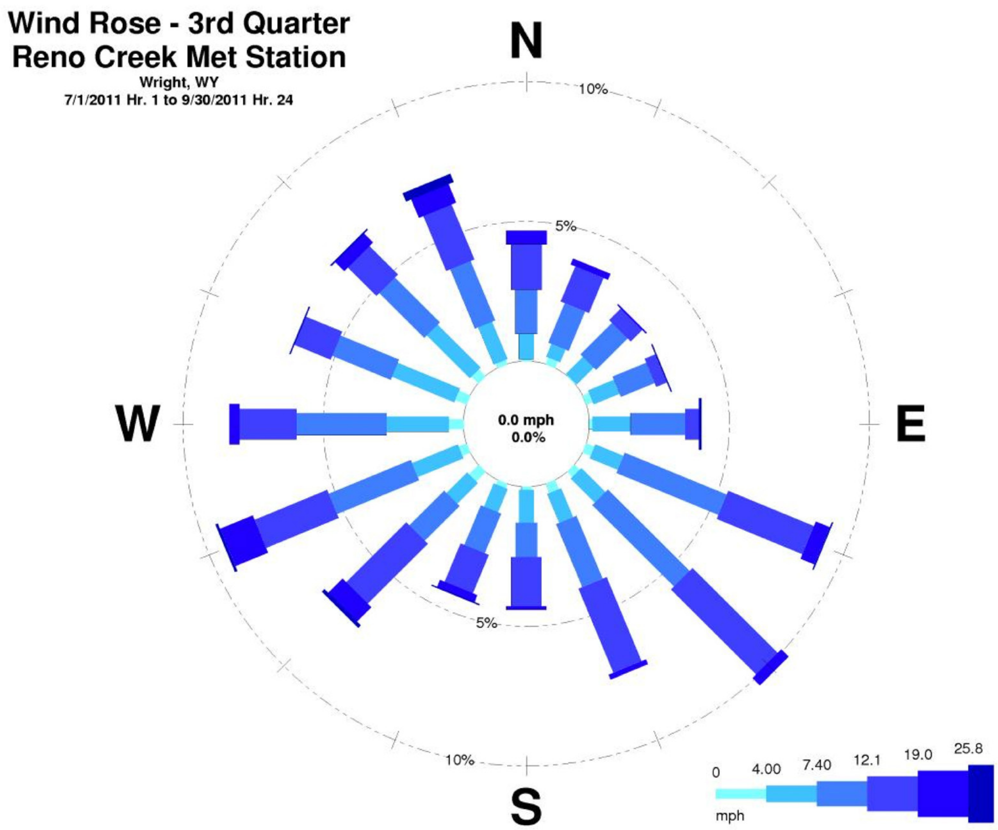
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year

Figure 3.6-26: Proposed Project Wind Rose: 2nd Quarter



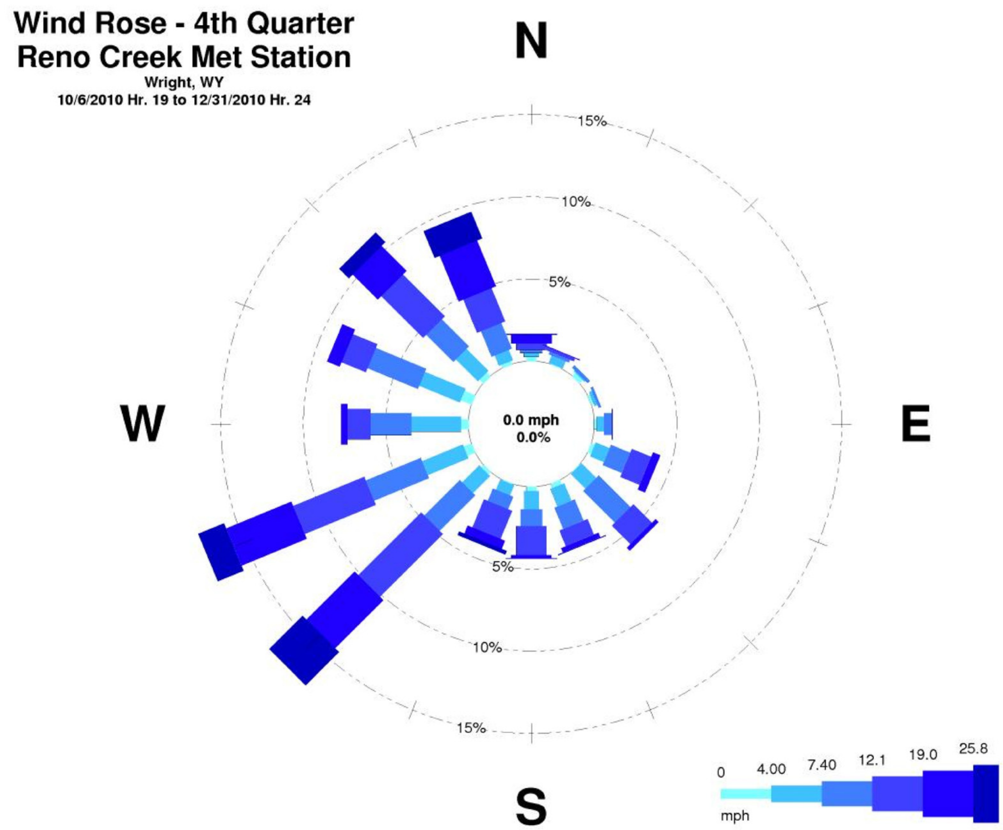
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year

Figure 3.6-27: Proposed Project Wind Rose: 3rd Quarter



Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year

Figure 3.6-28: Proposed Project Wind Rose: 4th Quarter



Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year

Figure 3.6-29: Proposed Project Wind Summary

Reno Creek

Wind Data Summary

10/6/2010 7:00:00 PM - 10/3/2011 2:00:00 PM

Hourly Data

		Average	Max	Min
Wind Speed (mph)		13.49	41.97	1.15
Sigma Theta (º)		10.49	73.66	0.39
Wind Direction				
	N	12.55	29.92	2.22
	NNE	11.26	23.97	2.07
	NE	9.49	22.42	2.12
	ENE	8.67	26.64	2.47
	E	9.46	27.56	2.23
	ESE	12.28	30.83	1.87
	SE	12.84	34.81	1.65
	SSE	10.93	28.52	1.54
	S	10.91	29.51	1.55
	SSW	12.37	30.30	1.83
	SW	17.34	41.97	1.36
	WSW	16.22	41.07	1.15
	W	11.14	34.83	1.18
	WNW	10.61	33.14	1.38
	NW	13.67	38.51	1.25
	NNW	15.68	35.83	2.19

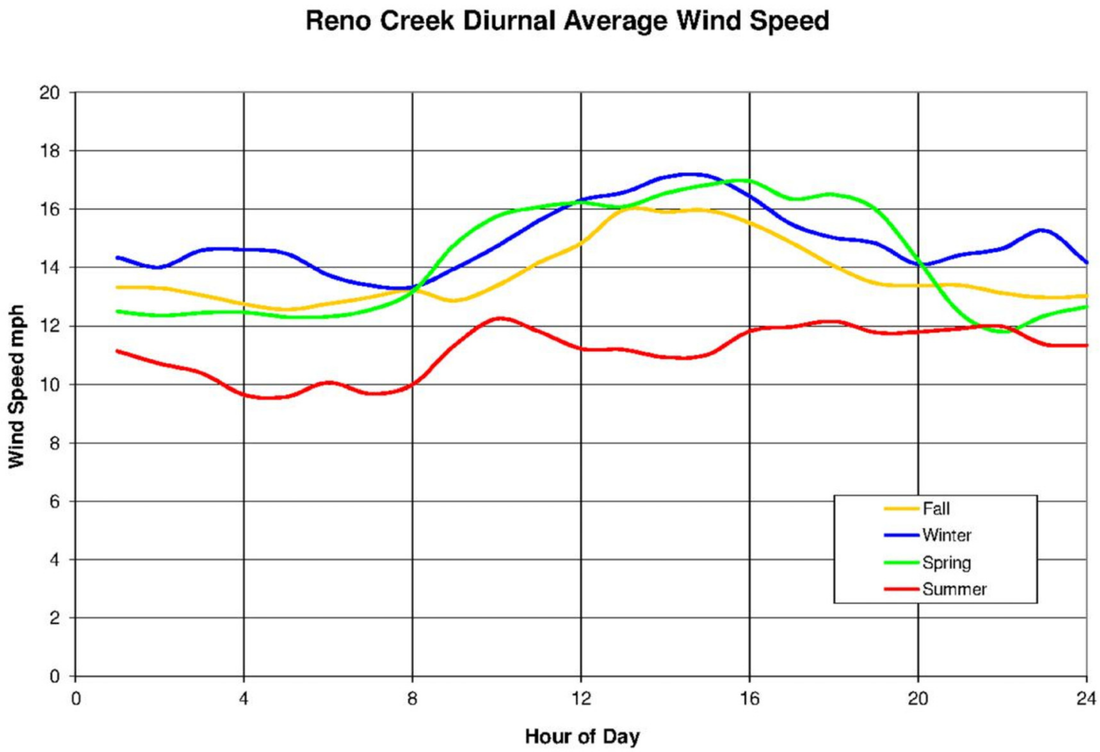
Predominant wind direction was from the WSW sector, accounting for 14.9% of the winds, the average wind direction was 255°.

Data Recovery

	Possible (hours)	Reported (hours)	Recovery
Wind Speed	8707	8670	99.58%
Sigma Theta	8707	8670	99.58%
Wind Direction	8707	8670	99.58%

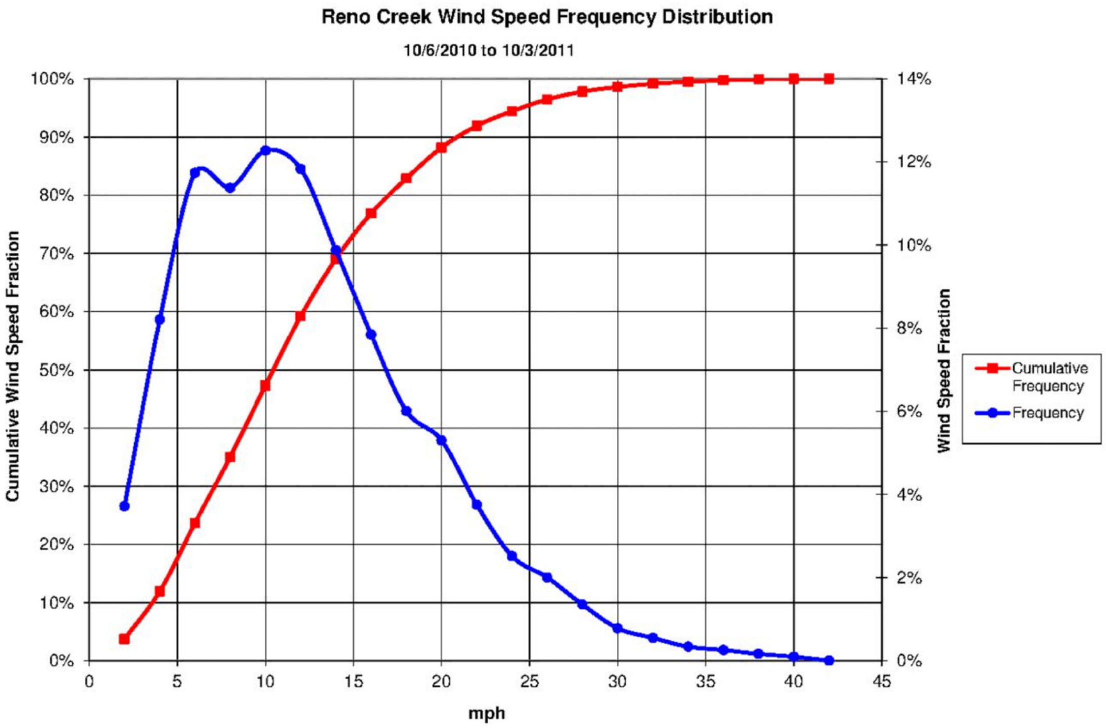
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year

Figure 3.6-30: Proposed Project Diurnal Average Wind Speeds



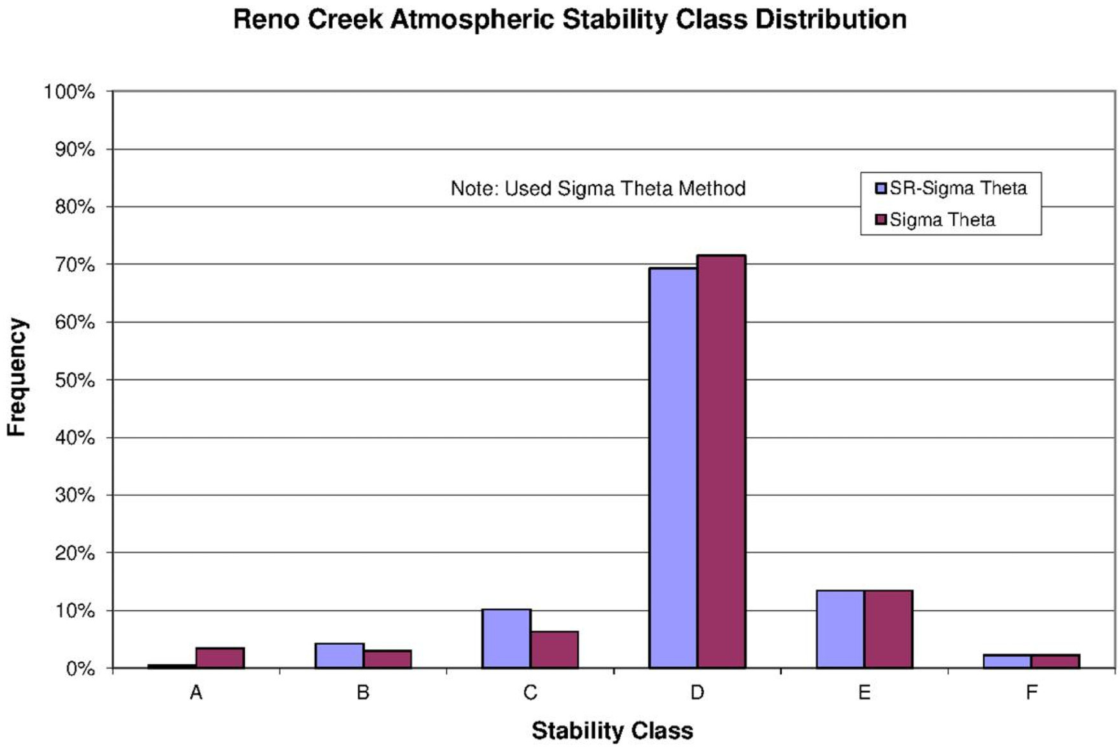
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year, 2010-2011

Figure 3.6-31: Proposed Project Wind Speed Frequency Distribution



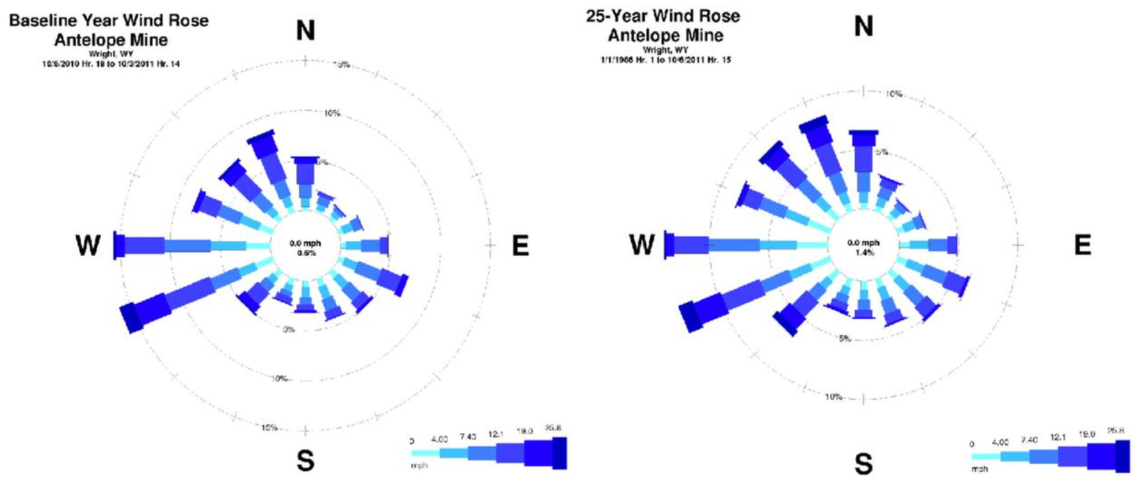
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year

Figure 3.6-32: Reno Creek Stability Class Analysis



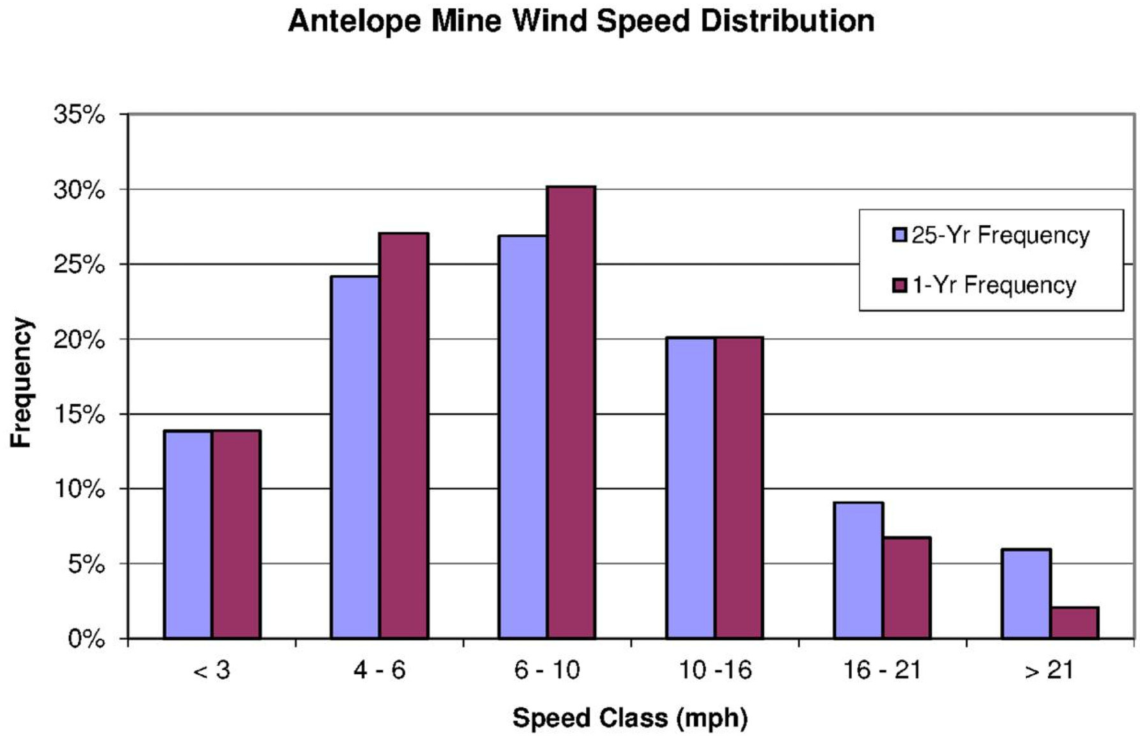
Source: Analysis by IML Air Science using meteorological database, 2011
Period: Baseline monitoring year, 2010-2011

Figure 3.6-33: Antelope Mine Short and Long-Term Wind Roses



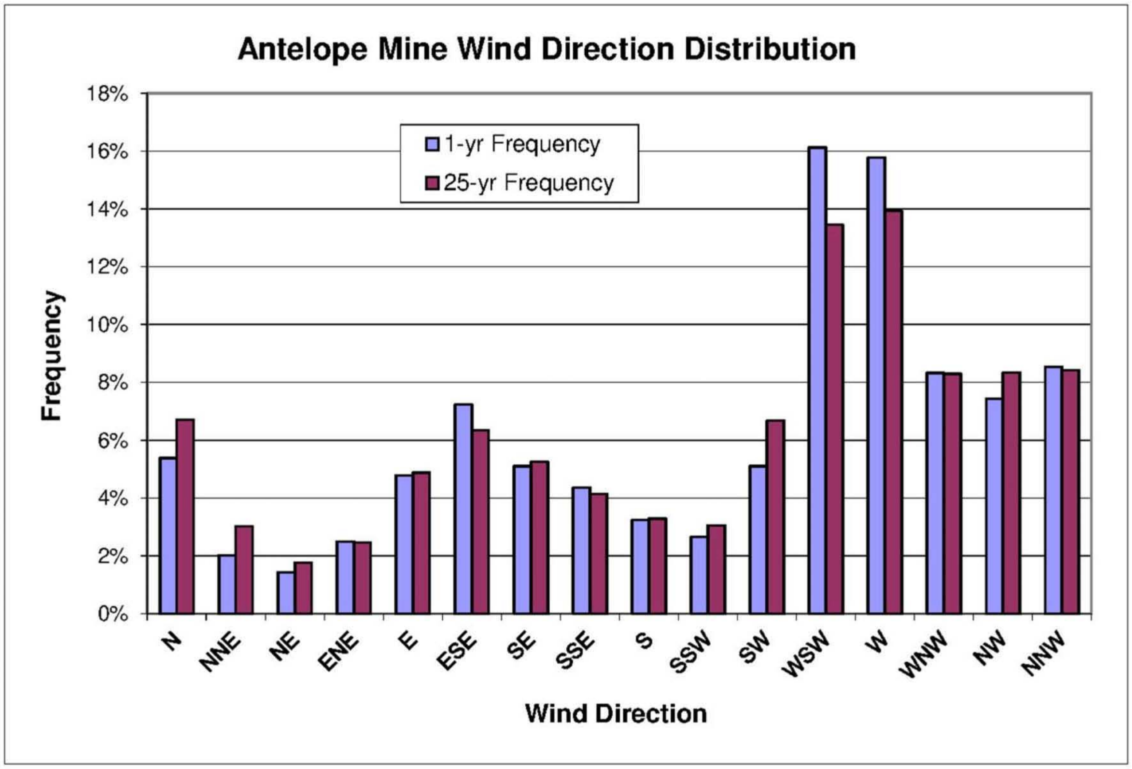
Source: IML Air Science meteorological database, 2011
Period: 1986-2011

Figure 3.6-34: Antelope Short and Long-Term Wind Speed Distributions



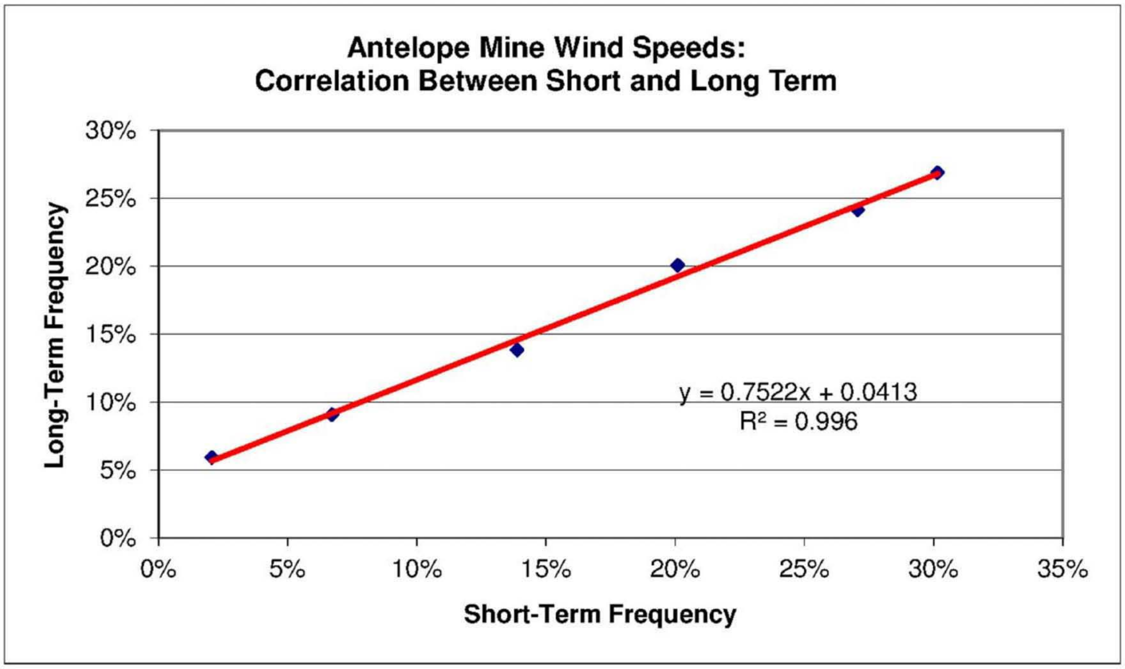
Source: IML Air Science meteorological database, 2011
Period: 1986-2011

Figure 3.6-35: Antelope Short and Long-Term Wind Direction Distributions



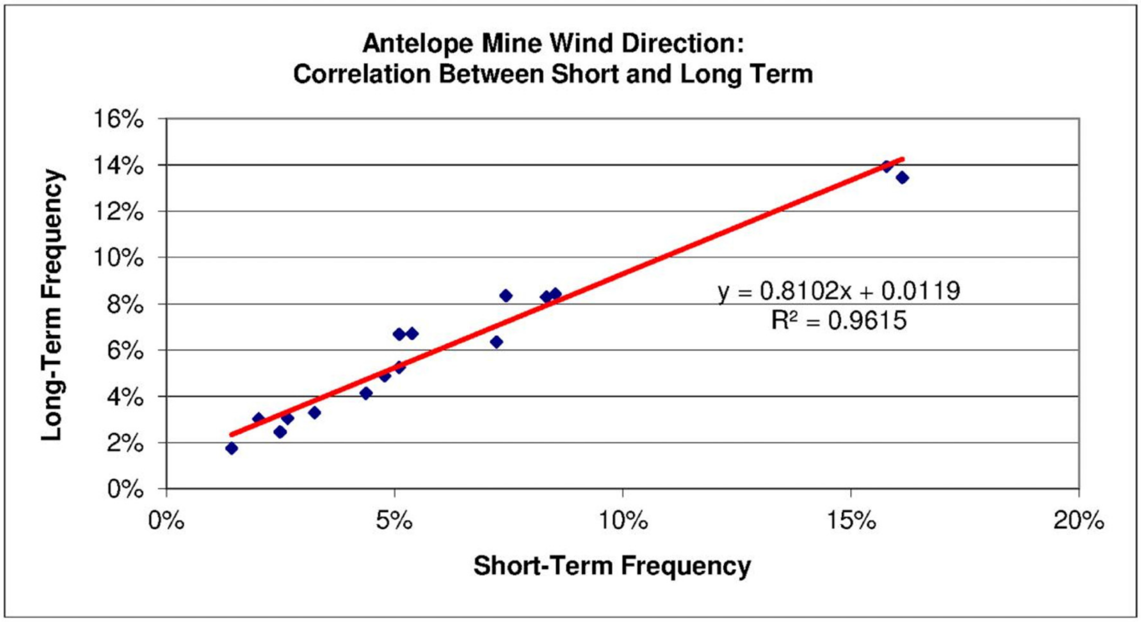
Source: IML Air Science meteorological database, 2011
Period: 1986-2011

Figure 3.6-36: Antelope 25-Year vs Baseline Year Wind Speed Distributions



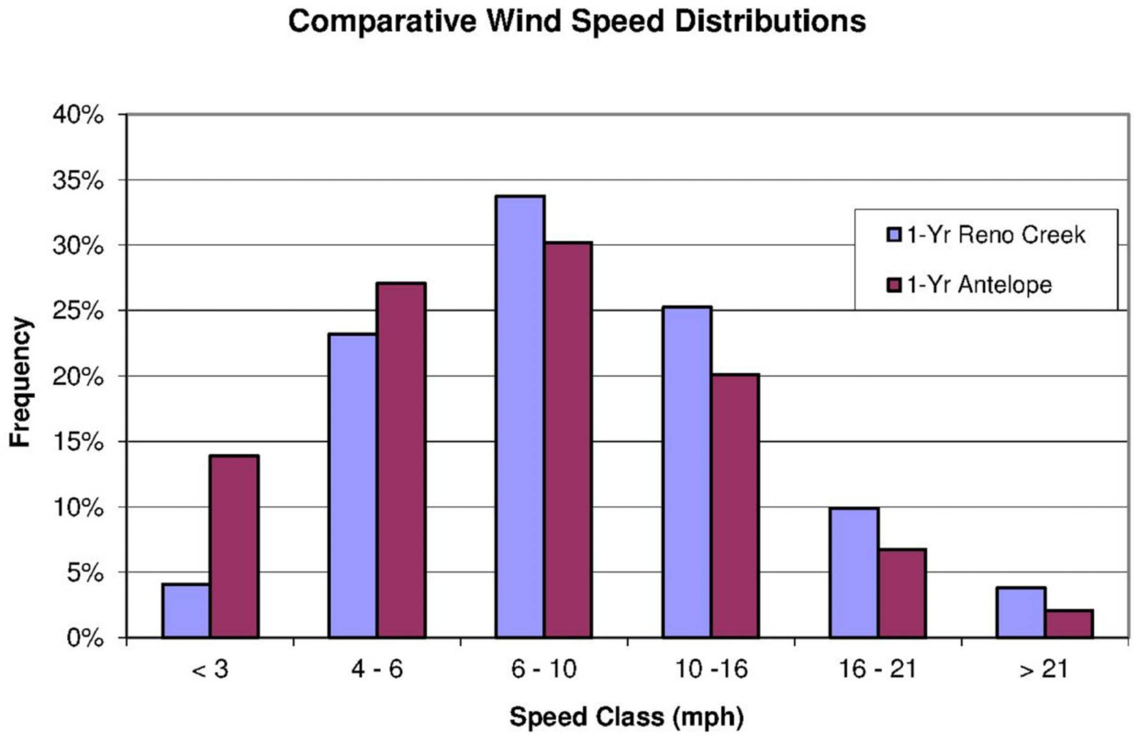
Source: Analysis by IML Air Science using hourly database from 1986 through 2011

Figure 3.6-37: Antelope 25-Yr vs Baseline Year Wind Direction Distributions



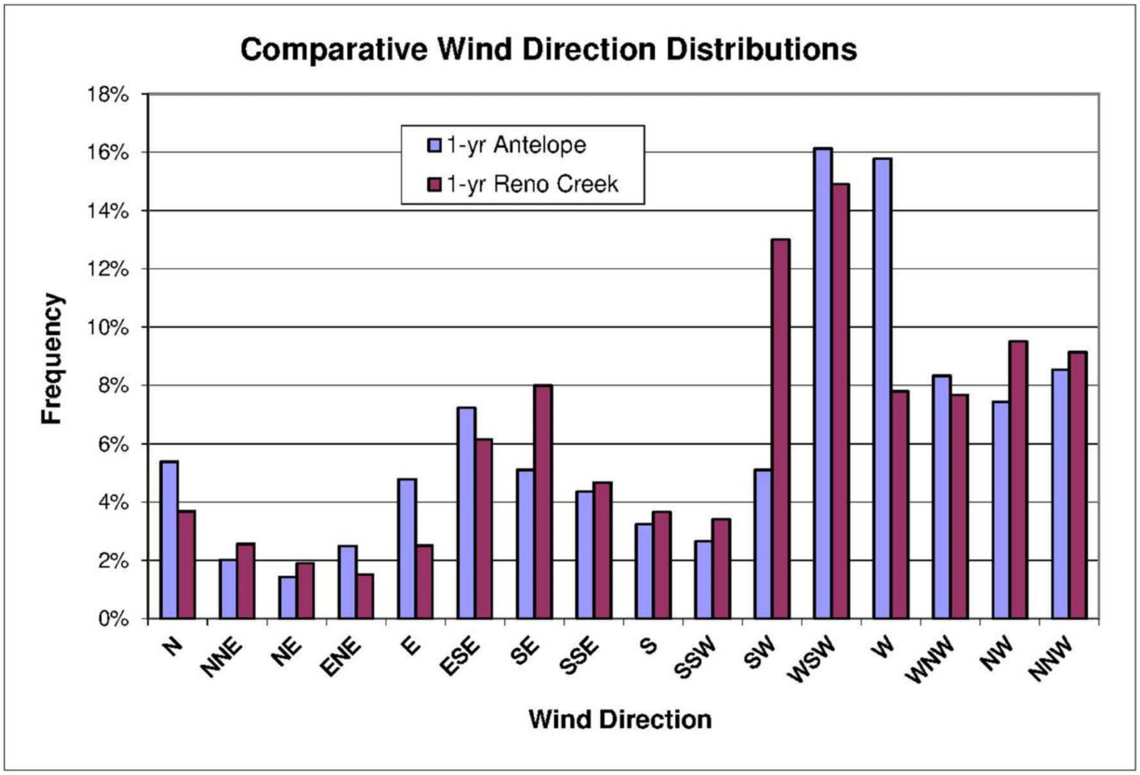
Source: Analysis by IML Air Science using hourly database from 1986 through 2011

Figure 3.6-38: Antelope vs Reno Creek Baseline Yr Wind Speeds



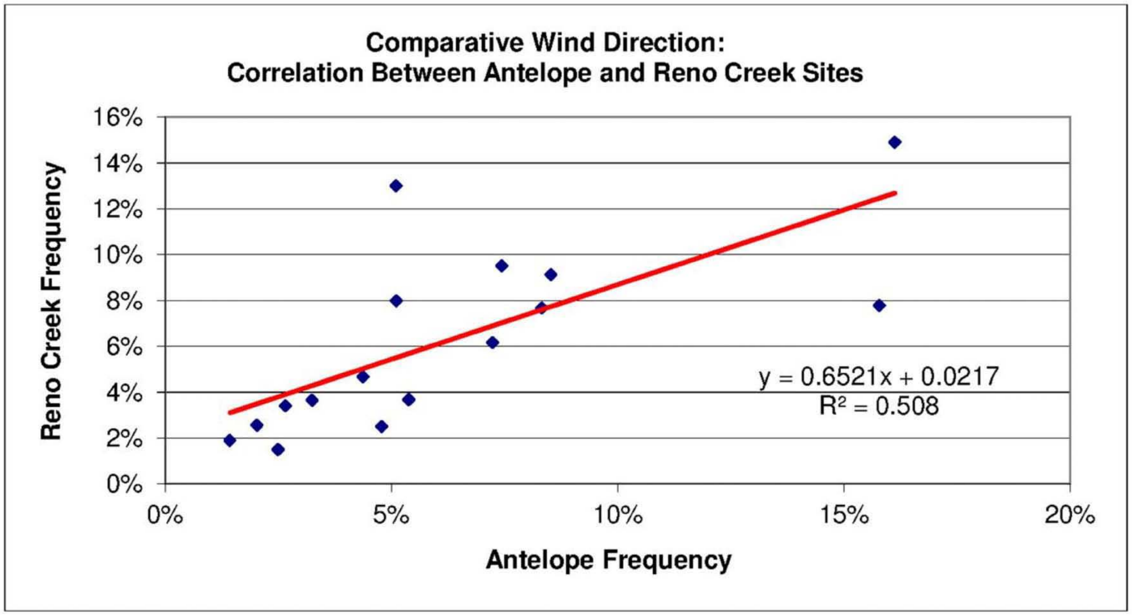
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year, 2010-2011

Figure 3.6-39: Antelope vs Reno Creek Baseline Yr Wind Directions



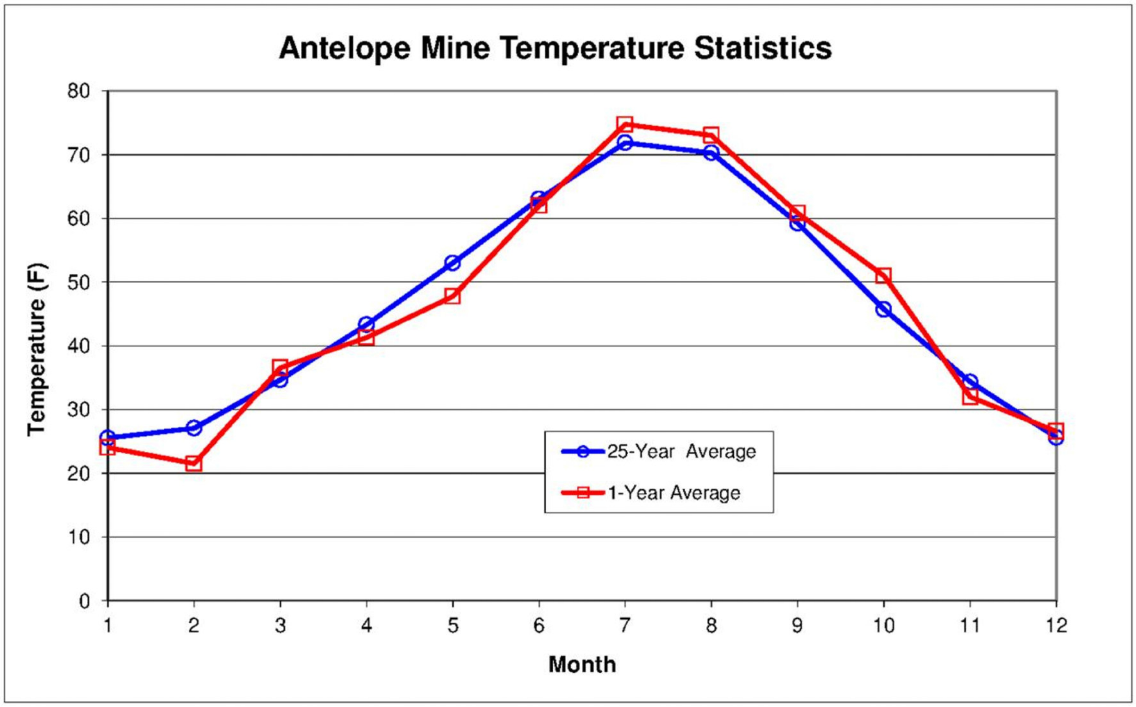
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year, 2010-2011

Figure 3.6-40: Antelope vs Reno Creek Baseline Yr Wind Direction Distributions



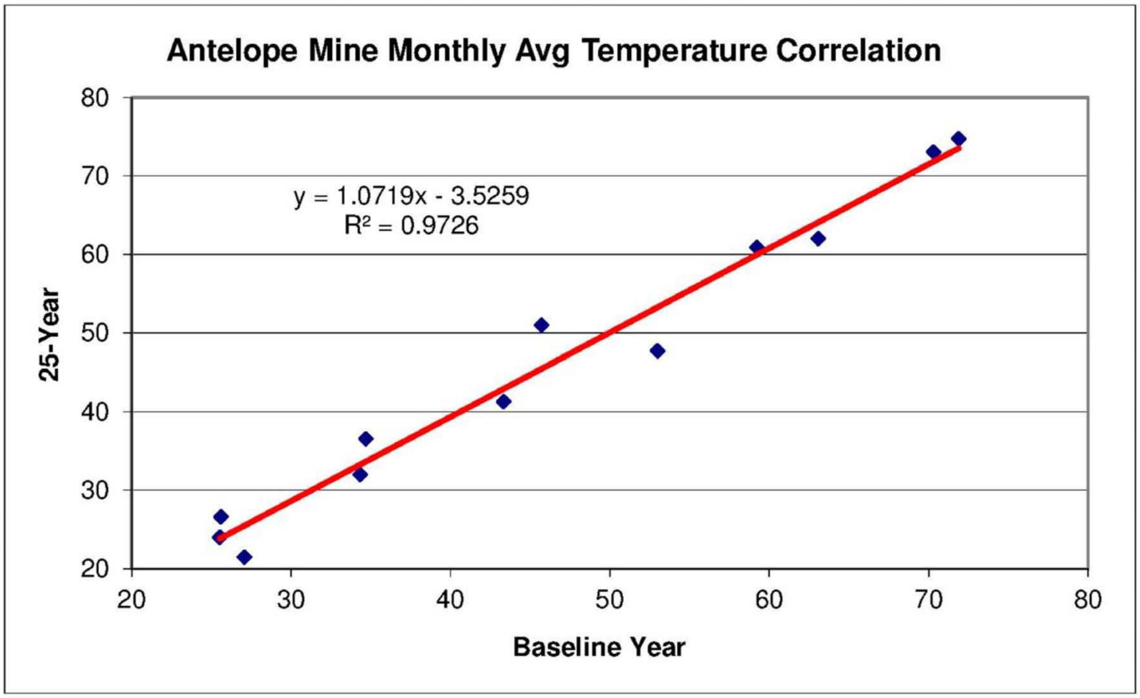
Source: Analysis by IML Air Science using meteorological databases
Period: Baseline monitoring year, 2010-2011

Figure 3.6-41: Antelope Short and Long-Term Monthly Average Temperatures



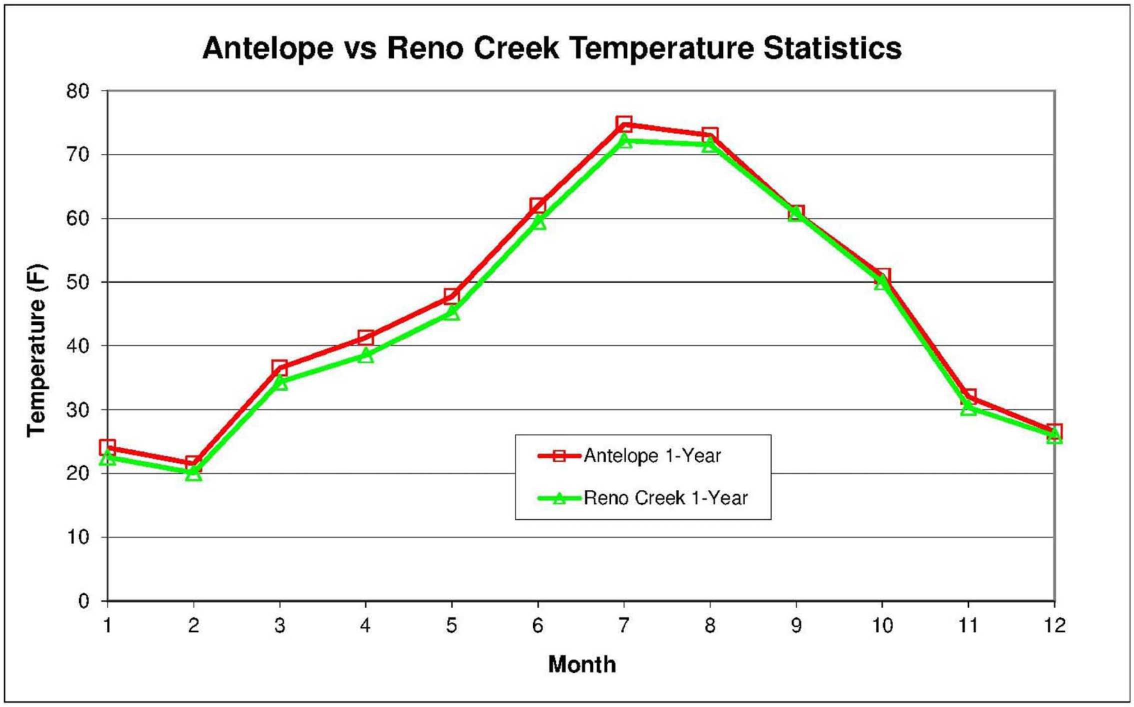
Source: IML Air Science meteorological database, 2011
Period: Baseline monitoring year, 1986-2011

Figure 3.6-42: Antelope Short and Long-Term Monthly Temperature Correlation



Source: Analysis by IML Air Science using meteorological databases
Period: 1986-2011

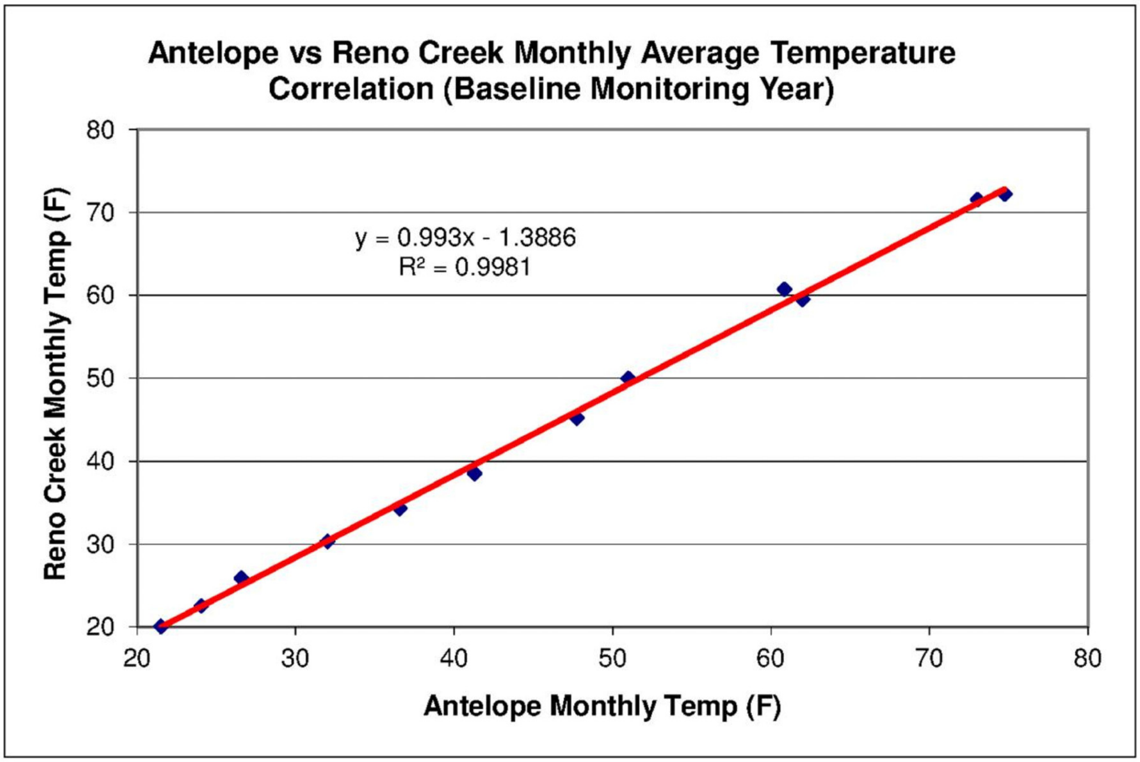
Figure 3.6-43: Antelope and Reno Creek Baseline Yr Monthly Avg. Temperatures



Source: IML Air Science meteorological database, 2011

Period: Baseline monitoring year, 1986-2011

Figure 3.6-44: Spatial Correlation of Monthly Average Temperatures



Source: Analysis by IML Air Science using meteorological databases
Period: Baseline monitoring year, 2010-2011

Figure 3.6-45: Proposed Project Meteorological Monitoring Map

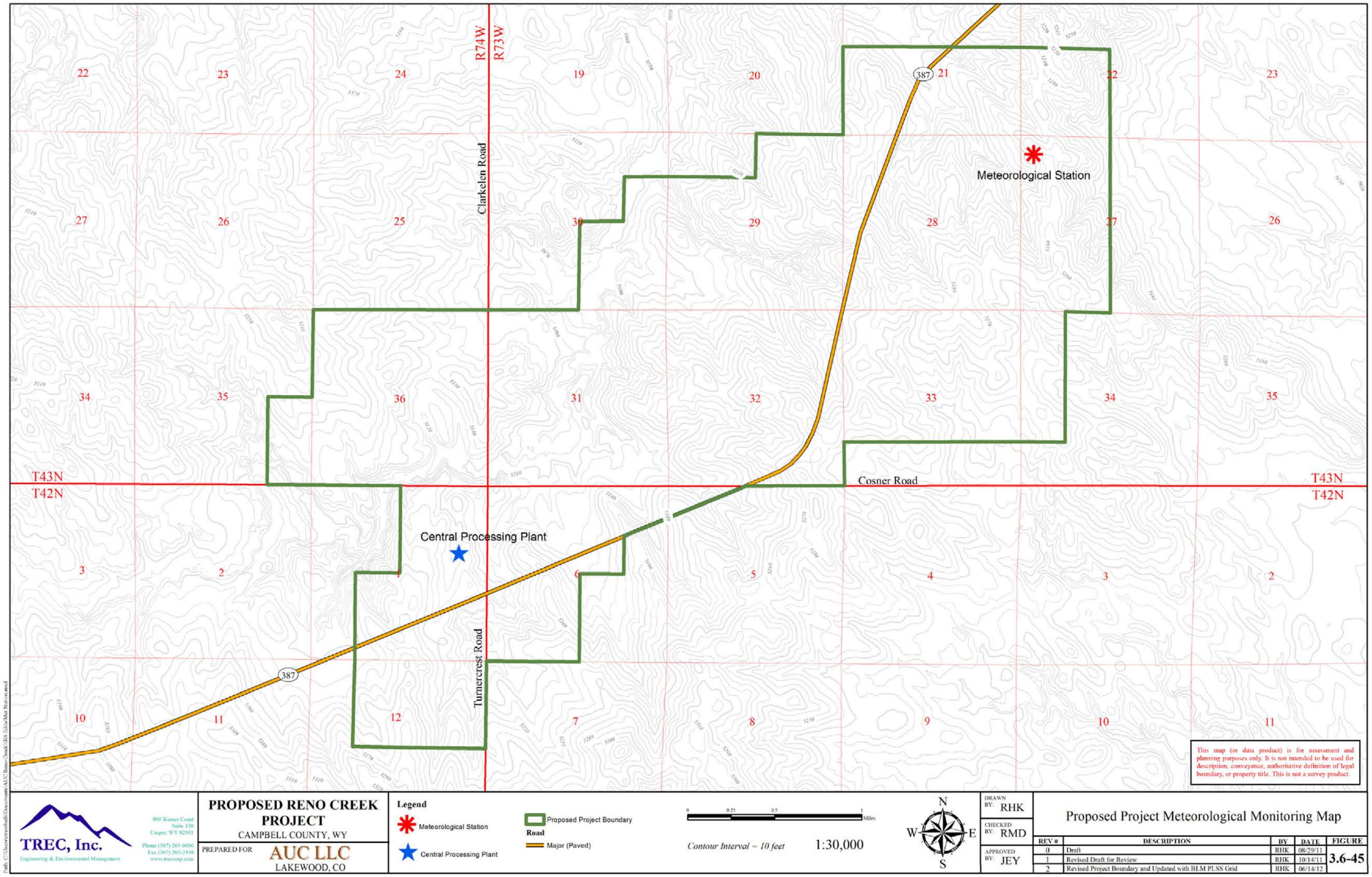


Figure 3.6-46: Reno Creek Meteorological Monitoring Station

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3.7 Noise

3.7.1 Affected Environment

This section describes the background noise sources within the Proposed Project area and presents the potential impacts of noise for the surrounding area. Existing noise sources within the Proposed Project area include county and local road traffic, livestock operations, CBM production operations, and wind. Further discussions regarding noise can be found in:

- Section 4.7 of this ER (Potential Noise Impacts);
- Sections 6.2.1.6 and 6.7 of this ER (Mitigation);
- Section 8.4.1.3 of this ER (Short-Term Costs); and
- Sections 7.1.8 and 7.2.8 of the TR (Environmental Effects).

Due to the remoteness of the Proposed Project, low population density of the surrounding area, and lack of noise generated from existing noise sources, the existing noise levels are generally low. As stated in NUREG-1910 (GEIS Section 3.3.7), the estimated ambient noise levels in undeveloped rural and more urban areas of the Wyoming East Uranium Milling Region are 22 to 38 decibels (dBA).

The nearest residence to the CPP is located approximately 2.2 miles away and is 0.42 miles away from the nearest Proposed Project boundary. Figure 3.7-1 depicts the location of the nearest residence in relation to the Proposed Project area.

Levels of noise close to industrial facilities and transportation corridors in the PRB are likely to be in the range of 50 to 70 dBA, depending on the proximity to these sources (BLM, 2003). The most significant ambient noise in the Proposed Project area is from traffic on State Highway 387, which traverses the Proposed Project area and CBM operations located within and around the project area. The ambient noise evaluation related to transporation and CBM are discussed below.

3.7.1.1 <u>Transportation</u>

The Federal Highway Administration (FHWA) and the Wyoming Department of Transportation(WYDOT) have noise impact assessment procedures and criteria to help protect the public health and welfare from excessive vehicular traffic noise. FHWA established Noise Abatement Criteria described in Table 3.7-1 according to land use, recognizing that different areas are sensitive to noise in different ways.

According to WYDOT procedures, a person is considered to be impacted by noise procedures when existing or expected future sound levels approach (within 1 dBA), are or exceed the Noise Abatement Criteria, or when expected future sound levels exceed existing sound levels by a substantial amount (15 dBA). These criteria were used to assess impacts at the Proposed Project. Cattle grazing, the primary land use within the Proposed Project area generates minor noise. However, State Highway 387, which traverses the Proposed Project area and Clarkelen Road, which accesses the site, are line sources of noise. Vehicular traffic sound a distance of 50 feet from the receptor has been estimated at 54 to 62 dBA for passenger cars and 58 to 70 dBA for heavy trucks (FHWA, 2011). Because noise from line sources such as roads is reduced by approximately 3 dBA per doubling of distance (FHWA, 2011), the maximum truck sound level of 70 dBA on the shoulder of either State Highway 387 or Clarkelen Road would diminish to the level of a Category "A" Activity, shown in Table 3.7-1, approximately 1,575 feet from the source, excluding the noise dampening characteristics of topographic interference and vegetation.

It was assumed that sound levels beyond a distance of 1,575 feet from State Highway 387 and Clarkellen Road would approximate 40 dBA, to conservatively overestimate a baseline that is consistent with the GEIS statement that existing ambient noise levels in this region would be 22 to 38 dBA. Table 3.7-2 provides examples of sound levels for common activities.

3.7.1.2 CBM Operations

The Proposed Project has CBM operations that are located on within and around the project area. In particular, a CBM compressor station located area uses multiple engines to move natural gas from central gathering facilities and along high-pressure transmission pipelines. As noted in NUREG-1910 (Supplement 1, Section 3.8), noise levels from CBM operations are expected to be unnoticeable from distances of 1,600 feet and beyond. The location of the CBM compressor station is shown on Figure 3.7-1.

Table 3.7-1: Noise Abatement Criteria

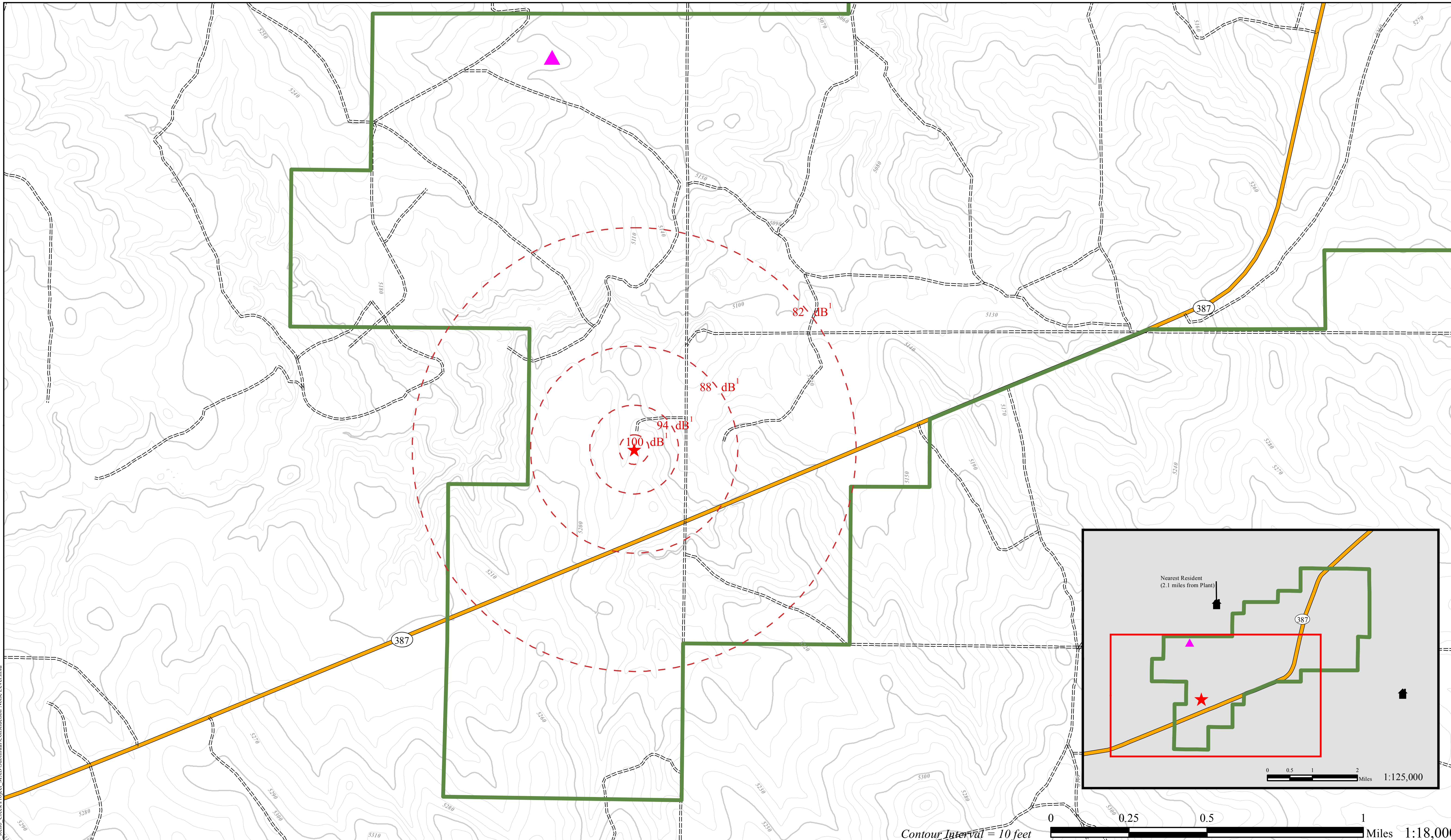
Active Category	L_{eq}(h)*	Description of Active Category
A	57 dBA (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purposes.
B	67 dBA (Exterior)	Residential (includes undeveloped lands permitted for this activity category).
C	67 dBA (Exterior)	Active sports areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio structures, recording studios, recreation area, schools, television studios, trails, and trail crossings.
D	52 dBA (Interior)-	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios.
E	72 dBA (Exterior)	Hotels, motels, offices, restaurants/bars, and other developed lands, properties, or activities not included in Categories A-D or F.
F	-	Agriculture, airports, bus yards, emergency services, industrial logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing.
G	-	Undeveloped lands that are not permitted.

*Leq(h) is an energy-averaged, one-hour, A-weighted sound level in decibels (dBA).
Source: 23 CFR Part 772, Procedures for Abatement of Highway Traffic Noise

Table 3.7-2: Relationship Between A-Scale dB Readings and Sounds of Daily Life

How It Feels	Equivalent Sounds	Decibels	Equivalent Sounds	How It Sounds
Near permanent damage level from short exposures	50 hp siren (100 ft) Jet Engine (75 ft)	130	Jackhammer Chainsaw	135 dB(A) *Appx 64 times as loud as 75 dB*
Pain to ears	Turbo-fan jet at takeoff power (100 ft)	120	Fire cracker (15 ft) Rock and Roll Band	125 dB(A) *Appx 32 times as loud as 75 dB*
Uncomfortably loud	Scraper loader	110	Unmuffled motor bike (2-3 ft)	115 dB(A) *Appx 16 times as loud as 75dB*
Discomfort threshold	Jet flyover (1000 ft)	100	Car horn Unmuffled cycle (25 ft)	*105 dB(A)* *Appx 8 times as loud as 75dB*
Very loud Conversation stops	Noisy newspaper press Air compressor (20 ft) Power lawnmower	90	Garbage trucks and city buses Diesel truck (25 ft)	95 dB(A) *Appx 4 times as loud as 75dB*
Intolerable for phone use	Steady flow of freeway traffic 10-HP outboard motor	80	Garbage disposal Food blender	85 dB(A) *Appx 2 times as loud as 75dB*
Extra auditory physiological effects	Automatic dishwasher Vacuum cleaner	70	Muffled jet ski (50 ft) Passenger car at 65 mph (25ft)	75 dB(A)
	Window air conditioner outside (2ft) Window air conditioner in room	60	Busy downtown area	
Quiet	Occasional private auto at 100 ft	50	Normal conversation	55 dB(A) *Appx 1/4 as loud as 75dB*
Sleep interference	Quiet home during evening	40		*45 dB(A)* *Appx 1/8 as loud as 75dB*
	Bird calls Library	30		*35 dB(A)* *Appx 1/16 as loud as 75dB*
	Soft whisper (5 ft)	20	In a quiet house at midnight	
	Leaves rustling	10		

Adapted from the ABCs of Our Noise Codes published by Citizens Against Noise, Honolulu, Hawaii



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PROPOSED RENO CREEK PROJECT

CAMPBELL COUNTY, WY

PREPARED FOR AUC LLC

LAKEWOOD, CO

Legend

- CBM Compressor Station
- Central Processing Plant
- Proposed Reno Creek Project Boundary

Road Classification

- Major (Paved)
- Minor (Unpaved)

N W E S

[1]Concentric noise circles are based on a six decible drop in loudness per doubled distance from initial expected construction area.

This map (or data product) is for assessment and planning purposes only. It is not intended to be used for description, conveyance, authoritative definition of legal boundary, or property title. This is not a survey product.

DRAWN BY: RHK

CHECKED BY: WB

APPROVED BY: JEY

Nearest Residence and Construction Noise Level

REV #	DESCRIPTION	BY	DATE	FIGURE
0	Draft for Review	RHK	09/15/11	3.7-1
1	Final	RHK	10/21/11	
2				

Path: O:\WY_Projects\2010-100_AUC_Reno Creek\Project_MXD\Submittal\Construction Noise Level.mxd

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3.8 Historic and Cultural Resources

This section provides a summary of the historic and cultural resources located within the Proposed Reno Creek Project (Proposed Project) area. Cultural resources, which are protected under the National Historic Preservation Act (NHPA) of 1966, are nonrenewable remains of past human activity. As noted in NUREG-1910 (GEIS, Section 3.3.8.4), there are no culturally significant places listed in either the National Register of Historic Places (NRHP) or state registers in the Wyoming East Uranium Region, including Traditional Cultural Places. This region includes the entire area of the Proposed Project. More comparable and/or detailed discussions regarding historic, cultural, and visual and scenic resources can be found in:

- Addendum 3.8-A of this ER (Confidential Information);
- Section 3.9 of this ER (Visual and Scenic Resources);
- Sections 4.8 and 4.9 of this ER (Potential Impacts);
- Sections 6.1.1.6, 6.2.1.7, 6.2.1.8, 6.8 and 6.9 of this ER (Mitigation);
- Section 2.4 of the TR (Historic, Cultural and Scenic Resources); and
- Sections 7.1.3 and 7.2.3 of the TR (Environmental Effects).

3.8.1 Regional/Site History

This portion of Wyoming appears to have been inhabited by aboriginal hunting and gathering people for more than 13,000 years. Throughout the prehistoric past, the area was used by highly mobile hunters and gatherers who exploited a wide variety of resources.

The Proposed Project is located in the prehistoric cultural sub-area known as the Northwestern Plains. The Northwestern Plains stretch from the central Alberta to southern Wyoming and from western North Dakota to western Montana. The Powder River Basin (PRB) of central Wyoming has a diverse cultural setting that exhibits influence of both the Northern Plains archaeological chronologies and the Great Basin archaeological chronologies (Francis and Loendorf 2002:9). The following sections provide a brief description for each of the cultural periods associated with the Proposed Project area and defined by the years before the present time (B.P.):

- Paleo-Indian period (13,000 to 7,000 years B.P.);
- Early Archaic period (7,000 to 5,000-4,500 years B.P.);
- Middle Archaic period (5,000-4,500 to 3,000 years B.P.);
- Late Archaic period (3,000 to 1,850 years B.P.);
- Late Prehistoric period (1,850 to 400 years B.P.);

- Protohistoric period (400 to 250 years B.P.); and
- Historic period (250 to 120 years B.P.)

3.8.1.1 Paleo-Indian Period

The prehistoric populations of the Northwestern Plains shared a single major economic adaptation that persisted over the course of 12,000 years with only minor changes in tool technology and subsistence strategy (Michlovic 1986; Reeves 1969:37). Throughout prehistory, the inhabitants of the Plains subsisted as semi-nomadic hunters and gatherers, but the species of plants and animals they exploited and the methods they used varied over time. The adaptations of human inhabitants of the Northwestern Plains during the last 4,000 years largely reflected their dependence on bison (Frison 1971:89).

Paleo-Indian culture is believed to have existed in the PRB as far back as 12,000 years ago. However, evidence to this effect is relatively sparse. The PRB is deeply filled with sediments, and older artifacts are assumed to be well covered. Since settlement by pioneers, archaeological finds have proceeded from the periphery of the Basin toward the center; however, most known archaeological sites are around the edges of the PRB.

3.8.1.2 Early Archaic Period

The early part of the Plains Archaic period occurred during a relatively dry climatic episode roughly 8,500 years ago. It is generally accepted that groups of people were concentrated in protected and humid locations such as mountains, foothills, and major river valleys (Husted 1969). This pattern of site distribution is not significantly different from that observed for the Paleo-Indian and may reflect the continuation of a generalized subsistence strategy. Most sites of this type are believed to be associated with the Plains Archaic and have been found in major river valleys (Davis 1976:81; Deaver et al. 1989; Greiser et al. 1983).

3.8.1.3 Middle Archaic Period

During the middle Plains Archaic period, groups began to adopt increasingly specialized subsistence and settlement strategies. In the Northern Plains, greater attention was devoted to bison hunting, resulting in increasingly regular movement across open prairie settings. There is evidence of a developing interest in open prairie living and resource procurement. In the southern portion of the Northwestern Plains, particularly in Wyoming's basin/foothill regions, archaic sites show an emphasis on a broader range of subsistence resources. In addition to bison, deer, pronghorn, and elk, smaller animals, such as rabbit, rodents, and fish were exploited. There is also a greater emphasis upon the utilization of plant resources. Associated with the exploitation of plant resources is an increase in the abundance of groundstone tools and *"food preparation pits"* (Frison 1991:89).

3.8.1.4 Late Archaic Period

The late Plains Archaic period is marked by further adaptations toward upland living and the exploitation of open prairie resources. Groups continued to occupy river valley and foothill settings while also devoting greater time and attention to the prairies. This change of focus is illustrated by their adoption of new cooperative hunting techniques and the development of the tipi, a specialized structure suited for open plains habitation.

Artifacts of the Plains Archaic period have been recovered in greater numbers than Paleo-Indian or early Plains Archaic types (Deaver and Deaver 1988:111). Late Plains Archaic sites occur in basin/foothill regions, river valley settings (Davis 1976:81-82), and in open prairie areas (Deaver and Aaberg 1977:98). With the continuation of the Atlantic climatic episode, periods of drought commonly occurred in the Great Plains. In many regions, this ecological stress caused indigenous populations to use a greater diversity of resources and resulted in corresponding modifications of subsistence strategies and point styles. In the Northern Plains, however, the subsistence patterns remained relatively stable and few differences in subsistence strategy from the Paleo-Indian tradition can be found.

3.8.1.5 Late Prehistoric Period

The Late Prehistoric period is characterized by an increasing specialization toward upland living and the utilization of open prairie resources, most importantly bison. The vast majority of Late Prehistoric/Woodland sites occur in open prairies rather than in protected hills or river valleys. The bow and arrow replaced atlatls, darts, and spears as the hunting implement of choice. This new weapon resulted in a much more efficient exploitation of upland game, particularly when employed with communal hunting techniques. The presence of pottery in Late Prehistoric/Woodland sites has led to several interpretations of the manner and significance of Eastern Plains influence in the Northwestern Plains.

3.8.1.6 Protohistoric Period

The Protohistoric period witnesses the beginning of European influence on prehistoric cultures of the Northwestern Plains. Additions to the material culture include most notably the horse and European trade goods, including glass beads, metal, and firearms. Projectile points of this period include side-notched, tri-notched, and unnotched points, with the addition of metal points. The occupants appear to have practiced a highly mobile and unstable residential mobility strategy.

3.8.1.7 Historic Period

The historical development of Wyoming begins with the arrival of non-Indian people. Unlike areas to the east, the first documented activities by Euro-Americans in Wyoming did not begin until the 1800s. The primary drive for the first incursions into the state was to identify and exploit the vast fur resources for export to the east. Beginning in the 1840s, emigrants of the "great western migration" passed along the Oregon-California Trail along the Platte and through South Pass, but few if any detoured through the PRB.

The PRB was disputed hunting grounds between the Sioux, Blackfoot and Crow nations during the late 19^{th} century. When gold was discovered in Montana during the 1860's, pioneers attempted to cross the PRB from the Platte River by means of the Bozeman Trail which sparked many conflicts between natives and settlers along the trail until 1880. The last of the major Indian wars of the northern plains were fought in the PRB area, including famous battles such as Fetterman, Wagonbox and Crazy Woman Fights (Larson, 1990).

The Proposed Project area is found in Campbell County which was created by law in 1911 out of the western halves of Crook and Weston Counties. Campbell County was named after both John A. Campbell, the first governor of the territory of Wyoming, and Robert Campbell who was with an early expedition to this part of Wyoming from 1825 to 1835. Campbell County officially organized in 1913.

Following World War I, Campbell County had an intense period of homesteading due to the growth of the "dry farming" movement and cattle and sheep ranching. Small coal mines were developed around the area as early as 1909 and major oil discoveries in Eastern Campbell County in 1956 set off the oil boom in the area and changed land use acreage minimally but added substantially to the economy of the area.

During the 1970's, the modern coal industry in Campbell County began to thrive. Major coal companies flocked to the County to harvest the PRBs low sulfur coal. Railroad companies began adding more lines to ship the coal away thus entering a new age of railroad history in Gillette. Today coal remains a vital industry in Campbell County (CCGov, 2011).

The initial discovery of uranium near the Proposed Project area was by Dr. John David Love. He asserted that uranium was likely to be found in and associated with the tuffaceous sediments of the Oligocene White River Formation (38-24 million years old) in the PRB and hypothesized that the deposit should occur in the Pumpkin Buttes area of southwest Campbell County. Love, who earned his Ph.D. at Yale University, was the recipient of the U.S. Department of the Interior's Meritorious Service Award and the American Geological Institute's first Legendary Geoscientist Award. Aerial surveys and field verifications in the early 1950's verified Love's assertions of uranium deposits. During the 1970's and 1980's, the uranium industry acquired large tracts of subsurface uranium mineral rights and leases (WSGC, 2011).

Substantial historical exploration, development, and mine permitting were performed on the Reno Creek Property. Beginning in the late 1960s and continuing into the mid-1980s, RME, a wholly owned mining subsidiary of the Union Pacific Railroad, drilled thousands of exploration borings on the Reno Creek Property. Significant permitting studies, including the construction, successful operation, groundwater restoration, and subsequent reclamation of an ISR pilot plant, were also performed over the years. Restoration and stabilization of the groundwater was acknowledged and signed off by the NRC in March of 1986 (Accession #8604040293/Docket #04008697).

3.8.2 Cultural Resources Survey

A Class I cultural resource inventory is a summary of existing records and data that discusses all relevant prior studies and their findings for a specific area. A Class III cultural resources survey is an intensive and comprehensive inventory of the Proposed Project area conducted by professional archaeologists and consultants. The goal of the surveys is to locate and evaluate for the NRHP all cultural resources 50 years and older that have exposed surface manifestations within the Proposed Project area. Cultural properties are recorded at a sufficient level to allow for evaluation for possible inclusion to the NRHP. Determinations of eligibility are made by the managing federal agency in consultation with Wyoming's State Historic Preservation Office (SHPO).

A Class I resource inventory SHPO Records Division file search was conducted on June 6, 2010 for information on previous Class III surveys and recorded cultural resources for the Proposed Project area by Drs. John and Mavis Greer from Greer Services. Greer Services also conducted a Class III Cultural Resource Evaluation between August 5, 2010 and December 11, 2010 with some additional field checking after that date through August 17, 2011 on the remaining 3,956 acres within the 6,057 acre review area that lacked existing Class III records.

Each site's integrity of location, design, materials, workmanship, feeling and association are considered in the evaluation as well as the National Register's four main criteria:

- **Criterion A** – the site must make a contribution to the major pattern of American history;
- **Criterion B** – the site is associated with significant people of the American past;
- **Criterion C** – the site embodies distinctive characteristics; and

- **Criterion D** – the site has yielded or may be likely to yield information important to prehistory or history. (NRHP 2011a)

3.8.3 Paleontological Resources

The BLM utilizes the Potential Fossil Classification System (PFYC) for land use planning efforts and for the preliminary assessment of potential impacts and proper mitigation needs for specific projects. It is intended to provide a tool to assess potential occurrences of significant paleontological resources. It is meant to be applied in broad approach for planning efforts, and as an intermediate step in evaluating specific projects. Using the PFYC system, geologic units are classified based on the relative abundance of vertebrate fossils or scientifically significant invertebrate or plant fossils and their sensitivity to adverse impacts, with a higher class number indicating a higher potential (BLM 2011). The five (5) primary classes of geologic units are:

- **Class 1**- Very Low;
- **Class 2**- Low;
- **Class 3**- Moderate or Unknown;
- **Class 4**- High; and
- **Class 5**- Very High.

The entirety of the Proposed Project area is considered the Wasatch Formation which the BLM designates a PFYC Class 5. Paleontological survey results are provided in Addendum 3.8A of the ER.

3.8.3.1 <u>Results</u>

Seventy-nine cultural localities are known within the Proposed Project area. Of these, 41 were previously recorded from previous surveys, and 38 were found during the 2010 inspection. Of the total localities, 33 have been assigned site numbers, and the others are considered isolated resources under current SHPO definitions. Cultural localities date to the prehistoric (42), historic (27), and combined prehistoric-historic (10). According to NUREG-1569 (Section 2.4.1), specific attention should be directed to properties included in or eligible for inclusion in the the National Register. Because none of the cultural remains in the Proposed Project are considered eligible for the National Register, no further archeological work or special consideration is recommended for the Proposed Project.

The Class III cultural resource inventory report submitted to WDEQ-LQD and NRC constitutes documentation for formal consultation with the SHPO and contains information that falls under the confidentiality requirement for archeological resources under the Section 304 (16 U.S.C. 470w-3(a)). The Wyoming Cultural Resource Forms are not included in Addendum 3.8A since these forms were not provided to the AUC due to disclosure restrictions in the NHPA Section 304. Accordingly, disclosure is specifically exempted by statute as specified in 10 CFR §2.390(a)(3). Therefore, AUC requests that all applicable portions of Addendum 3.8A remain "CONFIDENTIAL" for the purpose of Public Disclosure of this application. Each page of the protected cultural resource information has been marked as follows:

"Confidential Information Submitted under 10 CFR 2.390"

The cover page for Addendum 3.8-A has been marked with a more detailed statement, as follows:

*"Confidential Information Submitted under 10 CFR 2.390
Disclosure is Limited Under the National Historic Preservation Act, Section 304 (16 U.S.C. 470w-3(a))."*

3.8.4 Tribal Consultation

Cultural resources that are considered sensitive and potentially sacred to modern Native American tribes include burials, rock art, rock features and alignments (such as cairns, medicine wheels, and stone circles), Indian trails, and certain religiously significant natural landscapes and features. Some of these resources may be formally designated as traditional cultural places (TCPs) or Indian Sacred Sites. A TCP is a site considered eligible for inclusion on the NRHP because of its association with cultural practices or beliefs of a living community which are (a) rooted in that community's history and (b) important in maintaining the continuing cultural identity of the community (NRHP 2011).

To date there are no Native American Heritage sites or TCPs which have been formally identified and recorded which are associated with the Proposed Project area. However, the Proposed Project area is geographically located 7.5 miles from the Pumpkin Buttes (and at least 5.5 miles outside of the Programmatic Agreement boundary) which have been identified as a TCP and has potential cultural affiliation with nine tribes. The Buttes are used in traditional Native American ceremonial activities including rituals and sacred narratives. Uranerz Energy Corporation's (URZ) NRC-approved Nichols Ranch ISR Project is located at the base of the Pumpkin Buttes. A Memorandum of Agreement (MOA) among URZ, NRC, BLM, ACHP, WY SHPO, and seven tribes regarding mitigation of adverse effects to historic properties was reconciled on June 27, 2011. It stipulates general mitigation measures and the procedures in the event of a discovery of a new cultural resource.

According to the Supplemental Environmental Impact Statement for the Uranerz (URZ) Nichols Ranch ISR Project (NUREG-1910, Supplement 2, Section 3.9.2.3), the TCP boundary for the North Middle Butte of the Pumpkin Buttes is 5,500 feet from the center of the top of the butte. The proposed Reno Creek Project area, unlike the URZ Nichols Ranch ISR Project, is located well beyond the TCP boundary. This distance between the Proposed Project and the Pumpkin Buttes negates the necessity to obtain a MOA for the operation of the Proposed Project facility pursuant to the BLM Programmatic Agreement. As noted in NUREG-1910 (GEIS, Section 3.3.8.4), there are no culturally significant places listed in either the NRHP or state registers in the Wyoming East Uranium Region.

Nevertheless, AUC commits to ongoing monitoring of historic and cultural resources as project development progresses. Mitigation measures proposed to avoid or reduce cultural resource impacts include:

- Consultations with Native American governments early in the planning process to identify traditional cultural properties, sacred landscapes, and other issues and concerns regarding the Proposed Project;
- If resources eligible for listing on the NRHP are present, modify the development plan to avoid significant cultural resources;
- Prepare an Unanticipated Discovery Plan (UDP) to manage AUC's activities in the event of a discovery of cultural resources during any phase of the project. A copy of the Plan will be provided to the NRC and to the Wyoming SHPO no less than 30 days prior to the commencement of construction on the Proposed Project. A brief outline of the UDP can be found in ER Section 7.5.
- Internal cultural resources management plan, if cultural resources are present in the area of potential effect or if areas with a high potential to contain cultural material are identified;
- An unexpected discovery of cultural resources during any phase of the project shall result in a work stoppage in the vicinity of the find until the resources can be evaluated by a professional archaeologist; and
- Use existing roads to the maximum extent feasible to avoid additional surface disturbance.

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Figures

3.9 Visual and Scenic Resources

Although the Proposed Project does not encompass any BLM properties, AUC chose to follow the guidance outline in NUREG 1910 (GEIS 3.3.9) by utilizing BLM's Visual Resource Management (VRM) system (BLM Manual 8400, 2007) in its assessment of visual and scenic resources. The BLM has developed this system as it is responsible for ensuring that the scenic values of public lands are considered before allowing uses that may have potentially negative visual impacts. BLM accomplishes this through its VRM system, which involves inventorying scenic values and establishing management objectives for those values through the resource management planning process, and then evaluating proposed activities to determine whether they conform to the management objectives. Further discussions regarding visual/scenic resources can be found in:

- Sections 4.1 and 4.9 of this ER (Potential Land Use/Visual Impacts);
- Sections 6.1.1.6, 6.2.1.7, 6.2.1.8, 6.8 and 6.9 of this ER (Mitigation Measures);
- Section 8.4.2 of this ER (Long-Term Costs);
- Section 2.4 of the TR (Historic, Cultural and Scenic Resources);
- Section 6.2 of the TR (Plans/Schedules for Reclaiming Disturbed Lands); and
- Sections 7.1.3 and 7.2.3 of the TR (Potential Environmental Effects).

3.9.1 Methods

The VRM system is the basic tool used by the BLM to inventory and manage visual resources on public lands. The VRM inventory process involves rating the visual appeal of a tract of land, measuring public concern for scenic quality, and determining whether the tract of land is visible from travel routes or observation points. AUC has inventoried the landscape within the Proposed Project area and the surrounding two-mile buffer area.

3.9.1.1 <u>Visual Resource Management Classes</u>

The elements used to determine the visual resource inventory class are the scenic quality, sensitivity levels, variety classes, and distance zones. Each of the elements used to identify the VRM Class (BLM 2007 and 2007a) is defined below.

Scenic Quality - Scenic quality is a measure of the visual appeal of a tract of land. In the visual resource inventory process, public lands are assigned an A, B, or C rating based on the apparent scenic quality, which is determined using seven key factors: landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications. During the rating process, each of these factors is ranked comparatively against similar features within the physiographic province.

Sensitivity Level – A degree or measure of viewer interest in the scenic qualities of the landscape. Factors to consider include: 1) type of users; 2) amount of use; 3) public interest; 4) adjacent land uses; and 5) special areas. Three levels of sensitivity have been defined:

- Sensitivity Level 1 – The highest sensitivity level, referring to areas seen from travel routes and use areas with moderate to high use;
- Sensitivity Level 2 – An average sensitivity level, referring to areas seen from travel routes and use areas with low to moderate use; and
- Sensitivity Level 3 – The lowest sensitivity level, referring to areas seen from travel routes and use areas with low use.

Distance Zones – Landscapes are subdivided into three distance zones based on relative visibility from travel routes or observation points. The zones are based on specified distances from the observer, particularly on roads, trails, concentrated-use areas, rivers, etc. The three categories are foreground-middleground, background, and seldom seen.

- Foreground/Middleground – The area visible from a travel route, use area, or other observer position to a distance of three to five miles. The outer boundary of this zone is defined as the point where the texture and form of individual plants are no longer apparent in the landscape and vegetation is apparent only in pattern or outline;
- Background - The viewing area of a distance zone that lies beyond the foreground and middleground. This area usually measures from a minimum of three to five miles to a maximum of about 15 miles from a travel route, use area, or other observer position. Atmospheric conditions in some areas may limit the maximum to about eight miles or increase it beyond 15 miles; and
- Seldom Seen – The area is not seen as foreground-middleground or background and is hidden from view by landforms, buildings, other landscape elements, or distance.

The visual resource inventory classes are used to develop visual resource management classes, which are generally assigned by the BLM through the resource management plan process. VRM objectives are developed to protect scenic public lands, especially those lands that receive the greatest amount of public viewing. The following VRM classes are objectives that outline the amount of disturbance an area can tolerate before it no longer meets the visual quality of that class.

- Class I Objective: To preserve the existing character of the landscape. The level of change to the characteristic landscape should be very low and must not attract attention;

- Class II Objective: To retain the existing character of the landscape. The level of change to the characteristic landscape should be low;
- Class III Objective: To partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate; and
- Class IV Objective: To provide for management activities which require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high.

According to NUREG-1910 (GEIS Section 3.3.9), the Proposed Project area does not contain any Class I resources. It goes on to state that the few Class II resources located within the Wyoming East Uranium Region are contained south of Interstate 25. That particular area is nearly 40 miles removed from the Proposed Project area. The Scenic Quality, Sensitivity Level, and Distance Zone inventory levels are combined to assign the VRM Class to inventoried lands as shown in Table 3.9-1.

3.9.1.2 Reno Creek Visual Resource Management Rating

The area surveyed for visual resources includes the Proposed Project area and two mile buffer area. The Proposed Project is located predominantly on privately owned land with one section of the project lying on state owned land. One area of managed land, Thunder Basin National Grassland, bisects the Proposed Project area into an east and west separation. Although the Thunder Basin National Grassland exists within the Proposed Project area, all lands encompassed by the Grassland are privately owned. Approximately 77.2 percent of the Proposed Project area, or 4,676 of the total 6,057 acres, is included within the designation Grassland.

Landscapes are characterized by a flat to rolling topography with small ephemeral drainages and large, open upland grassland mixed with sagebrush shrubland. There are areas of modified landscape within the study area (including the two mile buffer area), including oil and gas production facilities and infrastructure, utilities, transportation infrastructure, agricultural infrastructure and three residences. AUC has inventoried the landscape within and near the Proposed Project, and has rated the areas as VRM Class III as shown in Figure 3.9-1 (BLM 2001).

The scenic quality inventory is based on methods provided in BLM Manual 8410 – Visual Resource Inventory as well as a review of the factors that contribute to the existing VRM Class III inventory for the Proposed Project area. The key factors of landform, vegetation, water, color, influence of adjacent scenery, scarcity, and cultural modifications were evaluated and scored according to the rating criteria. The criteria for each key factor range from high to moderate to low quality based on the variety of line, form, color, texture and scale of the factor within the landscape. A score was associated with each rating criteria, with a higher score applied to greater complexity and variety for each factor in the landscape. Figure 3.9-2 depicts the viewshed (areas from which the CPP would be visible) for the Proposed Project area. The CPP was selected for the viewshed evaluation since it would be the most noticeable (largest and tallest) structure in the Proposed Project area. Figure 3.9-3 shows photographs taken from residences, roads, and a scenic quality inventory site located at a high point near the center of the Proposed Project area. These photographs, along with field reconnaissance, were used to determine the visual resource rating. The location of which these photos were taken is shown on Figure 3.9-2.

Based on guidance provided in NUREG-1569 (Section 2.4.3), if the visual resource evaluation rating is 19 or less, no further evaluation is required. Based on the study conducted in July 2011, the total score of the scenic quality inventory for the Proposed Project is eight out of the possible 32 as shown in Table 3.9-2. Therefore, under the NUREG-1569 guidance, no further evaluation is required for existing scenic resources and any changes to scenic resources from Proposed Project facilities.

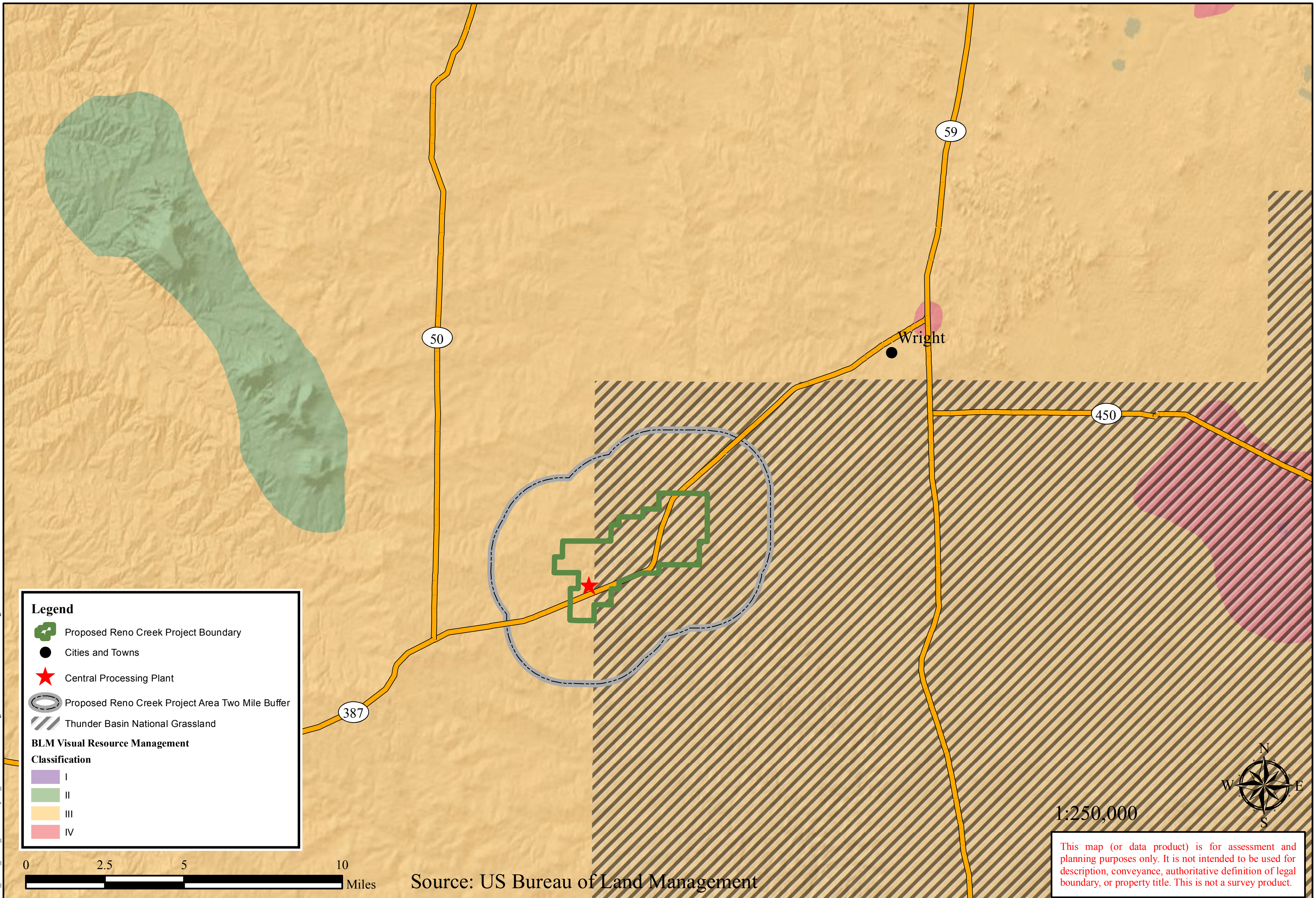
Table 3.9-1: Determining BLM Visual Resource Inventory Classes

Visual Sensitivity		High			Medium			Low
Special Areas		I	I	I	I	I	I	I
Scenic Quality	A	II	II	II	II	II	II	II
	B	II	III	III/IV	III	IV	IV	IV
	C	III	IV	IV	IV	IV	IV	IV
Distance Zones		f/m	b	ss	f/m	b	ss	Ss

Source: BLM Manual H-8410-1 - Visual Resource Inventory; f/m = foreground-middle ground; b = background; ss – seldom seen

Table 3.9-2: Scenic Quality Evaluation Ratings

Key Factor	Rating Criteria	Score
Landform	Flat to rolling terrain with some areas of steeper topography in the background; few or no interesting landscape features.	1
Vegetation	Little variety in vegetation, which consists of grazed grassland with sage and other shrubs. There are a few large trees present on the site which offer some variety in form.	2
Water	Present, but not noticeable. Water bodies consists of small stock ponds, CBM outfalls, and surface runoff.	1
Color	Vegetation and soil have some subtle color variations but generally shift from green tones in the spring to tan tones throughout the remainder of the year.	2
Influence of Adjacent Scenery	Adjacent scenery is very similar to the Proposed Project area, and provides little variety in line, form, color, and texture.	1
Scarcity	Landscape is common for the region.	1
Cultural Modifications	Existing modifications consist of numerous oil and gas production facilities and infrastructure, and grazing activities.	0
	Total Score	**8**



Path: O:\WY_Projects\2010-100_AUC_Reno_Creek\Project_MXD\Submittal\Regional Visual Resource Management Classification.mxd

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PROPOSED RENO CREEK PROJECT
CAMPBELL COUNTY, WY

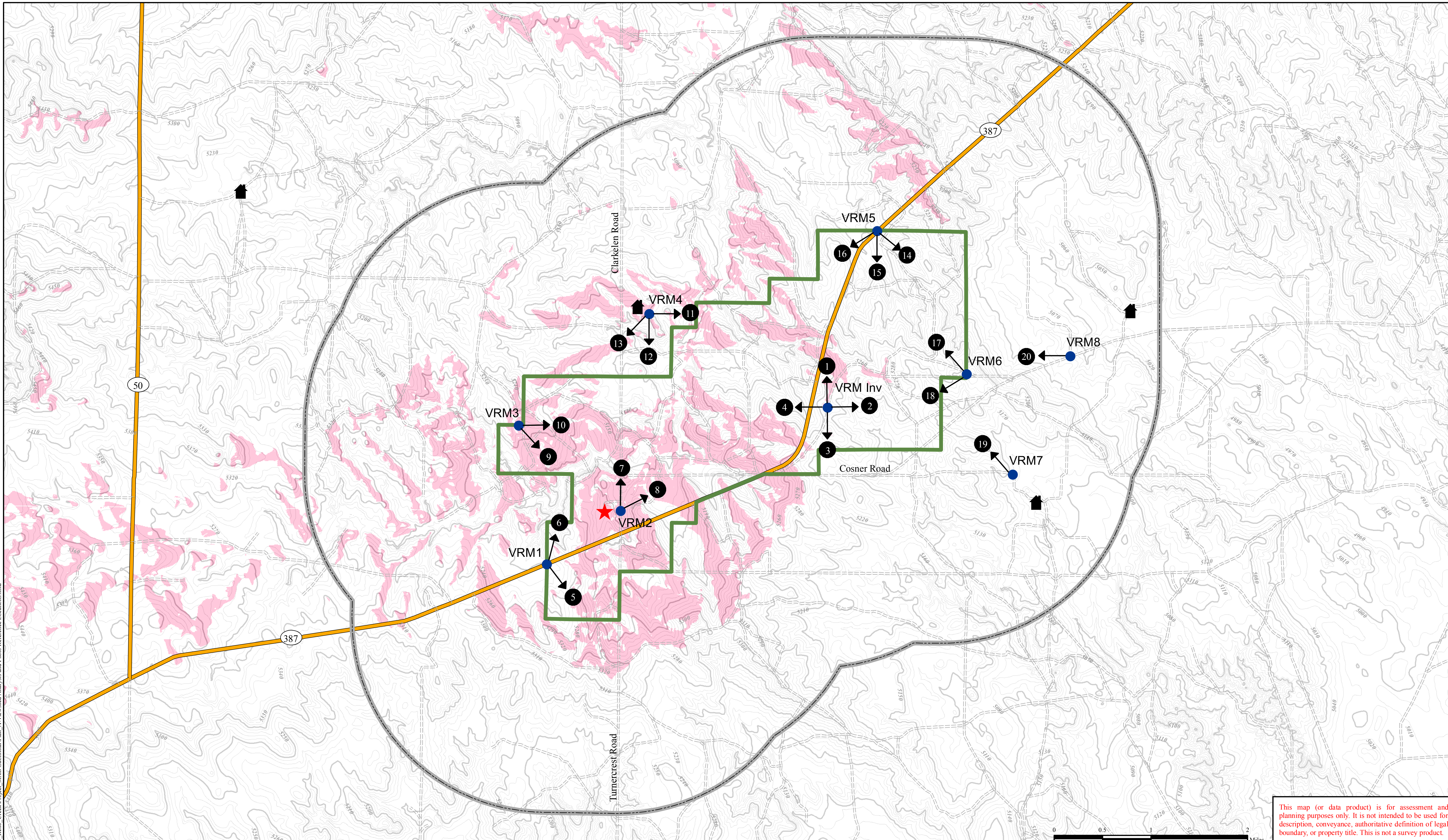
PREPARED FOR: AUC LLC
LAKEWOOD, CO

Regional Visual Resource Management Classification

Drawn: RHK
Checked: RMD
Approved: JEY

Figure 3.9-1

Rev. #	Description	Date
0	Draft	08/16/2011
1	Revised Draft for Review	08/19/2011
2	Final	08/20/2011



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PROPOSED RENO CREEK PROJECT

CAMPBELL COUNTY, WY

PREPARED FOR AUC LLC
LAKEWOOD, CO

Legend

- Areas Where Facility Will Not Be Visible
- Areas Where Facility Will Be Visible
- Residence
- Visual Resource Photo Location
- Proposed Reno Creek Project Boundary
- Central Processing Plant (Height = 50')
- Proposed Reno Creek Project Area Two Mile Buffer

Road Classification

- Major (Paved)
- Minor (Unpaved)

Contour Interval = 10 feet

1:58,000

N S E W

DRAWN BY: RHK

CHECKED BY: RMD

APPROVED BY: JEY

Viewshed Analysis and Photo Reference Locations

REV #	DESCRIPTION	BY	DATE
0	Draft	RHK	08/16/2011
1	Draft Revision	RHK	10/18/2011
2	Final	RHK	10/21/2011

FIGURE 3.9-2

Figure 3.9-3: Scenic Quality Photographs

Photo 1: Scenic Quality Inventory Point (VRM Inv) looking North

Photo 2: Scenic Quality Inventory Point (VRM Inv) looking East

Photo 3: Scenic Quality Inventory Point (VRM Inv) looking South

Photo 4: Scenic Quality Inventory Point (VRM Inv) looking West

Photo 5: VRM Site 1- View from Highway 387 looking South East

Photo 6: VRM Site 1- View from Highway 387 looking North East

Photo 7: VRM Site 2- View from Clarkelen Road looking North

Photo 8: VRM Site 2- View from Clarkelen Road looking North East

Photo 9: VRM Site 3- View from East end of the Proposed Project area within the Proposed Project area looking South East

Photo 10: VRM Site 3- View from East end of the Proposed Project area within the Proposed Project area looking East

Photo 11: VRM Site 4- View from potential residence north of the Proposed Project area looking East

Photo 12: VRM Site 4- View from potential residence north of the Proposed Project area looking South

Photo 13: VRM Site 4- View from potential residence north of the Proposed Project area looking South West

Photo 14: VRM Site 5- View from Highway 387 looking South East

Photo 15: VRM Site 5- View from Highway 387 looking South

Photo 16: VRM Site 5- View from Highway 387 looking South West

Photo 17: VRM Site 6- View from West end of the project boundary looking North West

Photo 18: VRM Site 6- View from West end of the project boundary looking South West

Photo 19: VRM Site 7- View from residence within the two-mile buffer looking North West

Photo 20: VRM Site 8- View from residence within the two-mile buffer looking West

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3.10 Socioeconomics

Information presented in this section characterizes those demographic and social characteristics of the counties and communities that may be affected by the proposed development of the Proposed Project in Campbell County, Wyoming. Data were obtained through the 1980, 1990, 2000, and 2010 U.S. Census Bureau (USCB), and various State of Wyoming government agencies among other sources. Further information can be found in:

- Sections 8 of the ER (Benefit/Cost);
- Section 4.10 of this ER (Potential Socioeconomic Impacts);
- Section 4.11 of this ER (Environmental Justice)
- Sections 5.11 and 5.12 of this ER (Cumulative Impacts);
- Section 2.3 of the TR (Population Distribution); and
- Sections 7.1.2, 7.2.2 and 7.6 of the TR (Environmental Effects).

3.10.1 Population

3.10.1.1 <u>Regional Population</u>

The Proposed Project is located in southwest Campbell County. There are several communties within approximately 50 miles that may be directly affected by the Proposed Project. Significant population centers and their 2010 population estimates include Wright (1,807), Edgerton (195), Midwest (404), and Gillette (29,087). The town of Casper (55,316) is located outside the 50 mile review area but may be a potential source of labor, services, and materials to support ISR operations.

Total population within the 50 mile area in 2010 was 45,807. Table 3.10-1 reflects the populations within varying radii utilizing the 16 compass sectors extending outward to within 50 mile of the Proposed Project. These sectors are shown in Figure 3.10-1.

Population trends in counties and communities within a 50 mile distance of the Proposed Project are shown in Table 3.10-2 between 1980 and 2010. Generally, population declined throughout Wyoming between 1980 and 1990, with the exception of Campbell County which grew by nearly one-fifth, primarily because of ongoing mineral resource development in the PRB. Population generally began to rebound in the 1990s. Between 2000 and 2010, population growth was strong throughout the 50 mile area. All counties in the Survey Area except Natrona, Niobrara and Weston exceeded state growth of 14 percent between 2000 and 2010. Among municipalities, the highest growth between 2000 and 2010 occurred in Gillette (48 percent) and Wright (34 percent).

In addition to the population numbers above, there are other persons who are not counted in the decennial census numbers. Although there are some seasonal residents who would not be counted in the census, the most significant population variable in the area is the number of shift workers who live somewhere else and commute to Wyoming in shifts (e.g., ten days on, ten days off). While working in Wyoming, they could be living in rental units, housing units owned by the company they work for, RV parks, on-site facilities (e.g., "workers camps" at the work site) and in hotels. Census population numbers for a place include only people who identify that place as their primary residence and do not include others who list their primary residence elsewhere (such as the "shift-labor" workers). As a result, the total of all permanent and part-time residents living in a place at any time could be significantly higher than the census count. Unfortunately, there is no standardized mechanism for counting part-time residents.

To address this issue, the Wyoming Department of Employment Research and Planning has begun to track workers without a Wyoming or Colorado driver's license. The most recent published information available by county are tables with quarterly information between 2005 and 2009. These data show that among all Wyoming Counties, Campbell County had the second highest number of worker inflow in the fourth quarter of 2009. Campbell County had 4,632 such workers. Natrona County had 3,241 such workers in the fourth quarter of 2009. All of the other counties in the seven-county 50 mile Study Area had less than 500 workers without a Wyoming or Colorado driver's license (WDOE 2010).

The 2010 population numbers by age and sex for counties within 50 mile of the Proposed Project are shown in Table 3.10-3. In all of the counties, the 40 to 64 year age group (which includes the 'baby boom' generation) comprises roughly a third or more of the population in each of the counties. According to the Wyoming Economic and Demographic Forecast: 2007 to 2016 (WDAI, 2007), the early baby boom population in Wyoming is one of the highest in the nation as a result of the in-migration of workers during the oil boom years in the late 1970s and early 1980s. In contrast, the population in the 27 to 42 year age group in most counties is relatively low. Noticeably different are Campbell and Natrona counties where the the 20-39 year age group is comparable to that of the 40 to 64 year age group.

In 2010, 93.7 percent of the total seven county population of 160,760 was classified as white and non-Hispanic. Hispanics (of any race) were estimated at 6.5 percent of the population. Persons of two or more races comprised 2.1 percent of the total population, Native American comprised 1.0 percent, and Blacks and Asians each comprised 0.6 percent. Persons of all other races comprised a total of 2.0 percent. The racial characteristics of the seven-county area were slightly less diverse than the State of Wyoming, which was estimated to have approximately 14.1 percent minority population, compared to the seven county minority population of 9.9 percent. The two largest population counties (Campbell and Natrona) had the highest proportion of minorities in the seven-county region (USCB 2010).

3.10.1.2 ***Population Projections***

The projected populations through 2030 for counties within the 50 mile radius of the Proposed Project are shown in Table 3.10-4. The population forecasts are developed by the Wyoming Department of Administration and Information, Economic Analysis Division, based on historic trends of demographic and economic variables. All of the counties in the region are expected to increase in population, many with increases exceeding 20 percent between 2010 and 2030. The projected growth rate for Campbell County is expected to outpace all of the regional counties and the state's growth as well. The population of Campbell County is expected to increase by approximately 43 percent.

3.10.2 Demography

3.10.2.1 ***Schools***

The Proposed Project is located in Campbell County. Communities in the 50-mile Study Area with public school systems are Wright (Campbell County), Midwest (Natrona County), Kaycee (Johnson County), and Gillette (Campbell County).

The Wright public schools are part of Campbell County School District No. 1, which includes all of Campbell County. There is an elementary school (K-6) and a junior-senior high school that serves grades 7-12. Both schools have room for additional enrollment, with the elementary school being closer to capacity. At the end of the school year in 2010, the elementary school enrollment was 278, and the junior-senior high enrollment was 244 (Strahorn 2011).

The public school system in Midwest includes an elementary school with one half-day preschool, a full-day kindergarten, and first through fifth grades. Midwest's secondary program serves students in sixth through 12th grades (Natrona County Schools). In January 2011, there were approximately 190 students in Pre-K through grade 12. Pre-K through grade 5 had room for approximately 20-25 more students; the junior high (grades 6-8) and the high school had room for approximately 30 additional students each. The student to teacher ratio is approximately 12 to 1 in all grade levels. The buildings are in good condition, and the physical space of the classrooms are large (Tobin, 2011).

The Kaycee school is K-12 and part of the Johnson County School District #1. The school building was completed five years ago. There are approximately 140 students in K-12. Class sizes are fairly small (senior class was 10 students). Class sizes have been relatively stable over the past 10-15 years. A few additional students in each class could have a fairly significant impact (Maynard, 2011).

In Gillette, there are 15 elementary schools, two junior high schools, and two high schools. Campbell County School District is the lone school district in the county and the third largest school district in Wyoming (CCSD 2012). In 2011-12 the student population in the district reached a record high of nearly 8,400. Most of these students attend school in Gillette. Between October 2005 and October 2009 student numbers increased by 12 percent and 90 percent of the growth was in elementary, with largest growth in grades K-3. The District has responded by replacing two older elementary schools with larger new facilities and has purchased land for another school to be completed in 2012. The District anticipates growth in the next 10 years to exceed past rates and is planning ahead to accommodate the growth (Strahorn 2011).

Wyoming also has seven community college districts. The Northern Wyoming Community College District consists of the main campus in Sheridan, a satellite college in Gillette, and outreach centers in Buffalo, Kaycee and Wright. The Gillette College campus is the closest post-secondary school to the Proposed Project area and is in a facility built in 2003.

3.10.2.2 Labor Market

In 2010, the civilian labor force in Campbell County was 27,158 (FedStats, 2010). The largest source of employment in Campbell County is the mining industry, which accounts for 26.5 percent of all jobs and 43 percent of all earnings in the county. Government-related jobs are the second largest source of employment in Campbell County, providing 13 percent of the total workforce, and retail trade accounts for nine percent of the employment.

3.10.3 Local Socioeconomic Baseline Conditions

The Proposed Project is located in Campbell County. However, social and economic characteristics are also described for Johnson County and Natrona County because there are communities in these counties that fall within the 50 mile Study Area. Table 3.10-5 summarizes unemployment rates and employment in Campbell, Johnson, and Natrona Counties.

The first four rows of Table 3.10-5 are annual averages employment and unemployment for calendar year 2010. These rows include labor force data from the Local Area Unemployment Statistics database of the Wyoming Department of Employment, Research and Planning Section. Unemployment rates rose sharply from 2008, when unemployment rates were 2.0 percent in Campbell County and 3.2 percent in Natrona County to highs of 6.0 to 8.3 percent in 2010.

Although annualized unemployment figures for 2011 were unavailable at the time this application was prepared, it was clear that unemployment rates had fallen by December 2011. As reported by the State of Wyoming's Department of Administration & Information-Economic Analysis Division in "Economic Summary: 3Q2011 (WDAI 2011a):"

> *"After a short, but severe recession, Wyoming's economy has turned around since the beginning of 2010, thanks to the robust rebound of the energy industries. The State's gradual recovery continued to be faster than the U.S. average. For the third quarter of 2011, Wyoming's recovery was still on track, and may have picked up speed. Compared to the third quarter of 2010, employment grew by 8,180 jobs, or 2.8 percent, the fastest annual increase since the third quarter of 2008. The unemployment rate dropped to 5.8 percent in the third quarter, while it remained 9.1 percent in the U.S. More industries displayed job growth during the period. Wyoming's pivotal mining industry demonstrated the fastest recovery, with an addition of 2,630 jobs, or 10.2 percent between the third quarter of 2010 and the third quarter of 2011."*

Enhancing this optimistic report are projections – particularly in the mining sector - released by the Wyoming Department of Administration & Information in its report *"Wyoming Occupational Projections, 2010 to 2020"* published in September 2011 (WDAI 2011b). This report anticipates the mining industry in Wyoming will grow by nearly 39 percent and account for nearly 9,400 new jobs in the upcoming decade.

The rest of Table 3.10-5 includes total employment numbers by type of employment for calendar year 2009. This is most recent year for which employment by industry sector is available at this level.

The economy of Campbell County is heavily dependent on the mining sector as more than a quarter of all employment is in this sector (DOL 2011). The mining sector includes coal mining, uranium recovery, oil and gas production, nonmetallic minerals, and field services that support these operations. The economies of Johnson County and

Natrona County are more diversified, but also have a large component (approximately 10 percent) of the workforce employed in mining.

The Wyoming Department of Employment, Research and Planning's report, "The Road to Work: Commuting in Wyoming" analyzes labor supply in Wyoming by place of residence by tracking employment and comparing it to the driver's license information of employees (WDOE 2010). The analysis concluded that a portion of the available labor pool in Wyoming consists of non-residents. According to the study, the construction sector is one of the industries with highest rates of commuters in Wyoming. Employment in construction accounted for 13.4 percent of the workforce in Campbell County, 10.6 percent in Johnson County, and 7.4 percent in Natrona County.

3.10.3.1 ***Per Capita Income***

Per capita personal income (PCI), as calculated by the U.S. Bureau of Economic Analysis (BEA), is the total personal income of a particular area divided by the total population of that particular area. According to figures compiled by the BEA and reported by the Wyoming State Division of Economic Analysis, per capita personal income in 2009 in Campbell County was $48,398, compared to state per capita income of $48,302, and national per capita income of $39,635. Natrona County had a slightly higher per capita income of $53,361, while Johnson County per capita income was $42,681 (WDAI 2011c).

3.10.3.2 ***Tax Base***

Campbell County taxes commercial personal property. The county determines assessed valuation of commercial property at 11.5 percent of the market value and applies a mill levy of around 60 mills (CCGov 2011). Lodging tax rates in Wyoming are set on a county-by-county basis. Currently Campbell and Johnson counties both impose a two percent tax while Natrona County assesses at three percent (WDOR, 2011).

Wyoming has a four percent sales tax and allows counties the option to increase sales tax up to four percent above the state rate. Currently Campbell County has two additional one-percent optional sales taxes for a total of six percent (WDOR 2011). The additional tax the county added comes back to the county. The average property tax rate in Campbell County is 6.25 percent. The average property tax rate in Natrona County is 6.9 percent while Johnson County is 7.13 percent (WDOR, 2007).
Finally, the state imposes an ad valorem or severance tax on mineral recovery. In 2008, Wyoming collected $1.2 million in taxes from uranium alone (WDOR, 2009). Severance taxes associated with uranium recovery in Campbell County are levied by the Mineral Tax Division of the State of Wyoming Department of Revenue. This is a four percent

uranium severance tax on taxable value coming from resource recovery operations (WDOR, 2009). Typical severance taxes collected in Wyoming from mineral development come from coal, trona, uranium, oil, and natural gas. Uranium had the lowest total severance tax collected from all mineral types at well below one percent (WDOR, 2007).

3.10.3.3 ***Housing***

There are seven communities within the 50-mile area to include Wright, Edgerton, Midwest, Kaycee, Gillette, Antelope Valley-Crestville, and Sleepy Hollow. As indicated in the map of significant population centers in Figure 3.10-1, the highest concentrations of population and housing are within or near these communities.

Table 3.10-6 shows total housing in each of these communities and the total for each county in which they are located for 2010. In 2010 there were 14,502 housing units in the seven communities in the 50 mile area. Between 2000 and 2010, the total number of housing units in the seven communities increased by 51 percent. During this same time period, the population of the area increased by about 41percent.

In 2010, the total number of vacant units in the seven communities was 1,461, compared to 781 in 2000. The vacancy rates in 2010 ranged from about three percent in Sleepy Hollow to 26 percent in Midwest.

3.10.3.4 ***Dwelling Types***

As shown in Table 3.10-7, most occupied units are owned rather than rented. In 2010, the communities with highest rental occupancy rates were Kaycee (34 percent), Edgerton (33 percent) and Gillette (32 percent). Lowest rates for renter occupancy were Sleepy Hollow (four percent), followed by Wright (25 percent).

As displayed in Table 3.10-8, of the total 1,461 vacant units in the seven communities, 661 (45 percent) were for rent and 209 (14 percent) were for sale. The remaining vacant units consisted of units that were rented but not occupied, sold but not occupied, and units for seasonal, recreational or occasional use, for migratory workers, or units that were otherwise unoccupied.

Rental unit vacancies reached very low levels around 2007 but by 2009 there was more supply than demand. Now demand appears on the increase. According to the Wyoming Vacancy Rental Survey, the rental vacancy rate in Campbell County reached its lowest point in ten years at 0.29 percent in December 2007. By the end of 2009, the vacancy rate had risen to 10.53 percent. By 2011 the vacancy rate was tightening again. In the first quarter of 2011 the statewide rental vacancy rate was 4.86 percent. In Campbell County it was 7.96 percent, in Johnson County it was 7.41 percent, and in Natrona County it was 3.68 percent (WCDA, 2011).

Based on assessors' data for Wyoming counties, the average sales price of a house in Wyoming in 2010 was $250,958. Campbell County average sales price in 2010 was $238,208; Johnson County was $204,277; and Natrona County was $201,425. As shown in Table 3-10.9, Campbell County had the highest rental rates of the three counties with communities in the 50 mile area.

The temporary lodgings closest to the Proposed Project are in Wright and Edgerton. Accommodations in Wright include a mobile home park, two motels, an RV park, one apartment complex and one hotel with 71 rooms (Town of Wright 2012). One motor lodge is located in Edgerton. There are 23 motels/hotels in Gillette, with a total capacity of 1,562 rooms (City of Gillette, 2012). There are also two RV parks in the Gillette area. In addition, the two campgrounds in the Gillette area provide RV hookups and tent sites. The Cam-Plex is multi-use facility located on 1,100 acres and funded by Gillette and Campbell County. The additional 1,821 RV sites at the Cam-Plex are available only for special events and not for the general public.

The Wyoming Housing Database Partnership (composed of the Wyoming Community Development Authority and other public and private entities) provide housing forecasts based on three scenarios: moderate growth, strong growth, and very strong growth. Under the moderate growth scenario, the number of Campbell County households would increase from 12,207 in 2000 to 20,601 in 2030. Johnson County household numbers would increase from 2,959 to 5,485, and Natrona County would see an increase from 26,819 to 38,013. This equates to an increase of 69 percent over the 30 year period for Campbell County, 85 percent for Johnson County, and 42 percent for Campbell County.

Forecasts are also provided for some cities. In Gilette, the moderate scenario forecast is for household numbers to increase by 92 percent over the 30 year period. The number of households in Wright would grow by 66 percent. The numbers of renter households will increase over the 30 year period but the percentages will decline slightly in Campbell County (from 9.5 percent to 8.9 percent of total households) and in Natrona County (from 12.1 percent to 11.1 percent) and rise slightly in Johnson County (10.9 percent to 11.4 percent) (WCDA, 2011).

3.10.3.5 Medical and Emergency Services

The primary health care facility in Campbell County is the Campbell County Memorial Hospital located in Gillette, which provides emergency care, a cancer care center, and clinical outpatient operations. This hospital is designated as an Area Trauma Hospital by the state of Wyoming Department of Public Health Emergency Services. The hospital also has two branch clinics located in Gillette and the town of Wright.

The nearest medical center offering full service emergency services is the Wyoming Medical Center in Casper, located approximately 63 miles southwest of the Proposed Project. This hospital is designated as a Regional Trauma Hospital by the state of Wyoming Department of Public Health Emergency Services. It includes Wyoming Life Flight, the state's only air ambulance program. The primary health care facility in Johnson County is the Johnson County Health Center, located in Buffalo, which is a fully equipped hospital with an outpatient medical clinic.

As noted in NUREG-1910 (GEIS Section 3.3.10.7), emergency response services near the area include 17 offices for police, sheriff or marshals in Campbell County (2), Converse County (3), Johnson County (3), Natrona County (4), Niobrara County (2) and Weston County (3).

3.10.4 Environmental Justice

In compliance with Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, ethnicity and poverty status in the vicinity of the Proposed Project have been examined and compared to city, regional, state, and national data to determine if any minority or low-income communities could potentially experience disproportionately high and adverse impacts by implementation of the Proposed Action. Similarly, in compliance with Executive Order 13045 – *Protection of Children from Environmental Health Risks and Safety Risks,* the distribution of children and locations where numbers of children may be disproportionately high in the vicinity of the Proposed Project was determined to ensure that environmental risks and safety risks to children are addressed.

Three criteria must be met for potential impacts to minority/low income communities to be considered significant. If any of these criteria are not met, then impacts with respect to environmental justice or protection of children are not significant:

1) There must be one or more populations within the region of influence:
2) There must be adverse (or significant) impacts from the Proposed Action.
3) The population under investigation must bear a disproportionate burden of those adverse impacts.

According to the environmental justice guidance provided by the Nuclear Regulatory Commission, *"percentage differences greater than 20 percentage points may be considered significant, and if either the minority or low-income population percentage in the radius of influence exceeds 50 percent, environmental justice should be* *considered in greater detail"* (Nuclear Regulatory Commission 2008:6.3). An examination of the 2010 census blocks indicates that the percentage of residents under the poverty level and the percentage of minority population surrounding the Proposed Project area, are significantly below the threshold. Therefore, the application will not analyze data for the environmental justice information.

Table 3.10-1: 2010 Population within 50 miles Radius of the Proposed Project Area

Radius in Kilometers														
Sector	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-10**	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**	**60-70**	**70-80**	**Total**
N	0	0	0	0	0	0	3	9	25	94	311	11,883	10,141	22,466
NNE	0	0	0	0	0	7	1	0	116	26	148	7,089	11,287	18,674
NE	0	0	1	2	3	18	1,756	36	91	26	10	20	53	2,016
ENE	0	1	2	3	4	30	326	24	39	0	0	18	16	463
E	0	1	2	2	1	3	41	0	17	25	15	26	49	182
ESE	0	1	1	0	0	0	4	0	2	0	6	10	5	29
SE	0	1	0	0	0	0	2	11	2	14	31	25	23	109
SSE	0	0	0	0	0	0	6	2	5	7	4	28	13	65
S	0	0	0	0	0	0	2	4	4	7	12	6	88	123
SSW	0	0	0	0	0	0	3	10	18	11	1	16	50	109
SW	0	0	0	0	0	0	5	0	5	1	2	6	12	31
WSW	0	0	0	0	0	1	0	4	12	9	675	5	7	713
W	0	0	0	0	0	2	0	9	0	30	88	39	383	551
WNW	0	0	0	0	0	6	4	3	2	18	15	0	41	89
NW	0	0	0	0	0	0	6	5	8	7	4	3	1	34
NNW	0	0	0	0	0	0	4	19	29	21	21	46	13	153
Total	0	4	6	7	8	67	2,163	136	375	296	1,343	19,220	22,182	45,807

Notes: Current population living between the project boundary and 50 mile (80 km) of the Proposed Project CPP locations were estimated using 2010 census block data. Field reconnaissance was conducted in 2011 to verify data collected within the Proposed Project area.

Table 3.10-2: 1980-2010 Population Change for Counties and Communities within 50 Mile Radius of the Proposed Project Area

State/County/City	Year				Percent Change		
	1980	1990	2000	2010	1980/ 1990	1990/ 2000	2000/ 2010
State of Wyoming	469,557	453,588	493,782	563,626	-3.4%	8.9%	14.1%
Campbell County	24,367	29,370	33,698	46,133	20.5%	14.7%	36.9%
• *Gillette*	12,134	17,635	19,646	29,087	45.3%	11.4%	48.1%
• *Wright*	-	1,236	1,347	1,807	-	9.0%	34.1%
• *Antelope Valley/Crestview*		1,099	1,642	1,658	-	49.4%	1.0%
• *Sleepy Hollow*		329	1,177	1,308	-	257.8%	11.1%
Converse County	14,069	11,128	12,052	13,833	-20.9%	8.3%	14.8%
Crook County	5,308	5,294	5,887	7,083	-0.3%	11.2%	20.3%
Johnson County	6,700	6,145	7,075	8,569	-8.3%	15.1%	21.1%
• *Kaycee*	271	256	249	263	-5.4%	-2.7%	5.6%
Natrona County	71,856	61,226	66,533	75,450	-14.8%	8.7%	13.4%
• *Edgerton*	510	247	169	195	-51.6%	-31.6%	15.4%
• *Midwest*	638	495	408	404	-22.4%	-17.6%	-1.0%
Niobrara County	2924	2499	2407	2,484	-14.5%	-3.7%	3.2%
Weston County	7,106	6,518	6,644	7,208	-8.3%	1.9%	8.5%

Source: U.S. Census Bureau Decennial Census

Table 3.10-3: 2010 Population by Age and Sex for Wyoming and the Counties within 50 mile Radius of the Proposed Project Area

Area	Age	Male	Female	Total	Total % Breakdown
State of Wyoming	Under 5	20,596	19,607	40,203	7.1%
	5 - 19	57,421	53,889	111,310	19.7%
	20 - 39	79,688	72,140	151,828	26.9%
	40 - 64	97,118	93,077	190,195	33.7%
	65+	32,614	37,476	70,090	12.4%
	Total	287,437	276,189	563,626	100.0%
Campbell County	Under 5	2,040	2,023	4,063	8.8%
	5 – 19	5,336	4,828	10,164	22.0%
	20 – 39	7,572	6,487	14,059	30.5%
	40 – 64	8,112	7,119	15,231	33.0%
	65+	1,198	1,418	2,616	5.7%
	Total	24,258	21,875	46,133	100.0%
Converse County	Under 5	519	451	970	7.0%
	5 – 19	1,470	1,399	2,869	20.7%
	20 – 39	1,648	1,601	3,249	23.5%
	40 – 64	2,555	2,414	4,969	35.9%
	65+	825	951	1,776	12.8%
	Total	7,017	6,816	13,833	100.0%
Crook County	Under 5	265	235	500	7.1%
	5 - 19	724	615	1,339	18.9%
	20-39	734	694	1,428	20.2%
	40-64	1,347	1,319	2,666	37.6%
	65+	578	572	1,150	16.2%
	Total	3,648	3,435	7,083	100.0%
Johnson County	Under 5	318	255	573	6.7%
	5 – 19	744	735	1,479	17.3%
	20 – 39	930	868	1,798	21.0%
	40 – 64	1,601	1,530	3,131	36.5%
	65+	772	816	1,588	18.5%
	Total	4,365	4,204	8,569	100.0%
Natrona County	Under 5	2,770	2,607	5,377	7.1%
	5 - 19	7,538	7,182	14,720	19.5%
	20 - 39	10,678	9,876	20,554	27.2%
	40 - 64	12,919	12,488	25,407	33.7%
	65+	4,077	5,315	9,392	12.4%
	Total	37,982	37,468	75,450	100.0%
Niobrara County	Under 5	46	50	96	3.9%
	5 - 19	236	178	414	16.7%
	20 - 39	206	349	555	22.3%
	40 - 64	436	470	906	36.5%
	65+	235	278	513	20.7%
	Total	1,159	1,325	2,484	100.0%
Weston County	Under 5	217	193	410	5.7%
	5 - 19	681	620	1,301	18.0%
	20 - 39	953	736	1,689	23.4%
	40 - 64	1,432	1,227	2,659	36.9%
	65+	507	642	1,149	15.9%
	Total	3,790	3,418	7,208	100.0%

Source: U.S. Census Bureau Decennial Census

Table 3.10-4: 2010-2030 Population Projections for Wyoming and the Counties within 50 Mile Radius of the Proposed Project Area

Area	Census 2010	Projected 2015	Projected 2020	Projected 2025	Projected 2030
State of Wyoming	563,626	594,710	622,360	644,050	668,830
Campbell County	46,133	51,970	56,890	61,350	66,060
Converse County	13,833	15,050	15,950	16,610	17,270
Crook Count	7,083	7,610	8,040	8,360	8,690
Johnson County	8,569	8,940	9,450	9,910	10,450
Natrona County	75,450	79,020	82,490	85,190	88,320
Niobrara County	2,407	2,590	2,660	2,690	2,710
Weston Count	7,208	7,690	7,950	8,040	8,120

Source: Wyoming Department of Administration and Information, Economic Analysis Division , October, 2011.

Table 3.10-5: Annual Average Labor Force and Unemployment Rates for 2010 and Employment by Industry for 2009 Campbell, Johnson and Natrona Counties

	Wyoming		Campbell		Johnson		Natrona	
	Numbers	%	Numbers	%	Numbers	%	Numbers	%
Labor Force (2010)	293,769		27,531		3,908		40,739	
Employment (2010)	273,313		25,888		3,582		37,805	
Unemployment (2010)	20,456		1,643		326		2,934	
Unemployment Rate (2010)		7.0		6.0		8.3		7.20
Total employment (2009)	392,431	100.0	34,302	100.0	6,106	100.0	54,023	100.0
Farm employment	12,502	3.2	688	2.0	382	6.3	483	0.9
Nonfarm employment	379,929	96.8	33,614	98.0	5,724	93.7	53,540	99.1
Private Employment	306,013	78.0	29,265	85.3	4,692	76.8	47,328	87.6
Forestry, fishing, and related activities	2,822	0.7	(D)		151	2.5	(D)	
Mining	33,273	8.5	8,898	25.9	580	9.5	5,401	10.0
Utilities	2,566	0.7	264	0.8	15	0.2	(D)	
Construction	33,273	8.5	4,602	13.4	647	10.6	3,974	7.4
Manufacturing	10,788	2.7	643	1.9	77	1.3	1,869	3.5
Wholesale trade	9,663	2.5	1,746	5.1	96	1.6	2,703	5.0
Retail Trade	39,111	10.0	2,821	8.2	497	8.1	6,313	11.7
Transportation and warehousing	14,231	3.6	1,441	4.2	173	2.8	1431	2.6
Information	4,744	1.2	244	0.7	49	0.8	624	1.2
Finance and insurance	16,625	4.2	615	1.8	313	5.1	2,613	4.8
Real estate and rental and leasing	19,047	4.9	664	1.9	401	6.6	2,790	5.2
Professional and technical services	16,810	4.3	1,082	3.2	260	4.3	2,496	4.6
Management of companies and enterprises	929	0.2	252	0.7	(L)		130	0.2
Administrative and waste services	12,191	3.1	995	2.9	159	2.6	2,070	3.8
Educational services	3,323	0.8	(D)		(D)		362	0.7
Health care and social assistance	28,900	7.4	1,166	3.4	(D)		6,368	11.8
Arts, entertainment, and recreation	6,707	1.7	165	0.5	180	2.9	928	1.7
Accommodation and food services	32,646	8.3	2,059	6.0	544	8.9	3,747	6.9
Other services, except public administration	18,364	4.7	1,462	4.3	248	4.1	3,179	5.9
Government and government enterprises	73,916	18.8	4,349	12.7	1,032	16.9	6,212	11.5
Federal, civilian	7,794	2.0	90	0.3	148	2.4	684	1.3
Military	6,252	1.6	268	0.8	52	0.9	454	0.8
State and local	59,870	15.3	3,991	11.6	832	13.6	5,074	9.4
State government	15,545	4.0	182	0.5	111	1.8	744	1.4
Local government	44,325	11.3	3,809	11.1	721	11.8	4,330	8.0

(D) = Not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals.
(L) = Less than 10 jobs, but the estimates for this item are included in the totals.
Sources:
Labor Force and Unemployment Rates – 2010: Wyoming Department of Employment, Research & Planning
Employment by Industry - 2009: U.S. Bureau of Economic Analysis

Table 3.10-6: 2010 Housing Units - Total, Occupied, Vacant

	Total Housing Units	Occupied Units		Vacant Units	
		Number	%	Number	%
Wyoming	261,868	226,879	86.6	34,989	13.4
Campbell County	18,955	17,172	90.6	1,783	9.4
• *Antelope Valley-Crestview*	644	593	92.1	51	7.9
• *Gillette*	12,153	10,975	90.3	1,178	9.7
• *Sleepy Hollow*	447	435	97.3	12	2.7
• *Wright*	813	685	84.3	128	15.7
Johnson County	4,553	3,782	83.1	771	16.9
• *Kaycee*	134	115	85.8	19	14.2
Natrona County	33,807	30,616	90.6	3,191	9.4
• *Edgerton*	111	90	81.1	21	18.9
• *Midwest*	200	148	74.0	52	26.0
Total 7 communities	14,502	13,041	89.9	1,461	10.1

Source: U.S. Bureau of the Census, 2010 Census Summary File 1

Table 3.10-7: 2010 Occupied Housing Units by Owned or Rented

	Total Occupied Housing Units	Owner occupied		Renter occupied	
		Number	%	Number	%
Wyoming	226,879	157,077	69.2	69,802	30.8
Campbell County	17,172	12,595	73.3	4,577	26.7
• *AntelopeValley-Crestview*	593	438	73.9	155	26.1
• *Gillette*	10,975	7,435	67.7	3,540	32.3
• *Sleepy Hollow*	435	417	95.9	18	4.1
• *Wright*	685	514	75.0	171	25.0
Johnson County	3,782	2,686	71.0	1,096	29.0
• *Kaycee*	115	76	66.1	39	33.9
Natrona County	30,616	21,508	70.3	9,108	29.7
• *Edgerton*	90	60	66.7	30	33.3
• *Midwest*	148	106	71.6	42	28.4
Total 7 communities	13,041	9,046	69.4	3,995	30.6

Source: U.S. Bureau of the Census, 2010 Census Summary File 1

Table 3.10-8: 2010 Vacant Housing Units by Type

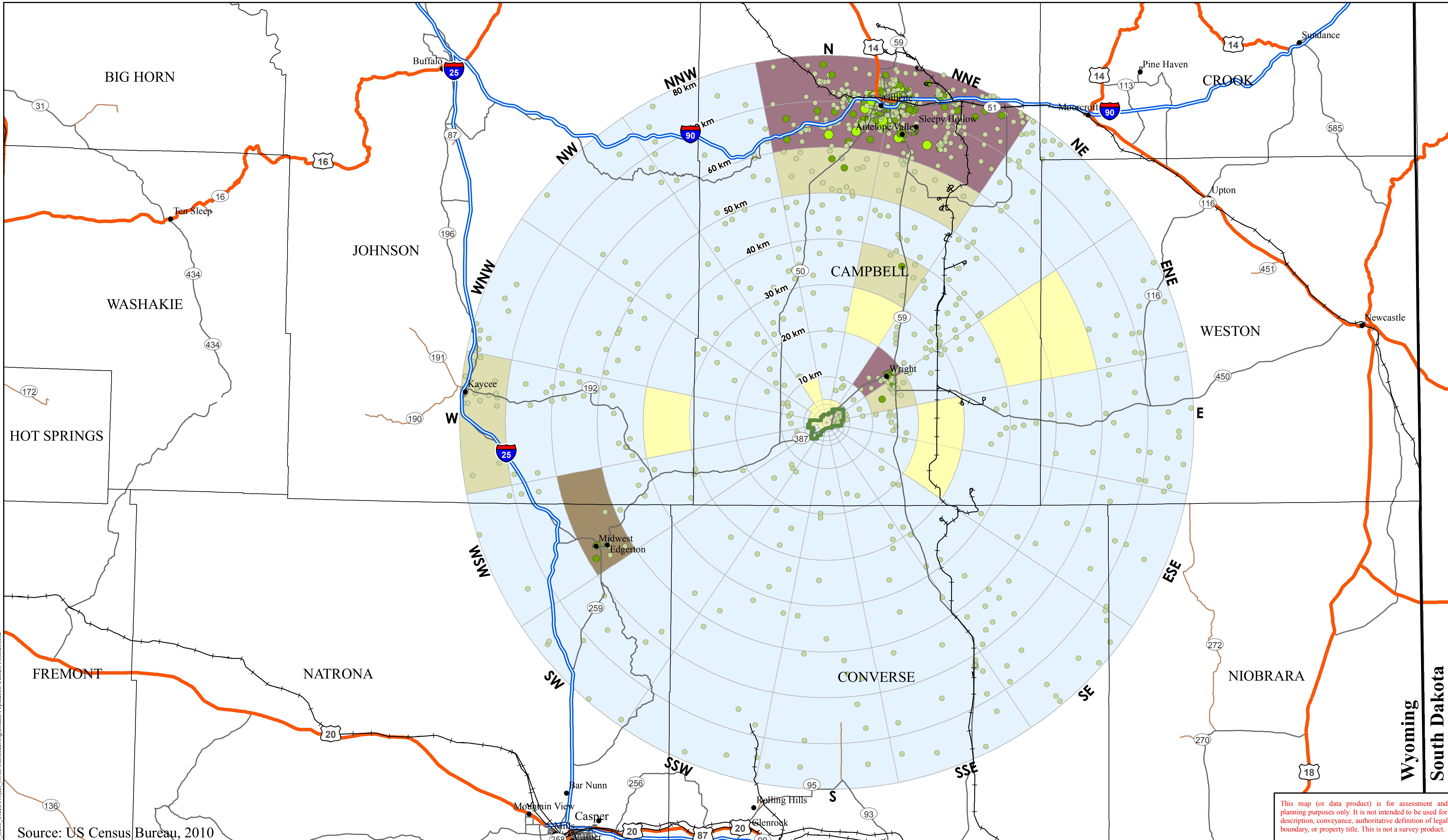
	Vacant Housing Units	For Rent		Rented, Not Occupied		For Sale Only		Sold, Not Occupied	
		Number	%	Number	%	Number	%	Number	%
Wyoming	34,989	7,304	20.9	458	1.3	3,376	9.6	781	2.2
Campbell County	1,783	689	38.6	42	2.4	264	14.8	51	2.9
• *AntelopeValley-Crestview*	51	33	64.7	0	0	3	5.9	2	3.9
• *Gillette*	1,178	561	47.6	37	3.1	183	15.5	25	2.1
• *Sleepy Hollow*	12	0	0	0	0	2	16.7	0	0
• *Wright*	128	38	29.7	0	0	19	14.8	2	1.6
Johnson County	771	141	18.3	4	0.5	49	6.4	7	0.9
• *Kaycee*	19	6	31.6	1	5.3	1	5.3	0	0
Natrona County	3,191	921	28.9	59	1.8	370	11.6	92	2.9
• *Edgerton*	21	10	47.6	0	0	0	0	0	0
• *Midwest*	52	13	25	0	0	1	1.9	1	1.9
Total 7 communities	1,461	661	45.2	38	2.6	209	14.3	30	2.1

Source: U.S. Bureau of the Census, 2010 Census Summary File 1

Table 3.10-9: Monthly Rental Costs - Fourth Quarter 2010

	Apartment	Mobile Home Lot	House	Mobile Home on a Lot
Wyoming	651	281	928	619
Campbell County	717	377	1,222	860
Johnson County	603	245	823	618
Natrona County	676	314	1,035	598

Source: Wyoming Housing Database Partnership



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PROPOSED RENO CREEK PROJECT
CAMPBELL COUNTY, WY

PREPARED FOR AUC LLC
LAKEWOOD, CO

Legend
- Proposed Reno Creek Project Boundary
- Cities and Towns
- Railroad
- Wyoming County Boundary
- Interstate
- Highway
- Major Road
- Local Road

2010 US Census Block Population Count
- 1 - 50
- 51 - 200
- 201 - 564

2010 US Census Population Apportioned to Sector
- 0
- 1 - 100
- 101 - 500
- 501 - 1,000
- Greater than 1,000

0 5 10 20 Miles

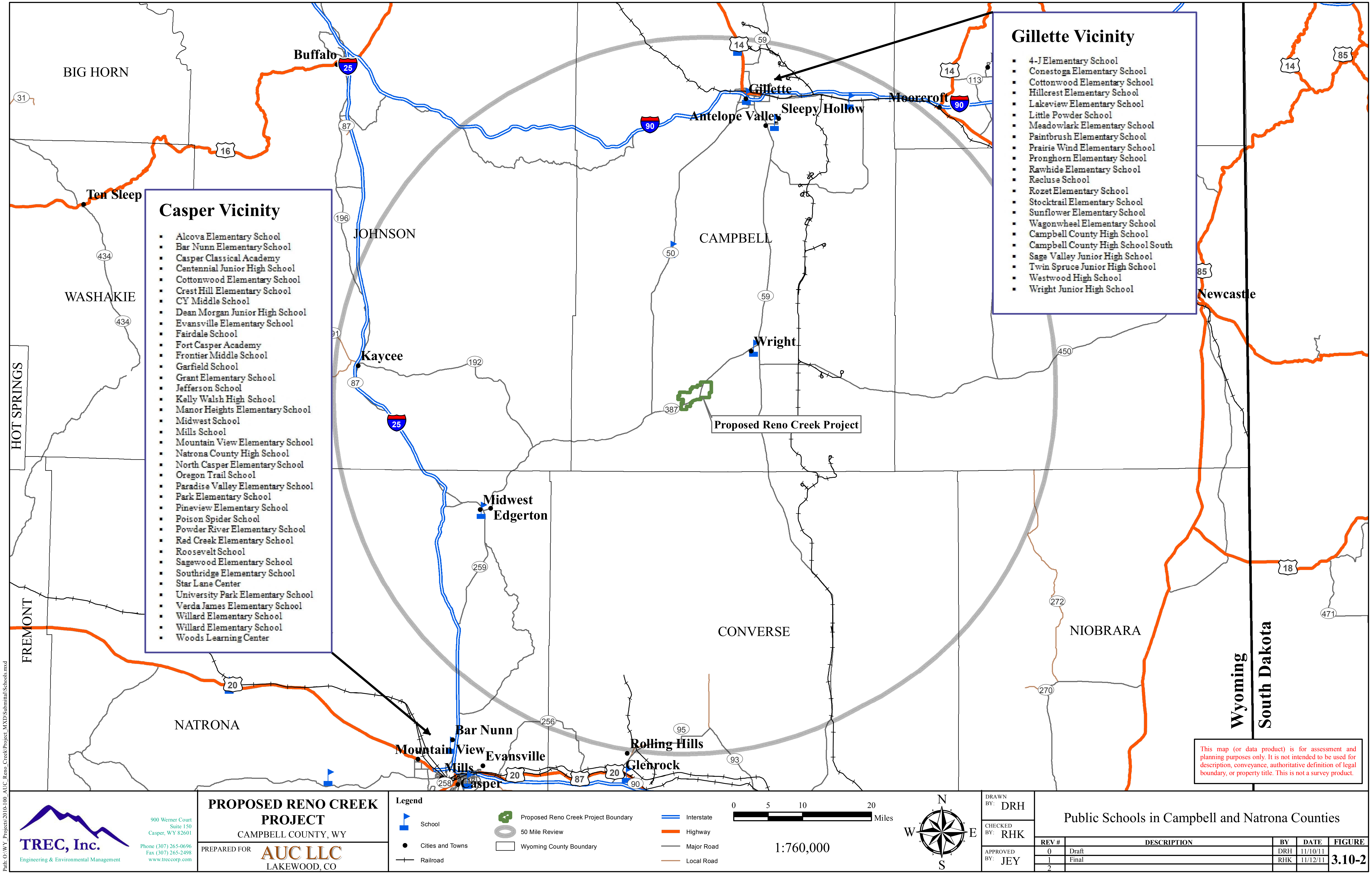
1:760,000

DRAWN BY: DRH
CHECKED BY: RHK
APPROVED BY: JEY

Population Block Analysis

REV #	DESCRIPTION	BY	DATE
0	Draft	DRH	10/19/11
1	Final	RHK	11/09/11
2			

FIGURE 3.10-1


Gillette Vicinity
4-J Elementary School
Conestoga Elementary School
Cottonwood Elementary School
Hillcrest Elementary School
Lakeview Elementary School
Little Powder School
Meadowlark Elementary School
Paintbrush Elementary School
Prairie Wind Elementary School
Pronghorn Elementary School
Rawhide Elementary School
Recluse School
Rozet Elementary School
Stocktrail Elementary School
Sunflower Elementary School
Wagonwheel Elementary School
Campbell County High School
Campbell County High School South
Sage Valley Junior High School
Twin Spruce Junior High School
Westwood High School
Wright Junior High School
Casper Vicinity
Alcova Elementary School
Bar Nunn Elementary School
Casper Classical Academy
Centennial Junior High School
Cottonwood Elementary School
Crest Hill Elementary School
CY Middle School
Dean Morgan Junior High School
Evansville Elementary School
Fairdale School
Fort Casper Academy
Frontier Middle School
Garfield School
Grant Elementary School
Jefferson School
Kelly Walsh High School
Manor Heights Elementary School
Midwest School
Mills School
Mountain View Elementary School
Natrona County High School
North Casper Elementary School
Oregon Trail School
Paradise Valley Elementary School
Park Elementary School
Pineview Elementary School
Poison Spider School
Powder River Elementary School
Red Creek Elementary School
Roosevelt School
Sagewood Elementary School
Southridge Elementary School
Star Lane Center
University Park Elementary School
Verda James Elementary School
Willard Elementary School
Willard Elementary School
Woods Learning Center
BIG HORN
WASHAKIE
HOT SPRINGS
FREMONT
NATRONA
JOHNSON
CAMPBELL
CONVERSE
NIOBRARA
Wyoming
South Dakota
Buffalo
Ten Sleep
Kaycee
Midwest
Edgerton
Gillette
Antelope Valley
Sleepy Hollow
Moorcroft
Newcastle
Wright
Bar Nunn
Mountain View
Evansville
Mills
Casper
Rolling Hills
Glenrock
Proposed Reno Creek Project
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PROPOSED RENO CREEK PROJECT
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Legend
School
Cities and Towns
Railroad
Proposed Reno Creek Project Boundary
50 Mile Review
Wyoming County Boundary
Interstate
Highway
Major Road
Local Road
0 5 10 20 Miles
1:760,000
N
S
E
W
DRAWN BY: DRH
CHECKED BY: RHK
APPROVED BY: JEY
Public Schools in Campbell and Natrona Counties
REV # | DESCRIPTION | BY | DATE
0 | Draft | DRH | 11/10/11
1 | Final | RHK | 11/12/11
2
FIGURE 3.10-2

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3.11 Public and Occupational Health

This section describes existing public and occupational health conditions related to the Proposed Project area. A discussion of exposures to populations and individuals is presented, with a focus on topics related to the intended use of the site. This section lays a foundation for later sections which describe potential impacts at the site, especially Section 4.12, Potential Public and Occupational Health Impacts. More discusssions regarding potential human health risk can be found in:

- Sections 4.12 of this ER (Potential Impacts);
- Section 8.4.4 of this ER (Potential Long-Term Costs);
- Section 2.9 of the TR (Baseline Radiological Characteristics);
- Addendum 2.9-A of the TR (SOP – Direct Gamma Field Sampling);
- Sections 5.2, 5.3, 5.5 and 5.7 of the TR (Operations); and
- Section 7 of the TR (Environmental Effects).

3.11.1 Background Radiological Conditions

As noted in 10 CFR part 20, "background radiation" involves cosmic sources, naturally occurring material in the earth's crust, and global fallout, which is primarily from nuclear weapons tests. Background radiation does not include radiation from source, byproduct or special nuclear materials regulated by the USNRC. The Hydro Resources, Inc. (HRI) case detailed the evaluation of radiation effects of ISR operations, which concluded that uranium ISR releases contribute a "a tiny fraction" of background radiation levels (10th Cir. March, 2010). In most locations, the largest source of natural background radiation exposure is radon gas and its decay products, from uranium and thorium decay in soil.

According to NUREG 1910, (GEIS Section 3.3-60), the average U.S. citizen receives three mSv per year from background radiation sources and 0.6 mSv per year from man-made sources, for an annual total averaging 3.6 mSv/yr. The man-made sources include radiation from medical procedures, consumer products and services (e.g., airline travel) and occupational exposures (Figure 3.11-1).

Levels of natural or background radiation can vary greatly from one location to the next as noted in Table 3.11-1. According to NUREG-1910 (GEIS Section 3.3.11.1), people residing in Wyoming are exposed to higher levels of cosmic radiation because of the State's higher elevations. In some areas of the state, there is exposure to higher levels of terrestrial radiation from soils enriched in naturally occurring radionuclides (mainly uranium and thorium). A map of gamma radiation exposure rates from terrestrial sources across the United States is shown in Figure 3.11-2.

Naturally occurring uranium, thorium and their decay products in the soil can result in significant exposure to radon gas and its decay products, particularly in structures. Of the man-made sources, medical computed tomography accounts for 24 percent of the total exposure, whereas occupational exposure and industrial activities contribute less than 0.1 percent. The nuclear fuel cycle which includes ISR is among the lowest contributors to annual dose, at less than 0.03 percent.

Estimates of total average exposure of the U.S. population to background radiation (both naturally occurring and manmade) have been published by the National Council on Radiation Protection and Measurements (NCRP). The latest estimates are found in NCRP Report Number 160 (NCRP, 2009). The average annual radiation dose for individuals has been increased to 620 mrem/yr (versus an estimate published in the 1980's of 360 mrem/yr), primarily due to a significant increase in the use of ionizing radiation for medical diagnostics and treatment. The doses are shown in Figure 3.11-1. Background sources of radiation at the Proposed Project site are characterized in Section 6 of this ER.

In addition to variations in annual averages, outdoor radon and decay product concentrations vary regionally, temporally and geographically, influenced by emanation rates from local and upwind soil, and dispersion patterns through the atmosphere. The amount of radon emanating from soil or bedrock depends on soil and rock type, porosity, and moisture content. Areas with bedrock such as granite or limestone have higher natural uranium concentrations and generally higher radon levels (NCRP 2009).

Inhalation of outdoor radon and progeny concentrations does not generally present a significant health hazard to workers or the public, since concentrations are generally low. Radon decay product concentrations can pose a significant hazard when in equilibrium inside of a structure, according to EPA, but only if radon sources (naturally-occurring uranium deposits) are located under the structure.

As noted in NUREG-1910 (GEIS Section 3.2.11.1), doses from sources in the general environment (such as terrestrial radiation, cosmic radiation and naturally occurring radon) are not included in the dose calculation for compliance with exposure limits in 10 CFR Part 20 (TEDE), even if these sources are from technologically enhanced naturally occurring radioactive material (TENORM), such as radioactive residues from prior uranium mining or well drilling.

Table 3.11-2 indicates that natural background radiation levels in the Proposed Project area are low, and generally consistent with levels found for similar projects in the region. Radon air concentrations are very low, even compared to some other Wyoming uranium resource areas, indicating that the uranium/radium sources are relatively deep underground, without large surface-expressed ore areas from which radon is escaping in quantity. The low and relatively uniform gamma radiation exposure rates found during the site GPS scanning work support this conclusion.

As a requirement to develop a license application, the applicant must conduct a radiological assessment to determine the impact from licensed ISR operations. A computer model known as MILDOS-AREA (Faillace 1997) is used to generate estimates of dose to the public. The doses are then compared to regulatory limits to determine whether a member of the public, or a licensee or other worker, may be exposed to radiation levels exceeding standards (NRC 2002). A detailed discussion of the MILDOS-AREA computer code and projected exposure rates for the Proposed Project can be found in Section 7.4.1 of the TR. A summary of the findings is found below.

3.11.2 Current and Historical Sources, and Levels of Exposure to Radioactive Materials

The maximum total effective dose equivalent (TEDE) calculated by MILDOS-AREA for a hypothetical individual at the project boundary is 4.3 mrem/yr. Dose to the nearest resident, located 2.2 miles from the proposed CPP, is calculated to be less than 1 mrem/yr, much less than the dose limit to a member of the public: 100 mrem/yr.

The second potential source of radiation exposure specific to the Proposed Project area would be the consumption of contaminated groundwater. As described in Section 3.4.2.7 of this ER, there is one domestic supply well (Taffner #1) within the Proposed Project area. The Taffner homestead is currently located where the proposed CPP will be located. AUC will acquire the Taffner property prior to construction and it will not thereafter be used as a residence. The domestic water well located at the Taffner residence will not be used once construction begins.

According to NUREG-1910 (GEIS Section 3.3.4.3.3), some uranium-bearing aquifers contain uranium and radium concentrations which typically exceed their respective USEPA MCLs and Wyoming class-of-use standards. Some groundwater locations also have radon concentrations above the proposed but not enacted USEPA MCL of 300 pCi/L.

3.11.3 Major Sources and Levels of Chemical Exposure

The remote location of the Proposed Project area is characterized by a very sparse population. The predominant land uses are livestock grazing, wildlife habitat, and oil/gas production. The region does not have long-term industrial activities which could be significant potential sources of chemical release, although oil/gas drilling operations may temporarily present such potential. The only chemicals currently present in significant quantity on the Proposed Project area are crude oil, produced water, propane, and methanol. Existing pole-mounted electrical transformers may contain polychlorinated biphenyls (PCBs); however, the potential for chemical exposure is low from intact transformers. There is no firm information regarding chemicals/quantities used in agricultural operations. The majority of the agricultural operations involve cattle grazing, and production of non-irrigated forage. There are no recognized sources of other hazardous chemicals at or near the Proposed Project.

3.11.4 Occupational Health and Safety

Occupational health and safety hazards within the Proposed Project area are limited by existing land uses, primarily agriculture and oil/gas production. Agricultural and oil and gas production workers face many of the same occupational health and safety hazards. According to the Wyoming Department of Employment (WDOE 2010), extraction workers, including oil and gas production workers, had a higher-than-average injury and illness rate in Wyoming in 2008. The most common injuries resulting in days away from work were strains and sprains, often the results of slips/trips/falls or lifting. The Wyoming Department of Employment does not track occupational injuries for farms or ranches with fewer than 11 employees, but the risks are generally similar. In addition, agricultural workers could be exposed to additional occupational health and safety hazards from tractor roll-overs, all-terrain vehicle (ATV) accidents, and horse-related injuries.

Radiation-related risks to future ISR workers, and to members of the public allowed access to the controlled areas, are regulated by the NRC via 10 CFR 20 (Subpart C, 20.1201, Subpart D, 20.1301(b)) and other guidance. Exposures to non-ISR personnel who may be on the property temporarily in non-restricted areas are estimated to be much less than 1 mrem/yr.

In addition to annual radiation dose limits, the regulations incorporate the principal of maintaining doses as low as reasonably achievable (ALARA). The ALARA concept encourages reduction of radiation dose to levels below the applicable standards, costs considered, via actions/activities including pro-active monitoring, proper worker training, engineering and administrative controls to minimize exposures and effluents, and the measurement and monitoring of radiation doses and effluents followed by routine dose-reduction reviews.

The ALARA principle takes into consideration the purpose of the licensed activity and its benefits, weighing costs and benefits to reduce radiation doses as practicable (including selecting the most cost-effective and efficient technologies for reducing doses), and quantifies the net benefits for each option to reduce radiation doses (and, by extension, exposures to any other non-threshold hazardous materials used at an ISR facility).

Radiation safety measures are required to protect workers and minimize worker doses at uranium ISR facilities, ensuring that radiation doses are less than the occupational limits and are maintained ALARA. The Proposed Project will conduct annual ALARA audits to ensure procedures in place have the maximum reasonably achievable effect on exposure reduction.

Also of interest with respect to occupational health and safety are industrial hazards and exposure to chemicals and other industrial hazards. An ISR operation may include industrial airborne emissions associated with service equipment, fugitive dust from access roads and wellfield activities, electricity and power tool hazards, slips/trips/falls, and chemicals used in the extraction process. Industrial safety and the use of chemicals at the Proposed Project site are regulated by the Wyoming Occupational Health and Safety Commission under the Wyoming Occupational Health and Safety Act, Title 27, Labor and Employment, Chapter 11, Occupational Health and Safety. More specific discussion regarding non-radioactive chemicals and accident impact is described in Section 4.12.1.2.2.1 of this ER.

Table 3.11-3 contains the incident rates of nonfatal occupational injuries and illnesses for the mining industry in the State of Wyoming for 2007. Incidence rates represent the number of injuries and/or illnesses per 100 full-time workers (10,000 full-time workers for illness rates) and were calculated using the following formula:

$\left(N/_{EH}\right) \times 200{,}000$ (20,000,000 for illness rates)

Where:

N	=	*number of injuries and illnesses*
EH	=	*total hours worked by all employees during a calendar year*
200,000	=	*base for 100 equivalent full-time workers*
20,000,000	=	*base for 10,000 equivalent full-time workers*

The incident rates for mining are contained under NAICS code 21 and include mining, and support activities for mining. ISR operations are included in metal/nonmetal mining Class since Wyoming defines ISR applications as "mining".

3.11.5 Summary of Health Effects Studies

Although there do not appear to be health effects studies in the open literature specifically related to ISR operations in Wyoming, and no health effects studies reported in the literature specific to Campbell County, there are numerous studies in the literature focusing on the potential health impacts to members of the public living near uranium recovery activities, including ISR operations (Brown, 2009).

These studies have generally concluded that no significant health effects have been observed when compared to the health status of other similar populations not living near uranium production facilities. Sources providing reliable evidence supporting this conclusion include:

- U.S. Department of Health and Human Services, Public Health Services, Agency for Toxic Substance and Disease Registry, *Toxicological Profile for Uranium*, 1999. Chapter 1: Public Health Statement for Uranium, Section 1.5: How Can Uranium Effect My Health? – "No human cancer of any type has ever been seen as a result of exposure to natural or depleted uranium."
- *Cancer and Noncancer Mortality in Populations Living Near Uranium and Vanadium Mining and Milling Operations in Montrose County, Colorado, 1950 - 2000*. Boice, JD, Mumma, MT et al. Journal of Radiation Research, 167:711-726; 2007: "The absence of elevated cancer mortality rates in Montrose County over a period of 51 years suggests that the historical milling and mining operations did not adversely affect the health of Montrose County residents."
- *Cancer Mortality in a Texas County with Prior Uranium Mining and Milling Activities, 1950 – 2001.* Boice, JD, Mumma, M et al. Journal of Radiological Protection, 23:247 – 262; 2003 – "No unusual patterns of cancer mortality could be seen in Karnes County over a period of 50 years, suggesting that the uranium mining and milling operations had not increased cancer rates among residents."

Table 3.11-1: Natural Background Radiation Doses

State	Cosmic	Terrestrial	Radon	Internal Sources[1] and Thoron, U.S. Average[2]	Total (mSv/y)
Wyoming	0.52	0.27	1.33	0.45	2.57
Colorado	0.49	0.39	3	0.45	4.33
Oregon	0.028	0.27	0.57	0.45	1.57
Virginia	0.28	0.27	1.37	0.45	2.3
U.S. Average	0.33	0.21	2.12	0.45	3.11

[1] Internal sources are primarily due to ingestion of naturally occurring materials
[2] Values for individual states are not available.

Sources: EPA 2006; National Research Council 2009; NCRP 2009

Table 3.11-2: Estimated Average Levels of Naturally Occurring Sources of Background Radiation at the Proposed Project Based on Baseline Monitoring Data

Natural Background Radiation Source	Mean Value	Units
Uranium in soil[1]	1.5	pCi/g
Thorium-232 in soil[1]	1.3	pCi/g
Potassium-40 in soil	20.3	pCi/g
Cosmic Radiation[2]	5.1	μR/hr
Terrestrial gamma radiation[3]	9.3±0.9	μR/hr
Mean total exposure rate[4]	14.4±0.9	μrem/hr
Average ambient radon[5]	0.43	pCi/L

Basis of Estimation

[1]Equilibrium assumed across all decay products

[2]Estimate based on elevation (Stone et al, 1998, NCRP, 1987)

[3]Based on project-specific gamma survey/soil radionuclide data

[4]Based on project-specific environmental dosimeter data

[5]Based on project-specific radon monitoring data

Table 3.11-3: Number and Rate of Nonfatal Occupational Injuries and Illnesses for the Mining Industry, Wyoming, 2010

(Numbers in thousands)

Characteristic	**Mining (except oil and gas) (code 212)**[1]	
	Number	Rate[2]
Injuries and Illnesses		
Total cases	0.2	1.8
Cases with days away from work, job transfer, or restriction	0.1	1.0
Cases with days away from work	0.1	0.6
Cases with job transfer or restriction	(3)	0.4
Other recordable cases	0.1	0.8
Injuries		
Total cases	0.2	1.7
Illnesses		
Total cases	(3)	(3)
Illness Categories		
Skin disorders	(3)	(3)
Respiratory conditions	(3)	(3)
Poisoning	(3)	(3)
Hearing loss	(3)	(3)
All other illness cases	(3)	(3)

Source: WY DOE, 2010, http://doe.state.wy.us/lmi/osh/OSH_10/tA.htm, accessed November 3, 2011.

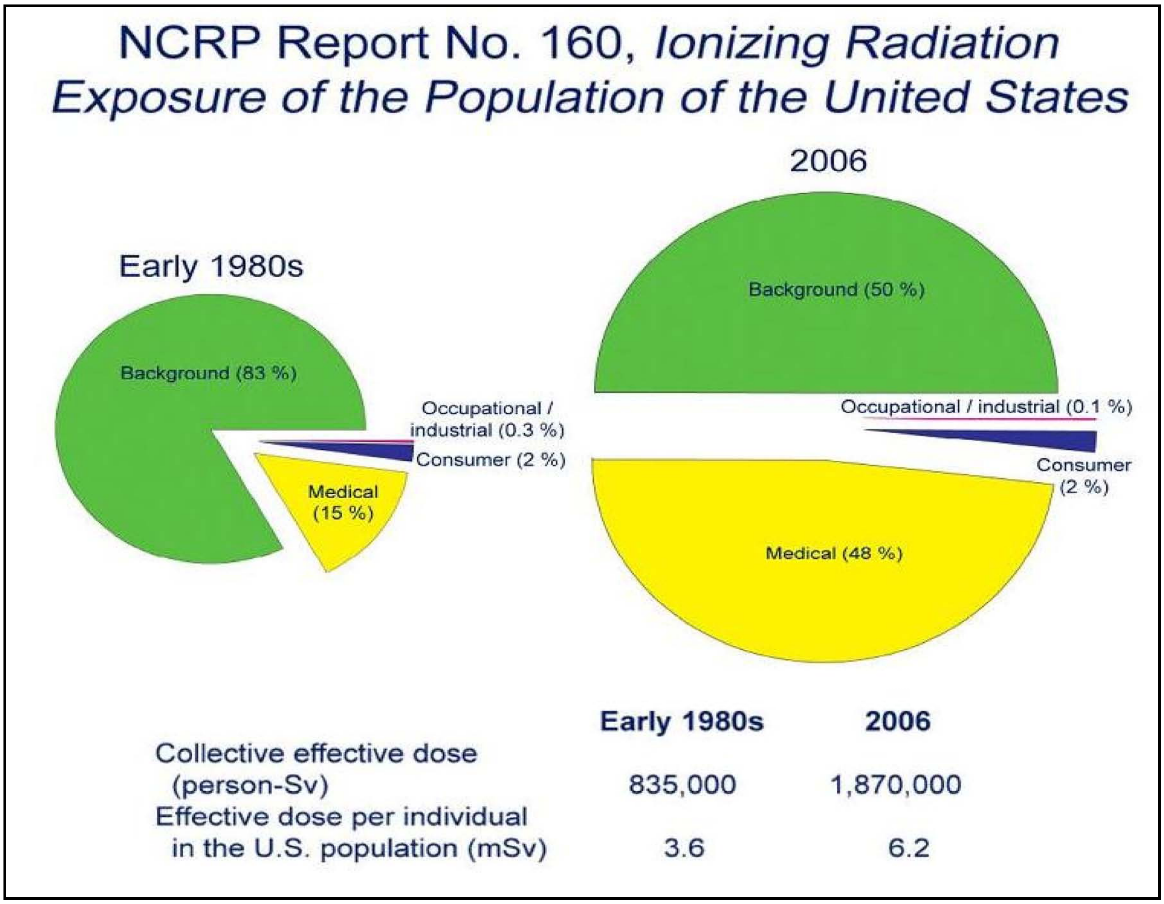
[1] The uranium mining NAICS code is 212291. No data exists solely for uranium mining.

[2] Incidence rates represent the number of injuries and/or illnesses per 100 full-time workers (10,000 full-time workers for illness rates) and were calculated as: (N / EH) X 200,000 (20,000,000 for illness rates) where,

N = number of injuries and/or illnesses
EH = total hours worked by all employees during the calendar year
200,000 = base for 100 full-time equivalent workers (working 40 hours per week, 50 weeks per year)
20,000,000 = base for 10,000 full-time equivalent workers (working 40 hours per week, 50 weeks per year).

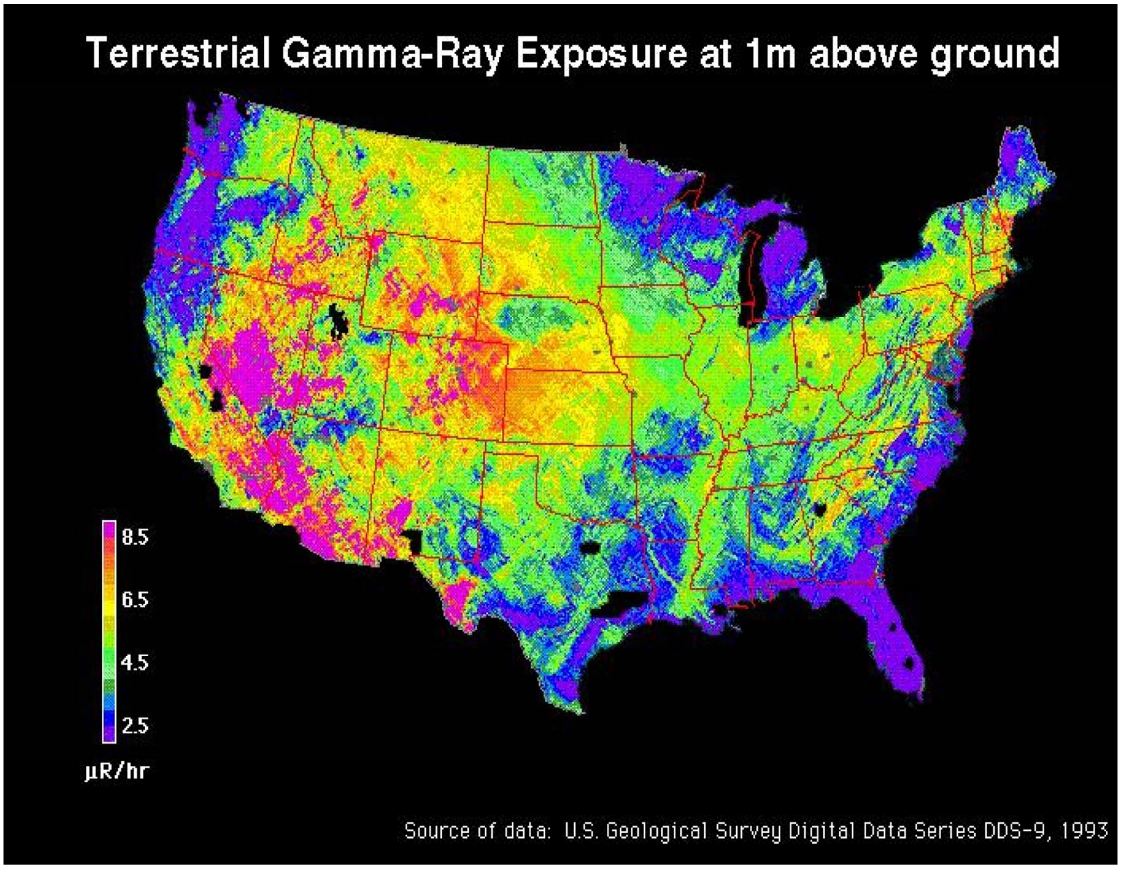
[3] Values too small to display

Figure 3.11-1: U.S. Average Gamma Exposure Rates, All Sources



Source: NCRP, 2009

Figure 3.11-2: Average Annual Radiation Doses to the U.S. Population



Source: NURE aerial surveys, USGS, 1993

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3.12 Waste Management

This section describes the existing sources of waste materials within the Proposed Project area and current management practices. There is no discussion of waste materials generated by the Proposed Project as these activities have not occurred pending licensing approval by the NRC. Proposed waste materials management practices and potential waste materials management impacts resulting from the Proposed Project operations are provided in Section 4.13 of this ER. Byproduct materials are separated into two base categories with several subcategories under each base category. These base categories for the purposes of this document are 11e.(2) byproduct material, and non-11e.(2) material. Further related discussions elsewhere in this document can be found in:

- Section 1.4.9 of this ER (Introduction);
- Sections 4.13 of this ER (Potential Impacts);
- Section 5.14 of this ER (Cumulative Impacts);
- Section 6.1 of this ER (Mitigation);
- Section 4.3 of the TR (Byproduct Material Management);
- Section 6.3.3 of the TR (Transportation and Disposal); and
- Section 7.5 of the TR (Environmental Effects).

Within the Proposed Project area, existing land uses include: oil and gas production, CBM production, transportation, livestock grazing, and wildlife habitat. The activities associated with these land uses generate little waste material. Management of this waste material is governed by Campbell County and the WDEQ/SHWD (Solid and Hazardous Waste Department). WDEQ/SHWD maintains a list of recognized hazardous materials according to characteristics of ignitability, corrosivity, reactivity, and toxicity (WDEQ/SHWD 2008), in addition to regulating the disposal of non-hazardous waste materials.

The 11e.(2) byproduct materials are defined in Paragraph 11e.(2) of the AEA, 10 CFR Part 40, Appendix A and NUREG 1910, Vol. 1., page 2-23 as "waste generated by extraction or concentration of uranium or thorium processed ores as defined under Section 11e.(2) of the Atomic Energy Act." Materials classified as 11e.(2) may be either liquid or solid in nature.

As there are no licensed uranium recovery activities currently under way on the Proposed Project property, no materials categorized as 11e.(2) are being generated or currently exist on site since this is a proposed new facility. All materials classified as 11e.(2) generated by Rocky Mountain Energy, Inc. during their operation of a pilot plant within the Proposed Project area in the 1980's were properly removed as supported by the NRC's sign off on facility closure.

All waste materials currently generated on site, as listed below, are classified as non-11e.(2) waste. These waste materials are both liquid and solid in nature. Categories that are generated on site currently are as follows:

- Liquid Waste
  - Domestic liquid septic waste from existing ranch facility;
  - Produced waters from existing oil and CBM wells;
  - Waste qualifying for the Conditionally Exempt Small Quantity Generator or Exploration and Production exemptions under Wyoming Department of Environmental Quality (WDEQ) solid and hazardous waste material regulations; and
  - Byproducts classified as Technically Enhanced Naturally Occurring Radioactive Material (TENORM) generated from current uranium exploration activities on the Proposed Project location.
- Solid Waste
  - Municipal solid waste materials generated from ranching, livestock, and oil & gas operations;
  - Waste materials qualifying for the Conditionally Exempt Small Quantity Generator or Exploration and Production exemptions under WDEQ solid and hazardous waste materials regulations; and
  - Byproduct materials classified as TENORM generated from current uranium exploration activities on the Proposed Project location.

3.12.1 Liquid Non-11e.(2) Byproduct Material

3.12.1.1 <u>Domestic Liquid Septic Waste</u>

The overall generation of septic waste by land use activities on the Proposed Project area is minimal due to the lack of occupied residences within the Proposed Project boundary. The overall impact of the past generation of this waste material should be nearly non-existent in regard to its potential impact to the activities of the Proposed Project.

3.12.1.2 <u>Produced Waters</u>

Activities associated with the oil and CBM industries have the potential to generate produced waters from their installed oil and gas wells within and surrounding the Proposed Project area. Produced waters are regulated in the State of Wyoming under the Wyoming Oil and Gas Commission and WDEQ/WQD (Water Quality Division). Both types of production have requirements for monitoring waters if they are surface discharged, or directed into surface impoundments for percolation or evaporation. All wells within the Proposed Project area have associated permits under WDEQ's WYPDES waste water discharge program and are depicted in Figure 2.7A-7 of Addendum 2.7-A of the TR. As these activities have a small footprint of operation, their likely potential impact to future ISR development activities is low.

3.12.1.3 Hazardous and CESQG Liquid Waste

Small quantities of hazardous and Conditionally Exempt Small Quantity Generator (CESQG) liquid wastes are likely generated on or near the Proposed Project area. Wastes associated with oil or CBM production have the potential to be classified as hazardous waste material under WDEQ/SHWD and USEPA regulations due to the aggregate generation rate of each firm. The actual quantity generated at the Proposed Project location by oil and CBM activities is likely to be very small. Wastes generated by the oil industry activities are likely to include methanol, descaling agents, solvents, and different grades of used oil. CBM industry activities generate smaller amounts of such material with the largest waste generation being hydraulic fluids used in compressor facilities.

Both oil and CBM industries are known to use fracking fluids in the installation process but this is highly dependent upon the formation geologic conditions. The classification of the fracking fluids is unknown due to the proprietary nature of the fluid makeup is not available to the public. Fracking fluids are customized to each location used and the operators are required to disclose the fluid composition to WDEQ. All fracking fluids are required to be evacuated from the well and containerized for disposal upon completion of the frack operation.

Ranching activities may generate small quantities of waste material classified as CESQG. These waste materials are likely to include used oils, spent solvents, herbicides, and pesticides. Additional waste material production and handling details can be found in Section 1.9. of this ER.

3.12.1.4 TENORM Liquids

Exploratory uranium drilling and baseline well installation also results in byproduct material, including drilling byproducts. Drilling byproducts, as defined by EPA (2008) for ISR facilities, include drill muds, other drilling fluids, or produced waters during well development and well sampling are classified as TENORM. The definition of which is provided by the USEPA:

> "TENORM is produced when radionuclides that occur naturally in ores, soils, water, or other natural materials are concentrated or exposed to the environment by activities, such as uranium mining or sewage treatment."

Drilling fluids and produced waters are typically disposed on-site in mud pits pursuant to State regulations or EPA TENORM guidance. NRC has recognized in NUREG-1910 that TENORM is not AEA waste.

3.12.2 Solid Non-11e.(2) Byproduct Material

3.12.2.1 Municipal Solid Waste

Agricultural operations within the Proposed Project area produce very limited quantities of miscellaneous waste. Some of this may be disposed off-site in small landfills near the Proposed Project area. According to the WDEQ Office of Outreach and Environmental Assistance (OOEA), small landfills are not subject to Wyoming rules and regulations for landfills as long as they are used only to dispose of materials generated in association with an individual's farming or ranching operations (WDEQ/OOEA 2010). Other wastes associated with farming and ranching operations is disposed in the nearest solid waste disposal facility, which is a landfill in Gillette approximately 52 road miles north.

3.12.2.2 Hazardous and CESQG Solid Waste

Small quantities of hazardous and Conditionally Exempt Small Quantity Generator (CESQG) wastes are likely generated on or near the Proposed Project area. Such materials associated with oil production or CBM production have the potential to be classified as hazardous waste under WDEQ/SHWD and USEPA regulations due to the aggregate generation rate of each firm. The actual quantity generated at the Proposed Project location by oil and CBM activities, is likely to be very small. These wastes generated by the oil industry activities are likely to include petroleum contaminated soils, oily rags, and sludges.

3.12.2.3 TENORM Solids

Exploratory uranium drilling and baseline well installation also results in byproduct material, including drill cuttings and drilling byproducts. Drilling byproduct material, as defined by EPA (2008) for ISR facilities, include drill muds, sludges, or evaporation products collected in excavated pits from byproduct water produced during drilling. Drill cuttings and drilling byproduct materials are typically disposed on-site in mud pits pursuant to EPA TENORM guidance. NRC has recognized in NUREG-1910 that TENORM is not AEA waste.