SEI016A

Ross ISR Project USNRC License Application
Crook County, Wyoming

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STRATA ENERGY

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LIST OF ABBREVIATIONS/ACRONYMS

AADT	Average Annual Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
ACL	Alternate Concentration Limit
ADT	Average Daily Traffic
AEA	Atomic Energy Act
ALARA	As Low As Reasonably Achievable
ALI	Annual Limits on Intake
AMC	Antecedent Moisture Condition
AMV	Ammonium Metavanadate
ANSI	American National Standards Institute
AOI	Area of Influence
AP	Airport
APE	Area of Potential Effect
AQD	Air Quality Division
AQS	Air Quality System
ASME	American Society of Mechanical Engineers
ASOS	Automated Surface Observing System
ASTM	ASTM International (formerly American Society for Testing and Materials)
ATV	All-Terrain Vehicle
B.P.	Before the Present Time
BACT	Best Available Control Technology
BGL	Below Ground Level
BHNF	Black Hills National Forest
BKS	BKS Environmental Associates, Inc.
BLM	U.S. Bureau of Land Management
BLS	Bureau of Labor Statistics
BMP	Best Management Practice
BNSF	BNSF Railway (formerly Burlington, Northern & Santa Fe)
BPT	Best Practicable Technology
BSM	Buckskin Mine
CAA	Clean Air Act
CAAA	Clean Air Act Amendments of 1990
CAD	Computer Aided Design
CAGR	Compounded Annual Growth Rate
CBNG	Coal Bed Natural Gas
CBW	Containment Barrier Wall
CCEMA	Campbell County Emergency Management Agency
CCMH	Campbell County Memorial Hospital
CCSD	Campbell County School District
CEDE	Committed Effective Dose Equivalent
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act

LIST OF ABBREVIATIONS/ACRONYMS (CONTINUED)

CESQG	Conditionally Exempt Small Quantity Generator
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
Commission	U.S. Nuclear Regulatory Commission
COOP	Cooperative Observer Program
COS	Central Operator Station
CPP	Central Processing Plant
CR	County Road
CREG	Consensus Revenue Estimating Group
CWA	Clean Water Act
D&D	Decommissioning and Decontamination
DAC	Derived Air Concentration
DDE	Deep Dose Equivalent
DEQ	Department Environmental Quality
DFM	Dry Fork Mine
DHS	Department of Homeland Security
DM	Deep Monitoring Zone
DM&E	Dakota, Minnesota & Eastern Railroad Corporation
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EC	Electrical Conductivity
EHS	Environmental Health and Safety
EIA	U.S. Department of Energy, Energy Information Administration
EIS	Environmental Impact Statement
EMR	Emergency Medical Responder
EMT	Emergency Medical Technician
EO	Executive Order
EOR	Enhanced Oil Recovery
EPA	U.S. Environmental Protection Agency
ER	Environmental Report
ESA	Endangered Species Act
EXREFA	External Reference Area
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FRP	Fiber Reinforced Plastic
FSA	Farm Service Agency
GDP	Gross Domestic Product
GEIS	Generic Environmental Impact Statement
GER	Generic Environmental Report (NMA 2007)
GPS	Global Positioning System
GR	Gamma Ray

LIST OF ABBREVIATIONS/ACRONYMS (CONTINUED)

GSP	Gross State Product
GT	Grade-Thickness
HAP	Hazardous Air Pollutant
HDPE	High Density Polyethylene
HEC	Hydrologic Engineering Center
HEPA	High Efficiency Particulate Air
HMI	Human Machine Interface
HMR	Hazardous Material Regulations
HMS	Hydrologic Modeling System
HPS	Health Physics Society
HRI	Hydro Resources, Inc.
HVAC	Heating Ventilation and Air Conditioning
HWL	High Water Line
IAEA	International Atomic Energy Act
IBC	International Building Code
ICRP	International Commission on Radiological Protection
ID	Inside Diameter
IDLH	Immediately Dangerous to Life and Health
IML	Inter-Mountain Laboratories
IMPROVE	Interagency Monitoring of Protected Visual Environments
IR	Intake Rate
ISL	In-situ Leach
ISR	In-situ Recovery
ISR GEIS	Generic Environmental Impact Statement for In-situ Leach Uranium Milling Facilities (NUREG-1910)
IX	Ion Exchange
JFD	Joint Frequency Distribution
LBA	Lease By Application
LCI	Lost Creek, Inc.
LiDAR	Light Detection and Ranging
LLD	Lower Limits of Detection
LOI	Letter of Intent
LQD	Land Quality Division
LSA	Low Specific Activity
MARSSIM	Multi-Agency Radiation Survey & Site Investigation Manual
MCL	Maximum Contaminant Level
MCS	Master Control System
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MET	Meteorological Monitoring Site
MIT	Mechanical Integrity Testing

MLS	Mass Layoff Statistics
MOA	Memorandum of Agreement
MSHA	Mine Safety & Health Administration
NAAQS	National Ambient Air Quality Standards
NAD	North American Datum
NAD83	North American Datum 1983
NADP	National Atmospheric Deposition Program
NAICS	North American Industry Classification System
NAIP	National Agriculture Imagery Program
NAPG	North American Power Group
NASS	National Agricultural Statistics Service
NCHRP	National Cooperative Highway Research Program
NCRP	National Council on Radiation Protection & Measurements
NEPA	National Environmental Policy Act
NFO	Newcastle Field Office
NFPA	National Fire Protection Association
NHPA	National Historic Preservation Act
NIOSH	National Institute for Occupational Safety and Health
NMA	National Mining Association
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NRPB	National Radiation Protection Board
NSPS	New Source Performance Standards
Nubeth	Nubeth Joint Venture
NUREG	Publication Prepared by NRC Staff
NUREG/ CR	Publication Prepared by NRC Contractors
NWI	National Wetlands Inventory
NWL	Normal Water Line
NWP	Nationwide Permit
NWS	National Weather Service
OD	Outside Diameter
ODP	Office of Domestic Preparedness
OOEA	Office of Outreach and Environmental Assistance
OSD	Optically Stimulated Dosimeter
OSHA	Occupational Safety & Health Administration
OSL	Optically Stimulated Luminescence
OSLI	Office of State Lands and Investments
OSM	U.S. Office of Surface Mining Reclamation and Enforcement

LIST OF ABBREVIATIONS/ACRONYMS (CONTINUED)

OSR	Optical Synchrotron Radiation Monitor
OZ	Ore Zone Monitoring Interval
P&A	Plugged and Abandoned
PCB	Polychlorinated Biphenyl
PCPI	Per Capita Personal Income
PFYC	Potential Fossil Yield Classification System
pH	Hydrogen ion activity
PLC	Programmable Logic Controller
PLIC	Public Lands Information Center
$PM_{2.5}$	Particulate Matter 2.5 Microns or Less
PM_{10}	Particulate Matter 10 Microns or Less
PMF	Probable Maximum Flood
PP	Polypropylene
PPE	Personal Protective Equipment
PRB	Powder River Basin
PSD	Prevention of Significant Deterioration
PSHA	Probabilistic Seismic Hazard Analysis
PSM	Process Safety Management
PTE	Potential to Emit
PV	Pore Volume
PVC	Polyvinyl Chloride
PVD	Pore Volume Displacement
QA	Quality Assurance
QAM	Quality Assurance Manual
QC	Quality Control
Quad	Quadrangle
R	Range or Roentgens
r	Resistivity
R&D	Research and Development
RAP	Restoration Action Plan
RCRA	Resource Conservation and Recovery Act
RFFA	Reasonably Foreseeable Future Actions
RG	Regulatory Guide
RMP	Risk Management Program
RO	Reverse Osmosis
RPP	Radiation Protection Program
RSO	Radiation Safety Officer
RWP	Radiation Work Permits
SA	Surficial Aquifer
SAIPE	Small Area Income and Poverty Estimates
SAR	Sodium Adsorption Ratio
SCS	Soil Conservation Service

LIST OF ABBREVIATIONS/ACRONYMS (CONTINUED)

SDI	Subsurface Drip Irrigation
SDWA	Safe Drinking Water Act
SEIS	Supplemental Environmental Impact Statement
SER	Safety Evaluation Report
SERP	Safety and Environmental Review Panel
SHPO	State Historic Preservation Office
SHWD	Solid and Hazardous Waste Division
SIP	State Implementation Plan
SM	Shallow Monitoring Zone
SODAR	Sonic Detection and Ranging
SOP	Standard Operating Procedure
SP	Spontaneous Potential
SPCC	Spill Prevention, Control, and Countermeasure
SS	Stainless Steel
Strata	Strata Energy, Inc.
SWPPP	Storm Water Pollution Prevention Plan
T	Township
T&E	Threatened and Endangered
TBNG	Thunder Basin National Grassland
TDS	Total Dissolved Solids
TEDE	Total Effective Dose Equivalent
TENORM	Technologically Enhanced Naturally Occurring Radioactive Material
TEOM	Tapered Element Oscillating Microbalance
TF	Thermal Fluid
TGLD	Task Group on Lung Dynamics
THC	Total Hydrocarbons
THPO	Tribal Historic Preservation Office
TLD	Thermoluminescent Dosimeter
TPI	Total Personal Income
TPQ	Threshold Planning Quantity
TQ	Threshold Quantity
TR	Technical Report
TRV	Target Restoration Value
TSCA	Toxic Substances Control Act
UBC	Uniform Building Code
UCL	Upper Control Limit
UDC	Uranyl Dicarbonate
UIC	Underground Injection Control
UMTRCA	Uranium Mill Tailings Radiation Control Act of 1978
UP	Union Pacific Railroad
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation

LIST OF ABBREVIATIONS/ACRONYMS (CONTINUED)

USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USDW	Underground Source of Drinking Water
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTC	Uranyl Tricarbonate
UTM	Universal Transverse Mercator Coordinate System
UW	University of Wyoming
VOC	Volatile Organic Compound
VRM	Visual Resource Management
WAAQS	Wyoming Ambient Air Quality Standards
WAQSR	Wyoming Air Quality Standards and Regulations
WARMS	Wyoming Air Resources Monitoring System
WDAI/EA	Wyoming Department of Administration and Information, Economic Analysis Division
WDEQ	Wyoming Department of Environmental Quality
WGFD	Wyoming Game and Fish Department
WL	Working Level
WNA	World Nuclear Association
WOGCC	Wyoming Oil and Gas Conservation Commission
WOHS	Wyoming Office of Homeland Security
WoUS	Water of the U.S.
WQD	Water Quality Division
WRCC	Western Regional Climate Center
WSEO	Wyoming State Engineer's Office
WSGS	Wyoming State Geological Survey
WW	Warm-Water
WWC	Western Water Consultants, Inc. or WWC Engineering
WWDC	Wyoming Water Development Commission
WYCRO	Wyoming Cultural Records Office
WYDOT	Wyoming Department of Transportation
WYNDD	Wyoming Natural Diversity Database
WYPDES	Wyoming Pollutant Discharge Elimination System

UNITS OF MEASURE

%	percent
% g	percent of gravitational acceleration
°	degrees
°C	degrees Celsius
°F	degrees Fahrenheit
ac	acre
ac-ft	acre-feet
ac-ft/yr	acre-feet per year
bcy	bank cubic yards
Bq/l	Becquerel per liter
cfm	cubic feet per minute
cfs	cubic feet per second
Ci/yr	Curies per year
cm	centimeter
cm/s	centimeters per second
cpm	counts per minute
cu ft	cubic feet
cy	cubic yards
cy/wk	cubic yards per week
cy/yr	cubic yards per year
dBA	A-weighted decibels
dpm	disintegrations per minute
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
dv	deciview
ft	feet
ft amsl	feet above mean sea level
ft/day	feet per day
ft/ft	foot per foot
ft^3	cubic feet
g	grams or gravitational acceleration
g/L	grams per liter
gpd	gallons per day
gpm	gallons per minute
gpm/ft^2	gallons per minute per square foot
ha	hectares
hp-hours	horsepower hours
hr	hour
in	inches
in/year	inches per year
kg	kilograms
km	kilometers
kV	kilovolts

UNITS OF MEASURE (CONTINUED)

kWh	kilowatt hours
lb	pounds
lb/mo	pounds per month
lbs	pounds
lbs/yr	pounds per year
m	meters
m/s	meters per second
m^2	square meters
m^3	cubic meter
m^3/hr	cubic meters per hour
Ma	mega annum
MeV	megaelectron volts
mg	milligrams
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
mg/yr	milligrams per year
MGD	million gallons per day
mi	miles
mi/mi^2	miles per square mile
mi^2	square miles
mm	millimeters
MM	million
mmhos/cm	millimhos per centimeter
mph	miles per hour
mR	milli Roentgens
mrem	millirem
mrem/yr	millirems per year
mSv	millisievert
mSv/yr	millisieverts per year
MW	megawatts
µCi	microcuries
µCi/mL	microcuries per milliliter
µg	micrograms
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
µmhos/cm	micromhos per centimeter
µR/hr	micro Roentgens per hour
µrem/hr	microrems per hour
µS/cm	microSiemens per centimeter
µSv	microsievert

UNITS OF MEASURE (CONTINUED)

NTU	nephelometric turbidity unit
pCi/g	picocuries per gram
pCi/L	picocuries per liter
pCi/m^2/s	picocuries per square meter per second
ppm	parts per million
psi	pounds per square inch
rad/d	rad per day
s.u.	standard units
tpy or t/y	tons per year
WL	working levels
yr	year(s)

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1.0 INTRODUCTION

Strata Energy, Inc. (Strata) hereby submits this Environmental Report (ER) to the United States Nuclear Regulatory Commission (NRC or the "Commission") as part of an application for a combined source and 11e.(2) byproduct material license to construct and operate an *in-situ* leach uranium recovery (ISR) facility at the proposed Ross project site in Crook County in the State of Wyoming (hereinafter the "Proposed Action"). The Proposed Action will consist of:

1) a series of sequentially developed wellfield modules utilizing injection and recovery wells for uranium recovery,
2) a monitor well network(s) for detection of potential excursions of recovery solutions outside the ore body/recovery zone, and
3) a central processing plant (CPP) consisting of pressurized, down-flow ion exchange (IX) columns, resin stripping/elution facilities, precipitation circuit, water treatment, recycling and disposal systems, yellowcake drying and packaging facilities, and a vanadium recovery circuit

In addition to uranium and vanadium production, the Proposed Action will include waste management facilities, office and laboratory buildings, storage facilities and other structures or facilities used to house work areas and equipment, each of which will be addressed in this ER.

As is typical for uranium ISR projects, the Proposed Action will be conducted in a roll-front uranium deposit amenable to the ISR process. Uranium deposits amenable to the ISR process occur in permeable sandstone aquifers that typically are confined above and below by less permeable strata. Confinement is a natural environmental condition that acts to assist in the creation of hydraulically isolated deposits of uranium. Deposition of the uranium is a natural result of groundwater flow through permeable sands between less permeable overlying and underlying confining layers. The groundwater flowing through the aquifer contains minute amounts of oxidized uranium which remains in solution until the oxygenated water reaches a reducing environment (i.e., an environment with chemical properties that causes the uranium ion to gain electrons and become less soluble), where precipitation of the uranium occurs. These naturally occurring uranium deposits can either be tabular or C-shaped deposits known as "roll fronts." The uranium roll front deposition like that in the proposed project area has taken

place over millions of years is *ongoing on a regional basis every day*. Regional roll fronts require broad areas of upgradient oxidation to keep uranium mobile until the oxygenated water moves downgradient and encounters a zone with sufficient reductant. It is at this regional *redox interface* where the oxygenated water is reduced and uranium is deposited in a reduced mineral phase in what is known as a *redistributed* ore body that ISR operations are conducted.

The ISR process envisioned by Strata is a phased, iterative process in which Strata will develop the Proposed Action by constructing a series of sequentially developed wellfield modules to recover uranium from identified ore bodies at the proposed project area. Each module will consist of approximately 30 to 40 injection/recovery well patterns and the associated module building, piping and monitor well network. Strata anticipates that 15 to 25 modules will be constructed within the proposed project area.

The development of these wellfield modules and the accumulation of a complete sampling database will begin when Strata is issued an NRC license and installs injection and recovery wells and a monitor well network. Strata's engineers and geologists will continuously assess data as they are obtained and apply this new information to the current or next phase or activity, thus ensuring that subsequent wellfield development and planning is based on the most up-to-date information possible to ensure proper placement of injection, recovery, and monitor wells. In addition, Strata has developed both a three dimensional geologic model and a three dimensional groundwater model for the proposed project area as described in Section 3.1.1 and Addendum 2.7-H of the TR, respectively. These models will be used extensively in wellfield planning and development as described throughout the Technical Report (TR). As wellfield modules are developed, all wells, including monitor wells, will be developed to assure that they function appropriately prior to being sampled and placed into service. Water quality sampling will establish baseline water quality within and outside the ore zone and will be used to determine upper control limits (UCLs), which will enable Strata to readily determine and promptly report if an excursion of recovery solutions has occurred. A "lessons learned" approach will be implemented, as the results in one module will be used by the site engineer or geologist to improve the design or operational procedure for the next module. This process is both phased and iterative, as each module is developed and tested while the uranium is progressively recovered from different parts of the ore body.

The proposed CPP will receive and process the uranium-rich groundwater generated from ISR operations in active wellfield modules. The uranium will be removed from the groundwater and converted to yellowcake product for shipment to a conversion facility for introduction into the nuclear fuel cycle. All wastes from the ISR process which are determined to be 11e.(2) byproduct material will be disposed of in a manner consistent with the Atomic Energy Act of 1954, as amended by the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) (hereinafter the "AEA"), applicable NRC regulations, and NRC guidance documents. As each wellfield module depletes its portion of the identified uranium ore body(ies), Strata will develop and commence production in the next module and will begin groundwater restoration in the module in which uranium recovery has been completed. Strata's goal is to restore groundwater in each depleted wellfield to water quality levels consistent with pre-operational or baseline water quality standards but, in any case, to satisfy the requirements of 10 CFR Part 40, Appendix A, Criterion 5(B)(5), which requires pre-operational baseline water quality or a maximum contaminant level (MCL), whichever is higher, or an alternate concentration limit (ACL). When all active ISR operations and groundwater restoration are complete in compliance with applicable regulations and relevant license conditions, Strata will initiate site reclamation activities, including decommissioning and decontamination (D&D) of the CPP, wellfield modules, access roads, piping, and the surrounding land areas with the ultimate goal of releasing the proposed project area for unrestricted (i.e., any) potential use.

In order to obtain authorization for the Proposed Action, Strata is seeking a combined source and 11e.(2) byproduct material license pursuant to the AEA; 10 CFR Part 40, Appendix A Criteria; 10 CFR Part 20, radiological protection limits; 10 CFR Part 51, National Environmental Policy Act (NEPA) regulations; and other relevant non-NRC-related regulations, including those of the United States Environmental Protection Agency (EPA) (e.g., 40 CFR Parts 190 and 192), and applicable NRC regulatory guides and guidance. Strata will also be required to obtain authorization for the Proposed Action under other provisions of EPA and Wyoming regulations pursuant to the Safe Drinking Water Act's (SDWA) underground injection control (UIC) program and to the Wyoming Department of Environmental Quality (WDEQ) rules and regulations for ISR projects (i.e., Permit to Mine), as well as a Plan of Operations from the

United States Bureau of Land Management (BLM) pursuant to BLM standards and guidelines.

1.1 Purpose and Need for the Proposed Action

Strata's purpose under the Proposed Action is to produce yellowcake for introduction into the commercial nuclear fuel cycle for conversion, enrichment, and eventual loading into nuclear power reactors. The Proposed Action is projected to produce approximately 750,000 pounds of uranium annually from the Ross ISR Project over a 4 to 8 year period. Strata is requesting that the proposed CPP be licensed to produce up to 3 million pounds of yellowcake per year. Strata's license application also requests that it be authorized to receive and process uranium-loaded IX resins from satellite ISR facilities, including those owned and/or operated by Strata or those owned and/or operated by other ISR licensees, and from other water treatment entities generating uranium-loaded IX resins that are the same as or substantially similar to those generated at ISR facilities. Based on this request, Strata's license application includes a detailed assessment of potential transportation, resin off-loading and handling, and waste management impacts associated with the production of up to 3 million pounds per year of yellowcake to include the receipt and processing of the aforementioned uranium-loaded IX resins. Strata understands that NRC Staff requires bounding criteria for determining permissible licensed operations for each license; so, Strata proposes that, for purposes of receiving and processing uranium-loaded IX resins from the aforementioned entities, NRC Staff issue a license condition permitting the receipt and processing of such resins so long as the processing of such resins does not require any material changes in the process operation for the proposed Ross CPP and there are no anomalous materials or constituents in the aforementioned resins. Strata's Safety and Environmental Review Panel (SERP) will be required to review and evaluate the receipt of any such uranium-loaded IX resins and certify that these two conditions have been satisfied prior to receiving and off-loading any such resins at the Ross CPP facility.

The need for this project stems from the fact that the current United States-based uranium production from uranium recovery facilities is approximately three (3) to four (4) million pounds per year (U.S. Department of Energy, Energy Information Administration, EIA, 2010), while domestic nuclear fuel reactors consume around 50 million pounds per year of yellowcake equivalent (WNA 2010). The Proposed Action will provide a significant

contribution to the United States becoming more energy independent and contributing to the nation's energy needs with an energy source that does not emit significant greenhouse gases.

Strata has prepared this ER in accordance with relevant NRC, EPA, and Wyoming regulations and guidance including but not limited to those listed in Table 1.1-1.

1.2 The Proposed Action

1.2.1 Background

Uranium exploration efforts in the 1950s and 1960s in the Powder River Basin (PRB) in Wyoming led to a number of discoveries, starting in the Pumpkin Buttes Uranium District of Johnson and Campbell counties. Nuclear Dynamics and Bethlehem Steel Corporation formed the Nubeth Joint Venture (Nubeth) to develop new uranium recovery districts in the western U.S. with specific attention focused on northeastern Wyoming's Powder River Basin. The initial discovery of uranium near Oshoto was made by a Mr. Albert Stoick using a hand held scintillometer during an over-flight of the area. This was followed by macroscopic sampling efforts and then regional exploration work by the joint venture group (Buswell 1982). In late 1970, airborne radiometric surveys in an area north of Moorcroft indicated large, low-order gamma ray anomalies in an area encompassing over 350 square miles. Host formations were believed to be the Late Cretaceous Lance and Fox Hills Formations. The mineralized area was therefore named the Lance District.

Beginning in late 1970 and continuing in 1971, anomalous gamma ray areas were mapped and sampled with low-grade mineralization and alteration fronts discovered. A review of conventional oil and gas drilling in the area confirmed anomalous gamma intercepts at depths above the regional confining layer (Pierre Shale). An aggressive land and mineral acquisition phase followed along with an exploration drilling program covering more than 110,000 acres and 3 million feet of drilling. Nubeth received a WDEQ/Land Quality Division (LQD) License to Explore (No. 19) in August 1976 with modifications to accommodate the research and development activities in 1978. Nubeth filed for an NRC source material license in November 1977 and achieved approval in April 1978 (SUA-1331).

A Research and Development (R&D) site was constructed in Section 18 of Township 53 North, Range 67 West. The R&D site consisted of a single 5-spot well pattern, with four injection wells and one recovery well, and a small plant with ion exchange, elution and precipitation that was capable of producing yellowcake slurry. The R&D plant could process 90 gpm of uranium-bearing groundwater. Hydraulic control at the site was accomplished with "buffer" wells, which were meant to serve as a hydraulic barrier and keep the lixiviant within the well pattern. The R&D site was operated from August 1978 through April 1979 and recovered only small amounts of uranium. Approximately 50% of the process equipment in the plant was never used. No precipitation of a uranium product took place and all of the recovered uranium was stored as a uranyl carbonate solution. After uranium recovery tests were completed, the single 5-spot used in the test was restored using groundwater sweep. Restoration was completed in February 1983 and Nubeth was notified by the WDEQ that the restoration was satisfactory on April 25, 1983. Final approval for the R&D site decommissioning was granted by the regulatory agencies in 1983 through 1986.

The overall success of the R&D operation was limited based on injection problems which eventually led to its premature shutdown. These problems were attributed to the build-up of fines and organic material in the wellfield. Although filtering equipment was used, it was insufficient. The injection rate ranged from 2.5 to 4 gpm in each injection well and 0.3 to 2 gpm in each buffer well. The recovery well flow rate ranged from 5 to 14 gpm. The highest U_3O_8 grade achieved was 54 mg/L, which occurred when the lixiviant concentration was aggressively increased during the period of February through April 1979. Lixiviant addition ended shortly after, and the target U_3O_8 grade was never reached. According to a summary report on production feasibility done by In-Situ Consulting in 1979, it was estimated that uranium production could average about 800 pounds per day using a 3,000 to 4,000 gpm plant. However, due to the declining price of uranium, commercial scale permitting and construction did not occur.

Addendum 1.2-A in the TR contains regulatory approval for the aforementioned groundwater restoration and decommissioning of the Nubeth R&D site. Figure 1.2-1 in this ER demonstrates the effectiveness of groundwater restoration at the Nubeth R&D site, which is further confirmed by current sample results that reveal long-term water quality stability for total

dissolved solids (TDS), natural uranium, radium-226, and selenium. Based on the Nubeth Restoration Summary Report (Nuclear Dynamics 1979), in excess of 1.8 million gallons of water or 4.2 pore volume displacements from the 5-spot R&D pattern were removed in the initial restoration efforts. Periodic sampling and subsequent pumping likely removed additional impacted water from the area but was not quantified in the report. In addition, use of several R&D site wells (789V and 19XX) by oil companies since 1980 has resulted in a cumulative removal of approximately 288 million gallons or 657 pore volume displacements.

Despite the problems associated with operating the R&D site, it proved that economic concentrations of uranium could be recovered within the proposed project area using the ISR process, including a sodium-bicarbonate based lixiviant. The information obtained from the R&D site helped Strata to make the decision to develop a full-scale ISR facility at this location. Key benefits derived from the R&D site include:

- Perceived ability to achieve exemption of the mineralized aquifer,
- Indications of strong geologic confinement, above and below the identified ore body(ies)
- Confirmation of fundamental hydrogeologic hypotheses regarding groundwater flow and behavior,
- Information to provide focus for potential regulatory and operational technical issues,
- A basis for studies pertaining to site hydrology, geology, wildlife, vegetation, soils, climate and radiological conditions,
- The ability to decrease disturbance to both the surface and subsurface based on data collected in the past, and
- Demonstration of successful reclamation, groundwater restoration and site decommissioning.

Peninsula Energy Ltd (formerly Peninsula Minerals Ltd) initiated mineral acquisition in the Lance District in 2007 and 2008. Exploration drilling programs conducted in 2008 and 2009 confirmed significant uranium resources in the Ross area. Strata Energy was incorporated in 2009 to facilitate drilling and to provide an entity to seek an NRC combined source and 11e.(2) byproduct material license, WDEQ/LQD Permit to Mine, and BLM Plan of Operations for the proposed Ross ISR Project.

1.2.2 *Corporate Entities Involved*

Strata's license application, including its ER and TR, are submitted by Strata Energy, Inc., a corporation registered in the State of Wyoming. Strata is a United States-based corporation and is the wholly owned subsidiary of Peninsula Energy Ltd, an Australian registered company. The Australian corporate office is located at 477 Hay Street, Level 1, Subiaco, Western Australia, Australia. The corporate headquarters of Strata is located at 406 W. 4th Street, Gillette, Wyoming. Peninsula Energy Ltd is a publicly traded corporation with shares traded (PEN) on the Australian Securities Exchange.

For purposes of conducting NRC-licensed ISR operations, Strata 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 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 to be located in Crook County, Wyoming, 21.5 miles north of Moorcroft and adjacent to the ranching community of Oshoto. The proposed project area encompasses approximately 1,721 acres in portions of Sections 7, 17, 18, and 19, Township 53 North, Range 67 West, and portions of Sections 12, 13, and 24, Township 53 North, Range 68 West. Figure 1.2-2 provides a general location of the site, Figure 1.2-3 depicts the proposed project area on U.S. Geologic Survey (USGS) 7.5-minute topography, and Figure 1.2-4 depicts the surface and mineral ownership within the proposed project area. The Proposed Action is to be located in an area utilized primarily for livestock grazing, dry land crop production, and oil production. The community of Oshoto, adjacent to the proposed project area, includes 11 residences within 2 miles (3.2 km) of the proposed license area. Access to the proposed project area is by county roads (D Road and the New Haven Road), which proceed north of Interstate 90 approximately 23 miles to the proposed project area. Bentonite mining and recreation are other activities in the vicinity of the project.

The primary access to the proposed project area is along D Road (CR 68) and the New Haven Road (CR 164) from the south. Beginning at I-90 exit 153, the primary access gate will be reached by traveling north on D Road for

18 miles, then north on the New Haven Road for an additional 3 miles. Figure 1.2-2 depicts the existing and proposed access roads within and in the vicinity of the proposed project area. D Road and the New Haven Road are existing, all-weather gravel roads maintained by Crook County, while the primary, secondary and tertiary roads within the proposed project area will be constructed or renovated as part of the Proposed Action. Figure 1.2-5 depicts the proposed plant area, including fencing and restricted areas.

While the proposed Ross ISR Project encompasses a total of 1,721 acres, the land potentially disturbed by the Proposed Action will be approximately 110 acres during the year preceding operation (including installation of a portion of the wellfield modules, construction of the CPP, associated facilities and structures, access roads, etc.). The land area potentially disturbed over the life of the Proposed Action is estimated to increase to approximately 280 acres, or approximately 16% of the proposed project area. Table 1.2-1 summarizes the surface ownership and potential disturbance within the proposed project area. No disturbance is planned outside of the proposed project area, including primary access road construction, unless required to bring utilities (natural gas and electric) to the proposed project area from nearby transmission lines. However, Strata will continue exploration drilling within the Lance District under a WDEQ/LQD Mineral Exploration Permit/Drilling Notification System.

Figure 1.2-6 depicts the proposed facilities on USGS topography and Figure 1.2-7 depicts the proposed facilities on 2010 aerial photography.

1.2.4 Ross ISR Project Ore Body

Prior to beginning development of the license application for the Ross ISR Project, Strata must determine whether its identified ore body is commercially viable for uranium production. Throughout the pre-application process, Strata has been evaluating the proposed project area's geologic and hydrologic characteristics to determine if the identified ore body is amenable to the ISR process. Factors evaluated by Strata include the permeability of the identified ore zone, the geological characteristics of the layers above and below the ore zone to determine confinement, and the nature of the "stacked" roll-front uranium deposits to better understand well placement. Based on its evaluation of these factors, Strata has determined that the ore body within the proposed project area is commercially viable and should be developed for uranium production.

Uranium targeted for production within the proposed project area is located in permeable sandstones of the Late Cretaceous Lance and Fox Hills Formations. The epigenetic roll fronts deposited in the Oshoto area demonstrate patterns similar to those across the Powder River Basin. The uranyl-bearing groundwater moved downdip with emplacement of uranium as a coating on sand grains primarily due to factors such as permeability, reducing groundwater conditions and groundwater flow (Buswell 1982). The roll front geometry at the proposed project area can vary due to differences in the depositional environment of the host sandstones. The deeper, Fox Hills alteration fronts are generally thicker and more massive due to the near-shore environment into which the sediments were deposited. While lower Lance Formation sandstones were deposited in a fluvial environment resulting in narrower, often stacked channel systems containing the mineralization. Due to the variability of the depositional environment and hence controls on groundwater movement, the roll fronts in the proposed project area are complex and consistently indicate increasing resource estimates. At this time, mineable resources within the proposed project area exceed 5.5 million pounds of uranium and based on current roll front projections are likely to increase as more delineation drilling results become available. Based on Strata's analysis and a review of the ISR GEIS (NRC 2009), it appears that the Proposed Action's ore body closely resembles the ore bodies 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.

It is anticipated that the wellfield at the proposed project area will operate at a maximum flow rate of 7,500 gpm. Native groundwater fortified with oxidizing and complexing agents (lixiviant(s), i.e., oxygen, hydrogen peroxide, carbon dioxide, and/or sodium bicarbonate) will be circulated throughout the ore body using installed and mechanical-integrity-tested injection wells, which will cause the uranium to be solubilized. The uranium-rich groundwater will be pumped to the surface using installed and mechanical-integrity-tested recovery wells and then piped to pressurized, down-flow IX columns for the first stage of uranium recovery. As the uranium-rich groundwater is pumped through the IX columns, the uranium will be loaded onto uranium-specific IX resins in the columns, and subsequently stripped from the IX resins by elution with a concentrated brine rinse. The barren resins will be returned to the appropriate IX column for further use. Any spent resins will be segregated and stored as 11e.(2) byproduct material

on-site until they are transported for off-site disposal, per Commission policy directives reflected in 10 CFR Part 40, Appendix A, Criterion 2, at a licensed uranium mill tailings or other appropriately licensed facility.

1.2.5 ISR Wellfield

After an ore body that is amenable to ISR processes is identified and delineated, Strata will develop wellfield module designs to progressively remove uranium from the identified ore body. The wellfield at the Ross ISR Project will be divided into two mine units, which will be further separated into wellfield modules. Wellfield modules will be used to delineate the portion of each mine unit assigned to a specific central collection facility called a module building. This type of facility is typically referred to in other ISR applications as a header house. Wellfield module design is based on grids with alternating injection and recovery wells, monitor wells above and below the recovery zone, and a "ring" of monitor wells surrounding the entire recovery zone to detect any potential "excursions" of recovery solutions. Excursions are defined as the exceedance of UCLs for two or more excursion indicators in a monitor well. Based on pre-application delineation drilling, Strata anticipates that 15 to 25 wellfield modules will be constructed within the proposed project area, each module containing approximately 35 to 40 wellfield patterns and incorporating an area of about 248,000 square feet. Approximately 2 to 6 modules will be constructed at one time, 2 to 10 operated at one time, and 2 to 10 will undergo aquifer restoration at one time.

Each wellfield module will be operated near the maximum continuous flow rate achievable without exceeding the maximum injection pressure. Injection and recovery flow rates will be monitored and adjusted as necessary on a daily basis, so that injection can be balanced with recovery across each wellfield pattern and across the wellfield modules, with the injection flow lower than the recovery flow by the amount of the production "bleed" rate. The production bleed rate varies according to ore body geometry, well pattern and magnitude, and direction of the natural groundwater velocity. Strata anticipates that the production bleed will range from 0.5% to 2% and average 1.25%. Proper wellfield balance, including the production bleed, maximizes recovery while protecting against excursions.

1.2.5.1 Well Construction and Integrity Testing

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

1.2.5.1.1 Well Construction Materials

In the proposed project area, injection, recovery and monitor wells will be constructed with 4 to 6-inch nominal diameter polyvinyl chloride (PVC) or fiberglass pipe with wall thickness sufficient to withstand the maximum anticipated injection pressure, the maximum external collapsing pressure, and the pressure of cementing in accordance with Wyoming State Engineer's Office (WSEO) and WDEQ requirements. In order to provide an adequate annular seal, the drill hole diameter will be at least 3 inches greater in nominal diameter than the outside diameter of the well casing. The annular seal will be pressure-grouted and sealed from the bottom up to the ground surface with neat cement slurry. Casing will be joined using an O-ring and spline locking system. Screw and glue joints will not be used for injection and recovery wells due to reported failures of screw and glue joints at similar facilities.

1.2.5.1.2 Well Construction Methods

The recovery and injection wells will be installed with identical completion methods (see Method 1 below) to allow the function to be changed if desired. The ability to change the well function allows for improved uranium recovery, more efficient restoration, and improved ability to respond to potential excursions. The monitor wells will be installed utilizing Method 2 or Method 3 also described briefly below. Refer to Section 3.1.2.1 in the TR for detailed well construction methods.

- Method 1 (See Figure 1.2-8): 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 neat cement slurry from the bottom of the casing to the surface. After allowing the cement to harden, underream the well through the mineralized zones to a diameter of 10 to 14 inches and install factory-slotted

well screen, if necessary, within the underreamed intervals. Filter sand may be placed between the screen and the underreamed hole.

- ♦ Method 2 (See Figure 1.2-9): 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 neat cement slurry from the bottom of the casing to the surface. After allowing the cement to harden, clean out the designated completion interval and underream if necessary. If necessary, install a factory-slotted screen assembly in the completed interval. Filter sand may be placed between the screen and the underreamed hole.
- ♦ Method 3 (See Figure 1.2-10): 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 neat 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, install a factory-slotted screen assembly in the completed interval and underream the completed interval. Filter sand may be placed between the screen and the underreamed hole.

Casing centralizers will be used to center the casing inside the borehole to ensure an effective cement seal within the annulus. Centralizers will be spaced no more than 40 feet apart and in accordance with site-specific conditions and regulations. For example, WDEQ/LQD Rules and Regulations, Chapter 11, Section b(e) requires, "Casing shall be equipped with centralizers placed at a maximum spacing of one per forty feet to ensure even thickness of annular seal and gravel pack." The annular space between the casing and the borehole will be sealed with neat cement slurry in compliance with Wyoming requirements. The grout will be injected into the annulus from the bottom to the surface, to ensure a complete seal.

1.2.5.1.3 Additional Construction Requirements

Prior to reaming the pilot holes that will be drilled to final diameter to run casing, ore grade gamma log, resistivity, spontaneous potential and deviation geophysical logs will be run in the pilot holes. These logs will determine the location and grade of uranium and the depths of the sand and

clay units to properly plan each wellfield pattern and to set the well screens at the proper depth to efficiently contact the identified uranium ore body.

1.2.5.1.4 Well Development

Wells will be developed after completion using conventional methods such as jetting, swabbing, air-lifting, pumping, or other appropriate method. The goal will be to remove drilling fluids and fines from the completion zone to provide good hydraulic communication and maintain the natural geochemical conditions. Well development will continue until produced water runs clear. Turbidity and water quality measurements such as pH and electrical conductivity and visual observation will typically be used as indicators to determine when well development is completed. Baseline water quality samples will be collected after each well is developed.

1.2.5.1.5 Well Integrity Testing

Each injection, recovery, and monitor well must be tested for mechanical integrity of the well casing before it can be used. Mechanical integrity testing (MIT) is required by State and Federal UIC Programs and the NRC. MIT is performed to ensure no hydraulic communication between the production aquifer and overlying water bearing zones. Prior to placing a well in service and periodically thereafter, MIT of each recovery, injection and monitor well will be performed. MIT will ensure that all wells are constructed properly and capable of maintaining pressure without leakage. All wells will be tested following initial construction, at least once every 5 years, and whenever there is any question of casing integrity. Specifically, MIT will be repeated if the well is entered by a drilling bit, underreaming tool, or if it is suspected that well damage is possible for any reason. Thus, as described in the ISR GEIS (pg. 2-12), operating wells will be tested for integrity prior to beginning operations, after repairs are made, and at least every 5 years.

NUREG-1569, the ISR GEIS and EPA guidance (Geraughty and Miller 1980) address MIT for injection wells. Most commonly, MIT is performed using inflatable packers installed inside the well casing at a depth just above the production zone and at the top of the casing. The pressure in the sealed casing is increased to a minimum of 25% above the maximum anticipated operating pressure, the well is closed, and all fittings are checked for leaks. After the pressure is stabilized, pressure readings are recorded at regular intervals for at

least 10 minutes. After the selected test duration, the well passes the test if less than 10% of the starting pressure was lost over the course of the test. If the pressure loss was greater than 10%, the well fails the test (ISR GEIS, pg. 2-12). If a well fails the test, it is repaired as appropriate and tested again. A well that fails the test repeatedly is plugged and abandoned in accordance with applicable Wyoming requirements. Site-specific integrity test methods are found in Section 3.1.2.3 of the TR. These include placing inflatable packers near the top of the casing and above the screen interval, pressurizing the interval between the packers to 175 psi, which is the maximum allowable injection pressure (140 psi) plus a safety factor of 25%, and measuring the pressure for 10 minutes. If the pressure is maintained within 10% for 10 minutes, the well passes the MIT.

1.2.5.2 Wellfield Layout and Design

During the operation (uranium recovery) phase of a wellfield's life, the key objective is to maximize the rate of uranium production from each recovery well in service while, at the same time, preventing the migration (i.e., excursion) of recovery solutions into adjacent, non-exempt aquifers outside of the recovery zone. As a result, wellfield management focuses on balancing wellfield flow. The injection rate must not exceed the recovery rate in any individual well pattern or a wellfield module as a whole. Maintaining the recovery rate of recovery wells is a key maintenance issue for flow balancing. During operation, injection and recovery wells will be routinely taken off line for maintenance and enhancement, which could include air lifting, swabbing, underreaming, or chemical treatment. Examples of chemicals used for enhancement include a weak acid solution to dissolve calcite or a sodium hypochlorite (bleach) solution to eliminate bacteria.

Details of the wellfield operations plan that relate to protecting against and responding to any potential excursion from the recovery zone in compliance with NRC license conditions and UIC program requirements will be detailed in a Site Operation Plan that is prepared prior to operations but after issuance of the requested NRC license. The plan will detail the planned recovery flow rates, bleed, injection rates/pressures, maintenance, instrumentation, and monitoring based on a pre-operational database and groundwater model.

Multiple uranium horizons will be delineated by drilling exploration boreholes and mapping them as "zones." Injection and recovery wells will be drilled, cased, cemented, pressure tested, and completed in the mapped ore zones. The wellfield will be installed as "modules" that are surrounded by monitor well rings at approved distances. Monitor wells will be installed in the water bearing zones immediately above and below the recovery zone at an approved density (e.g., one well per four acres). The wellfield will be divided into mine units, which will further be divided into modules for scheduling development and for establishing pre-operational baseline water quality data for UCLs, restoration criteria, and monitoring requirements. There can be a number of modules in various stages of construction, operation and aquifer restoration at any one time. Aquifer restoration will begin after active recovery operations cease and will occur at the same time as other modules are developed and produced.

The injection and recovery wells at the proposed project area will be arranged in 5-spot, 7-spot, direct line drive, or staggered line drive patterns. The well pattern used will depend on the spatial extent of the ore zone and will be designed for optimum uranium recovery. Examples of well patterns are shown in Figure 1.2-11. The 5 and 7-spot patterns will generally be used on wider ore bodies, while direct line drive and staggered line drive patterns will be used on narrower ore bodies. Any combination of well patterns may be used to fit the specific characteristics of the ore body. Injection and recovery wells will have identical construction and completion methods so that the flow direction can be reversed to optimize uranium recovery and groundwater restoration and to help respond to potential excursions of recovery solution.

As noted above, monitor wells will be placed in a "ring" around the recovery zone(s), and in water bearing zones directly overlying and underlying the production zone. Selected wells will be monitored for water level and sampled for certain water quality parameters on a regular basis to ensure that the injected lixiviant stays within the defined production zone (ISR GEIS, pg. 2-19).

In each module, more water is extracted than injected, which creates a production "bleed." This overproduction creates a localized hydrogeologic cone of depression or pressure sink. This pressure gradient provides containment of the lixiviant by causing groundwater movement from the surrounding area toward the recovery unit which, in turn, dilutes contaminant build-up that

could adversely affect the efficiency of uranium recovery operations. The over production or "bleed" rate typically ranges from 1% to 3% of the extraction flow rate from any given module (ISR GEIS, pg. 2-17). Strata anticipates that the bleed rate for the proposed Ross ISR Project will range from 0.5% to 2% and average 1.25%. This bleed rate is supported by pre-application groundwater modeling (see TR Addendum 2.7-H).

Design, construction, testing, and operation of injection and recovery wells are subject to the UIC program regulated by EPA or a State with "primacy" under the SDWA. In the case of the Ross ISR Project, ISR injection and recovery wells are permitted as Class III injection wells through WDEQ/LQD. Class III injection wells are defined by EPA as Mining Wells (e.g., salt, copper, and ISR recovery techniques). The wells are constructed and approved by EPA and/or approved State programs. The methods and materials to construct injection and recovery wells are in accordance with EPA's requirements for Class III injection wells found in 40 CFR Part 146 and WDEQ/LQD Rules and Regulations, Chapter 11. Strata plans to obtain a Class III UIC permit for such wells from the State prior to commencing operations.

1.2.5.3 Wellfield Operational Monitoring

The ISR wellfield will include a series of monitoring systems intended to prevent the migration of recovery solutions outside of the recovery zone (i.e., excursions). The wellfield instrumentation includes the well head, valves, pressure gages, totalizing meters, and flow meters. Injection and production flow rates are monitored to balance the injection and recovery across the wellfield, with injection rates lower than the production flow by the amount of the bleed. Since ISR production facilities operate continuously, meters in wellfield module buildings and at the CPP are monitored consistently for repair or replacement as part of a larger operational maintenance program. System fault interrupts (fail-safe interlocks) will be installed to enable shutdown or to assist with shutdown of the system in the event of an unwanted condition. These will include pipe break detection by flow and pressure monitoring and leak detectors in module buildings, valve manholes, and well heads to provide early warning of a leak. Video cameras may also be used in module buildings. Additional information is found in TR Section 3.1.7.

As noted above, ISR operators monitor injection and recovery systems in both the wellfield and the CPP. The metering systems permit continuous

pressure monitoring on both the injection and recovery pipeline systems, and provide visual and audible alarms for plant operators in the event of leaks or ruptures. Additionally, formal visual inspections will be conducted and documented regularly. All licensee personnel who conduct routine construction and maintenance in the wellfield areas will have been trained to provide wellfield surveillance. Inspection intervals for various components of the wellfield, CPP, and associated facilities are presented in Section 5.3 of the TR.

Strata also will assure that its ISR plants are equipped with adequate secondary containment in the form of curbs, berms, and sumps/pumps to prevent any potential spills from all processing/storage equipment from escaping into the environment. Details of the secondary containment structures at the proposed project area are discussed in Section 3.2 of the TR.

Routine environmental monitoring will be conducted independently of operational monitoring. Strata's ISR environmental monitoring systems will be based on an outline provided in NRC's Regulatory Guide 4.14 (NRC 1980) or current revisions thereof.

Normally, an applicant's proposed environmental and plant monitoring and documentation systems (including associated routine and non-routine reporting procedures) will be included as conditions in the approved NRC license. Strata's in-plant radiation monitoring and occupational safety programs also will be reviewed and approved by the NRC.

Lined retention ponds will be constructed to store permeate and brine resulting from processing ISR fluids. Ponds will include double liners and leak detection systems as described in Section 4.2.2 of the TR. Routine inspection of the leak detection systems and embankments will guard against release of permeate, brine, or other 11e.(2) liquids from the lined ponds.

1.3 Proposed Operating Plans and Schedules

1.3.1 Proposed Operating Plan

Strata 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, construction of the first group of wellfield modules, the CPP and associated facilities, including lined retention ponds and other facilities, will commence. Barring any anomalous conditions after SERP review of the initial wellfield package is completed, uranium recovery

operations will commence immediately. As described in the responses to comments in the final Moore Ranch Supplemental Environmental Impact Statement (SEIS) (NRC 2010a), current NRC policy allows SERP review and approval of wellfield packages under performance-based license conditions as long as there are no unusual geologic or groundwater flow conditions or other anomalies that would require NRC review and approval.

When the initial wellfield modules are depleted to uneconomical recovery levels, Strata will begin uranium recovery operations in the next group of modules and prepare to commence aquifer restoration as the modules are depleted. Strata's goal will be to restore groundwater in each depleted module to water quality levels consistent with pre-operational or baseline water quality standards but, in any case, to satisfy the requirements of 10 CFR Part 40, Appendix A, Criterion 5(B)(5), which requires pre-operational baseline water quality or an MCL, whichever is higher, or an ACL. Strata will not apply for an ACL for a specific parameter without demonstrating that Best Practicable Technology (BPT) has been applied, there are no specific hazards, and the resulting concentration is ALARA. For the duration of the proposed Ross project, Strata intends to operate in the standard "phased" mode with one group of modules in active ISR operations while the preceding group of modules is engaged in groundwater restoration. Subsequent modules will be developed on the same schedule to ensure that all NRC requirements for active ISR operations and aquifer restoration are satisfied.

After regulatory approval is received for successful aquifer restoration in a given wellfield module, Strata will engage in appropriate site D&D activities for each module in accordance with NRC regulations at 10 CFR Part 40, Appendix A, specific license conditions, and associated guidance and policies. These activities include but are not limited to: (1) well abandonment and plugging; (2) removal of piping, tanks, module buildings and other ancillary facilities; (3) cleanup of surface soils to 10 CFR Part 40, Appendix A, Criterion 6 requirements; and (4) re-vegetation of disturbed areas.

When active ISR operations and aquifer restoration are completed for all Ross wellfield modules, Strata will engage in final D&D of the CPP and associated facilities and structures. In the event that Strata determines that the Ross CPP and its associated facilities are to be used for the milling of uranium-loaded resins from other future Strata ISR projects, satellite facilities owned and/or operated by other uranium recovery companies, or water

treatment entities, such facilities and structures will be maintained in accordance with NRC regulations and will remain licensed via NRC's licensing process, as necessary. Accordingly, it is likely that the proposed Ross CPP will serve as the central processing location for future Strata satellite facilities and, potentially, satellite facilities owned and/or operated by other uranium recovery companies or water treatment entities; however, for purposes of the current license application, Strata intends for the Ross CPP to service only ISR operations within the proposed Ross license boundary. A site-specific Restoration Action Plan (RAP), which addresses both surface reclamation and groundwater restoration, is found in Addendum 6.1-A of the TR.

1.3.2 Proposed Project Schedule

The proposed project schedule is provided in Figure 1.3-1. Construction of the CPP, associated facilities, and initial wellfield modules is expected to last 6 to 12 months, beginning when the requested NRC license is approved. Strata anticipates initiating pre-construction site preparation work prior to issuance of the requested NRC license subject to the currently proposed NRC rulemaking revising the definition of "construction" in 10 CFR 40.32(e) (NRC 2010b) and subject to WDEQ/LQD approval. Pre-construction activities could include site exploration, including pre-construction monitoring to establish background information related to the suitability of the site; site preparation such as clearing and grading and construction of drainage, erosion and other mitigation measures; erection of fences and other access control measures that are not related to the safe use of, or security of, radiological materials; excavation; erection of support buildings; construction of building service facilities such as roads, parking lots, exterior utility and lighting systems, domestic sewage facilities, and transmission lines; and other activities which have no measurable nexus to radiological health and safety or common defense and security. Further, Strata plans to prepare and submit a pre-construction exemption request to NRC for the installation of one deep disposal test well, to better characterize the hydrologic and geochemical properties of the Deadwood and Flathead Formations within the proposed project area, and for the baseline monitor wells in the first mine unit. Authorization for this work would be requested in order to establish background information related to the suitability of the site.

Construction of each wellfield module is anticipated to take 6 to 12 months, including installation, development, and MIT of injection, recovery,

and monitor wells and installation of module buildings, piping, and utilities. Wellfield construction will be phased, with two to six wellfield modules in various stages of construction at one time. The overall duration of construction is anticipated to be 3 to 5 years.

Uranium recovery operations are anticipated to begin 6 to 12 months after initiating construction of the CPP and initial wellfield modules. The duration of operation of each wellfield module is estimated to be 21 months, but this duration may be longer or shorter depending on the uranium recovery level and available production plant capacity. Operations will be phased with approximately two to ten modules in operation at one time. The overall duration of operations is anticipated to be 4 to 8 years for the proposed Ross ISR wellfield.

The anticipated aquifer restoration schedule is described in detail in TR Section 6.1 and Addendum 6.1-A in the TR. The duration of active aquifer restoration for each wellfield module is expected to be 6 to 9 months, followed by 12 months of stability monitoring. Strata will adhere to the timelines in decommissioning regulations of 10 CFR 40.42. When aquifer restoration begins in a given wellfield module, Strata will determine the restoration schedule. If it is anticipated to exceed 24 months, strata will submit an alternate schedule request for regulatory approval. Aquifer restoration will be phased, and it is anticipated that two to ten modules will be in various stages of active restoration or stability monitoring at one time. The total duration of aquifer restoration is expected to be 4 to 7 years for the proposed Ross ISR wellfield.

D&D of the CPP, access roads, lined retention ponds, and associated infrastructure is expected to last 12 to 18 months. D&D activities described above for wellfield modules will likely commence after receiving NRC and WDEQ/LQD approval of successful aquifer restoration in each wellfield module.

The total project life is expected to be 8 to 12 years; however, the duration of operations may be extended by processing uranium-loaded IX resin from satellite facilities owned and/or operated by Strata or other company(ies) or from water treatment entities. In this case, the project life of the CPP and related facilities would be extended to 10 to 20 years or more.

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

This section describes typical ISR processing plant facilities and details specifications that have been or are generally applied to such facilities. It is understood that Strata's specifications may be revised from time to time as improved materials or process equipment are developed. Therefore, Strata proposes to select equipment adequate to meet specific performance objectives, rather than being limited to only particular equipment types or materials.

Processing plant facilities typically include the following major structures: a CPP building housing the uranium processing equipment, drying and packaging equipment, aquifer restoration water treatment equipment; a warehouse and maintenance building; and a reagent and liquid materials storage facility. In addition to this, the proposed Ross CPP will include vanadium processing, drying and packaging equipment.

The proposed CPP will contain various vessels to hold and process liquid solutions. The principal vessels will include pressurized, down-flow IX columns, elution columns, vanadium recovery equipment, yellowcake precipitation tanks, and washing, dewatering, and yellowcake and vanadium drying equipment. The main plant will contain tanks for storage of various liquids including barren lixiviant, barren eluant, process chemicals, and yellowcake slurry. Designated areas will also be provided for hydrocarbon storage (fuel, oil, etc.) and hazardous waste storage (used oil, etc.). 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

Strata proposes to construct and operate a single CPP within the proposed project area (see Figures 1.2-5 and 1.2-6). This proposed CPP is intended to be the central processing location for all uranium recovery processes starting with production of uranium in sequentially developed wellfield modules and ending with the production of the final uranium product, yellowcake. In short, uranium recovered from a wellfield will be extracted from solution by IX and stripped from the loaded IX resin (elution), precipitated, thickened resulting in uranium slurry, de-watered, and finally dried and packaged as yellowcake. Vanadium will also be recovered through a separate circuit.

The proposed CPP will be housed in a pre-engineered metal building which will contain the following systems: (1) IX systems; (2) chemical addition; (3) filtration; (4) elution circuit; (5) precipitation and thickening circuit; (6) product de-watering, drying, and packaging circuit; (7) liquid waste stream circuit; (8) vanadium circuit; and (9) restoration circuit. Based on a preliminary site evaluation, the proposed CPP will be located in the NESE of Section 18, T53N, R67W with chemical storage units located adjacent to the CPP.

A discussion of the areas in the proposed plant facility where vapors or gases could be generated can be found in Sections 4.1 and 5.7.1 of the TR. The potential sources are minimal in the IX process area since the recovery solutions contained in the process equipment are maintained sealed under a positive pressure, and thus are not vented to the atmosphere except during resin transfers. During such events and to minimize potential occupational exposure, vents and exhaust fans will be located in these areas. Vents will draw in fresh air and exhaust fans will discharge plant air out to the atmosphere, thus avoiding any buildup of radon daughters.

1.4.2 Ion Exchange System

The proposed CPP will be equipped with pressurized, down-flow IX columns intended to remove uranium from solution. The proposed IX systems will consist of 14 fixed bed IX columns and will be operated as 7 sets of 2 vessels in series. These IX vessels will be connected directly to the trunk line carrying pregnant lixiviant from the wellfield. The IX system will be operated at a recovery rate of up to 7,500 gpm with each vessel, as noted above, operated in a pressurized down-flow mode. As the recovery solutions pass through the IX resin, the uranyl dicarbonate (UDC) and uranyl tricarbonate (UTC) ions are preferentially removed from the solutions by exchanging with chloride, bicarbonate, and sulfate ions on the resin. The vanadium in the recovery solution also will have an affinity for the IX resin. The barren recovery solution leaving the IX units normally contains less than 2 mg/L of uranium. IX “guard” columns will be used to ensure that all possible uranium is removed from bleed and restoration streams before further treatment. Based on the standard ISR techniques employed by Strata using pressurized, down-flow IX columns, 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

from the Proposed Action. Page 2-33 of the ISR GEIS notes, "Pressurized processing systems … contain most of the radon in solution."

After leaving the IX vessels, the barren recovery solutions will be re-fortified with additional oxidizing and complexing agents to the extent necessary to continue re-circulation of such solutions through the identified ore body for continued uranium and vanadium recovery. In addition, Strata plans to add permeate (nearly pure water generated from the production and restoration reverse osmosis units) to the injection stream to help reduce the buildup of salts and other dissolved constituents in the producing wellfield modules.

1.4.3 Elution System

Once loaded with complexed uranyl carbonate, the uranium-loaded resins will be eluted using a four-stage elution circuit. Resin will be contacted with elution brine to strip the uranyl carbonate anions and regenerate the IX resin. The fresh brine solution is prepared by mixing the proper quantities of a saturated sodium chloride (salt) solution and saturated sodium carbonate (soda ash) solution and water. The elution process will consist of four stages: three eluant stages and one rinse stage. An additional regeneration stage using hydrochloric acid or a sodium bicarbonate solution may also be used. Uranyl carbonates will be recovered in the eluate solutions. The vanadium in the elution system will be stripped from the resin in a similar fashion after the uranium is recovered.

1.4.4 Precipitation System

The precipitation process will be designed to break the uranyl carbonate complexes, precipitate the uranium as uranium peroxide, and settle the precipitated solids from the eluant solution. The precipitation process will include a series of chemical addition steps, each causing a specific change in the rich eluate solution. Prior to beginning the precipitation process, the rich eluate transfer pump will be used to transfer the rich eluate from the rich eluate tank to the precipitation tank. The precipitation tank contents will be mixed via an agitator. The first stage of chemical addition will be to add sulfuric or hydrochloric acid to bring the pH down to a range of approximately 2-3 standard units. This change in pH will cause the uranyl carbonate

complexes to break down, liberating carbon dioxide, which will be vented from the tank as illustrated in the following chemical reaction.

$$Na_4[UO_2 (CO_3)_3] + 3H_2SO_4 \rightarrow UO_2SO_4 + 2 Na_2SO_4 + 3CO_2\uparrow + 3H_2O$$

Following completion of CO_2 evolution, sodium hydroxide (caustic soda) will be added to raise the pH of the solution to between 4 and 5 standard units. When the pH has stabilized, hydrogen peroxide (H_2O_2) will be added to the solution to form insoluble uranium peroxide (UO_4). Following addition of H_2O_2, the agitator speed will be slowed down to promote crystal growth.

$$UO_2SO_4 + H_2O_2 + 2H_2O \rightarrow UO_4 \cdot 2H_2O \text{ (precipitates)} + H_2SO_4$$

After a precipitation period of up to 8 hours, sodium hydroxide will be added to raise the pH to approximately 7, and the contents of the precipitation tank will be pumped into the thickener using the precipitation transfer pumps. The vanadium in the eluate will remain in solution form throughout the uranium precipitation process due to the use of hydrogen peroxide, which, as described in TR Section 3.2.3, selectively complexes uranium in the presence of vanadium. The vanadium-rich solution will be separated from the uranium precipitate as the overflow in the thickeners and pumped to the vanadium recovery circuit. Section 3.2.3 of the TR describes how a second stage of precipitation will be used to remove impurities entrained in the first precipitate.

1.4.5 Yellowcake De-Watering/Drying/Packaging System

The gravity-thickened yellowcake solids will be pumped into a plate and frame filter press for dewatering. Dewatered yellowcake is transferred to an indirect fired (hot oil heated) vacuum paddle dryer. The yellowcake will be dried in a low temperature vacuum dryer at less than 300°F. Paddles attached to a central shaft in the dryer will agitate the filter cake to promote even drying. The dryer will be heated with a thermal fluid (e.g., MultiTherm IG-4) that will be circulated through the dryer shell and the rotating central shaft. The thermal fluid (TF) will be heated by an electric heater with a pump for circulating the TF through the shell and central shaft of the dryer.

The vapor pulled from the dryer by the vacuum pump will be filtered through a baghouse filter located on the top of the dryer to remove particulates. The vapor exiting the baghouse will be cooled using a condenser to remove water vapor and remaining small particles. Liquid ring vacuum pumps will provide the vacuum source. The water that will be collected from the condenser

will be pumped to the solids removal tank in the wastewater system. One or more rotary vacuum dryers, baghouses, and packaging equipment will be housed in a separate room in the CPP. The vacuum pump and condenser system for each dryer, and the TF heaters and pumps will be located in the main CPP area to provide access for operation and maintenance. The vacuum pumps will discharge to the dryer room. Air in the dryer and packaging room will be monitored routinely for airborne dust.

Strata proposes to utilize vacuum dryers at its proposed CPP as part of its overall yellowcake drying circuit. As a matter of process, the use of vacuum dryers has proven to reduce potential yellowcake particulate emissions to virtually zero, which provides for significant, additional reductions in potential for occupational exposure from airborne yellowcake particulates, as well as potential exposure to members of the public outside the fence-line or to members of the public who are permitted to be inside the license boundary but who are not part of the Strata operation such as oil workers or ranchers. As stated on pg. 4.2-53 of the ISR GEIS, "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." Further discussion is provided in Section 4.12 of this ER and Sections 5.7.1 and 7.3.1 of the TR.

<u>Packaging:</u> The packaging system will be operated on a batch basis and will include conveyors, scales, and a spray booth. When the yellowcake is dried sufficiently, it will be discharged from the drying chamber through a rotary air lock valve on the bottom port of the dryer into steel drums. The rotary air lock valve will create a sealed and pressurized system to guard against particulate contamination to the surrounding area. Steel drums will be sealed only after the yellowcake has cooled sufficiently to avoid the potential for pressure build-up in sealed containers. Strata will develop a standard operating procedure (SOP) for yellowcake packaging to address appropriate temperature levels. A weigh scale will be used to determine when a drum is full. A conveyor system will allow drums from the dryer(s) to be moved from beneath the dryer to an enclosed spray booth where each drum will be rinsed with a spray of water. The conveyor system will then move the drum to a scanning station where the drum will be hand scanned for radioactivity and then placed in the storage area or rinsed further.

Effluent Monitoring: The drying process produces virtually no gaseous discharge since it operates as a batch process, and the water that evaporates from the wet yellowcake is collected in the condenser. Water collected from the condenser will be recycled to the precipitation circuit, eluant makeup, or disposed with other process water. Air in the CPP will be monitored routinely for airborne particulate as discussed in Section 5.7.3 of the TR.

Controls: The system will be instrumented and controlled sufficiently to operate automatically and to shut itself down for malfunctions such as heating or vacuum system failures, including the unlikely but credible possibility of a seal rupture in the dryer of the gas treatment system, which is addressed in TR Section 7.5.2. A seal rupture would be immediately identified through changes in monitored process parameters, and employee safety would be protected through continuously monitoring process parameters and use of personal respiratory protection and breathing zone monitors when the dryer is in operation.

1.4.6 Yellowcake Storage/Shipment Approach

The dried yellowcake product in the U.S. Department of Transportation (DOT)-approved steel drums will be stored for shipment within a restricted storage area and shipped by an appropriately permitted exclusive use transporter to Metropolis, Illinois for further processing. A dedicated enclosed room, adjacent to the yellowcake drying area, will be provided for the storage of yellowcake. On-site inventory of drummed yellowcake typically will be less than 200,000 pounds; however, during periods of inclement weather or in the event of other interruptions in product shipments, all production will be stored on-site in the dedicated restricted storage area. As noted above, particulates from the yellowcake dryer process are contained to minimize or eliminate potential occupational exposure. The drummed yellowcake will be shipped by exclusive use transport to another licensed facility for further processing. All yellowcake shipments will be made in compliance with applicable DOT and NRC regulations.

1.4.7 Vanadium Precipitation, Drying and Packaging Circuit

The vanadium-bearing solution removed from the yellowcake thickeners will be pumped to the vanadium precipitation circuit. The circuit will include a feed surge tank, precipitation conversion tank and four precipitation tanks. In

the conversion tank steam, plant air and ammonia will be added in vigorous agitation to convert the vanadium to the pentavalent (+5) state. The solution will then be pumped to the precipitation tanks where ammonium sulfate will be added to precipitate ammonium metavanadate or AMV (NH_4VO_3). The precipitation slurry will be pumped to a horizontal vacuum belt filter to separate the solution from the solid AMV. The filtrate from the belt filter will be transferred to the disposal surge tank, while the AMV filter cake will be dried in a batch vacuum paddle dryer prior to packaging. The vanadium precipitation tanks and vacuum dryer vacuum pump will be vented to a wet off-gas scrubber to recover the ammonia and ammonium sulfate that will be pumped back to the vanadium precipitation system as make-up.

1.4.8 Aquifer Restoration and Bleed Treatment Circuits

The aquifer restoration circuit will be used to treat groundwater from wellfield modules during aquifer restoration. The aquifer restoration circuit will comprise IX column(s) and reverse osmosis (RO) units for a maximum capacity of 1,100 gpm. The IX column will remove uranium, while the RO system will be operated in series to remove dissolved solids prior to reinjection into the wellfield. Two-stage RO will be used, such that the permeate recovery rate will be approximately 80% to 85%. Almost all of the permeate will be recycled to wellfield modules undergoing aquifer restoration or uranium recovery operations.

A bleed treatment circuit consisting of a two-stage RO system will be used to treat a portion of the barren recovery solution in order to control the build up of salts and other dissolved constituents in the ore zone. The production bleed may or may not be routed through the bleed treatment circuit depending on the recovery solution water quality and the liquid disposal capacity.

1.4.9 Chemical Storage Facilities

The ISR process requires chemical storage and feeding systems to store and use chemicals at various stages in the extraction, processing, and waste treatment processes. Chemical storage and feeding systems will include some or all of the following: sulfuric and/or hydrochloric acid, sodium hydroxide, hydrogen peroxide, carbon dioxide, oxygen, sodium chloride, sodium carbonate, barium chloride, anhydrous ammonia, and non-process related

chemicals such as gasoline, diesel and propane. Each chemical storage and feeding 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 feeding 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). Designing, constructing, and maintaining chemical storage facilities in accordance with applicable regulations will help ensure the safety of Strata employees and members of the public, both in regard to the specific chemicals and in regard to the potential release of radioactive materials if the chemicals were not stored properly.

Process chemicals will be located either in the CPP or in the chemical storage area. The chemical storage area will be located adjacent to the CPP as shown on Figure 1.2-5. The chemical storage area will be constructed with secondary containment for all storage vessels. The area will be divided into two areas, one of which will be enclosed in a building and one outside. Chemicals stored outside within the chemical storage area will include oxygen (if stored at the CPP), ammonia, and carbon dioxide. A figure showing the layout of the proposed chemical storage area is included as Figure 3.2-8 in the TR.

1.4.9.1 Sodium Chloride Storage

Sodium chloride will be used to make up fresh elution brine and will be stored in tanks as a saturated solution (approximately 26% by weight) in equilibrium with a bed of crystals in each storage tank. Dry sodium chloride will be delivered by truck and will be blown into the storage tanks using air pressure. A storage area for dry sodium chloride will likely be provided within or adjacent to the CPP.

1.4.9.2 Sodium Carbonate Storage

Sodium carbonate (soda ash) will be used to make up fresh elution brine and will be stored in tanks as a saturated solution in equilibrium with a bed of crystals in the storage tank. Sodium carbonate solution must be kept above 100°F (38°C) to prevent precipitation in the tank and piping. This will be accomplished by heating the water added to the tank, and continuously

circulating liquid from the tank through a heat exchanger. An electric heater will be used to heat a thermal fluid to heat the exchanger. Dry sodium carbonate will be delivered by truck and will be blown into the storage tanks using air pressure.

1.4.9.3 Acid Storage and Feeding System

The acid storage and feeding system will include one or more storage tanks and delivery pumps. The storage tank will be located adjacent to the CPP building in the chemical storage area. The chemical storage area will include a lined concrete secondary containment basin designed to contain at least 110% of the largest tank volume. This secondary containment basin for acid storage will be separate from the containment basins for other chemical systems. The acid feed pump(s) will be located inside the building, near the storage tank(s).

1.4.9.4 Sodium Hydroxide Storage and Feeding System

The sodium hydroxide system will include a storage tank and delivery pump. The storage tank will be located adjacent to the CPP building in the chemical storage area in a concrete secondary containment basin designed to contain at least 110% 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. Sodium hydroxide will be purchased as aqueous caustic soda, and will be pumped directly into the storage tank from the supplier's tanker trucks.

1.4.9.5 Hydrogen Peroxide Storage and Feeding System

The hydrogen peroxide system will include a storage tank and delivery pump. Hydrogen peroxide will be stored as a 50% solution. The hydrogen peroxide storage tank will be located adjacent to the CPP building in the chemical storage area in a concrete secondary containment basin designed to contain at least 110% of the tank volume. This secondary containment basin will be separate from the containment basins for other chemical systems. Specifically, the hydrogen peroxide storage tank will be isolated from the storage areas for acids and reducing agents. The hydrogen peroxide feed pump will be located inside the building, near the storage tank.

1.4.9.6 Oxygen Storage and Feeding System

Oxygen will be added to the injection stream either upstream of the injection manifolds within the module buildings or at each well head. Oxygen will be stored as a cryogenic liquid either near the wellfield module buildings or in the chemical storage area adjacent to the CPP. Oxygen will be stored in storage vessels designed, fabricated, tested, and inspected in accordance with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. Oxygen storage vessels 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. Oxygen will be delivered and stored as a cryogenic liquid and then conveyed to the injection point (either upstream of the injection manifold within the module building or at each well head) as a gas through stainless steel piping. Oxygen storage and delivery systems will be designed and fabricated in accordance with NFPA 55 and OSHA standards for the installation of bulk oxygen systems on industrial premises (29 CFR 1910.104).

1.4.9.7 Carbon Dioxide Storage and Feeding System

The carbon dioxide storage and feeding system will be used to dissolve carbon dioxide into the pregnant lixiviant to improve recovery of uranium in the IX vessels and to add complexing agent to the barren lixiviant prior to injection. This system will be a vendor-supplied packaged system including cryogenic tank, vaporizer, pressure gauges, and pressure relief devices. Carbon dioxide will be stored adjacent to the CPP in the chemical storage area. Floor-level ventilation and carbon dioxide monitoring at low point(s) within the CPP will be provided to protect workers from accidental leaks of carbon dioxide.

1.4.9.8 Barium Chloride Storage and Feeding System

A barium chloride storage and feeding system will be designed to dissolve solid barium chloride in water to make up the solution for feeding into permeate if needed for radium precipitation. If needed, the barium chloride storage and feeding system will include a storage tank, agitator, and chemical metering pump. This system will be located in a metal building located adjacent to the lined retention ponds. If the feed solution is added to the ponds, the discharge pipe will release the solution along with permeate below the pond surface to minimize radon release.

1.4.9.9 Anhydrous Ammonia Storage and Feeding System

Anhydrous ammonia will be used at the CPP as part of the vanadium recovery circuit and, potentially, to adjust the pH of the eluate solution in the precipitation tanks. The anhydrous ammonia system will include a storage tank, piping, instrumentation, and safety control devices. Detailed information about the anhydrous ammonia system is found in Section 4.12.1.2.2.1 of this ER and TR Section 3.2.8.1.3. All components of the anhydrous ammonia system will be designed in accordance with the American National Standards Institute (ANSI) K61.1 (ANSI 1999) and 29 CFR 1910.111, "Storage and Handling of Anhydrous Ammonia." Ammonia will be stored as a cryogenic liquid outside of the CPP in the chemical storage area. The storage tank will be designed, fabricated, tested, and inspected in accordance with the ASME Boiler and Pressure Vessel Code. The storage tank will include a safety relief valve, a liquid level gaging device, and a clear label identifying the contents as anhydrous ammonia. All piping and fittings will be made of materials suitable for anhydrous ammonia service and complying with the applicable ANSI/ASME or ASTM standards. An excess flow valve will automatically close if the flow in the supply piping exceeds a specified value.

1.4.9.10 Non-Process Related Chemicals

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

1.4.10 Waste Management

Section 4.13 of this ER describes the proposed waste management system. Liquid and solid wastes are divided into two general categories: AEA-regulated waste and non-AEA-regulated waste. The proposed waste management system is summarized below for each category of waste.

AEA-Regulated Liquid Waste

AEA-regulated liquid waste includes brine generated from RO treatment of the production bleed and from RO treatment of the aquifer restoration water and excess permeate that is not recycled to the wellfield. It also includes other process waste water (e.g., spent eluate), wellfield waste water (e.g., fluids generated from work over operations on injection and recovery wells), and decontamination water (e.g., employee showers).

There are several disposal options for AEA-regulated liquid waste. Most permeate generated during RO treatment of the production bleed and restoration flows will be recycled back to wellfield modules undergoing operation or aquifer restoration and will not be considered waste. The balance of permeate will be discharged into lined retention ponds, after which it will be recycled back to the wellfield or disposed by one of four alternate methods, including: surface discharge, recycling for use as plant make-up water, Class I deep disposal wells, or land application. Sections 4.2.3.1 in the TR and 4.13 in the ER describe the permeate disposal options in detail.

Brine and other AEA-regulated liquid waste will primarily be disposed in deep disposal wells. Strata proposes to utilize up to five Class I deep disposal wells within the proposed project area. A Class I UIC permit application for the injection wells was submitted to WDEQ/Water Quality Division (WQD) on June 15, 2010 with a round of responses completed in October/December 2010 (refer to Addenda 4.2-A and 4.2-B in the TR). The wells will target the Cambrian-age Deadwood and Flathead Formations. These zones were selected based on their position in the stratigraphic column, permeability and porosity thickness, confinement and estimated water quality. Estimated depths to the top of the Deadwood Formation at the Ross ISR Project are 8,160 feet below ground surface and 8,560 feet below ground surface for the Flathead Formation. These proposed injection depths are below the lowermost potential Underground Source of Drinking Water (USDW) (Madison Formation), with at least 500 feet of separation between the intervals. Confinement above the Deadwood/Flathead zone is provided by approximately 400 feet of shale and other low-permeability stratigraphic horizons, and confinement below the target injection zone is provided by the Precambrian basement rocks.

Deep disposal wells will be constructed according to WDEQ/WQD Class I and EPA SDWA disposal well construction standards, which are protective of USDWs and include casing and cementing programs designed to isolate, both

mechanically and geologically, the wellbore of the injection well from both shallow (e.g., Fox Hills Formation) and deep (e.g., Madison Formation) aquifers. The location, depth, and construction methods for deep disposal wells will be designed to geologically isolate liquid waste from any USDWs. In order to permit the wells, Strata will demonstrate that there will be no migration of injected fluids into nearby wells or USDWs. Strata will also perform routine monitoring consisting of quantity and pressure recordation and perform internal and external MIT in accordance with the Class I UIC permit requirements.

The secondary method of AEA-regulated liquid waste disposal for the Proposed Action is evaporation in lined retention ponds. The ponds will be designed and constructed in accordance with the requirements of NRC Regulatory Guide 3.11 (NRC 2008), and Wyoming Water Quality Rules and Regulations, Chapter 11. Lined pond design, construction, and inspection criteria are provided in Sections 4.2.2 and 5.3.2 of the TR. Two lined retention ponds are planned, each including three cells. Figure 1.2-5 depicts the proposed lined retention ponds. Interconnected piping will allow the transfer of liquids between cells. Ponds will include double liners and leak detection systems. The water levels in the ponds cells will be maintained such that the total volume of liquid in any one cell can be transferred to the other two cells during maintenance or response to a leaking pond liner. In addition, 3 feet of freeboard will be maintained to contain the 100-year, 24-hour precipitation event and wave runup. Routine inspection of the leak detection systems and embankments will guard against release of brine or permeate from the lined retention ponds.

Reliance solely upon evaporation ponds has been rejected because of the large surface impoundment areas that would be required, the increased environmental risk associated with storing large quantities of brine in surface impoundments and the lack of evaporation during winter (refer to Section 2.1.3.5). The use of the evaporation process in conjunction with liquid waste disposal in on-site deep disposal wells is considered to be the best alternative to dispose of these types of liquid waste.

AEA-Regulated Solid Waste

AEA-regulated solid waste will include filtrate and spent filter media, scale and sludge from equipment maintenance, contaminated soil, damaged IX resin, contaminated solids from ISR wells, contaminated PPE, and

contaminated materials and equipment from decommissioning that cannot be decontaminated to approved levels. These materials will be disposed at a licensed 11e.(2) disposal facility. Prior to beginning active ISR operations, Strata will provide NRC Staff with an executed 11e.(2) byproduct material disposal agreement with an appropriately AEA-licensed disposal facility in compliance with NRC Staff's interpretation of 10 CFR Part 40, Appendix A, Criterion 2. The transportation and waste management potential impact analyses in Chapter 4 of this ER evaluate four alternatives for 11e.(2) byproduct material disposal, including one disposal facility in Wyoming, two in Utah, and one in Texas.

Non-AEA-Regulated Liquid Waste

Non-AEA-regulated liquid waste will include drilling fluids from monitor wells and fluids from the construction and development of recovery and injection wells prior to using the wells for ISR uranium recovery. These fluids will be regulated as Technologically Enhanced Naturally Occurring Radioactive Material (TENORM) and disposed in temporary mud pits adjacent to the wells in accordance with WDEQ/LQD and EPA requirements.

Non-AEA-regulated liquid waste will also include domestic sewage. Domestic sewage will be disposed using one of several methods. During construction and decommissioning, domestic sewage may be captured in holding tanks permitted through WDEQ/WQD and transported by a licensed contractor to a municipal wastewater treatment system. During operation and aquifer restoration, domestic sewage will be disposed in an onsite wastewater disposal or treatment system permitted through WDEQ/WQD. This may include septic tanks and a gravity fed or pressure-dosed drainfield. Alternately, Strata may design and permit an onsite wastewater treatment system with advanced treatment and disinfection that would include surface discharge of high quality effluent under a Wyoming Pollutant Discharge Elimination System (WYPDES) permit.

Non-AEA-regulated liquid waste will also include liquid hazardous waste such as used oil, expired laboratory reagents, solvents, cleaners, and degreasers. Hazardous waste will be stored in secure containers in a designated hazardous waste storage area. The containers will be compatible with the materials stored and labeled with contents. The hazardous waste storage area will include secondary containment designed to contain 110% of the largest tank volume plus a 25-year, 24-hour storm event. Hazardous waste

will be transported by an appropriately licensed transport company to an off-site treatment, storage and disposal facility that is licensed by WDEQ/Solid and Hazardous Waste Division (SHWD) or a nearby state for recycling or disposal.

Non-AEA-Regulated Solid Waste

Non-AEA-regulated solid waste will include construction debris, decontaminated materials and equipment, general office trash, and solid hazardous waste. All non-AEA-regulated solid waste will be managed in accordance with existing regulations and disposed of in a landfill that has been permitted under subtitle D of RCRA or a hazardous waste recycling or disposal facility permitted through WDEQ/SHWD or a nearby state.

1.5 Instrumentation and Control

Sections 3.1 and 3.3 of the TR provide 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. In the wellfield, the pressure and flow rate for each injection and recovery well flow line and for injection and recovery feeder lines will be measured in the module buildings. Pressure measurement will include digital or analog pressure gauges as well as pressure transmitters that will be remotely monitored at the CPP. Flow meters will measure instantaneous and cumulative flow rate and will also be monitored locally and at the CPP.

Instrumentation will provide early warning of potential leaks or excursions. State-of-the-art water sensors and alarms will be provided to detect the presence of liquid in well head covers, module buildings, and valve manholes. Pressure transducers will also be provided in monitor wells to provide early detection of potential excursions of recovery solutions.

In the process areas within the CPP, storage and process tanks will be equipped with automated level measuring instruments. Flow rates and line pressures will be monitored throughout the CPP to manage and guide operations. Pressure transmitters also will be included on all pressurized vessels such as IX columns. Additional instrumentation will be provided within specific systems in the CPP to monitor pH, temperature, and other process variables. Alarms will activate whenever these parameters are out of normal operating ranges. Hourly records of key process parameters will be collected

and stored for a minimum of three years in accordance with 10 CFR Part 40, Appendix A, Criterion 8.

Process control at the CPP will be conducted from a Master Control System within the central control room. The Master Control System will include programmable logic controllers (PLCs), which will communicate with PLCs in the module buildings. Process control in the wellfield will include automatic and manual control operations. Individual well flow lines will be adjustable by manual control valves, although Strata may also provide electrically actuated valves to remotely control the valves. The individual well flow targets will be determined on a per pattern basis to assure that local wellfield areas are balanced on at least a weekly basis. The injection manifolds within the module buildings will include pressure control valves and pressure transmitters. Injection and recovery feeder lines will also include flow meters and pressure transmitters. Changes in flow or pressure that are outside of normal operating parameters will result in the activation of visual and audible alarms and the eventual automatic shutdown of the affected pumps if the condition is not corrected promptly. All pumps and motors will have individual Hand-Off-Auto switches and will be monitored and controllable through the Master Control System. The wellfield control philosophy at the Ross ISR Project will be based on a fault hierarchy that allows adjustment through the PLCs for fault settings and allowable time intervals for fault values. This will allow parameters to stabilize, such as during startup or in the event of a brief anomalous condition, before triggering a fault. This will allow Strata to reduce the number of automatic faults and subsequent shutdowns that are not related to potential equipment failure.

Handheld radiation detection instruments and portable samplers will be used to monitor radiological conditions at the proposed CPP.

1.6 Applicable Regulatory Requirements, Licenses, Permits, and Required Consultations

In order for Strata to construct, operate, and decommission the proposed Ross ISR Project, several licenses and permits from multiple federal and State agencies will be required under several statutory and regulatory regimes. This section provides information to NRC Staff regarding the relevant agencies, the types of licenses/permits, and the current status of applications for such license/permits associated with the Proposed Action. Table 1.6-1 provides this

information. It is well understood by Strata that no licensed ISR operations may take place until all required licenses/permits are secured.

Strata has consulted with a number of federal, State, and local agencies and/or organizations and nearby resident(s) in the preparation of the license application for the Proposed Action. Table 1 in Addendum 1.6-A provides a list of agencies, organizations and individuals consulted, their location, the aspects of the Proposed Action for which consultation was conducted and the number of times consultation was conducted. A detailed summary of public involvement during the pre-application process is provided in Addendum 1.6-A and is summarized below.

In January 2010, Strata established a Public Involvement Plan to set forth specific strategies and methods for the engagement of private citizens, businesses, government entities, and other organizations potentially affected by the Ross ISR Project. As part of its public involvement methodology, Strata maintains an open-door policy to the public at its corporate office in Gillette and its field office in Oshoto adjacent to the proposed project area. Local landowners are encouraged to visit either office as needed to discuss matters of concern. The Strata field office staff also makes regular contact with landowners in and around the proposed project area. Strata also has prepared a media release to introduce the Ross ISR Project to the public and hosted and/or participated in a number of public forums and stakeholder meetings. Public involvement is an ongoing process, and it will continue throughout the licensing process and throughout the life of the project. Thus far, Strata has consulted with dozens of stakeholders, including more than 30 landowners in and near the proposed project area, 5 members of non-governmental organizations, 8 members of local government and conservation districts, both U.S. Senators and the U.S. Representative from Wyoming and their staffs, and numerous state and federal organizations, including WDEQ, BLM, and NRC.

Strata is not only seeking an NRC combined source and byproduct material license and a WDEQ/LQD Permit to Mine. Strata is also seeking a *social license to mine*. By engaging the people who live near and are potentially affected by the proposed Ross ISR Project in public meetings, interviews, landowner handouts, and informal conversations, Strata's goal has been to identify concerns and address those concerns in the design of the Proposed Action. As part of Strata's Public Involvement Plan, Strata maintains a matrix of the concerns that have been expressed by stakeholders. Following submittal

of the license applications to NRC and WDEQ/LQD, Strata will follow up with stakeholders and indicate how their concerns will be addressed during construction, operation, aquifer restoration, and decommissioning of the proposed ISR facility.

1.7 Financial Assurance

Pursuant to 10 CFR Part 40, Appendix A, Criterion 9, Strata will provide adequate financial assurance for the Proposed Action. The Commission currently requires that ISR license applicants provide an RAP or the equivalent in a license application to provide NRC Staff with preliminary financial assurance cost estimates for all aspects of the Proposed Action, including groundwater restoration, surface reclamation, and D&D of Proposed Action facilities. In the past, NRC Staff has reviewed and approved the format associated with a RAP from Hydro Resources, Inc. (HRI) for its Crownpoint Uranium Project in the State of New Mexico. Addendum 6.1-A in the TR contains a RAP in accord with the RAP format used by HRI while taking into account current, relevant NRC Staff requirements.

Pursuant to Criterion 9, licensees are required to submit *annual* financial assurance updates to reflect potential changes (upwards or downwards) in costs for specific licensed activities resulting from inflation, changes in equipment or personnel costs or new activities proposed to be started or completed prior to the proceeding annual update. In order to be granted a license, an applicant must propose and receive NRC approval of financial assurance cost estimate calculation methodologies and initial cost estimates for whatever phase of the project that will exist prior to the next annual update; but the applicant is not required to provide a financial assurance mechanism supporting that NRC-approved cost estimate until licensed operations commence. Pursuant to these requirements, Strata 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 1.1-1. Applicable Regulations and Guidance Documents

Federal Regulations	
AEA	U.S. Atomic Energy Act of 1954, as amended
CAA	Clean Air Act of 1970, as amended
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CWA	Clean Water Act, Federal Water Pollution Control Amendments of 1972, as amended
ESA	Endangered Species Act
NEPA	National Environmental Policy Act of 1970, as amended
NHPA	National Historic Preservation Act
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act of 1974, as amended
UMTRCA	Uranium Mill Tailings Radiation Control Act of 1978, as amended
Code of Federal Regulations	
6 CFR 27	Chemical Facility Anti-Terrorism Standards
10 CFR 2	Rules of Practice for Domestic Licensing Proceedings and Issuance of Orders
10 CFR 20	Standards for Protection Against Radiation
10 CFR 40	Domestic Licensing of Source Material
10 CFR 51	Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions
29 CFR 1910	Occupational Safety and Health Standards
36 CFR 800	Protection of Historic Properties
40 CFR 50	National Primary and Secondary Ambient Air Quality Standards
40 CFR 52	Approval and Promulgation of Implementation Plans
40 CFR 60	Standards of Performance for New Stationary Sources
40 CFR 61	National Emission Standards for Hazardous Air Pollutants
40 CFR 68	Chemical Accident Prevention Provisions
40 CFR 122	EPA Administered Permit Programs: The National Pollutant Discharge Elimination System
40 CFR 131	Water Quality Standards
40 CFR 141	National Primary Drinking Water Regulations
40 CFR 144	Underground Injection Control Program

Table 1.1-1. Applicable Regulations and Guidance Documents (Continued)

Code of Federal Regulations (Continued)	
40 CFR 146	Underground Injection Control Program: Criteria and Standards
40 CFR 190	Environmental Radiation Protection Standards for Nuclear Power Operations
40 CFR 192	Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites
40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 355	Emergency Planning and Notification
40 CFR 440	Ore Mining and Dressing Point Source Category
49 CFR 172	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements
50 CFR 402	Interagency Cooperation--Endangered Species Act of 1973, As Amended
NRC Guidance Documents	
NUREG-0706	Generic Environmental Impact Statement on Uranium Milling
NUREG-1569	Standard Review Plan for In Situ Leach Uranium Extraction License Applications
NUREG-1748	Environmental Review Guidance for Licensing Actions associated with NMSS Programs
NUREG-1910	Generic Environmental Impact Statement for *In-Situ* Leach Uranium Milling Facilities
NUREG-5849	Manual for Conducting Radiological Surveys in Support of License Termination
NUREG/CR-6733	A Baseline Risk-Informed, Performance-Based Approach for In-Situ Leach Uranium Extraction Licenses
NUREG/CR-6870	Consideration of Geochemical Issues in Groundwater Restoration at Uranium In-Situ Leach Mining Facilities
NRC Regulatory Guides	
RG-1.86	Termination of Operating Licenses for Nuclear Reactors
RG-3.11	Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities
RG-3.46	Standard Format and Content of License Applications, Including Environmental Reports, for In Situ Uranium Solution Mining
RG-3.59	Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations

Table 1.1-1. Applicable Regulations and Guidance Documents (Continued)

NRC Regulatory Guides (Continued)	
RG-3.63	Onsite Meteorological Measurements Program for Uranium Recovery Facilities--Data Acquisition and Reporting
RG-4.14	Radiological Effluent and Environmental Monitoring at Uranium Mills
RG-4.15	Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) -- Effluent Streams and the Environment
RG-8.22	Bioassay at Uranium Mills
RG-8.25	Air Sampling in the Workplace
RG-8.30	Health Physics Surveys in Uranium Recovery Facilities
RG-8.31	Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as is Reasonably Achievable
RG-8.34	Monitoring Criteria and Methods to Calculate Occupational Radiation Doses
Wyoming Statutes	
Title 35, Chapter 11	Wyoming Environmental Quality Act
WDEQ/LQD Rules and Regulations	
Ch. 2	Regular Noncoal Mine Permit Applications
Ch. 3	Noncoal Environmental Protection Performance Standards
Ch. 6	Self-Bonding Program
Ch. 11	Noncoal In Situ Mining
WDEQ/LQD Guidelines	
Guideline 1	Topsoil and Overburden
Guideline 2	Vegetation
Guideline 3	Radiological Survey
Guideline 4	In-Situ Mining
Guideline 5	Wildlife
Guideline 6	Organization and Topic Guideline for an Application for a "Permit to Mine" or an "Amendment"
Guideline 8	Hydrology
WDEQ/WQD Rules and Regulations	
Ch. 1	Surface Water Quality Standards
Ch. 2	WYPDES Permitting Regulations
Ch. 8	Quality Standards for Wyoming Groundwater

Table 1.1-1. Applicable Regulations and Guidance Documents (Continued)

WDEQ/WQD Rules and Regulations (Continued)	
Ch. 11	Design and Construction Standards for Sewerage Systems, Treatment Works, Disposal Systems or other Facilities Capable of Causing or Contributing to Pollution
Ch. 16	Class V Injection Wells and Facilities, Underground Injection Control Program
WSEO Rules and Regulations	
Groundwater	
Ch. 3	Well Construction
Ch. 4	Well Completion and Maintenance
Water Well Minimum Construction Standards	
Ch. 1	Water Well Minimum Construction Standards
Surface Water	
Ch. 1	Procedure for Obtaining a Surface Water Right
Ch 5	Reservoirs

Table 1.2-1. Proposed Project Area and Disturbance Area

Surface Ownership	Total Acres within Proposed Project Area	Acres Disturbed During Year Preceding Operation	Acres Disturbed Over Life of Proposed Action
BLM	40.0	1.3	1.3
State of Wyoming	314.1	40	80
Private	1,367.2	69	199
Total	**1,721.3**	110	280

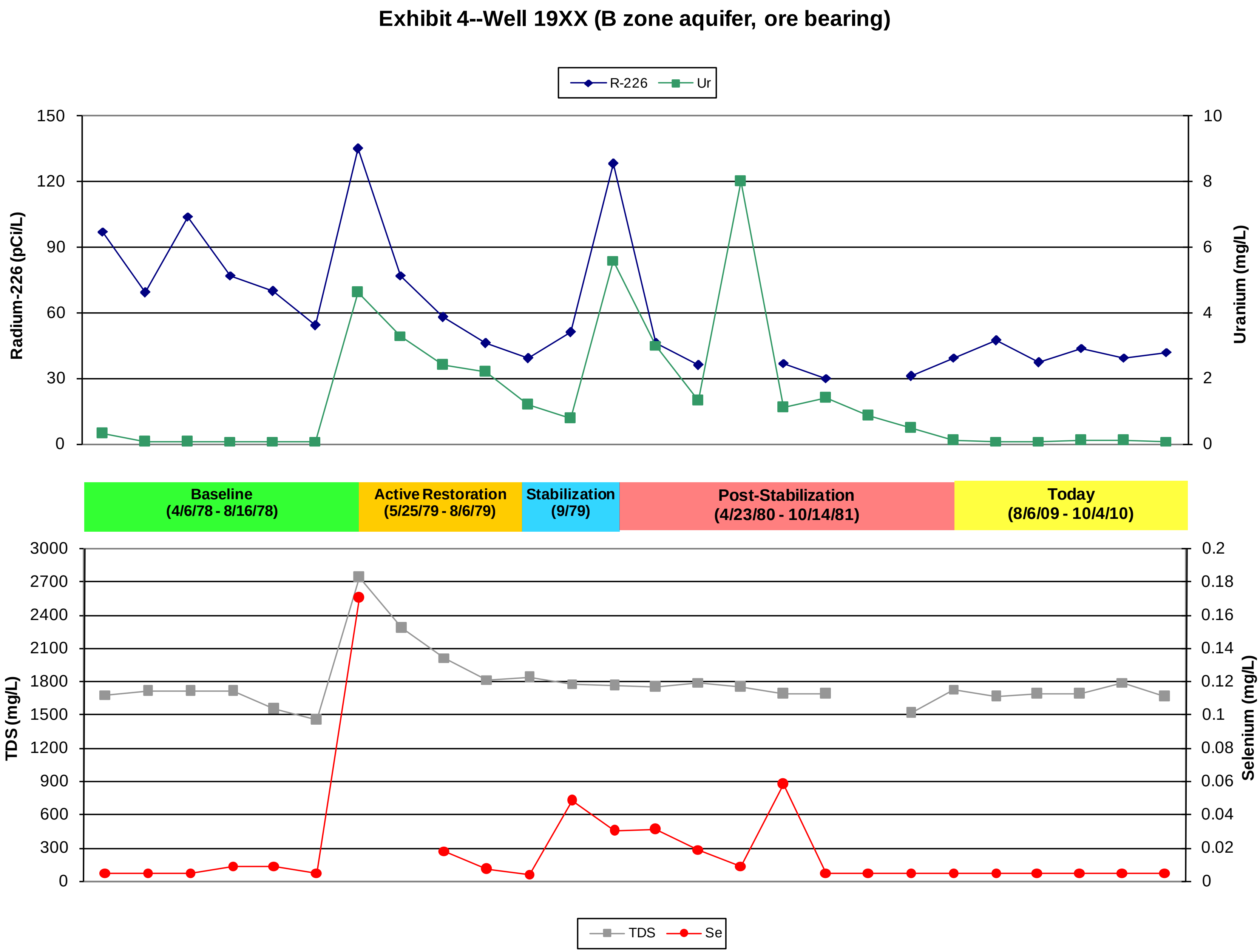
Table 1.6-1. Summary of Proposed, Pending and Approved Licenses and Permits for the Ross ISR Project

Regulatory Agency	Permit or License	Status
Federal		
NRC	11e.(2) Source and Byproduct Material License	Application submitted herein, including license application, an Environmental Report (ER), and a Technical Report (TR)
EPA	UIC Class I Permit (deep disposal wells)	See WDEQ/WQD permits; Wyoming has primacy for the UIC Program
	Aquifer Exemption (Class I wells)	
	UIC Class III Permit (injection and recovery wells)	
BLM	Plan of Operations	Being prepared
	BLM Right of Way (roads)	Being prepared
	Notice of Intent to Explore	Being prepared
USACE	Verification of Preliminary Wetlands Delineation	Application submitted September 9, 2010
	Nationwide Permit Coverage Authorization	Application to be prepared
State		
WY State Land & Farm Loan Office	Uranium Minerals Mining Lease	Approved #0-40979
WDEQ/AQD	Air Quality Permit	Being prepared
WDEQ/LQD	Permit to Mine	Application to be submitted January 2011 to WDEQ District 3, Sheridan, Wyoming; TFN #5 6/110.
	UIC Class III Permit (injection and recovery wells)	To be prepared
	Mineral Exploration Permit/Drilling Notification	Approved #384DN
WDEQ/WQD	UIC Class I Permit (deep disposal wells)	Application submitted June 23, 2010 to UIC Program in Cheyenne, Wyoming; TFN #WYS-011-00031.
	Aquifer Exemption (Class I wells)	
	Aquifer Exemption (Class III injection and recovery wells)	To be prepared
	Permit to Construct Domestic Wastewater System	To be prepared
	Stormwater WYPDES Permit (industrial/mining)	To be prepared
	Stormwater WYPDES Permit (construction)	To be prepared
	Temporary WYPDES Permit (discharge during well testing)	Approved #WYG720229

Table 1.6-1. Summary of Proposed, Pending and Approved Licenses and Permits for the Ross ISR Project (Continued)

Regulatory Agency	Permit or License	Status
WSEO	Permit to Appropriate Groundwater for ISR Wellfield	To be prepared
	Permit to Appropriate Groundwater for Monitor Wells	Approved Permit #'s: 191679-191702; 192703-192705 (regional baseline monitor wells) To be prepared for ISR monitor wells
County		
Crook County	County Development Permits (access road approach and emergency services agreement)	To be prepared

Figure 1.2-1. Well 19XX Restoration Results



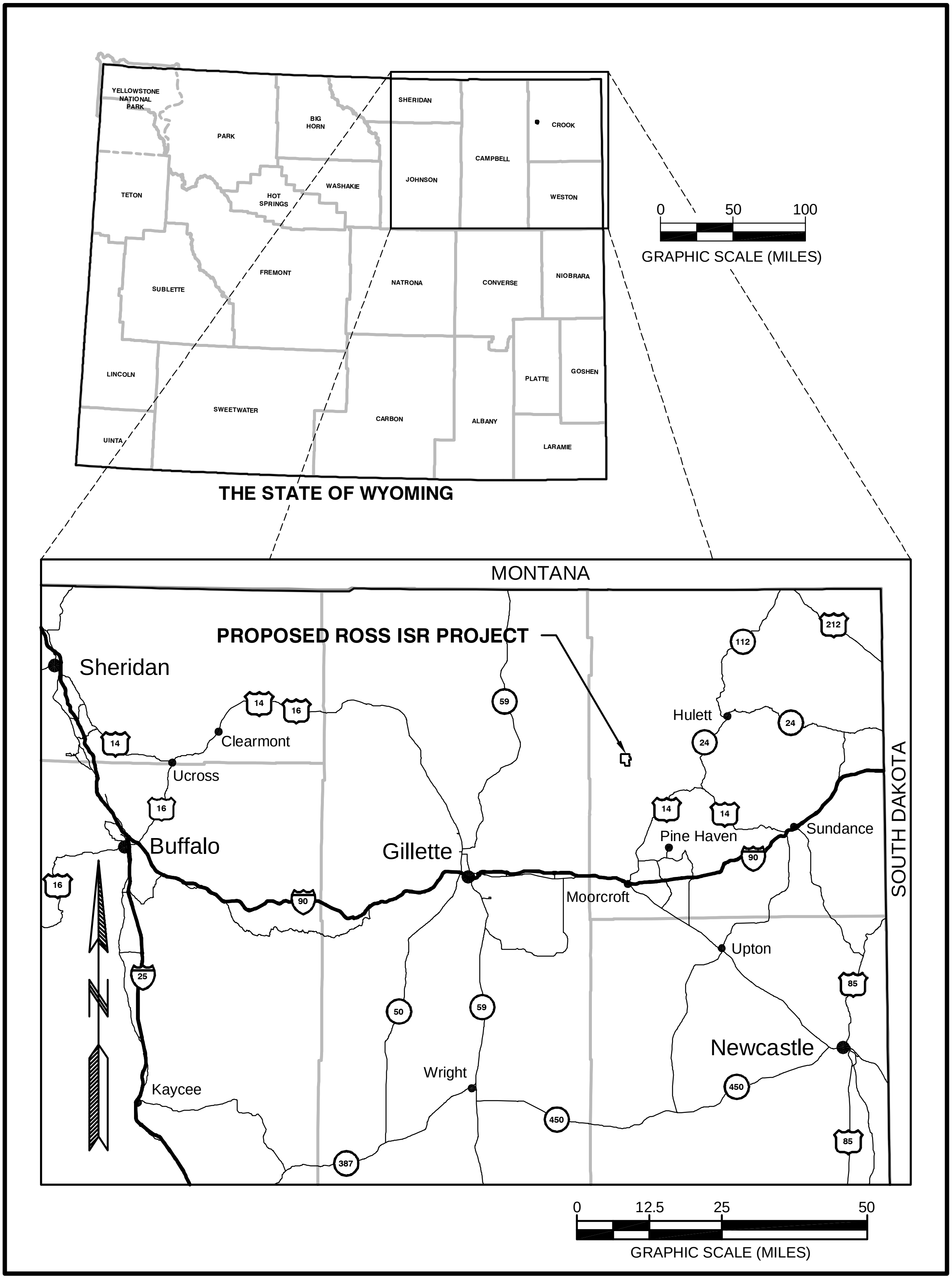


Figure 1.2-2. General Project Location

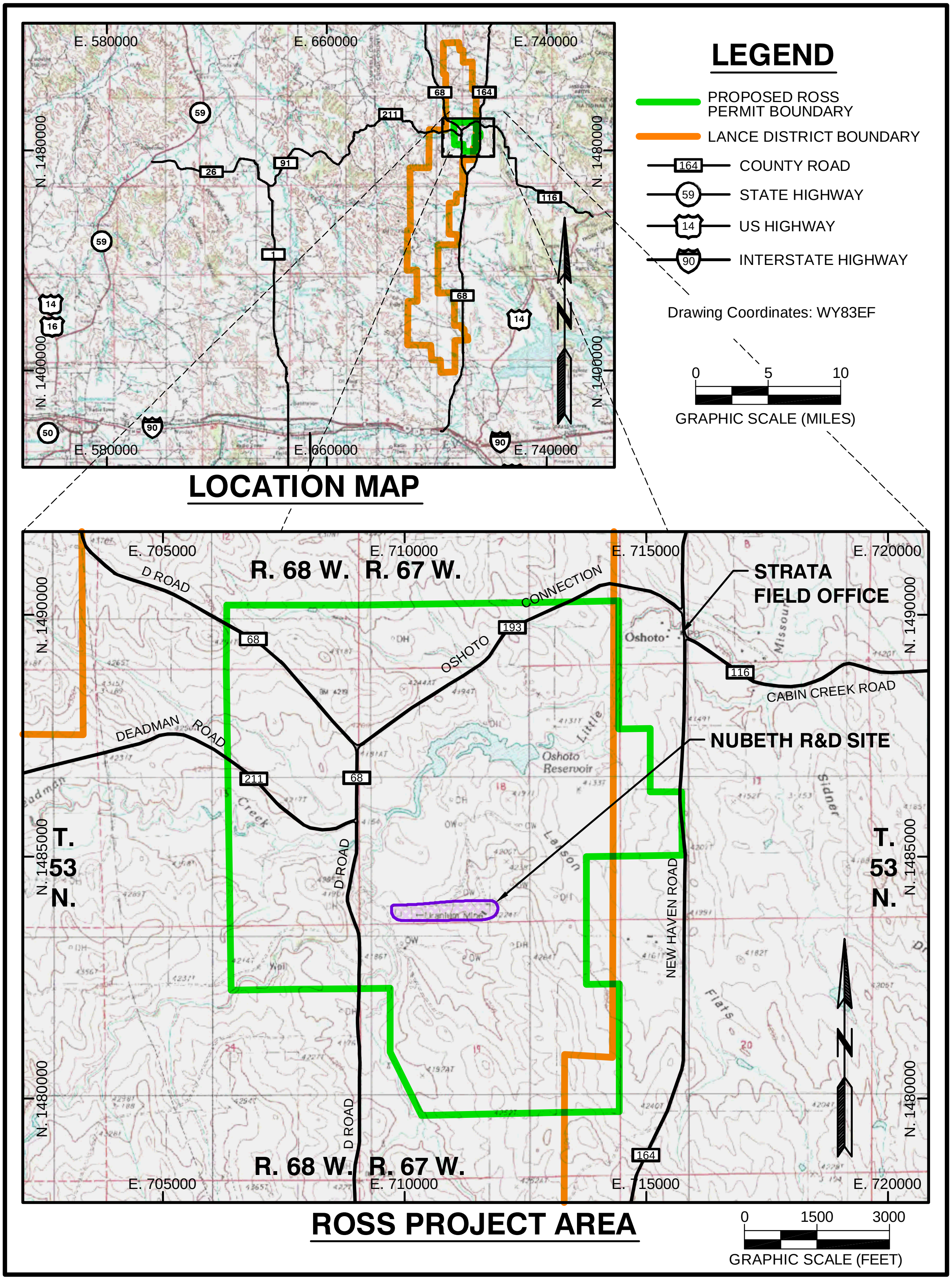


Figure 1.2-3. Proposed Project Area

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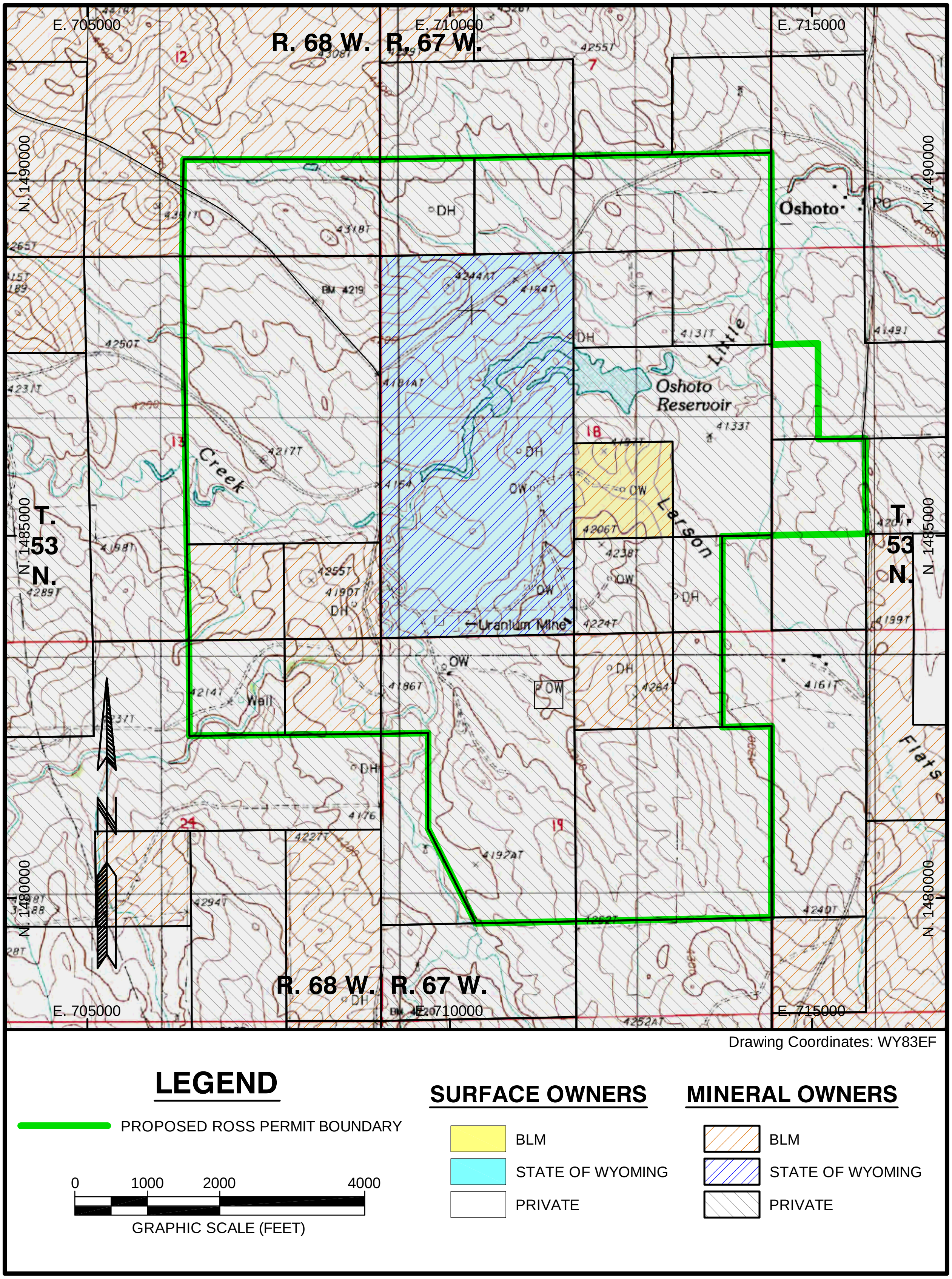
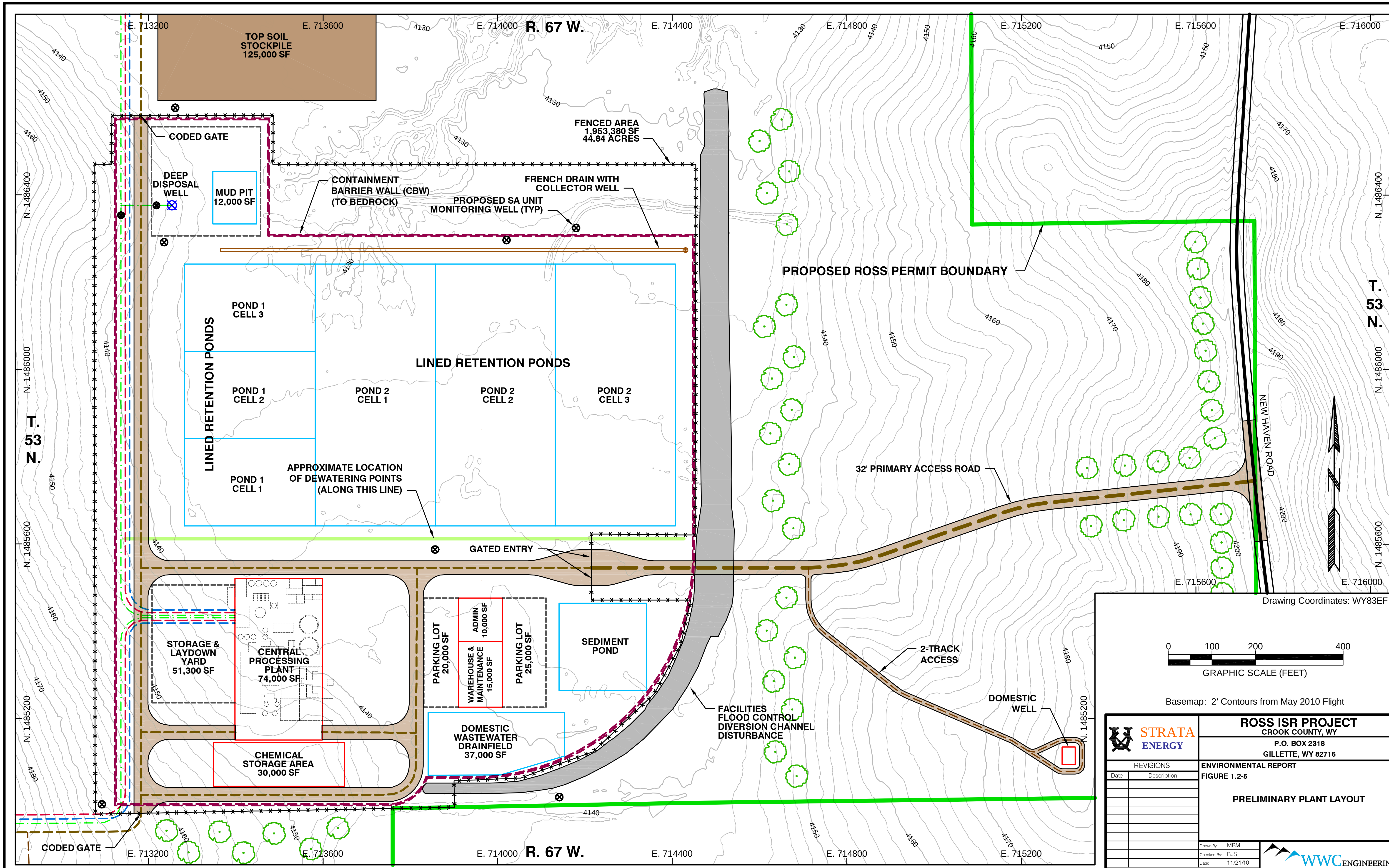
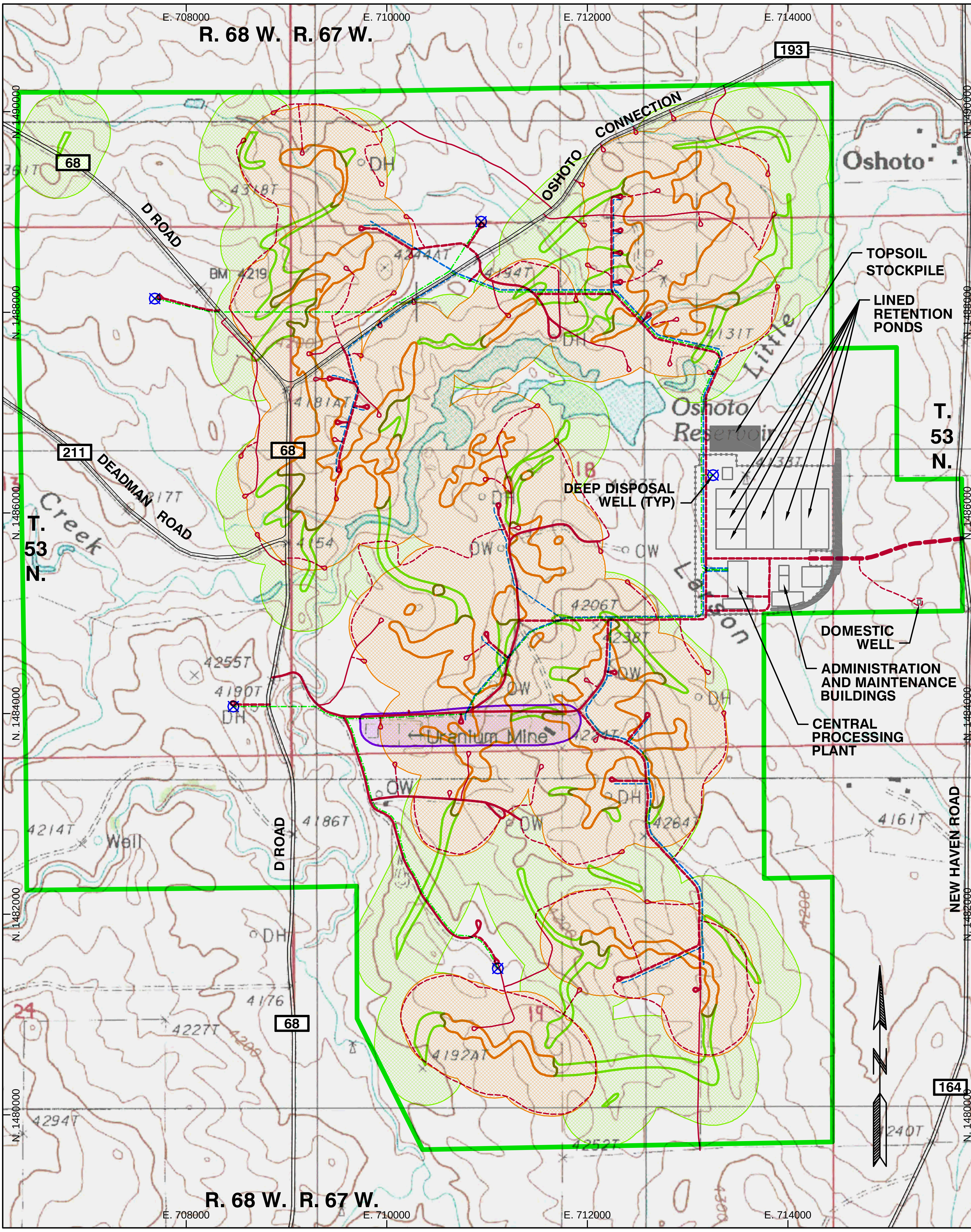


Figure 1.2-4. Surface and Mineral Ownership


R. 67 W.
T. 53 N.
E. 713200
E. 713600
E. 714000
E. 714400
E. 714800
E. 715200
E. 715600
E. 716000
N. 1486400
N. 1486000
N. 1485600
N. 1485200
TOP SOIL STOCKPILE 125,000 SF
CODED GATE
DEEP DISPOSAL WELL
MUD PIT 12,000 SF
CONTAINMENT BARRIER WALL (CBW) (TO BEDROCK)
FENCED AREA 1,953,380 SF 44.84 ACRES
FRENCH DRAIN WITH COLLECTOR WELL
PROPOSED SA UNIT MONITORING WELL (TYP)
PROPOSED ROSS PERMIT BOUNDARY
LINED RETENTION PONDS
POND 1 CELL 3
POND 1 CELL 2
POND 1 CELL 1
POND 2 CELL 1
POND 2 CELL 2
POND 2 CELL 3
APPROXIMATE LOCATION OF DEWATERING POINTS (ALONG THIS LINE)
GATED ENTRY
32' PRIMARY ACCESS ROAD
NEW HAVEN ROAD
STORAGE & LAYDOWN YARD 51,300 SF
CENTRAL PROCESSING PLANT 74,000 SF
CHEMICAL STORAGE AREA 30,000 SF
PARKING LOT 20,000 SF
ADMIN 10,000 SF
WAREHOUSE & MAINTENANCE 15,000 SF
PARKING LOT 25,000 SF
SEDIMENT POND
DOMESTIC WASTEWATER DRAINFIELD 37,000 SF
FACILITIES FLOOD CONTROL DIVERSION CHANNEL DISTURBANCE
2-TRACK ACCESS
DOMESTIC WELL
Drawing Coordinates: WY83EF
0 100 200 400
GRAPHIC SCALE (FEET)
Basemap: 2' Contours from May 2010 Flight
STRATA ENERGY
ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716
REVISIONS
Date Description
ENVIRONMENTAL REPORT
FIGURE 1.2-5
PRELIMINARY PLANT LAYOUT
Drawn By: MBM
Checked By: BJS
Date: 11/21/10
FILE: ROSS_TR_FAC_SITE_PLAN
WWC ENGINEERING



ROSS PROJECT AREA

Drawing Coordinates: WY83EF

LEGEND

- PROPOSED ROSS PERMIT BOUNDARY
- 164 COUNTY ROAD
- NUBETH R&D LOCATION
- AREAS OF KNOWN MINERALIZATION
- FUTURE DRILLING TARGET AREAS
- APPROXIMATE WELLFIELD PERIMETER
- WELLFIELD PERIMETER ACCOUNTING FOR FUTURE DRILLING

FACILITIES

- PROPOSED CONVEYANCE PIPELINE
- PROPOSED DEEP DISPOSAL WELL PIPING
- PROPOSED PRIMARY ACCESS ROAD
- EXISTING SECONDARY ACCESS ROAD
- PROPOSED SECONDARY ACCESS ROAD
- EXISTING 2-TRACK ROAD
- PROPOSED TERTIARY ROAD
- PROPOSED DEEP DISPOSAL WELL

0 500 1000 2000
GRAPHIC SCALE (FEET)

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS

Date	Description

ENVIRONMENTAL REPORT
FIGURE 1.2-6

APPROXIMATE AREAS OF MINERALIZATION AND PROPOSED FACILITIES

Drawn By: MBM
Checked By: JWF
Date: 11/16/10

WWC ENGINEERING
www.wwcengineering.com

FILE: ROSS_ER_FACILITIES

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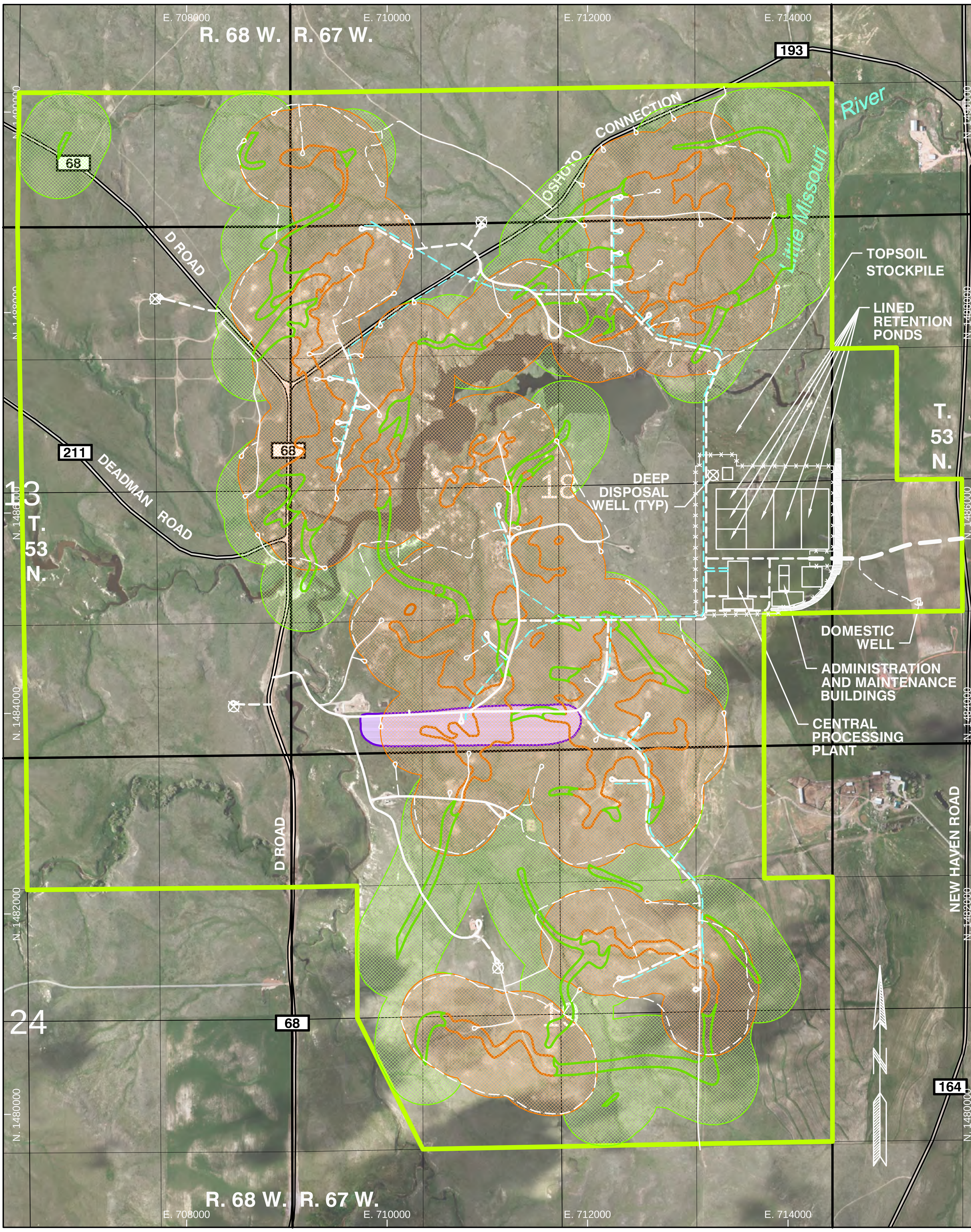

Drawing Coordinates: WY83EF

ROSS PROJECT AREA

LEGEND

- PROPOSED ROSS PERMIT BOUNDARY
- 164 COUNTY ROAD
- NUBETH R&D LOCATION
- AREAS OF KNOWN MINERALIZATION
- FUTURE DRILLING TARGET AREAS
- APPROXIMATE WELLFIELD PERIMETER
- WELLFIELD PERIMETER ACCOUNTING FOR FUTURE DRILLING

FACILITIES

- PROPOSED CONVEYANCE PIPELINE
- PROPOSED DEEP DISPOSAL WELL PIPING
- PROPOSED PRIMARY ACCESS ROAD
- EXISTING SECONDARY ACCESS ROAD
- PROPOSED SECONDARY ACCESS ROAD
- EXISTING 2-TRACK ROAD
- PROPOSED TERTIARY ROAD
- PROPOSED DEEP DISPOSAL WELL

0 500 1000 2000
GRAPHIC SCALE (FEET)

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS

Date	Description

ENVIRONMENTAL REPORT
FIGURE 1.2-7

PROPOSED FACILITIES
ON MAY 2010 AERIAL PHOTOGRAPHY

Drawn By: MBM
Checked By: JWF
Date: 11/14/10

WWC ENGINEERING
www.wwcengineering.com

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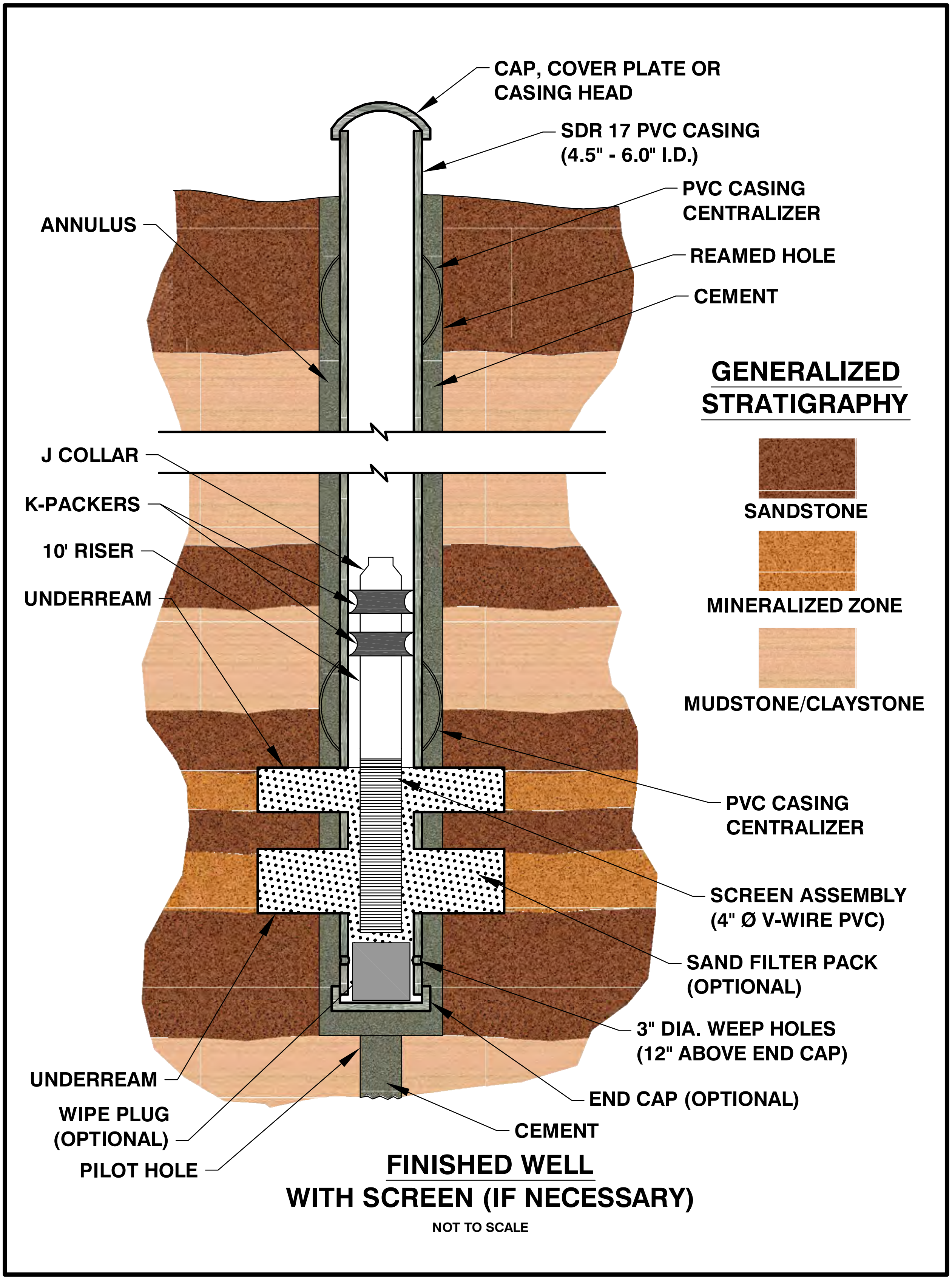


Figure 1.2-8. Proposed Well Installation - Method 1

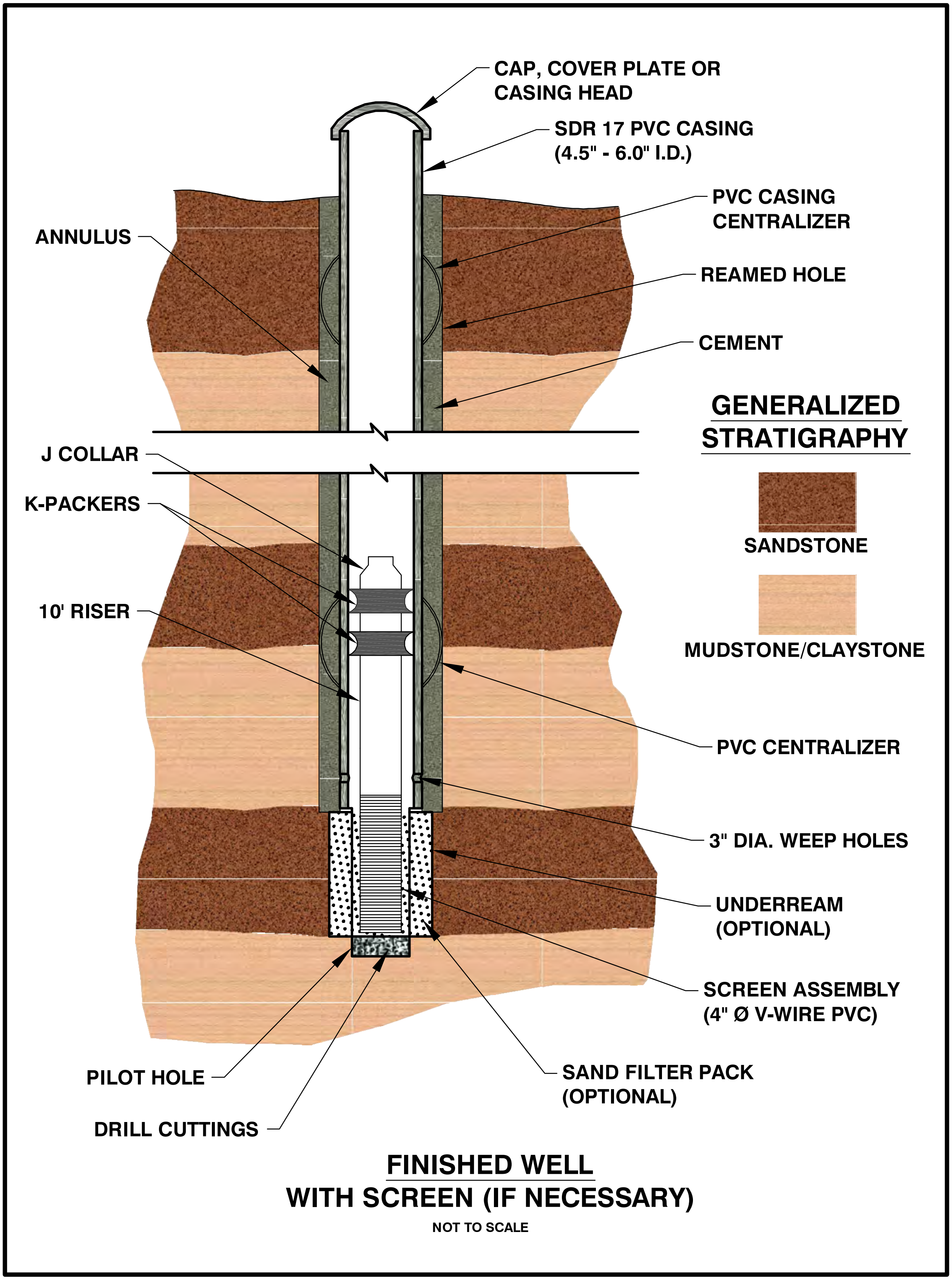


Figure 1.2-9. Proposed Well Installation - Method 2

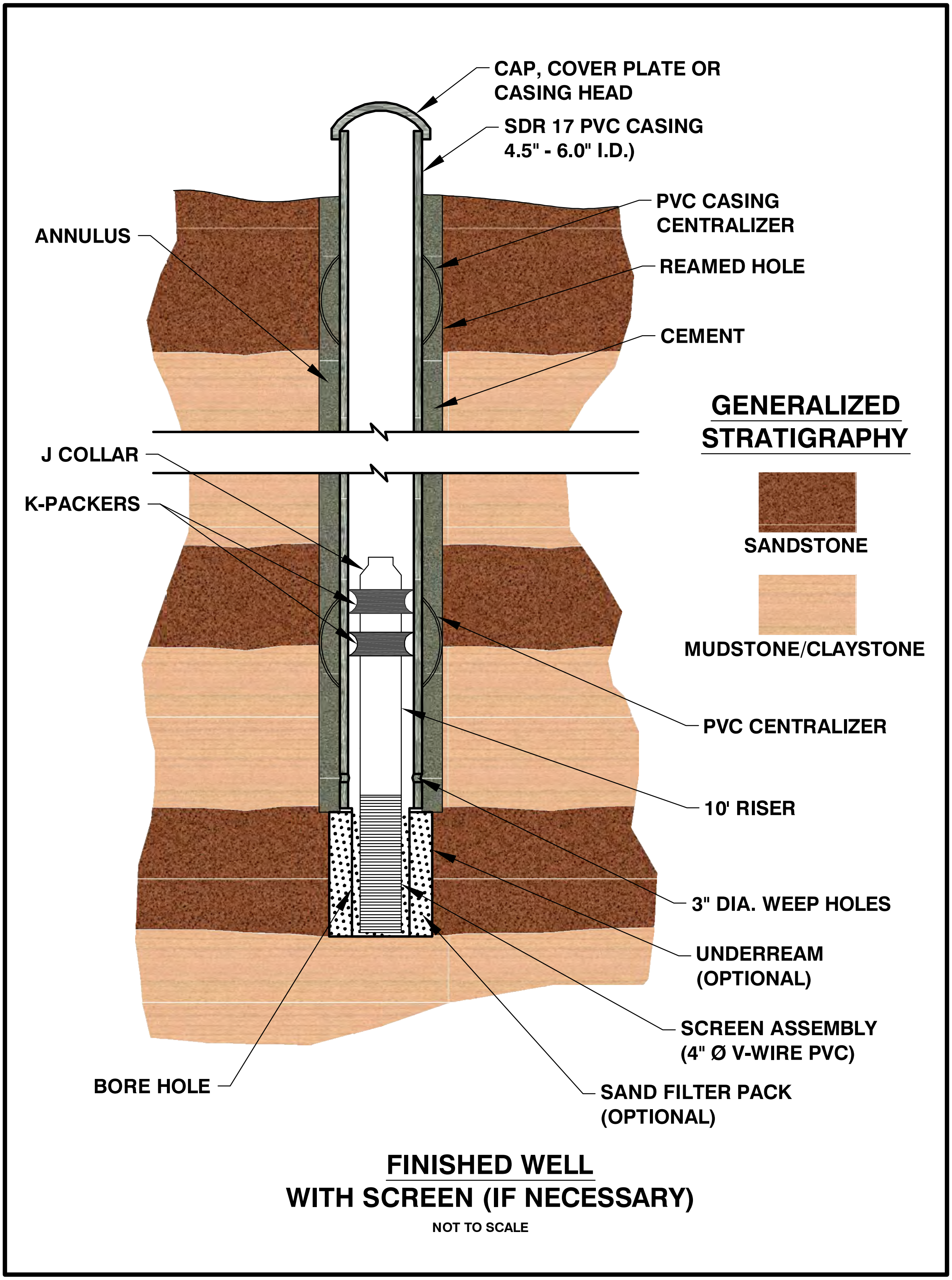


Figure 1.2-10. Proposed Well Installation - Method 3

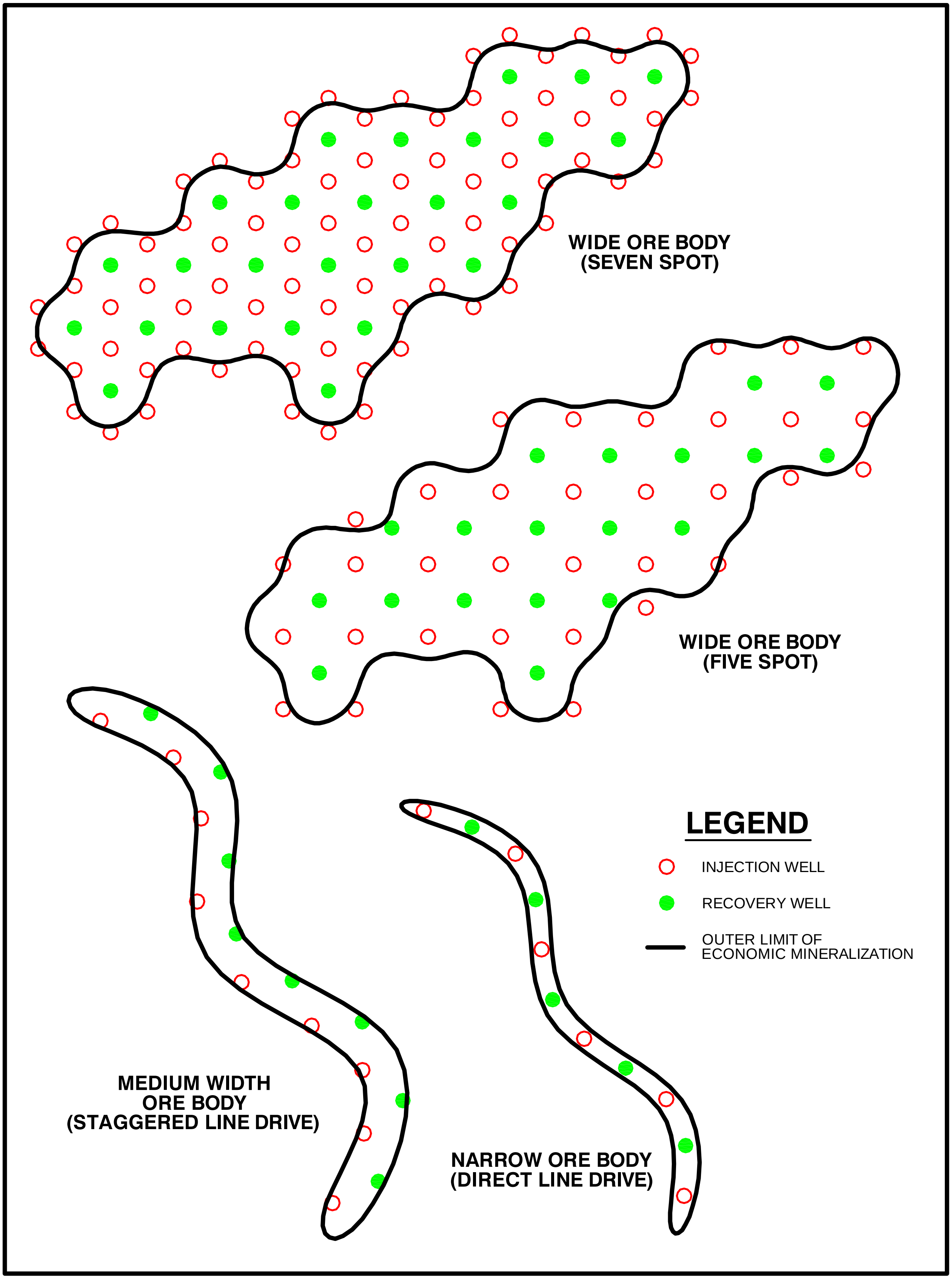
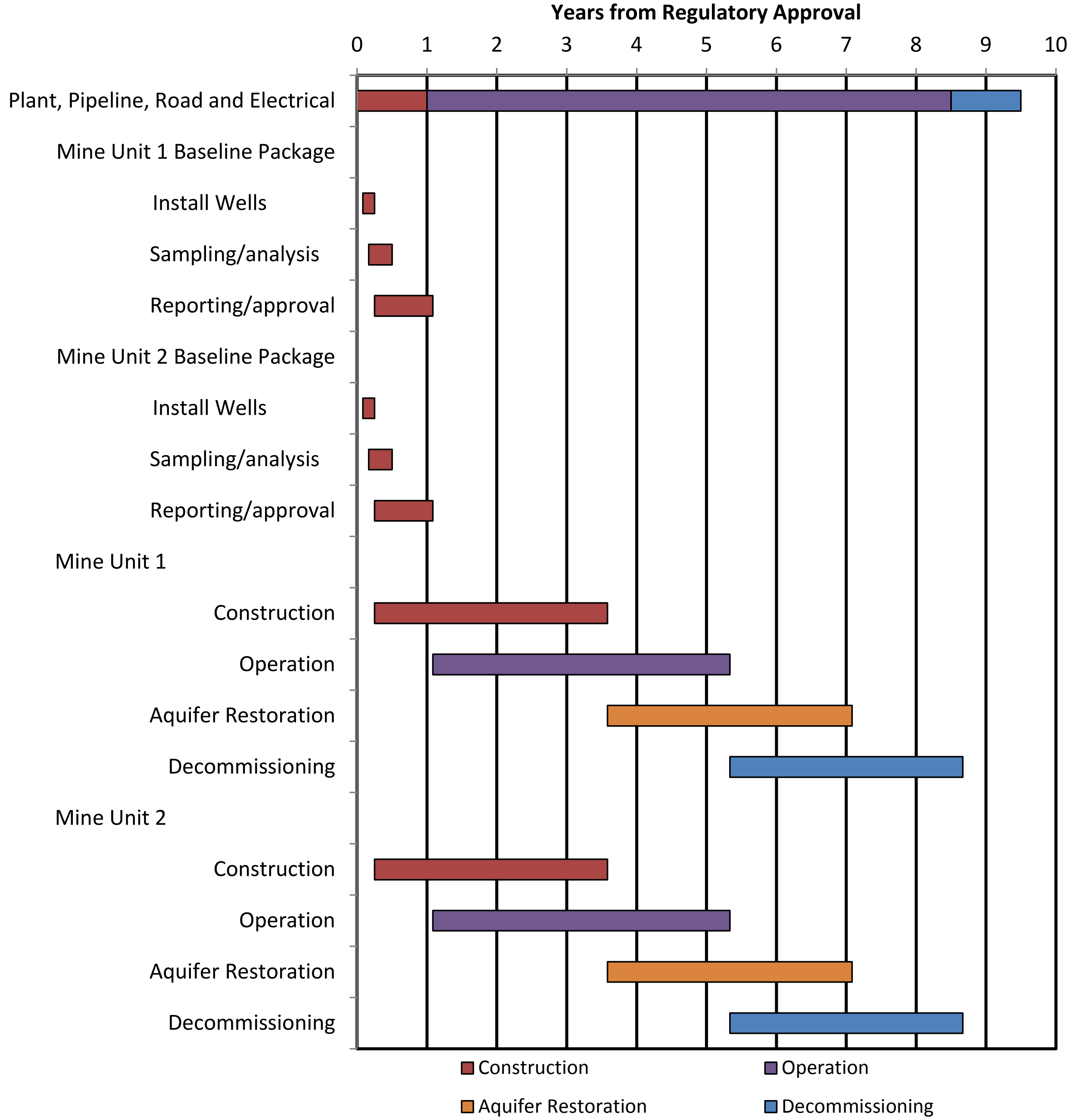


Figure 1.2-11. Proposed Wellfield Patterns

Figure 1.3-1. Ross ISR Project Schedule



1.8 References

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_____, 2010b, Proposed Rulemaking to Revise the Definition of Construction in 10 CFR Parts 30, 36, 39, 40, 51, 70, and 150 (M0812211 - Staff Requirements), Commission Paper SECY-10-0018, February 5, 2010. Available from website on the Internet as of December 2010: <http://148.184.174.31/reading-rm/doc-collections/commission/secys/2010/secy2010-0018/2010-0018scy.pdf>

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2.0 ALTERNATIVES

2.1 Description of Alternatives

As required by NRC regulations at 10 CFR Part 51 adopted by the Commission pursuant to NEPA, this chapter provides a listing of alternatives to the Proposed Action, including but not limited to: (1) the No Action Alternative; (2) the Proposed Action; and (3) Reasonable Alternatives considered but not carried forward for detailed analysis. These alternatives are considered below.

2.1.1 No Action Alternative

10 CFR Part 51 as adopted by the Commission under NEPA requires that Strata assess the “No Action” alternative in its ER. Under the No Action Alternative, Strata would not receive a combined source and 11e.(2) byproduct material license to construct, operate, and decommission the proposed Ross ISR Project. Under this alternative, Strata would not construct and operate the proposed CPP and associated facilities and wellfield and there will be none of the potential impacts identified and analyzed as part of the Proposed Action. Moreover, none of the approximately 5.5 million pounds of uranium proposed to be recovered over the 4 to 8-year production lifecycle of the Ross ISR wellfield will be realized in the commercial nuclear fuel cycle. Furthermore, none of the uranium-loaded IX resin would be processed from satellite facilities owned and/or operated by Strata or other ISR licensees or from other water treatment entities. Currently, the U.S. nuclear power generating industry is the world’s largest producer of nuclear power, generating approximately 800 billion kWh of electricity in 2009, or over 20% of the total U.S. output (WNA 2010a). The U.S. imports approximately 86% percent of its uranium from foreign sources such as Canada, Australia, Russia, and Kazakhstan. In 2009, domestic uranium recovery companies produced 3.7 million pounds of yellowcake uranium (EIA 2010). By comparison, U.S. nuclear fuel reactors consumed 50.8 million pounds of yellowcake equivalent in 2009 (WNA 2010b). Thus, domestic nuclear power generating companies were required to import or receive from government-based programs (i.e., down-blending of U.S. and Russian-based highly-enriched uranium) approximately 93 percent of their required uranium. As a result of the No Action Alternative, the domestic nuclear power generating capacity will be deprived of enough uranium to supply approximately 1.5 nuclear power reactors per year, based on 750,000

pounds of annual production from the Ross ISR Project wellfield and an average requirement of about 500,000 pounds of yellowcake equivalent per year for the 104 U.S. nuclear reactors operated in 2009 (EIA 2010). Accordingly, these power reactors will be required to import sufficient uranium to fill this requirement and the U.S. will continue to be as dependent on foreign sources of uranium for the foreseeable future.

Under the No Action Alternative, baseline conditions will be influenced by natural processes and by any other industrial, commercial, or residential development in the area. Groundwater in the ore-bearing aquifer will remain unsuitable for drinking because of high naturally occurring levels of radionuclides, constituents in the uranium decay series, total dissolved solids, and sulfate, as described in Section 3.4.3 and elsewhere in this ER.

2.1.2 Proposed Action

As described in Section 1.2 of this ER, the Proposed Action involves Strata utilizing ISR processes and methodologies to recover uranium from an identified ore body that is amenable to such processes and methodologies in the proposed project area. ISR involves the circulation of native groundwater fortified with oxidizing and complexing agents (i.e., oxygen, hydrogen peroxide, carbon dioxide, and/or sodium bicarbonate) to create a recovery solution, which is pumped into the ore recovery zone using injection wells. As uranium is dissolved into the recovery solution, the solution is pumped to the surface using recovery wells and is passed through pressurized, down-flow IX columns where the uranium attaches to synthetic IX resins. After the uranium attaches to these resins, it is stripped using the elution process with the stripped resins returning to the IX columns for further use unless they are exhausted. The eluted uranium will be precipitated, washed, filtered, pressed and dried into the final product—yellowcake. The Proposed Action also includes a separate vanadium recovery, processing, and packaging circuit.

As part of the ISR process, groundwater pumped to the surface to recover uranium is re-fortified with the above-mentioned reagents and re-circulated through the recovery zone in a continuous process until the economically recoverable uranium resources in a given wellfield module are removed. After uranium recovery is complete in a given wellfield module, groundwater in that module is restored. Groundwater will be restored to the groundwater protection standards presented in 10 CFR 40, Appendix A, Criterion 5(B)(5) on a

parameter-by-parameter basis using Best Practicable Technology (BPT). If the restoration activities are unable to achieve the background or maximum contaminant levels (whichever is greater) in Criterion 5(B)(5), Strata will submit a license amendment application request for NRC approval of ACLs, but only after demonstrating that there are no specific hazards and the restored constituent concentrations are as low as reasonably achievable (ALARA). All surface facilities specifically associated with any given wellfield module will be subject to D&D requirements such that, ultimately, there will be no visual evidence of site use and the entire disturbance area can be released for "unrestricted use." Successful groundwater restoration and D&D was demonstrated within the proposed project area by the Nubeth R&D facility. A detailed description of the Proposed Action, including the methods by which well design and layout will be completed, is presented in Chapter 1 of this ER and Chapter 3 of the TR.

2.1.3 Reasonable Alternatives Considered but Not Carried Forward for Detailed Analysis

2.1.3.1 Wellfield Layout

Typically, an ISR production unit consists of an ISR-amenable ore body located within a sandstone unit bounded by upper and lower hydrologic and geologic barriers. In the simplest scenario, there would be a single production zone and a monitor well ring radially bounding that production zone with monitor wells within the ore zone aquifer and in aquifers above and below the upper and lower hydrological barriers. Proper wellfield balance (including a "bleed") is the means of ensuring control of recovery solutions within a production unit. In more complex systems, there may be more than one production unit stacked vertically within a sandstone unit, and there may be more than one sandstone unit, with multiple production zones stacked vertically (e.g., LCI 2008). However, generally the geologic and hydrologic parameters will be consistent with the concept of some greater or lesser confining structures above and below production zones.

Within the proposed project area, there exist stacked uranium roll-front deposits that can be recovered using two potential wellfield layout plans. In the first option, uranium recovery and aquifer restoration would occur in the same injection and recovery wells. This would be accomplished by recovering the deepest roll front, recompleting the wells by plugging back, underreaming, and

then recovering the next upper roll front. This would be repeated for any other shallower stacked fronts. After recovering the shallowest roll front, each zone would be restored individually with another sequence of well recompletion necessary between each restoration. This method would be difficult and time-consuming to manage, and any cost savings associated with re-use of recovery and injection wells would be consumed by added recompletion and integrity testing costs. Furthermore, there is significant risk that drilling out cement plugs in the PVC well casing would result in integrity failure, which would require replacement wells to be installed. Due to the added time and well integrity risks associated with sequentially recovering and restoring stacked roll fronts in the same wells, this option was not considered for further analysis.

In the Proposed Action, uranium will be recovered in stacked roll fronts and the aquifer will be restored according to whether or not the stacked roll fronts occur in the same sand unit. Stacked roll fronts in the same sand unit without confinement between the stacked roll fronts will be recovered by opening multiple zones in the same injection and recovery wells. If the mineralized zones which meet the GT (grade-thickness) cutoff are in separate sand units, a well would be installed to target the ore zone in each sand. In other words, where this situation exists there will be twin wells at each location with one group of recovery and injection wells on top of the other. The stacked roll fronts would be recovered and restored together. Additional information and a figure showing the proposed method of ISR uranium recovery in stacked roll fronts is included in TR Section 5.7.8.

2.1.3.2 Conventional Uranium Mining/Milling, Including Heap Leaching

As stated in the Generic Environmental Report for ISR facilities (GER) (NMA 2007), conventional methods of uranium mining/milling (including heap leaching) are alternatives or adjuncts to the ISR method of uranium recovery. These alternatives are considered but not carried forward for detailed analysis in this report because they were assessed in the 1980 GEIS for conventional uranium mining/milling. Conventional uranium mining, milling, and heap leaching are summarized below; the Final GEIS on Uranium Milling (NUREG-0706) should be consulted for additional detail (NRC 1980).

Open-pit and underground uranium mining alternatives to ISR operations at the proposed Ross ISR project site were considered but

eliminated based on economics, health, safety, and environmental impacts. As a general matter, conventional uranium recovery methods are not 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 mill. Low-grade uranium ores produce a relatively small quantity of uranium per unit of rock moved. The higher capital and operating expenditures for open pit and underground mining operations are not justified when pursuing recovery of lower grade ores like those at the proposed Ross project site. Further discussion of conventional uranium mining methods is provided below.

Open-pit uranium mining involves the removal of all overburden above the identified ore body and then the ore itself to recover the uranium. The overburden is generally stockpiled and then used to fill in the pit after mining is completed. The ore is transported to a mill for processing, which involves grinding the ore, leaching the uranium from the ground ore, and concentrating and drying the recovered uranium into yellowcake. The tailings (ore from which the uranium has been removed) from the milling process require safe disposal in a properly designed and licensed facility. As stated in the GER, the maximum depth of open-pit mining in the United States is usually about 550 ft (NMA 2007), which places the Ross ISR Project ore zone at or near the maximum limit for surface mining. Open-pit mining at the Ross site would require dewatering of several aquifers (see Section 3.4.3), and the considerable amount of water produced would likely require treatment prior to discharge. Surface water features such as the Little Missouri River and Oshoto Reservoir would also require extensive management during open pit mining.

The milling process can be completed using one of two potential business models. The first model involves recovering the identified uranium ore and transporting the ore to a conventional uranium milling facility for processing pursuant to a contractual arrangement with a uranium recovery company currently operating such a facility (i.e., toll milling). From an economic perspective, this alternative was eliminated due to the lack of potential financial benefit to Strata. This alternative could also result in significant transportation impacts, since there are no conventional uranium mills within 50 miles (80 km) of the proposed project area. The second model involves the recovery of the uranium ore and the construction and operation of a uranium milling facility by Strata. The construction and operation of a conventional uranium milling facility involves significant capital expenditures for the

construction of a mill plant, uranium mill tailings impoundments and other associated facilities and structures. Further, the overall footprint of the mine and mill site would be substantially larger than that of an ISR site and would result in significant surface disturbance. For example, NRC determined that the Moore Ranch ISR Project was estimated to disturb a total of 150 acres, compared to 741 acres that would be disturbed during construction of a conventional milling operation (NRC 2010a).

Wastes generated by a conventional mining and milling operation would be substantial and would result in permanent, irretrievable impacts to the local topography. In addition, conventional mining and milling results in higher potential risks for personal injury and from potential radiological exposures than those posed by ISR operations and would require substantially more effort to complete surface reclamation and site closure. Further, the area where the conventional mill and associated mill tailings impoundments would be located would not be able to be released for unrestricted use like an ISR site. For these reasons, Strata eliminated the alternative of open-pit mining and conventional milling.

Underground uranium mining involves sinking shafts in the vicinity of the identified ore body, driving crosscuts and drifts to the ore body at different levels, removing the ore and transporting the recovered ore to a uranium milling facility for processing. As with open-pit mining, the uranium ore is transported to a conventional uranium milling facility owned and/or operated by another company pursuant to a contractual arrangement for toll milling, or Strata could construct and operate a uranium milling facility at the Ross site.

The potential risks and impacts associated with underground mining are somewhat similar to those described above for open-pit mining. Less overburden is removed, so waste stockpiles are smaller. Surface disturbance is generally less for underground mining than for surface mining. At the Ross site, where the ore zone and overburden both contain highly confined aquifers, dewatering would be required in order to operate an underground mine. The water would likely need to be treated prior to discharge. There are health and safety risks associated with underground mining and potential exposure of miners to radon daughters if the mine is not properly ventilated in accordance with Mine Safety and Health Administration (MSHA) regulations. There are also potential exposures to members of the public from radon and its daughters if the mine is not operated according to Clean Air Act (CAA) regulations (e.g., 40

CFR Part 61, Subpart B). For these reasons, Strata eliminated the underground mining and conventional milling alternative.

As an alternative to conventional milling, low-grade ore that is recovered by open-pit or underground mining operations can undergo further processing to remove and concentrate the uranium by heap leaching. This process is described in the GER (NMA 2007). Heap leaching occurs at or very near the mine site. The low-grade ore is crushed to a fine size and mounded above grade on a prepared pad. The heap leaching pads must be constructed to the same standards as tailings impoundments per 10 CFR Part 40, Appendix A, including the requirement for a double liner. A sprinkler or drip system distributes leach solution over the mound. For ores with low lime content (less than 12 percent), an acid solution is used, while alkaline solutions are used when the lime content is above 12 percent, which is the case for the Ross site. The leach solution trickles through the ore and mobilizes uranium, as well as other metals, into solution.

The solution is collected at the base of the mound by a manifold and processed to extract the uranium. The uranium recovery from heap leaching is expected to range from 50 to 80 percent, resulting in a final tailings material of around 0.01 percent U_3O_8 content. Once heap leaching is complete, the depleted materials are 11e.(2) byproduct material that must be placed in a tailings impoundment unless NRC grants an exemption for disposal in place. Heap leaching was used mostly on an experimental basis in the 1970s and 1980s, but generally is not in use in the United States today, although it may be in the future. While the impacts from heap leaching may be less than those from conventional milling, the impacts from the associated open-pit or underground mining would still be substantial. For these reasons, this alternative is not carried forward for detailed analysis.

2.1.3.3 Alternate Location of Central Processing Plant

Prior to preparation of this license application, Strata considered two potential locations for the CPP in the proposed project area. The first site, referred to as the south site, is located southeast of the Oshoto Reservoir, primarily in NE¼SE¼ Section 18, T53N, R67W (see Figure 1.2-6). The second site, referred to as the north site, is located north of the Oshoto Reservoir in S½SW¼ Section 27, T53N, R67W. The following is a list of factors which led Strata to select the south site for construction of the CPP.

The south site is situated on relatively flat topography, which would minimize the amount of earthwork and surface disturbance required to prepare the site for construction of the CPP, associated buildings and parking/staging area. The surface is entirely private, and baseline instrumentation is currently adequate for all baseline environmental studies. There is little mineralization beneath the south site, and what there is could be accessible without major modification of the wellfield and monitor well layout. Preliminary geotechnical studies at the south site indicate that subsoil materials are relatively impermeable and have adequate strength for the proposed structures. Preliminary estimates of the radionuclide release rates from the entire project including the south CPP site indicated that the average annual radiation dose to the nearest receptor was less than 6% of the annual limit. The owner of the south site is also the owner of the Oshoto Reservoir, so a surface use agreement, lease, or purchase of this area would afford Strata control over this impoundment.

The north site has more varied topography, so leveling the site for construction of the CPP and related facilities would require more earthwork and surface disturbance. The site is screened from view relatively from all directions except the south. There is mineralization beneath the site, which might require reconfiguration of the wellfield and monitor well layout. This site is also closer to the proposed license boundary than the south site, which could, following completion of all baseline modeling and impact analyses, require that the site boundary be relocated further to the north, which would in turn require a new round of baseline studies.

In addition to the two optional Ross sites for the CPP, as described above, Strata considered construction of the CPP within the Barber Amendment Area, some 15 miles south of the Ross ISR Project area. Strata has identified significant uranium resources within the Lance District (see Figure 1.2-3). The proposed Ross ISR Project is intended to be just the first of several ISR project sites to be developed in the area. If these other sites are developed, it is likely that they will serve as ancillary or satellite facilities to the proposed Ross project site, with all satellite facilities using the same CPP. The Barber Amendment Area is currently being evaluated by Strata as an ISR satellite to the proposed Ross ISR Project. Since the Ross site has been identified as the first area for ISR development, and has been evaluated based on the extensive geologic, hydrologic, and ISR uranium recovery characteristics regarding the

site and surrounding environment, it is logical that this would be the site for the CPP. Delaying construction of the CPP until another project is ready to permit and license within the Lance District would require that Strata enter into a contract for toll milling until the CPP is permitted and constructed. The Ross ISR site has the additional advantage of having data from a successfully operated R&D project (Nubeth) licensed through both the NRC and WDEQ/LQD, with authorized decommissioning that proved the feasibility of aquifer restoration and D&D. These factors made the Ross ISR Project a strong candidate site for full commercial production. Consideration of the alternative CPP location was not analyzed in detail because a site has not been selected and it is likely that the environmental effects of constructing and operating the CPP at a different location within the Lance District would be essentially the same as for the Proposed Action.

2.1.3.4 Alternate Lixiviants

Alternate lixiviant chemistry was also considered for the operations phase of the proposed action, including acid leach solutions and ammonia-based lixiviants. As discussed in the final SEIS for the Moore Ranch ISR Project (NRC 2010a), acid-based lixiviants such as sulfuric acid dissolve heavy metals and other solids associated with uranium in the host rock and create chemical compounds that require additional remediation and have greater environmental impacts.

At a small-scale research facility in Wyoming, test patterns were developed using acid-based lixiviants. During operations, two significant problems developed. The mineral gypsum precipitated on the well screens and in the aquifer, which plugged the wells and reduced the efficiency of the wellfield restoration. Aquifer restoration had limited success because of the gradual dissolution of the precipitated gypsum, which resulted in increased salinity and sulfate levels in the affected groundwater (NRC 2010a). As described in Section 1.2.1, an R&D ISR project at the Ross Site was operated in 1978 and 1979 and restoration was approved by the regulatory agencies by 1986. That project is considered to have demonstrated the feasibility of uranium recovery and groundwater restoration using a sodium-bicarbonate based lixiviant on the ore zone at the Ross site. Because it is technically more difficult to restore uranium recovery sites when acid is the lixiviant and this technology has not been proven feasible at the Ross Site, the use of an acid-based lixiviant was eliminated from further consideration by Strata.

Ammonia-based lixiviants have been used at ISR operations in Wyoming. However, operational experience has shown that ammonia tends to adsorb onto clay minerals in the subsurface and then slowly desorbs from the clay during restoration, therefore requiring that a much larger volume of groundwater be removed and processed during aquifer restoration (NRC 2010a). An example of this is early production at the Irigaray ISR operation in Johnson County. According to the Irigaray Wellfield Restoration Report (Cogema 2005), ammonium bicarbonate was used as the lixiviant in Mine Units 1 through 5, but not in Mine Units 6 through 9. Traces of the ammonium bicarbonate lixiviant remained in the aquifer upon completion of extensive aquifer restoration. Because of the greater consumptive use of groundwater to meet aquifer restoration requirements, the use of an ammonia-based lixiviant was eliminated from detailed analysis.

2.1.3.5 Alternate Waste Management

Plans for management of liquid waste from the operation and aquifer restoration are described in Section 4.13 of this ER. Figures 4.13-1 through 4.13-3 show the project water balance in schematic and tabular forms. Most permeate generated during RO treatment of the production bleed and restoration flows will be recycled back to wellfield modules and used in operation or aquifer restoration and will therefore not be considered waste. The balance of the permeate will be discharged into lined retention ponds, after which it will be recycled back to the wellfield or disposed by surface discharge, for plant make-up water, Class I deep disposal wells, or land application (refer to Sections 4.2.2.1 in the TR and 4.13 in this ER for more detail).

Deep well disposal was selected as the preferred method of brine disposal due to its minimal impact to human health and the environment. Although there will be lined retention ponds to store permeate, brine and other 11e.(2) liquids such as spent eluate, reliance solely upon evaporation for wastewater disposal was rejected as the primary alternative because of the large area that would be required to build the ponds and the increased environmental risk associated with storing large quantities of brine and other 11e.(2) liquids in surface impoundments. As shown in Figure 4.13-2, an average of 227 gpm of these fluids are estimated to require disposal during concurrent operation and aquifer restoration. This may range between 90 and 300 gpm. The average net evaporation rate for brine ponds at uranium recovery operations (for this study the brine contained about 55,000 mg/L TDS) in northeastern Wyoming is

about 30 inches per year (Pochop et al. 1985). The water surface necessary to evaporate 227 gpm would average about 146 acres. Considering the requirement (e.g., ISR GEIS, NRC 2009, pg. 2-37) to maintain reserve capacity to transfer the entire contents of any one pond into the other ponds in the event of a leak, and the need to allow for fluctuations in brine and eluate production rates as well as seasonal and annual variations in precipitation and evaporation rates, the actual footprint occupied by evaporation ponds could easily total 200 acres or more if evaporation were to be the only method of water disposal. Since the Proposed Action would disturb only about 280 acres as planned, the evaporation pond alternative would require significantly more surface disturbance, and this disturbance would last throughout the construction, operation, aquifer restoration and decommissioning phases of the project.

As an alternative to evaporation ponds, Strata also evaluated the potential to use enhanced evaporation technology to eliminate the liquid waste stream. For this option the brine would be boiled away using natural gas as the heat source because a natural gas pipeline is very near to the property and natural gas would provide a smaller carbon footprint than coal. For a waste liquid flow of 227 gpm and a gas cost of $3.50 per million BTU, it is estimated that the cost of the natural gas alone could total about $6 million per year. For a yellowcake production rate of 750,000 pounds per year, this natural gas cost would add $8 per pound to the cost of production. There would also be significant capital and operating costs of the evaporation system.

For any evaporation technology, the dried solids that remain after evaporation of the liquid would require disposal as 11e.(2) byproduct material. A brine rate of 227 gpm with a dissolved-solids content of 35,000 mg/L TDS (reference Table 4.2-5 in the TR) represents a salt load of about 17,000 tons per year that would require disposal in a licensed facility. This is equivalent to about 500,000 cubic feet of 11e.(2) byproduct material, which for a disposal cost of $10 to $20 per cubic foot would result in an additional annual operating cost of $5 to $10 million per year, or $7 to $13 per pound of yellowcake produced.

On the basis of costs, environmental impacts, possible carbon footprint, and 11e.(2) byproduct material disposal issues, brine disposal by evaporation alone was not carried forward for further consideration.

2.1.3.6 Uranium Processing Alternatives

2.1.3.6.1 Single Stage RO

The Proposed Action includes two phases of RO for treatment of the production bleed and restoration solutions as described in Section 3.2.5 and 3.2.6 of the TR and as shown on Figures 4.13-1 through 4.13-3 of this ER. The brine generated from the Phase 1 production and restoration RO systems will be passed through the Phase 2 (recovery) RO system. Brine from the Phase 2 RO system will be discharged to lined retention ponds for deep well disposal, while all permeate will be recycled to the wellfield or discharged to lined retention ponds designated for permeate storage and subsequently recycled back to the wellfield or plant or disposed by land application, surface discharge, or deep well injection.

An alternative considered by Strata 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 lined retention ponds 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 wastewater to be converted to permeate. Most of this permeate will be put to beneficial use through (1) injection into wellfields undergoing operations or aquifer restoration, (2) plant makeup water, (3) land application, or (4) surface discharge, all of which are beneficial uses. Reducing the amount of brine through the use of two-stage RO treatment reduces the size of lined retention ponds necessary for storage of the brine and reduces the amount of water disposed of by evaporation and deep well injection, both of which are non-beneficial consumptive uses of water. Because of 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 Strata.

2.1.3.6.2 No RO Treatment of Groundwater Sweep Recovery Solution

Section 6.1.2.1 of the TR describes the groundwater sweep process that will be employed by Strata to restore groundwater quality in the ore zone after uranium recovery is completed. During groundwater sweep, water is pumped from recovery wells to the CPP for uranium removal and/or RO treatment with none of the RO permeate being reinjected into the modules undergoing

groundwater sweep. As described in the ISR GEIS (pg. 2-28), groundwater sweep causes uncontaminated, native groundwater to flow into the ore body, flushing contaminants from areas that have been affected by injection of lixiviant during uranium recovery. Groundwater sweep also helps recover lixiviant from areas of low permeability within the production zone. Typically, groundwater sweep is the first phase of restoration, but Strata may decide to use groundwater sweep on all or a portion of a wellfield module at any time during restoration.

A drawback of groundwater sweep without reinjection is the additional consumptive use of groundwater. If permeate is not reinjected into a module actively undergoing groundwater sweep, and if there is not an active wellfield module where the permeate can be injected as part of the uranium recovery process, then the permeate from the groundwater sweep adds to the waste disposal stream. WDEQ/LQD has determined that groundwater sweep with direct disposal of produced water is not considered BPT due to excessive consumption of groundwater and resultant impacts to groundwater resources (LCI 2009). Strata proposes the following strategy to minimize consumptive use of groundwater during groundwater sweep:

- Water produced during groundwater sweep will be treated by two phases of RO to minimize brine, thereby avoiding any occurrence of groundwater sweep with direct disposal of produced water.
- Whenever possible, permeate generated from one module undergoing groundwater sweep will be reinjected into another module undergoing RO treatment with permeate reinjection.
- Much of the permeate discharged into the lined retention ponds will be recycled to the CPP for make-up water.
- Groundwater sweep may be used selectively (e.g., around the perimeter of the module) rather than throughout the entire module to maximize benefits while minimizing consumptive use of groundwater.
- The total volume of water planned for groundwater sweep is much lower than that planned for RO treatment with permeate injection.

Groundwater modeling within the project area has shown that some portions of a wellfield will likely be easier to restore than others due to localized aquifer hydraulic properties and wellfield geometry. Strata anticipates that by updating the groundwater model presented in TR Addendum 2.7-H with site specific data used to develop the wellfield packages, aquifer restoration

activities can be modeled. Results of the aquifer restoration modeling will indicate where groundwater sweep activities are likely be the most effective. The use of the groundwater model to help direct selective sweep operations has the potential to significantly decrease the consumptive use of water during the sweep portion of the groundwater restoration process while at the same time significantly increasing the effectiveness of the restoration process.

Because WDEQ/LQD does not consider groundwater sweep without permeate injection to be BPT due to excessive groundwater consumption, Strata eliminated this option from further consideration.

2.1.3.7 Alternate Size of CPP

As described in TR Section 1.8, the IX circuit of the CPP at the Ross ISR Project will be designed to handle a flow rate up to 7,500 gpm and produce 750,000 pounds of uranium annually over a 4 to 8 year period. The CPP will have the capacity to process up to 3 million pounds of U_3O_8 per year from the current Ross ISR operations as well as future ISR facilities operated by Strata and other uranium-loaded resin generators as discussed above. This could potentially extend the life of the proposed CPP an additional 20 years.

The capacity of the CPP is larger than would be justified by the proven reserves at the Ross ISR Project alone. Strata considered other sizes for the CPP and IX circuit before selecting the preferred alternative. The primary consideration is that the Ross area occupies only a small portion of the roughly 56-square mile Lance District, where Strata is actively exploring for additional reserves.

Strata's license application includes a request for authorization to receive and process uranium-loaded resins from satellite ISR facilities, including those owned and/or operated by Strata or those owned and/or operated by other ISR licensees, and from other water treatment entities generating uranium-loaded IX resins that are substantially similar to those generated at the Ross ISR facilities. In support of this request, Strata's license application includes a detailed assessment of potential transportation, resin off-loading and handling, and waste management impacts associated with the production of up to 3 million pounds per year of yellowcake to include the receipt and processing of the aforementioned uranium-loaded IX resins.

Because NRC requires financial assurance to support permissible licensed operations for each license, Strata proposes that, for purposes of

receiving and processing uranium-loaded IX resins from the aforementioned entities, NRC Staff issue a license condition permitting the receipt and processing of such resins so long as the processing of such resins does not require any material changes in the process operation for the proposed Ross CPP and there are no anomalous materials or constituents in the aforementioned resins. Strata's SERP will be required to review and evaluate the receipt of any such uranium-loaded IX resins and certify that these two conditions have been satisfied prior to receiving and off-loading any such resins at the Ross CPP.

Having excess capacity in the CPP will allow Strata to run more recovery wells for a longer period of time, even after their optimal uranium recovery rates have passed, which will reduce the amount of water consumed during restoration and improve overall uranium recovery for the project.

Having excess capacity in the CPP will increase safety in the plant since there will be less incentive to push pipelines, valves and other process equipment to their maximum limits.

Basing the analysis of potential environmental consequences on a larger CPP should provide a conservative analysis and help to streamline future license amendments.

Several factors, including hydraulic characteristics of the ore body as determined from aquifer tests and modeling and the relatively low grade of the ore, support the theory that more water movement through the wellfield and CPP will enable more complete removal of the uranium from the ore zone. Having excess plant capacity will provide Strata with the flexibility to increase throughput to achieve operational goals without being constrained by system capacity.

The potential environmental impacts of the CPP are essentially the same irrespective of capacity. There is little difference in the plant footprint for a plant capable of handling 1 or 3 million pounds of U_3O_8 per year; only the size of the lined retention ponds is directly proportional to liquid throughput capacity.

For these reasons, Strata has selected the plant capacity described for the Proposed Action and alternate sizes were not carried forward for detailed analysis.

2.1.3.8 Arsenic and Selenium Recovery

Strata commissioned a cursory review by Lyntek Incorporated of the technology and economic viability of capturing arsenic and selenium along with uranium and vanadium from the Ross ISR Project. Standard practice within the industry is to remove the selenium and the arsenic from the recovered water with an RO unit during aquifer restoration operations. The arsenic and selenium are retained in the brine and disposed in the deep disposal wells or with the evaporation residue along with the other 11e.(2) byproduct material. Strata considered selectively capturing the selenium and arsenic during uranium recovery operations rather than during aquifer restoration.

Potentially economical technologies for recovery/treatment of arsenic and selenium are to co-precipitate these metals with iron or to adsorb the metals onto an iron substrate, such as iron-impregnated resin. Historically, the cleanest, cheapest and easiest method employs the use of IX resins, which also allows the opportunity to generate a clean product that might be saleable.

For the analysis, it was assumed that a separate IX system would be used to capture selenium and arsenic at a flow rate up to 7,500 gpm, or the maximum flow rate anticipated for the pressurized, down-flow IX columns used to capture uranium and vanadium. Vendors indicated a cost for an IX resin specific for arsenic and selenium would be about $350/cu ft. The selenium and arsenic system would require approximately a total of 3,000 cu ft or 3 columns each with a 1,000-cu ft capacity. It was assumed that the system would be installed within the CPP and operated by the same plant operators. Therefore, the incremental capital and operating costs for those services were ignored for this conceptual analysis.

Capital costs for the columns, resin, pumps, piping and strip circuit were estimated at roughly $2.4 million. Operating costs were estimated at $0.001 per gallon of water treated, for a total of $10,800 per day or $3.9 million per year.

According to the USGS Minerals Yearbook dated November 2010, the annual average New York dealer price for selenium was $23.07 per pound in 2009 and was 26% lower than the annual average price in 2008. The price remained about $20 per pound for the first 7 months of 2009, down from the year-end 2008 price of $23 per pound. An optimistic value of $30 per pound was used for this cursory analysis. The USGS Minerals Yearbook indicates a

recent price for arsenic of around $1,000 per ton, or $0.50 per pound, which is negligible compared to the price of selenium. Therefore, the evaluation was performed to see if there would be any value in producing selenium and whether the costs of removing selenium from the process water stream would be economical for the 7,500-gpm flow rate. Two different selenium concentrations were considered for this cursory evaluation, a low level of 0.03 mg/L and a high level of 0.28 mg/L based upon the leachate characteristics determined by laboratory leach tests with core sample from the ore zone. The evaluation considered only the basic processing costs with an assumption of 100% selenium recovery, and ignored the costs of packaging produced material. Using the higher concentration for selenium of 0.28 mg/L, it was estimated that the value of selenium produced would be about $760 per day, compared with an operating cost to produce this selenium of $10,800 per day.

Even though this evaluation was cursory in nature, the results show that the disparity between production costs and sales price of selenium would be large, and this clearly this would not be an economically viable operation. As stated in the assumptions, arsenic has a lower economic value than selenium, so it can be assumed that the arsenic will have even poorer economics and would also not be feasible as a revenue generation concept.

With an operating cost on the order of $10,800 per day, or $3.9 million per year, the operating costs alone would add roughly $5.25 to the production cost of the yellowcake at the Ross ISR Project. The small quantities of selenium and arsenic produced can best be disposed of with the RO brine in the deep disposal wells. For these reasons the recovery and sale of selenium and arsenic as a byproduct of uranium recovery was not carried forward for further analysis.

2.2 Cumulative Effects

2.2.1 General

This section provides a discussion of how other land uses in the Ross ISR Project region of influence might act to create cumulative impacts. Other land uses in the region of influence considered in this analysis of cumulative effects include:

- past mineral activities (uranium, oil, gas, and bentonite),

- current other uses (oil production plus grazing), and
- other reasonably foreseeable future actions (RFFA) in the area of influence, including mineral development and agriculture.

Cumulative impacts result from the incremental impacts of an action added to other past, present, and reasonably foreseeable future actions, regardless of who is responsible for such actions. Cumulative impacts can result from individually minor, but collectively significant, actions occurring over time. This section considers the cumulative effects analysis presented in Chapter 5 of the ISR GEIS and affirms that the cumulative effects of the Ross ISR Project are within the range of cumulative effects considered in the ISR GEIS and other NEPA documents that address activities within the region of influence.

2.2.2 Land Uses in the Region of Influence

Land uses within 5 miles of the Ross ISR Project are described in Section 3.1 and include livestock grazing on rangeland, oil production, crop production, communication and power lines, transportation, recreation (hunting), reservoirs and wildlife habitat. Future land uses are anticipated to remain the same as historic and current land uses. The dominant land use in terms of area is livestock grazing on rangeland. A minor amount of land (42 acres within the proposed project area) is used for grain production and another small amount (50 acres) is used for dryland hay production. Very small but important amounts of land are used for roads to provide access to the local residences and for truck traffic for the hauling of bentonite mined in the Colony area northeast of the project area to processing plants near Upton southeast of the project area. Recreational use of the land for hunting deer, antelope, sage grouse, wild turkeys and small game is limited since the land is nearly all privately owned (see Section 3.1.6).

Federal actions regarding land uses in the general region of the Ross ISR Project have been analyzed for environmental effects in numerous programmatic and project-specific Environmental Impact Statements (EISs) as listed in Tables 5.2-3, 4 and 5 of the ISR GEIS. In addition, land use within the region of influence is specifically affected by two land use plans, the Newcastle Resource Management Plan (BLM 2000) and a land use plan prepared by Crook County (1998). As described in Section 3.1.11, these land use plans have identified the potential for conflicts between mineral exploration and

development and other land uses such as livestock grazing, wildlife habitat, and hunting. Due to the small quantity of surface disturbance associated with the Proposed Action and the release of the proposed project area for unrestricted use following D&D, potential land use conflicts are expected to be small.

2.2.3 Transportation

Transportation resources within the region of influence are discussed in Section 3.2. The road system within this area includes Interstate 90 about 20 miles south of the proposed project area, U.S. Highway 14 about 10 miles southeast, State Highway 59 about 20 miles west, U.S. Highway 212 about 40 miles northeast, and a county road system that connects these highways and the various communities and homes in the region. Transportation resources are shown on Figure 3.2-1 of this ER. A traffic analysis (see Section 3.2.2 and Addendum 3.2-A) conducted for this license application indicates that the local road system is adequate, with minor mitigation and maintenance, to provide adequate service to local residents, farmers, ranchers, and proposed ISR operations for at least 20 years. Current traffic on all local roads averages less than 150 vehicles per day (see Table 3.2-2), which compares to a rule of thumb that at a traffic level of about 400 vehicles per day it becomes more cost effective to pave a road rather than maintaining a gravel surface (see Section 3.2.1).

2.2.4 Air Quality

Air quality at the proposed project area is within ambient air quality standards, and the analysis presented in Section 4.6 of this application indicates that the Ross ISR Project will not adversely affect air quality. The primary potential impact will be fugitive dust from construction activities and traffic on local gravel roads.

Table 5.3-2 of the ISR GEIS lists 15 coal mining projects in the Wyoming PRB. Five of these large surface coal mines are within about 30 miles of the proposed project area. All have intensive air quality monitoring programs and all are deemed "in compliance" with all applicable standards by WDEQ/AQD (see Section 3.6). The nearest bentonite mines are in the Colony area some 30 miles north of the Ross ISR Project area. Like the coal mines, the bentonite mines have not been subject to permitting under Prevention of Significant

Deterioration (PSD) regulations because their emissions fall below applicability thresholds. The regional mines are not expected to cause cumulative air quality impacts regarding the Ross ISR Project due to distance and low emission rates.

2.2.5 Noise

Ambient noise levels in the proposed project area are generally low. A baseline noise study conducted for the preparation of this ER (Section 3.7 and Addendum 3.7-A) shows ambient noise levels in the 35 to 40 dBA range, with maximum values of 85 to 90 dBA resulting from bentonite haul trucks traveling along the New Haven Road. The major sources of increased noise from the Ross ISR Project will be from the well drilling equipment and the trucks hauling supplies and materials to the site and hauling product away from the site.

As discussed in Section 4.7, noise from Ross ISR Project activities, particularly during construction, will add to existing ambient noise levels and will vary in intensity both spatially and temporally, but will not cause cumulative impacts because of the sparse population of the area and the brief and sporadic nature of the sound sources, which will be primarily mobile equipment.

2.2.6 Water Resources

2.2.6.1 Surface Water Resources

Section 3.4.1 describes the surface water features of the proposed project area. All streams in the area are ephemeral, flowing only in direct response to rainfall or snow melt runoff events, or intermittent, receiving flow from groundwater part of the year. The only perennial surface water is found in reservoirs, created by constructing an earthfill embankment across the channels to impound the occasional runoff events.

As discussed in Section 4.4.1, potential impacts to surface water include the possibility of increased sediment from disturbed areas reaching the streams or the possibility of a leak or spill of fuels or chemicals near the streams. The likelihood of such impacts can be minimized by implementing best management practices (BMPs) for erosion and sediment control and adhering to strict safety protocols for handling fuels and chemicals transported to and stored on site.

Because of the infrequency of runoff events in this semiarid region, it is unlikely that a spill would be transported off site in a stream and reach a watercourse downstream. Therefore, no cumulative surface water impacts are likely to result from the Ross ISR Project.

2.2.6.2 Groundwater Resources

Potential impacts to groundwater resources are described in Section 4.4.2 and include changes in water levels in the ore zone aquifer in the vicinity of the well fields and the possibility of leaks, spills, and excursions. A detailed hydraulic modeling study (see TR Addendum 2.7-H) shows that the effects on groundwater levels will be primarily confined to the proposed project area, and nearby wells will be closely monitored during operations. Strata commits to providing alternate sources of water for any adjacent groundwater uses in the event that Strata's activities prevent full use of the resource. The instrumentation and control system and excursion monitoring system are designed to quickly detect any leaks, spills, or potential excursions, so any area of impact would be small. Thus, there is an extremely small likelihood of any groundwater impacts extending off-site to create cumulative impacts.

2.2.7 Mineral Activities in the Region of Influence

2.2.7.1 Uranium

Wyoming has been the nation's leading producer of uranium ore since 1995, and also hosts the nation's largest uranium reserves (WSGS 2010). The ISR GEIS identifies four uranium milling regions: the Wyoming West Region, Wyoming East Region, Nebraska-South Dakota-Wyoming Region, and Northwestern New Mexico Region (see Figure 3.1-6 in this ER for the location of the proposed project area in relation to the uranium milling regions). Numerous uranium recovery sites, both potential and existing, are present in these regions. Wyoming's only currently producing uranium recovery operation, the Smith Ranch-Highland operation, is located in Converse County in the Southern Powder River District of the Wyoming East Region. The Smith Ranch-Highland operation is owned by Power Resources, Inc. (dba Cameco Resources) and uses the ISR process. Two other uranium recovery operations in the PRB are currently licensed by the NRC. The Christensen Ranch/Irigaray operation (owned by Uranium One Americas, Inc.) is located in Johnson and Campbell counties (NRC 2010). Efforts are underway to restart ISR operations

at Christensen Ranch in the near future. The NRC recently issued a license for a new uranium recovery facility in the PRB (Moore Ranch). The Moore Ranch project, owned by Uranium One (dba Energy Minerals Corporation), is located in Converse County.

Due to increased overall demand for energy in recent years, uranium spot prices increased from a low of $7 a pound in 2001 to over $138 a pound in 2007 and are currently around $60 per pound. Long-term contract prices are typically higher. In response to the increased price of uranium, additional uranium developments currently are proposed in the Wyoming PRB study area. In addition to the recent license issued for Moore Ranch, NRC is currently reviewing an application for another new uranium recovery facility in the PRB: the Nichols Ranch-Hank Unit (NRC 2010). The Nichols Ranch-Hank Unit, owned by Uranerz Energy Corporation, is located in Campbell and Johnson counties. The Moore Ranch and Nichols Ranch-Hank Unit license applications were submitted in 2007. They are located in the Pumpkin Buttes District and would use the ISR method of uranium recovery. The NRC is also currently reviewing a license application for another proposed ISR project in Wyoming. The Lost Creek Project is proposed by UR Energy (dba Lost Creek ISR, LLC) in the Great Divide Basin about 220 miles southwest of the proposed project area and outside of the PRB study area.

NRC expects to receive additional applications for new uranium recovery facilities, as well as requests for restarts and expansions of existing facilities. Table 2.2-2 provides information on projects currently proposed in the region. The actual number of the proposed developments that will become operational will depend on several factors including uranium prices and approval of permits. All the listed uranium recovery projects are located some distance away from the Ross ISR project, are in different watersheds, will have similarly small impacts on air quality, and will not cause cumulative impacts.

Section 1.2.1 describes the history of uranium exploration in the proposed project area. An R&D ISR project was operated at the Nubeth R&D site between August 1978 and April 1979. Commercial operations never commenced due to market conditions, and the groundwater was restored and regulatory agencies approved decommissioning of the site in 1986. No other historic exploration or production of uranium on the site is known to have occurred.

Strata has identified significant uranium resources within the Lance District (see Figure 1.2-2). The proposed Ross project site is intended to be the first of several ISR project sites to be developed in the area. It is likely that these proposed sites will serve as ancillary or satellite facilities to the proposed Ross project site, with all satellite facilities using the Ross ISR Project CPP. In the event that Strata determines that these project sites are suitable for uranium recovery, license and permit applications will be submitted to the appropriate regulatory agencies, including NRC. Absent any site-specific features that could preclude development of these other sites (e.g., historical and cultural resources), ISR operations at additional sites likely will result in essentially the same potential impacts analyzed in this ER for the Proposed Action. Development of these sites may act to produce cumulative effects by increasing or prolonging the impacts analyzed for the Proposed Action, but the impacts will be distributed proportionately throughout the region of influence and therefore are not expected to significantly increase the severity of any impact. Such impacts will be appropriately addressed through license and permit amendments when any development plans are finalized.

2.2.7.2 Coal, Oil and Gas

One indicator of present and reasonably foreseeable future actions in a region is the number of EISs prepared by federal agencies within a time period. Chapter 5 of the ISR GEIS lists 32 project-specific EISs and 10 programmatic and large-scale EISs for the states of Wyoming, South Dakota or Nebraska or the general areas surrounding the four uranium milling regions between January 7, 2005 and February 22, 2008. A similar check of the EPA database for the period February 22, 2008 to November 15, 2010 (EPA 2010) showed an additional 35 draft or final EISs published in Wyoming alone, of which 15 are for programs or projects in northeastern Wyoming or NRC projects in Wyoming in general (see Table 2.2-1).

BLM recently completed a regional technical study, called the PRB Coal Review, to help evaluate the cumulative impacts of coal and other mineral development in the PRB. This Coal Review was reviewed to evaluate whether the cumulative impacts of existing and reasonably foreseeable development evaluated by BLM would occur within the Ross ISR Project region of influence. The PRB Coal Review consisted of three tasks:

- Identify existing resource conditions in the PRB for the baseline year (2003) and, for applicable resources, update the BLM's 1996 status check for coal development in the PRB.
- Define past and present development activities in the PRB and their associated development levels as of 2003 and develop a forecast of reasonably foreseeable development in the PRB through 2020. The reasonably foreseeable activities fall into three broad categories: coal development; oil and gas development, including major transportation pipelines; and other development, which includes development that is not energy-related as well as other energy-related development.
- Predict cumulative impacts that could be expected to occur to air, water, socioeconomics, and other resources if the development occurs as projected in the forecast developed under the second task.

Results of the PRB Coal Review task studies were presented in a series of reports. The Task 1, 2, and 3 reports represent components of a technical study of cumulative development in the PRB; they do not evaluate specific proposed projects, but they provide information that BLM is using to evaluate the cumulative impacts that would be expected to occur if specific projects or applications are approved. The completed reports are available for viewing on the BLM website (BLM 2009a). The following discussion presents summarized information from this Coal Review where such information indicates that the cumulative impacts identified by BLM might affect the Ross ISR Project region of influence or might act with the Ross ISR Project to increase the severity or duration of any identified impacts.

The Wyoming portion of the PRB is the primary focus of the PRB Coal Review reports. For several resources, the Task 1 and Task 3 study areas include only potentially affected portions of the Wyoming PRB Coal Review study area; for other resources, the study area extends outside of Wyoming and Montana because the impacts would extend beyond the PRB. For example, groundwater drawdown is evaluated in the area surrounding and extending west of the mines, because that is the area where surface coal mining operations and coal bed natural gas (CBNG) production operations would impact groundwater resources. This impact area does not include the Ross ISR Project region of influence. However, BLM evaluated air quality impacts over a multi-state area because some aspects of air quality, such as regional haze, were estimated through computer modeling to extend across a large area.

2.2.7.2.1 Past, Present, and Reasonably Foreseeable Development

Past, present, and reasonably foreseeable development in the Wyoming PRB was considered in the Task 1 and Task 2 reports for the PRB Coal Review. The Task 1 reports describe the existing situation as of the end of 2003, which reflects the past and present levels of development. The Task 2 Report defines the past and present development activities in the PRB as of the end of 2003 and projects reasonably foreseeable development in the Wyoming PRB through 2020. Task 2 was updated based on actual levels of development through 2007 and current development estimates available through year 2009 (BLM 2009b).

Between 1990 and January 2009, the BLM's Wyoming State Office held 25 competitive coal lease sales and issued 20 new federal coal leases using the lease by application (LBA) process. This is consistent with BLM's objective, which was to use the LBA process to lease federal coal to maintain production at existing mines. Each lease sale was analyzed through the NEPA process.

In 2003, the baseline year for the PRB Coal Review Task 1 and Task 2 studies, there were 12 active surface coal mines and one inactive mine in Wyoming's PRB. Since 2003, the inactive mine (Coal Creek) has resumed operations. These mines are all located in Campbell and Converse counties, just west of the outcrop of the Wyodak coal, where the coal is at the shallowest depth.

From 1989 to 2008, coal production in the PRB increased by an average of 6% per year. In 2009, production from the Wyoming PRB coal mines dropped by about 7% from the 2008 levels, the first drop since the early 1990s. This drop coincided with a national coal production decline due to reduced industrial electricity demand in 2009.

Task 2 of the PRB Coal Review projected coal development into the future for the years 2010, 2015, and 2020. Two coal production scenarios (representing an upper and a lower production level) were developed to bracket the most likely foreseeable regional coal production level. The basis for the projected production levels considered:

1) historic PRB production in comparison to Gross Domestic Product (GDP) and national coal demand;
2) PRB coal market forecasts that model the impact of GDP growth, potential regulatory changes affecting coal-fired power plants, and mining and transportation costs on PRB coal demand;

3) availability, projected production cost, and quality of future coal reserves within the PRB region; and

4) availability of adequate infrastructure for coal transportation.

The projected upper and lower production levels were allocated to individual mines based on past market shares. Then the projected future production was aggregated on a subregion basis. Having prepared the coal production scenarios, BLM than prepared estimates of baseline year and projected impacts including socioeconomics, surface disturbance, and effects on regional resources including land uses, ecological resources, water resources, wildlife, and air quality.

2.2.7.2.2 Coal-Related Development

Coal-related development as defined for the BLM analysis includes railroads, coal-fired power plants, major (230-kV) transmission lines, and coal technology projects.

Coal Transportation

The PRB Coal Review projected that two coal transportation projects would be developed prior to 2020 in Wyoming: expansion of the BNSF & UP rail facilities south of Gillette, and the construction of the Dakota, Minnesota & Eastern Railroad Corporation (DM&E) rail line in Wyoming and South Dakota. A third project proposed by the Tongue River Rail Company would be built between Decker and Miles City, Montana. None of these transportation projects affects the Ross ISR Project region of influence and these projects are not considered further in this analysis.

Electric Power Generation

There are five coal-fired power plants in the Wyoming study area for the PRB Coal Review Tasks 1 and 2. Black Hills Power Corporation owns and operates the Neal Simpson Units 1 and 2 (21.7-megawatts [MW] and 80-MW, respectively), Wygen I, II and III (80-MW, 95-MW and 110-MW, respectively), and Wyodak (330-MW) power plants, all of which are located approximately five miles east of Gillette, Wyoming. Pacific Power and Light's Dave Johnston Power Plant is located near Glenrock, Wyoming, outside of the Ross ISR region of influence.

Basin Electric Power Cooperative expects to begin operating a 385-MW coal-fired power plant (Dry Fork Station) north of Gillette in 2011. The cooling technology includes a dry scrubber, a type of operation commonly installed for PRB coal-fired units due to shortage of water for conventional cooling. The water source for the Dry Fork Station is the Lance-Fox Hills aquifer, the same aquifer that contains the ore zone at the Ross ISR Project. At Dry Fork, some 30 miles west-southwest of the Ross ISR Project area, wells completed in the Lance-Fox Hills aquifer are about 4,000 feet deep and can produce over 400 gpm for several decades according to the Water Supply and Yield Analysis prepared by Basin Electric and approved by the WSEO as a part of the permitting process for the Dry Fork Station.

There are also three separate interconnected gas-fired power plants (Hartzog, Arvada, and Barber Creek) located near Gillette, Wyoming. Each contains three separate 5-MW-rated turbines that provide electric power to Basin Electric and its customers. In winter, the maximum capacity can reach 22.6-MW from each site. All units are in operating condition, although they do not operate at maximum capacity.

The BLM Coal Review study identified the following additional power plant projects as likely for 2015 development:

- The North American Power Group (NAPG) 280-MW coal-fired power plant (Two Elk Unit #1) is permitted at a 40-acre site located approximately 15 miles southeast of Wright, Wyoming (over 60 miles south of the Ross ISR Project area). Operation of this facility by 2015 is considered moderately likely by BLM.
- Wyoming Power Company (a subsidiary of NAPG) has submitted a permit application for Two Elk Unit #2, 750-MW supercritical pulverized coal-fired electric generating unit that would be on a 60-acre site adjacent to Two Elk Unit #1. Operation of this unit was considered by BLM to be moderately likely in 2015.

Transmission Lines

Major transmission lines in the Wyoming PRB study area are associated with the Dave Johnston power plant located near Glenrock, Wyoming, and the power plants owned by Black Hills Power Corporation, which are located east of Gillette, and Basin Electric Power Cooperative, located north of Gillette. These transmission lines have been in place for several years, and their associated

long-term disturbance is minimal. Distribution power lines associated with conventional oil and gas development also occur within the study area.

The PRB Coal Review estimated that by 2020, four major transmission lines would be constructed. The size and location of such facilities are not known as of this time. Because transmission lines are a necessary supporting infrastructure for power generating facilities to provide connection to the grid, the PRB Coal Review assumes they would be required as part of the overall system development for the proposed power plants discussed previously. Six specific proposals for these transmission lines were identified by the PRB Coal Review analysis update. There is currently insufficient information to analyze or assign likelihood of development by 2020.

In April 2005 the governors of California, Nevada, Utah, and Wyoming entered into a Memorandum of Understanding to encourage development of a high voltage power transmission line, the Frontier Line, connecting those states. Since that time, no specific plans have been announced as to the location or timing of the Frontier Line. The 345-kV Wyoming-Colorado Intertie, as well as the Trans West and Gateway West and South projects, have been proposed in Wyoming in order to move power from Wyoming to growing Idaho and Nevada and other western U.S. load demand areas (Casper Star Tribune 2007). The TransWestern Express proposes to move electric power from Wyoming to Arizona through Colorado or Utah. The High Plains Express is proposed to move power from Wyoming to New Mexico and Arizona. None of these transmission lines is likely to be on or near the Ross ISR Project area and they are not considered further in this cumulative impact analysis.

Coal Conversion Technology

With rising energy prices, there has been interest in enhancing the quality of PRB coal and/or converting the coal to other fuels. Test facilities have been built at various mines, but no commercial production has occurred and these facilities have either been dismantled or are no longer in use.

Several coal conversion projects have been proposed but were not included in the PRB Coal Review analysis because the likelihood of their occurrence was not known when the analysis was conducted. They are not in the Ross ISR area of influence and are not considered further in this cumulative impact analysis.

Carbon Sequestration

No carbon sequestration projects currently exist in the Wyoming PRB study area. However, there is CO_2 being injected underground for the purpose of enhanced oil recovery (EOR) about 100 miles southwest of the proposed project area in the Salt Creek Oil Field near Midwest and Edgerton, Wyoming. Because there is oil production in the Ross ISR Project area of influence, the possibility of carbon sequestration in the project area cannot be discounted. However, because no specific projects have been proposed it is not included in the reasonably foreseeable future actions for this area. Strata considered the possibility of providing CO_2 to the oil company operating with the proposed project area or to another nearby operating oil company for EOR in the Minnelusa Formation, but the quantity of CO_2 that could be captured (primarily that from combustion of natural gas to heat thermal fluid in the uranium and vanadium drying systems and the CO_2 released from the breakdown of UDC and UTC in the precipitation circuit) is likely too small to justify a CO_2 sequestration project.

2.2.7.2.3 Oil and Gas Development

Conventional Oil and Gas

As described in Section 4.1.1.1.3, there are three producing oil wells, two water injection wells and three water supply wells used for EOR within the Ross Project area. Oil is produced from a depth of 6,000 feet or more, which is more than a mile deeper than the uranium mineralization in the proposed project area. The oil wells and water injection wells will not be impacted by the Proposed Action, but the water supply wells used to obtain water for EOR will likely be impacted. This is addressed in Section 4.1.1.1.3 as a potential impact of the Ross ISR Project, but is restricted to the proposed project area and has no known implications for cumulative impacts in the surrounding region.

CBNG Development

Commercial development of CBNG resources began in limited areas west of and adjacent to the northernmost surface coal mines near Gillette in the late 1980s. Since that time, CBNG development spread south and west into other parts of the PRB west (down-dip) from Gillette and away from the Ross ISR Project area. Since the economic recession began in late 2007 the demand for energy in the U.S. has declined and the pace of CBNG production has slowed

considerably. Unemployment in Wyoming has increased accordingly as discussed in Section 3.10.3.

The Ross ISR Project area is stratigraphically below the Wasatch and Fort Union formations where the CBNG production occurs. These formations crop to the west of the Ross area and are not present at this location (see Section 3.3). Therefore, CBNG production in the PRB will not cause cumulative impacts with the Ross ISR Project other than possibly providing a source of labor familiar with shallow well construction and installation of utility corridors similar to many of the tasks required for ISR uranium recovery, as discussed in Sections 3.10.3 and 4.10.1.

Oil and Gas Related Development

Oil and gas related development activities include major transportation pipelines and refineries.

Major transportation pipelines for the transport of product to outside markets are a key factor in the development of oil and gas resources in Wyoming. As described in Section 3.1.8, there is a crude oil pipeline running north-south parallel and adjacent to D Road through the Ross ISR Project area. This connects with the gathering lines from the oil wells in this area and will need to be addressed when constructing the Ross ISR Project, particularly the wells and connecting utility corridors. Strata will develop an SOP for safe well and pipeline construction in the vicinity of the crude oil pipelines. A gas transmission line that runs generally north-south to the west of the proposed project boundary and a crude oil pipeline that runs generally east-west to the north of the proposed project boundary will not be affected by the Ross ISR Project although they could be affected by the future ISR projects discussed in Section 2.2.7.1.

The BLM's PRB Coal Review discusses two proposed natural gas transportation pipeline projects that would cross the PRB study area. Neither of these crosses the Ross ISR Project area and therefore they are not considered further in this cumulative impact analysis.

The nearest refinery to the Ross ISR Project is the Wyoming Refining Co. refinery in Newcastle, about 70 miles south of the proposed project area. This refinery is not within the area of influence of the Ross ISR Project and will not be subject to cumulative impacts. No other reasonably foreseeable plans for

construction and operation of new petroleum refineries in the area of influence have been identified.

2.2.7.3 Other Mining

Bentonite, sand, gravel, and clinker (or scoria) have been and are being mined in the Wyoming PRB. There is also the potential for a future rare earth elements mine near Sundance, Wyoming.

Bentonite is weathered volcanic ash that is used in a variety of products, including drilling mud and kitty litter, because of its absorbent properties. There are three major bentonite producing districts in and around the PRB: the Colony District in the Northern Black Hills, the Clay Spur District in the Southern Black Hills, and the Kaycee District west of Kaycee, Wyoming. The bentonite mined in the Colony District some 30 miles north of the Ross ISR Project area is hauled to a processing plant near Upton, Wyoming some 40 miles south-southeast of the proposed project area. The haul trucks utilize the county road system that passes by and through the proposed project area, and the potential traffic impacts of this traffic combined with the traffic that will result from construction, operation, aquifer restoration and decommissioning of the Ross ISR Project are discussed in Section 4.2. It is expected that mining and hauling of bentonite from existing mines in the Colony District will continue throughout the life of the Ross ISR Project, but no new bentonite mines in the area are known to be in the planning stages.

Aggregate, including sand, gravel, and stone, is used for construction purposes. In the PRB, the more important aggregate mining localities are located on the western and eastern margins of the basin where the bedrock formations crop along the Big Horn Mountain and Black Hills, respectively. There are no good gravel sources on the Ross ISR Project area, and it is not expected that the Ross Project will impact or be impacted by existing or future aggregate mining operations.

According to the USGS (2010), Rare Earth Elements, Ltd has delineated rare earth elements-thorium deposits in the southern Bear Lodge Mountains about 5 miles northwest of Sundance in Crook County, or some 25 miles east-southeast of the proposed project area. There are no recognized cumulative impacts associated with a potential rare earth elements mine due to the distance from the proposed project area.

2.2.8 Air Quality

The Task 1A Report for the PRB Coal Review (BLM 2005a) documents the modeled air quality impacts of operations during a baseline year, 2002, using actual emissions and operations for that year. The baseline year analysis evaluated impacts both within the PRB itself and at selected sensitive areas surrounding the region. The analysis looked at impacts of coal mines, power plants, CBNG development, and other development activities. Results were provided for both Wyoming and Montana. The Task 2 Report for the PRB Coal Review (BLM 2005b) identifies reasonably foreseeable development activities for the years 2010, 2015, and 2020.

The Task 3A Report for the PRB Coal Review (BLM 2006) evaluates impacts on air quality and air quality-related values for the year 2010 using the development levels projected for 2010 and the same model and meteorological data that were used for the baseline year study in the Task 1A Report. BLM updated the model and conducted impact analysis for the year 2015 (BLM 2008). The updated Task 3A report for the PRB Coal Review Cumulative Air Quality Effects for 2015 uses a revised baseline year of 2004 with revised projected 2015 scenarios. BLM subsequently updated the model and conducted impact analysis for the year 2020 (BLM 2009c). The updated Task 3A report for the PRB Coal Review Cumulative Air Quality Effects for 2020 uses the same baseline year of 2004 with revised projected 2020 scenarios. The revised baseline year emissions inventory was developed using 2004 actual emissions data or emissions estimates and incorporated the recent analyses of emissions in Wyoming and Montana, which were not available when the 2010 modeling study was done.

Existing and projected emissions sources for the baseline year (2004) and 2015 and 2020 analyses were identified within a study area comprised of the following counties in the PRB in Wyoming and Montana:

- Campbell County, all of Sheridan and Johnson counties except the Bighorn National Forest lands to the west of the PRB, and the northern portion of Converse County, Wyoming.
- Rosebud, Custer, Powder River, Big Horn, and Treasure counties, Montana.

A dispersion model was used to evaluate impacts of the existing and projected source emissions on several source groups, as follows:

- Near-field receptors in Wyoming and Montana covering the PRB Coal Review Task 1A and 3A study area in each state;
- Receptors in nearby federally designated pristine or "Class I" areas; and
- Receptors at other sensitive areas (Class II sensitive areas).

The EPA guideline CALPUFF model system version 5.8 (Scire et al. 2000) was used for this study. The impacts for the baseline year (2004) and for 2015 and 2020 lower and upper coal production scenarios were directly modeled, and the criteria pollutants modeled were particulates (PM_{10} and $PM_{2.5}$), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2). As discussed above, the modeling domain extends over most of Wyoming, southeastern Montana, southwestern North Dakota, western South Dakota, and western Nebraska and therefore includes the Ross ISR Project area.

The modeling approach for the updated Task 3A Report used actual emissions from existing sources representative of 2004 operations and projected those emissions for the expected level of development in 2015 and in 2020. No specific emissions data were available for the projected levels of development. Key major sources were included, such as the coal-fired power plants, gas-fired power plants, and sources that were included in the Title V (operating permit) program. The Dave Johnston power plant, which is located in Converse County, was included in the baseline year study and in the projected emissions. Emissions from other sources, including estimated construction-related fugitive dust emissions, were computed based on EPA emission factors and on input data from WDEQ/AQD.

Existing regional air quality conditions generally are very good in the PRB. There are limited air pollution emissions sources (few industrial facilities, including power plants and surface coal mines, and few residential emissions in relatively small communities and isolated ranches) and good atmospheric dispersion conditions. The available data show that the region is in compliance with the ambient air quality standards for NO_2 and SO_2. There have been no monitored exceedances of the annual particulates (PM_{10}) standard in the Wyoming PRB.

Air quality modeling indicates projected activities at the surface coal mines will be in compliance with the PM_{10} and $PM_{2.5}$ near-field and short-term NO_2 air standards for the 2015 and 2020 modeled air quality impacts at their currently permitted mining rates. Visibility data collected around the region

indicate that, although there are some days with notable impacts at Class I areas, the general trend in the region shows little change in visibility impacts at the Badlands and Wind Cave National Parks and the Bridger/Fitzpatrick and Cloud Peak Wilderness Areas over the period from 1989 to 2008.

Predicted impacts from baseline year (2004) and projected 2015 and 2020 emissions were modeled for four air quality criteria pollutants (NO_2, SO_2, $PM_{2.5}$, and PM_{10}), along with changes in air quality-related values at Class I areas and at identified sensitive areas. For regulatory purposes, the Class I PSD evaluations are not directly comparable to the air quality permitting requirements because the modeling effort does not identify or separately evaluate increment-consuming sources that would need to be evaluated under the PSD program. The cumulative impact analysis focuses on changes in cumulative impacts, but not on a comparison to PSD-related evaluations, which would apply to specific sources.

Table 2.2-3 presents the modeled impacts on ambient air quality at the near-field receptors in Montana and Wyoming. Results indicate the maximum impacts at any point in each receptor group, and data are provided for the baseline year (2004) analysis and for both coal production scenarios for 2015 and 2020. BLM cautions that the model results should not be construed as predicting an actual exceedance of any standard, but are indicators of potential impacts.

The results of the modeling depict the anticipated changes under both development scenarios. For the Wyoming near-field receptors, the predicted impact of the 24-hour PM_{10} and $PM_{2.5}$ concentrations show localized exceedances of the National Ambient Air Quality Standard (NAAQS) for the baseline year (2004), as well as for both development scenarios for 2015 and 2020. The 2020 development scenarios show the concentration increases by a factor of 2.5 relative to the base year for these parameters. Additionally, while down about 10% from 2015, 2020 development scenarios show a 20% increase of annual PM_{10} and $PM_{2.5}$ concentrations at peak Wyoming near-field receptors. This level of increase indicated modeled exceedances of annual standards for $PM_{2.5}$. Impacts of NO_2 and SO_2 emissions are predicted to be below the NAAQS and Wyoming Ambient Air Quality Standards (WAAQS) at the Wyoming near-field receptors.

None of the modeled Class I areas currently has, or is predicted to have, NAAQS or WAAQS exceedances. Modeling results for all sensitive Class II areas are below PSD increment levels for both 2020 development scenarios.

For the baseline year, the maximum visibility impacts at Class I areas were determined to be at the Northern Cheyenne Indian Reservation in Montana and at Wind Cave and Badlands National Parks in South Dakota. For these locations, modeling showed more than 200 days of impacts with a change of 10% or more in extinction. A 10% change in extinction corresponds to 1.0 deciview (dv).

Table 2.2-4 provides a detailed listing of visibility impacts for all analyzed Class I and sensitive Class II areas. As with the 2015 modeling results, 2020 modeled visibility impacts at the identified Class I areas continue to show a similar pattern as exhibited for the base year (2004), with a high number of days with a greater than 10% change in visibility at the most impacted Class I areas. Visibility impacts at Badlands National Park, the Northern Cheyenne Indian Reservation, and Wind Cave National Park all have greater than 10% change for more than 200 days a year during the base year. These Class I areas are the top three Class I areas with the highest predicted change in light extinction in 2020. All but four of the sensitive Class II areas have more than 100 days per year with greater than a 10% change during the base year. The most significant visibility change to sensitive Class II areas in 2020 is predicted for Black Elk Wilderness Area and Mount Rushmore National Monument. Class II areas do not have any visibility protection under federal or state law. To provide a basis for discussing the modeled visibility impacts resulting from the projected increased production under the lower and upper coal production scenarios for 2020, the modeled visibility impacts for 2004 were subtracted from the model results for 2020.

Power plants currently are the major contributors to all SO_2 impacts in the near-field in both states. However, the projected impacts are well below any ambient standard or PSD increment. According to the PRB Coal Review Air Quality modeling analysis, predicted future expansion modeled to the year 2020 should not jeopardize the attainment of those standards. Impacts on NO_2 concentrations are the result of emissions from all the source groups. No one source group dominates the NO_2 impacts in the near-field.

2.2.9 Socioeconomics

The cumulative socioeconomic analysis area for the Coal Review was comprised of two economic regions: Campbell County alone, and those Wyoming counties bordering Campbell County and linked to its economy by established industrial and consumer trade linkages and by workforce commuting patterns. Results for the second region were analyzed to focus on the five counties, Converse, Crook, Johnson, Sheridan, and Weston, that are the most directly linked. Collectively, these five counties are referred to in the PRB Coal Review Task 3C Report (BLM 2005c) as the surrounding counties. Additional analysis was undertaken to translate the population and employment forecasts for each of the surrounding counties into housing needs and to project future school enrollment.

The most recent period of extended energy development was accompanied by substantial economic changes and benefits, including economic growth, employment opportunity, tax revenue growth, and infrastructure development for local governments, both locally and across Wyoming, funded by tax revenues generated by production of coal and other energy resources. At the same time, periods of rapid growth stressed certain communities and their social structures, housing resources, and public infrastructure and service systems.

The emergence of the coal and other energy resource development industries in the PRB has had long-term cumulative effects on regional social and economic conditions. In general, Campbell County and the entire PRB region have developed an enhanced capacity to respond to and accommodate growth. The regional coal industry also provides a measure of insulation from dramatic economic and social dislocations. Key cumulative social and economic conditions identified in the PRB Coal Review are described below.

2.2.9.1 Employment and the Economic Base

According to the BLM Coal Review, energy resource development since 1970 resulted in substantial economic expansion across the PRB. Total employment expanded by 163% as 40,674 net new jobs were added between 1970 and 2004. The most rapid expansion occurred between 1975 and 1980. After modest growth and slight decline in the 1980s and early 1990s, employment growth resumed in the late 1990s, led by increases in coal mine employment, including subcontractors, and CBNG development. Across the

six-county area, total employment was 65,597 in 2004. Nearly half of the net job gain occurred in Campbell County, where total employment increased from 6,026 jobs in 1970 to 25,921 jobs in 2004.

The economic stimuli associated with the gains in mining and CBNG employment and the long-term population growth was accompanied by secondary job gains in construction, trade, services, and government. In 2004, business and consumer services accounted for 51% of all jobs in the region, while mining and government accounted for 14% and 16% of all jobs, respectively. Farm employment in the region, as a share of total employment, declined from 14% in 1970 to 5% in 2004, primarily due to growth in non-farm employment rather than declines in farming. Total farm employment in the PRB recorded a net decline of only 375 jobs, from 3,571 to 3,196 (U.S. Bureau of Economic Analysis in BLM 2005c).

Beyond 2010, the BLM PRB Coal Review projects that total mining industry employment will decline as major infrastructure development (e.g., additional CBNG compression capacity) is completed and the pace of conventional oil and gas drilling decreases. Increases in CBNG production and coal mining employment are projected thereafter, such that total mining employment would approach pre-2010 levels by the end of the forecast period (2020). Construction of three new power plants, having a combined capacity of 1,000 MW and a peak work force of approximately 1,550 in 2007-2008, is essentially complete. Under the upper production scenario, a second temporary construction work force impact could occur between 2016 and 2020 in conjunction with the construction of an additional 700-MW power plant.

2.2.9.2 Labor Market Conditions

Personal Income

According to the BLM Coal Review, personal incomes in the region will increase over the time period 2007-2020, both in aggregate and on a per capita basis, in conjunction with the economic outlooks foreshadowed by the projected development scenarios. In 2004, total personal income in the six-county area was $3.24 billion. Under the lower production scenario, total personal income would more than double to $7.57 billion in 2020. The upper production scenario would generate an additional $266 million per year in Campbell County and an additional $35 to $40 million per year in the surrounding counties by 2020. Annual per capita incomes are projected to

increase by approximately 27% (in real terms) across the region between 2003 and 2020. Households with one or more workers employed directly in the energy industry, associated service firms, and the construction industry likely would realize larger shares of the gains (BLM 2005c).

Population and Demographics

Population change over time is perhaps the single best indicator of cumulative social and economic change in the PRB. Campbell County was not among the original 13 counties when Wyoming was admitted to statehood, but was carved from Weston and Crook counties in 1911. Campbell County's 1920 population of 5,233 ranked it 17th among Wyoming's counties. Forty years later and prior to the onset of coal development in the region, Campbell County ranked 18th among Wyoming's 23 counties in terms of population, with 5,861 residents. Neighboring Converse, Sheridan, and Weston counties all had larger populations.

By 1980, Campbell County's population had increased by more than 300%, to 24,367, 7th among Wyoming's counties. Energy development contributed to population growth in Sheridan, Converse, Johnson, and Crook counties during that period. Weston County recorded a population decline during the period; however, the combined population of the PRB climbed from 49,311 in 1960 to 82,598 in 1980.

Annual coal production in the PRB has increased by nearly 560% since 1980, accompanied by expanded mine service and rail transportation capacity, stimulating further growth. The region's population gained a relatively modest 11%, 9,318 residents, between 1980 and 2000, reaching 91,916. Campbell County registered a net gain of 9,331 residents during that period, raising its total population to 33,698 in 2000, fourth highest in the state. Across the PRB, the loss of about 2,000 residents in Converse County was offset by modest gains in the other four counties (source: U.S. Census Bureau in BLM 2005c).

After 2000, the PRB saw renewed population growth, primarily linked to CBNG development. Population estimates for 2006 indicate a total regional population of 100,504, a 9.3% increase over the 2000 census population. Gains were reported for all six counties, ranging from 118 persons in Weston County to 5,236 persons in Campbell County (Table 2.2-5).

The magnitude and timing of projected employment changes from 2003-2020 under either coal production scenario would trigger corresponding effects to population across the PRB, particularly in Campbell County.

Under the lower coal production scenario, Campbell County's population is projected to increase by more than 14,550 residents between 2003 and 2020. The projected energy and mineral development in the lower coal production scenario would also result in substantial population growth elsewhere in the PRB, with Sheridan, Johnson, and Converse counties all projected to gain substantial population. Population growth, like employment growth, is projected to moderate after 2010. Projected population growth between 2003 and 2020 ranges from 0.5% compounded annual growth rate (CAGR) in Weston County to 2.0% CAGR in Campbell County. In absolute terms, the net change ranges from 537 additional residents in Weston County to a gain of 14,557 residents in Campbell County. The total population of the six-county study area is projected to climb to 120,178 in 2020, a 1.3% CAGR.

The BLM PRB Coal Review indicates that population and employment in Crook County will be minimally impacted by the projected growth due to PRB energy development, and therefore it is concluded that the minor impacts from the Ross ISR Project described in Section 4.10 will have insignificant cumulative impacts on the PRB or the Ross ISR Project region of influence.

Housing

While the population grew by 55% in the 1970s, the housing stock in the PRB Coal Review study area grew by almost 78%. Housing growth was especially rapid during the 1970s in Campbell County, where population grew by 88% and the housing stock grew by 140%. The expansion in housing supply, combined with the slowdown in the rate of population growth, produced double-digit vacancy rates for rental housing in the late 1980s and early 1990s. After growth resumed in the mid-1990s, most county-level vacancy rates for ownership units were at or below the state levels in 2000. Vacancy rates for rental units declined even more sharply. Vacancy rates fell even more in the early 21st century, to rates below 1.5% in five of the six counties in the study area, and that in Johnson County at only 2.8% (Table 2.2-6).

In 2000, the housing inventory in the six-county study area was 41,203 units (Table 2.2-7). Total housing inventory had expanded to 43,363 units in 2005, a net addition of 2,160 since 2000.

In 2005, the average sales price of homes in the study area varied from $80,303 in Weston County to $186,095 in Sheridan County. The average home price statewide in 2006 was $178,183 (Wyoming Housing Database Partnership in BLM 2005c). In addition to Sheridan County, Campbell ($185,874) and Johnson ($180,209) counties also had average home sale prices above the statewide average in 2006.

Both projected coal production scenarios indicate a strong demand for housing across the six-county study area through 2020. Net housing requirements under the lower coal production scenario are for approximately 9,110 units through 2020, a 21% increase above the 2006 existing inventory. New housing requirements under the upper coal production scenario are estimated at 10,900 units, a 25% increase compared to the 2006 inventory and 1,790 units more than for the lower coal production scenario. Approximately 60% of the overall demand for new housing would be in Campbell County.

The BLM PRB Coal Review was written before the economic downturn which began in late 2007. As discussed in Section 4.10, employment for the Ross ISR Project is expected to be met largely from the existing labor force, and will comprise only a small fraction of the currently unemployed workers in the area (Section 4.10.1). Therefore, even if the projections in the BLM Coal review are borne out by 2020, the cumulative impacts on housing and employment with the Ross ISR Project will be minimal.

Public Education

Public school enrollment trends generally mirrored population trends during the period of rapid population growth. District-wide enrollment in Campbell County grew by more than 4,600 students (131%) between 1975 and 1985. Enrollment in Campbell County School District (CCSD) #1 subsequently peaked, but remained near record high levels for nearly a decade. Elsewhere in the region enrollments generally declined with a combined enrollment of 9,525 in the other study area districts in 2005, the lowest since 1975 (source: Wyoming Department of Education in BLM 2005c). Recent natural gas and mining development tempered, but did not reverse, the trend of declining school enrollments across the region.

According to the BLM PRB Coal Review, communities across the PRB study area would see population growth due to economic migration from 2003 to 2020; however, the effects of such migration on public school enrollments would vary. As the demographics of the population change, school districts in the PRB would be affected by new trends. In some counties, the size of the school-age population may even trend in the opposite direction of total population in the short term due to underlying demographics of the established resident population.

The demographic projections for BLM's two coal production scenarios forecast growth in elementary school enrollments in Campbell County through 2010 and after 2010 for most PRB school districts. Projected enrollments in CCSD #1 would be approximately 10% higher by 2020 under the upper coal production scenario, with those in the surrounding districts about 1% higher. However, several districts still may experience enrollment levels in 2020 below current levels, as growth from 2010 to 2020 would not offset recent declines or those projected to occur before 2010.

Under either scenario, projected enrollments may cause short-term school capacity shortages, depending on the specific grade levels and residential locations of the additional students. Under the Wyoming School Facilities Commission planning guidelines, impacted school districts generally need to accommodate minor capacity shortages through the use of temporary facilities, such as portable classrooms. For larger and more long-term increases, the Commission's policy is to fund capital expansion where warranted by projections developed during updates of school districts' 5-year plans. The approved 5-year plan for CCSD #1 has a $57.4 million budget covering construction of several new schools and numerous major maintenance and facility upgrade projects. The approved 5-year plans for the other school districts have a combined cost of $163 million. Capital investment in public education facilities has been a statewide priority in Wyoming for the past decade, with taxes and royalties on mineral and energy resources the primary source of program funding (sources: Wyoming School Facilities Commission and Wyoming CREG in BLM 2005c).

Facilities and Services

The types and levels of facilities and services provided by local governments reflect service demand, revenue availability, and community

values regarding appropriate services and service standards. As with most socioeconomic characteristics, the level and availability of local government facilities and services vary by county and community across the PRB. There are several hundred separate service providers in the region. Although virtually all local government facilities and services are affected by energy development and the demand related thereto, the critical facilities and services include municipal water and sewer systems, law enforcement at the county level, and medical facilities. However, the baseline studies described in Section 3.10 revealed no critical needs or shortfalls and indicated that Crook and Campbell counties are engaged in an ongoing long-term process to maintain and improve emergency and medical facilities and services to meet community needs and to comply with various regulations and standards.

The PRB Coal Review socioeconomic analysis focuses on water supply and wastewater systems (two essential services that are costly and have the longest lead times to develop) and law enforcement, emergency response, and road maintenance (three services that typically are most affected by energy development).

Water supply and wastewater systems in most communities have the capacity to accommodate the cumulative population growth associated with either projected coal production scenario through 2020, assuming ongoing or planned improvements are completed. In Gillette, there may be a timing issue with planned water supply system expansions, as completion of planned improvements would occur when substantial growth is anticipated under both projected coal production scenarios. Consequently, Gillette may experience water shortages in the summer months for several years, particularly if growth follows that under the upper coal production scenario.

Growth rates and resultant increases in service demands would slow substantially during both the 2011 to 2015 and 2016 to 2020 periods under either projected coal production scenario.

<u>Fiscal Conditions</u>

Federal mineral royalties and state and local taxes levied on coal and other mineral production are vitally important sources of public revenue in Wyoming. Taxes, fees, and charges levied on real estate improvements, retail trade, and other economic activity supported by energy development provide additional revenues to support public facilities and services. These revenues

benefit not only those jurisdictions within which the production or activity occurs, but also the federal treasury, state coffers, school districts, and local governments across the state through revenue-sharing and intergovernmental transfer mechanisms.

Minerals produced in Wyoming, regardless of ownership, are subject to ad valorem taxation by local taxing entities and a statewide severance tax to support public services, particularly education.

Because Campbell County has been the primary beneficiary of mineral production gains over the past three decades and the recent gains tied to CBNG, the county's assessed valuation in 2008 ($4.72 billion) was nearly 30 times that of Crook County ($161 million) (refer to Section 3.10.3.3).

Taxes and mineral royalties levied on energy and mineral resource production accruing to the state are disbursed to the Permanent Water Development Trust Fund, Wyoming School Foundation and Capital Facilities funds, capital construction fund for state and local government facilities, and other programs according to a legislatively-approved formula. Through these funds, the revenues derived from resource development benefit the entire state, not just agencies, businesses, and residents of the PRB.

County governments and school districts will realize benefits from future energy and mineral resource development in the form of ad valorem taxes (see Section 3.10.3 and 4.10.1.2). Local governments will benefit from property taxes on new development, as well as from sales and use taxes on taxable sales within their boundaries. Such revenues for the Ross ISR Project are described in Section 4.10.1. Such revenues are a small part of the State total, and therefore will have a small cumulative impact but will be a significant revenue source for Crook County.

Social Setting

Cumulative energy development in the PRB through the year 2020 has the potential to generate beneficial and adverse effects on community social conditions. Social effects of development activities in the PRB will vary between counties and communities based on the existing social setting and the type of development that occurs.

Beneficial social effects would be associated with an expanding economy and employment opportunities associated with energy development and

resulting improvements in living standards for those employed in energy-related industries. Adverse social effects could occur as a result of conflicts over land use and environmental values. Negative social effects also could occur if the pace of growth exceeds the abilities of affected communities to accommodate energy-related employees and their families with housing and community services.

Social effects on communities in the PRB other than Gillette and Campbell County are likely to be minimal to moderate. Energy-related population growth is anticipated to be moderate in these other communities. Converse, Weston, and Crook counties could experience spillover growth from projects in Campbell County.

2.3 Comparison of the Predicted Environmental Impacts

As discussed above, Strata has identified and developed the Proposed Action as the best approach to recovering uranium resources from the proposed Ross ISR Project. Table 2.3-1 presents a chart of predicted potential impacts associated with the No Action Alternative (Section 2.1.1) compared to the Proposed Action (Section 2.1.2), and alternatives considered but eliminated from further analysis in this ER, including: alternate wellfield layout (Section 2.1.3.1), conventional mining/milling, including heap leaching (Section 2.1.3.2), alternate CPP locations (Section 2.1.3.3), alternate lixiviants (Section 2.1.3.4), alternate waste management (Section 2.1.3.5), uranium processing alternatives (Section 2.1.3.6), alternate CPP size (Section 2.1.3.7) and arsenic and selenium recovery (2.1.3.8). Chapter 4 of this ER provides a more detailed discussion of potential environmental impacts of the Proposed Action and No Action Alternative.

Table 2.2-1. Draft and Final EISs Related to Northeastern Wyoming or NRC Projects from February 2008 to December 2010

Date	Agency	Report	Title
5/30/2008	USFS	Draft EIS	Inyan Kara Analysis Area Vegetation Management, Niobrara and Weston Counties
9/5/2008	USFS	Final EIS	Inyan Kara Analysis Area Vegetation Management, Niobrara and Weston Counties
10/24/2008	BLM	Draft EIS	South Gillette Area Coal Lease Applications, Campbell County
12/19/2008	BLM	Final EIS	West Antelope Coal Lease Application, Converse and Campbell Counties
6/26/2009	BLM	Draft EIS	Wright Area Coal Lease Project, Campbell County
8/17/2009	BLM	Final EIS	South Gillette Area Coal Lease Applications, Campbell County
10/9/2009	USFS	Draft EIS	Rattlesnake Forest Management Project, Crook County
10/16/2009	USFS	Final EIS	Thunder Basin National Grassland Prairie Dog Management Strategy, Campbell, Converse, Niobrara and Weston Counties
12/11/2009	NRC	Draft EIS	Lost Creek ISR Project, Proposal to Construct, Operate, Conduct Aquifer Restoration, and Decommission an ISR Uranium Milling Facility, Sweetwater County
12/11/2009	NRC	Draft EIS	Moore Ranch ISR Project, Proposal to Construct, Operate, Conduct Aquifer Restoration, and Decommission an ISR Uranium Milling Facility, Campbell County, WY
12/11/2009	NRC	Draft EIS	Nichols Ranch ISR Project, Proposal to Construct, Operate, Conduct Aquifer Restoration, and Decommission an ISR Uranium Milling Facility, Campbell and Johnson Counties
3/12/2010	BLM	Draft EIS	Buckskin Mine Hay Creek II Project, Campbell County
5/14/2010	USFS	Final EIS	Rattlesnake Forest Management Project, Crook County
7/30/2010	BLM	Final EIS	Wright Area Coal Lease Project, Campbell County
8/27/2010	NRC	Final EIS	Moore Ranch ISR Project, Proposal to Construct, Operate, Conduct Aquifer Restoration, and Decommission an ISR Facility, Campbell County

Source: EPA 2010

Table 2.2-2. Status of Uranium Recovery Facility Applications, Reviews, and Letters of Intent

ID #	Company	Site	State	County	Design Type	Application Date	Status Code[1]	Letter of Intent[2]
1	Uranium One	Christensen Ranch	WY	Johnson-Campbell	ISR - Restart	Apr-07	5	None
2	Cameco (Crow Butte Resources, Inc.)	Crow Butte - North Trend	NE	Dawes	ISR - Expansion	Jun-07	4	None
3	Cameco (Crow Butte Resources, Inc.)	Crow Butte - Plant Upgrade	NE	Dawes	ISR - Expansion	Oct-06	5	None
4	Lost Creek ISR, LLC	Lost Creek	WY	Sweetwater	ISR - New	Mar-08	4	5/23/07
5	Uranerz Energy Corp.	Nichols Ranch	WY	Johnson-Campbell	ISR - New	Dec-07	4	6/27/07
6	Uranium One	Moore Ranch	WY	Converse	ISR - New	Oct-07	4	5/31/07
7	Uranium One	Jab and Antelope	WY	Sweetwater	ISR - New	Sep-08	3	5/31/07
8	Powertech Uranium Corporation	Dewey Burdock	SD	Custer-Fall River	ISR - New	Aug-09	4	1/26/07
9	Uranium One	Ludeman	WY	Converse	ISR - Expansion	Jan-10	3	2/26/09
10	Cameco (Crow Butte Resources, Inc.)	Three Crow	NE	Dawes	ISR - Expansion	Jul-10	1	1/11/10
11	Uranium One	Allemand-Ross	WY	Converse	ISR - Expansion	Sep-10	1	2/26/09
12	Lost Creek ISR, LLC	Lost Creek	WY	Sweetwater	ISR - Expansion	Nov-10	1	1/06/10
13	Strata Energy, Inc.	Ross	WY	Crook	ISR - New	Dec-10	1	10/05/09[3]
14	UR-Energy Corp.	Lost Soldier - Amendment	WY	Sweetwater	ISR - Expansion	Dec-10	1	1/06/10
15	Cameco (Power Resources, Inc.)	Smith Ranch/Highland CPP	WY	Converse	ISR - Expansion	FY 2011	1	1/14/10
16	Titan Uranium USA, Inc.	Sheep Mountain	WY	Fremont	Heap Leach - New	Apr-11	1	2/16/10
17	Neutron Energy	Marquez	NM	Sandoval	Conventional - New	May-11	1	1/15/10
18	Uranium Energy Corporation	Grants Ridge	NM	Cibola	Heap Leach - New	Jun-11	1	2/04/10
19	Rio Grande Resources	Mt. Taylor	NM	McKinley	Conventional - New	TBD	1	12/15/09
20	Wildhorse Energy	West Alkali Creek	WY	Fremont	ISR - New	TBD	1	1/07/10
21	Strathmore Minerals Corporation	Gas Hills	WY	Fremont	Conventional - New	Oct-11	1	1/18/10
22	Strathmore Minerals Corporation	Roca Honda	NM	McKinley	Conventional - New	Dec-11	1	1/18/10
23	AUC LLC	Reno Creek	WY	Campbell	ISR - New	Dec-11	1	4/13/10
24	Cameco (Crow Butte Resources, Inc.)	Marsland	NE	Dawes	ISR - Expansion	Jun-12	1	1/11/10
25	Cameco (Power Resources, Inc.)	Ruby Ranch	WY	Campbell	ISR - Expansion	FY 2013	1	1/14/10

[1] Code indicating the status of the application where: (1)=Not Received, (2)=Acceptance Review Ongoing, (3)=Not Accepted, Withdrawn, or Review Postponed, (4)=Technical Review Ongoing, and (5)=Licensing Action Completed

[2] Date of Letter of Intent if one was received by NRC, otherwise "None" - the Letter of Intent is used to notify the NRC of an impending application

[3] Submitted as Peninsula Minerals Ltd.

Source: NRC 2010

Table 2.2-3. Projected Maximum Potential Near-field Impacts (µg/m³)

Pollutant	Averaging Time	Base Year (2004) Impacts	2020 Lower Coal Development Scenario Impacts	2020 Upper Coal Development Scenario Impacts	NAAQS	Wyoming AAQS	Montana AAQS	PSD Class II Increments
				Wyoming Near-field				
NO_2	Annual	31.3	30.5	30.6	100	100	---[1]	25
SO_2	Annual	15.3	16.4	16.5	80	60	---	20
	24-hour	112.3	143.3	143.3	365	260	---	91
	3-hour	462.0	936.7	936.7	1,300	1,300	---	512
$PM_{2.5}$	Annual	13.4	**16.3**	**16.3**	15	15	---	---
	24-hour	**87.6**	**218.4**	**218.4**	35	35	---	---
PM_{10}	Annual	38.4	46.6	46.6	---	50	---	17
	24-hour	**250.4**	**624.1**	**624.3**	150	150	---	30
				Montana Near-field				
NO_2	Annual	3.3	2.5	2.6	100	---	100	25
	1-hour	409.0	440.1	442.7	188.1	---	564	---
SO_2	Annual	1.6	3.0	3.1	80	---	80	20
	24-hour	16.1	24.7	27.1	365	---	365	91
	3-hour	65.0	138.9	138.9	1,300	---	1,300	512
	1-hour	162.9	237.0	259.1	---	---	1,300	---
$PM_{2.5}$	Annual	1.0	0.9	0.9	15	---	15	---
	24-hour	10.2	10.2	10.2	35	---	35	---
PM_{10}	Annual	2.8	2.5	2.6	---	---	50	17
	24-hour	29.1	29.3	29.3	150	---	150	30

[1] Indicates no value, standard, or increment
Value units are microgram per cubic meter (µg/m³)
Bold values indicate projected exceedance of AAQS
Source: PRB Coal Review Task 3A Update Report (BLM 2009c)

Table 2.2-4. Modeled Change in Visibility Impacts at Class I and Sensitive Class II Areas

Location	Base Year (2004) No. of Days >10%	2020 Lower Coal Development Scenario Change in No. of Days >10%	2020 Upper Coal Development Scenario Change in No. of Days >10%
Class I Areas			
Badlands National Park	218	44	44
Bob Marshall Wilderness Area	8	0	0
Bridger Wilderness Area	144	5	5
Fitzpatrick Wilderness Area	91	6	6
Fort Peck Indian Reservation	105	20	21
Gates of the Mountain Wilderness Area	55	4	4
Grand Teton National Park	70	6	6
North Absaroka Wilderness Area	61	8	8
North Cheyenne Indian Reservation	243	59	60
Red Rock Lakes	42	3	3
Scapegoat Wilderness Area	27	2	2
Teton Wilderness Area	57	8	8
Theodore Roosevelt National Park	178	24	24
UL Bend Wilderness Area	77	18	18
Washakie Wilderness Area	83	8	8
Wind Cave National Park	262	28	31
Yellowstone National Park	84	5	5
Sensitive Class II Areas			
Absaroka Beartooth Wilderness Area	101	10	10
Agate Fossil Beds National Monument	251	26	26
Big Horn Canyon National Rec. Area	331	1	1
Black Elk Wilderness Area	236	47	47
Cloud Peak Wilderness Area	126	29	30
Crow Indian Reservation	360	3	3
Devils Tower National Monument	274	31	32
Fort Belknap Indian Reservation	66	14	15
Fort Laramie National Historic Site	260	15	16
Jedediah Smith Wilderness Area	79	3	5
Jewel Cave National Monument	261	36	37
Lee Metcalf Wilderness Area	97	2	2
Mount Naomi Wilderness Area	51	1	1
Mount Rushmore National Monument	222	49	52
Popo Agie Wilderness Area	139	6	6
Soldier Creek Wilderness Area	268	19	19
Wellsville Mountain Wilderness Area	130	17	17
Wind River Indian Reservation	217	9	10

Source: PRB Coal Review Task 3A Update Report (BLM 2009c)

Table 2.2-5. Recent and Projected PRB Population

Year	Campbell County	Converse County	Crook County	Johnson County	Sheridan County	Weston County	Six County PRB Total
				Census			
2000	33,698	12,104	5,895	7,108	26,606	6,642	92,053
2003	36,381	12,326	5,971	7,530	27,116	6,665	95,989
2006	38,934	12,866	6,255	8,014	27,673	6,762	100,504
				Lower Coal Production Scenario			
2010	45,925	13,103	6,542	8,389	28,459	7,108	109,526
2015	48,905	13,671	6,759	8,867	30,016	7,174	115,392
2020	50,995	14,193	6,989	9,326	31,467	7,208	120,178
				Upper Coal Production Scenario			
2010	47,662	13,160	6,570	8,424	28,579	7,137	111,532
2015	51,558	13,763	6,802	8,924	30,214	7,219	118,480
2020	54,943	14,313	7,045	9,403	31,733	7,266	124,703

Source: USCB in PRB Coal Review Task 3C Report (BLM 2005c)

Table 2.2-6. Rental Housing Vacancy Rates, 2004 4Q and 2006 4Q

Year	Campbell County	Converse County	Crook County	Johnson County	Sheridan County	Weston County	Wyoming
2004 4Q	2.8%	8.3%	10.4%	2.1%	4.5%	5.0%	4.8%
2006 4Q	0.4%	1.4%	1.0%	2.8%	0.5%	0.0%	2.4%

Source: Wyoming Housing Database Partnership in PRB Coal Review Task 3C Report (BLM 2005c)

Table 2.2-7. Total Housing Stock in 2000 and 2005

Year	Campbell County	Converse County	Crook County	Johnson County	Sheridan County	Weston County	Six-county PRB Region
2000	13,288	5,669	2,935	3,503	12,577	3,231	41,203
2005	14,085	5,852	3,132	3,694	13,283	3,317	43,363
Change	797	183	197	191	706	86	2,160

Source: USCB in PRB Coal Review Task 3C Report (BLM 2005c)

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives

Potential Impact	Alternative	Potential Impacts
Potential Land Surface Impacts	Proposed Action	Surface disturbance on about 280 acres, or about 16% of proposed project area. Disturbance will range from short term for construction of well pads and utility corridors that will be reclaimed after construction to long term for roads, buildings, parking areas, and ponds that will remain until final D&D. All disturbance will be reclaimed to be suitable for pre-construction uses after aquifer restoration and D&D.
	No Action	None
	Alternative Wellfield Layout	Not analyzed in detail, but surface disturbance would be similar in severity and of longer duration than Proposed Action.
	Conventional Mining/Milling including Heap Leaching	Open-pit mining could disturb up to five times as much area for pit, ramps, and material stockpiling and would create permanent topographic changes. Conventional milling requires crushing of ore and disposal of tailings, creating long-term or permanent 11e.(2) byproduct material disposal area.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Disposal in evaporation ponds would require considerably more long-term surface disturbance due to evaporative surface required. Residue left after evaporation would be 11e.(2) byproduct material that would require disposal in an appropriately licensed facility.
	Uranium Processing Alternatives	Use of single-stage rather than two-stage RO treatment of bleed and restoration solutions would create twice as much brine as Proposed Action, requiring larger storage ponds - much larger ponds if evaporation is selected for waste water disposal. Reducing RO treatment of water recovered during aquifer restoration would increase surface area required for water storage and may increase the duration of the project due to longer time to achieve aquifer restoration.
	Alternate Size of CPP	Same as Proposed Action
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Land Use Impacts	Proposed Action	Restricted access on up to 1,721.3 acres for 8-12 years (construction through decommissioning) which will have small impacts on livestock grazing and hunting.
	No Action	None
	Alternative Wellfield Layout	Not analyzed in detail, but land use restrictions would be similar in severity and of longer duration than Proposed Action.
	Conventional Mining/Milling including Heap Leaching	Area used for pit, ramps, haul roads, overburden stockpiles and topsoil stockpiles would be unavailable for any other uses for the duration of the operation, including decommissioning. Tailings piles would be a permanent restricted-use area.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Larger area required for water retention ponds would be unavailable for any other uses during project duration.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Same as Proposed Action
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Transportation Impacts	Proposed Action	Approximately 30 acres will be disturbed for life of project to construct access roads. Traffic will increase on local public roads, peaking during construction. Chemicals being hauled to the site and products being hauled away, including small quantities of 11e.(2) byproduct material, pose small risk of spill during project life. Some roads might remain after decommissioning if they support the post-decommissioning land use and are desired by the surface owner.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Open-pit mine would most likely require relocation of local roads to accommodate pits, overburden stockpiles, and tailings impoundments. Conventional mining methods would require more employees with accompanying traffic on local roads.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action, possibly for longer duration since aquifer restoration could require more time.
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Use of single-stage RO treatment would require more area used for ponds than Proposed Action.
	Alternate Size of CPP	A smaller CPP would require fewer people and less materials to construct. If uranium-loaded IX resin were not processed, there would be no shipments of resin and fewer shipments of chemicals and yellowcake.
	Arsenic and Selenium Recovery	Similar to proposed action, with slightly more equipment, chemical, and product shipments.

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Geology and Soils Impacts	Proposed Action	No significant impacts on geology. About 280 acres will be stripped of topsoil for construction of facilities. Topsoil will be stockpiled and protected from erosion until it is replaced during reclamation. After topsoil is replaced and revegetated, the land will support the pre-construction uses of livestock grazing and limited hunting.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Open-pit mining would be much more radical in terms of impacts on geology and soils. All the materials from the surface through the ore zone would be removed. Overburden would be stockpiled during mining and replaced in the pit after mining as a relatively homogeneous mixture of the original, stratified overburden.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action, although project duration could be extended if alternative lixiviants require more time for aquifer restoration.
	Alternate Waste Management	More area for retention/evaporation ponds would require more topsoil removal and stockpiling, which would last for the life of the operation.
	Uranium Processing Alternatives	Use of single-stage RO treatment would require more area used for ponds (hence, topsoil removal) than Proposed Action.
	Alternate Size of CPP	Similar to Proposed Action. There would be slightly less soil disturbance for a smaller CPP.
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Surface Water Impacts	Proposed Action	Small risk of increased sediment load to ephemeral stream channels due to surface disturbance. Small risk of spill of chemicals or fuels during project life. Small potential for impacting surface water if excess permeate is managed through WYPDES discharge or land application. Risks minimized by applying BMPs.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Open-pit mining would alter the surface drainage network, including requirement to divert surface water around the pit and stockpile area and restore all affected streams after mining. Larger disturbed area would present larger risk of sediment contributions to surface waters. Large amount of groundwater to be treated and discharged for either open-pit or underground mine would impact drainages which normally see only ephemeral flow events.
	Alternate CPP Location	Similar to Proposed Action, depending on CPP proximity to surface water.
	Use of Alternate Lixiviants	Increased potential risk to surface water associated with potential spill of acid or ammonia-based lixiviant compared to sodium-bicarbonate based lixiviant.
	Alternate Waste Management	Larger ponds would pose greater risk of spill to surface waters and disturb more acreage, presenting more risk of increased sediment load to streams.
	Uranium Processing Alternatives	Larger ponds would pose greater risk of spill to surface waters and disturb more acreage, presenting more risk of increased sediment load to streams. Little or no excess permeate would be generated if groundwater sweep solutions were not treated by RO. Potential surface water impacts from WYPDES discharge or land application of permeate would therefore be avoided.
	Alternate Size of CPP	Same as Proposed Action
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Groundwater Impacts	Proposed Action	Small risk that adjacent aquifers could be contaminated by excursion of recovery solution and would require cleanup. Small risk that shallow groundwater could be contaminated by leaks or spills. Small net withdrawal of water from the ore zone aquifer during operation to contain fluids. Some of the water withdrawn will be evaporated in ponds or disposed by deep well injection and thus represents a consumptive use. Water consumed will be replaced by natural recharge over time.
	No Action	None
	Alternative Wellfield Layout	Repeated recompletion of wells and potential well integrity problems would add to duration of operation and aquifer restoration.
	Conventional Mining/Milling including Heap Leaching	Open-pit and underground mining would drastically alter the hydrogeology of the area. All discrete aquifers from the surface to the bottom of the ore zone would be exposed in the pit, requiring water management, dewatering, treatment and disposal, and possibly creating safety hazards from highwall failures or cave-ins. Changes to aquifers would be permanent. Groundwater removed to allow conventional mining would have to be discharged, affecting streamflow patterns.
	Alternate CPP Location	Similar to Proposed Action, depending on CPP proximity to shallow groundwater.
	Use of Alternate Lixiviants	Same as Proposed Action, possibly with longer duration due to extended time for aquifer restoration.
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Use of single-stage RO or not treating groundwater sweep recovery solutions with RO would increase net amount of groundwater withdrawn from ore zone aquifer.
	Alternate Size of CPP	Same as Proposed Action
	Arsenic and Selenium Recovery	Similar to Proposed Action, except that aquifer restoration could require less time if selenium is recovered during operations.

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Ecological Impacts	Proposed Action	No threatened or endangered species will be impacted. No critical game habitat will be impacted. Small, temporary loss of habitat for some species will occur for life of project. BMPs will limit waterfowl and other wildlife access to lined retention ponds.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Much more surface disturbance, which will represent loss of habitat for life of project. Large quantities of water to be treated and discharged or stored in ponds would alter habitat for life of project.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Similar to Proposed Action, possibly for longer duration if aquifer restoration occurs more slowly.
	Alternate Waste Management	More terrestrial habitat lost due to need for larger impoundments.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Same as Proposed Action
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Air Quality Impacts	Proposed Action	Slight increases in fugitive dust will occur, mostly during construction. Fugitive dust will increase over baseline levels for life of project due to increased traffic over local road system. No violation of air quality standards will result. Combustion and greenhouse gas emissions are estimated and will be relatively low. Greenhouse gas emissions will be offset by the power generated from the recovered uranium.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Open-pit mining would expose much more disturbed surface to potential wind and water erosion and fugitive dust. Earthmoving equipment would increase emissions of greenhouse gases. Tailings piles and ponds and heap leach pads would increase risk of airborne contaminants, including radioactive materials.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Similar to Proposed Action, possibly for longer duration if alternative lixiviants require more time for aquifer restoration.
	Alternate Waste Management	More surface disturbance caused by need to construct larger ponds would increase emissions of fugitive dust.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Similar to Proposed Action. While there would be slightly fewer combustion emissions and greenhouse gas emissions if uranium-loaded IX resin were not received and processed, there would also be less carbon-offsetting power generated by the recovered uranium.
	Arsenic and Selenium Recovery	Similar to Proposed Action. Combustion emissions would be slightly higher due to increased material shipments.

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Noise Impacts	Proposed Action	Noise will increase over ambient levels, which are 35 to 45 dBA, over life of project, mostly from construction equipment and vehicles. Nearest residence could experience short-term noise above the 55-dBA "annoyance" threshold if construction occurs near the license boundary at its shortest distance from the residence.
	No Action	None
	Alternative Wellfield Layout	Similar to Proposed Action. Slight reduction in noise levels due to the installation of fewer injection and recovery wells would be offset by added noise due to recompletion and additional MIT.
	Conventional Mining/Milling including Heap Leaching	Open-pit mining would entail use of much more heavy equipment, a primary source of noise.
	Alternate CPP Location	Similar to Proposed Action, although local effects could vary depending upon location with respect to existing roads and residences.
	Use of Alternate Lixiviants	Similar to Proposed Action, possibly for longer duration if alternative lixiviants require more time for aquifer restoration.
	Alternate Waste Management	The need to construct larger ponds would increase severity and/or duration of noise from earthmoving equipment.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Similar to Proposed Action, with slightly fewer material shipments for a smaller CPP.
	Arsenic and Selenium Recovery	Similar to Proposed Action, with slightly more material shipments.

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Historical and Cultural Impacts	Proposed Action	Impacts will be small, since sites eligible for NRHP will be avoided, a phased process will be used to identify previously undiscovered cultural resources and a stop-work provision will be provided if any cultural resources are discovered during construction.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Same as Proposed Action, except that increased surface disturbance increases the risk that historical or cultural resources will be impacted if they are not noticed during construction.
	Alternate CPP Location	Similar to Proposed Action, although potential impacts could vary according to location with respect to historical and cultural resources.
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Similar to Proposed Action, except that additional surface disturbance caused by larger ponds increases risk that unknown historical or cultural resources will be impacted.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Same as Proposed Action
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Visual/Scenic Impacts	Proposed Action	Slight visual impacts will occur from new structures and construction equipment but will maintain consistency with BLM visual resource classification of the area.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Open-pit mine would create a significant visual impact, with large stockpiles and a large tailings impoundment that would be present for the life of the operation.
	Alternate CPP Location	Similar to Proposed Action. Potential impacts would depend on location relative to residences and roads.
	Use of Alternate Lixiviants	Same as Proposed Action, possibly for longer duration if alternative lixiviants prolonged the aquifer restoration phase.
	Alternate Waste Management	More and larger impoundments than required under the Proposed Action would have localized visual impacts.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Similar to Proposed Action. Potential impacts would be slightly less with smaller central plant area.
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Socioeconomic Impacts	Proposed Action	Most of the workforce is projected to come from the local area so there will be minimal impact on housing and local services. Project could employ up to 14% of the currently unemployed workforce in Campbell and Crook counties during construction, with employment declining during operation and decommissioning. Project would have slight, positive benefit to the State on severance tax, royalty, and sales and use tax collections and moderate benefits to Crook County on property and production taxes. Remoteness of the site might indicate slight need for increased emergency services (fire and ambulance service).
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Conventional mining and milling would require more employees than ISR recovery, and underground mining would likely require more employees than open-pit mining for the same amount of yellowcake produced per year. Local labor force might still be able to supply most of the employees, but would not be experienced in underground mining. Revenues to the State, which are based on production, would be similar to Proposed Action, but Crook County revenues from property taxes would be more due to additional equipment required for conventional mining.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action, possibly for longer duration if alternative lixiviants prolong aquifer restoration. The aquifer restoration phase has no revenues from mineral production and would require fewer employees than the operation phase, so impacts of extended aquifer restoration would be slight.
	Alternate Waste Management	Same as Proposed Action, possibly with extended construction period due to need to construct more and/or larger impoundments.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Fewer employees would be required to construct and operate a smaller CPP, and less tax revenue would be generated.
	Arsenic and Selenium Recovery	Similar to Proposed Action with slightly more revenue to Crook County due to higher property and production taxes.

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Nonradiological Health Impacts	Proposed Action	Slight risk of public exposure through chemical leaks and spills will be mitigated by employing BMPs.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Open-pit and underground mining have risk of more accidents and more severe accidents than ISR recovery operations. Safety hazards from conventional mining at the Ross site would be compounded by the depth of the ore zone (average nearly 500 feet) and weakly cemented, saturated sands in the ore zone and shallower aquifers, which would create risk of highwall and roof failures.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Similar to Proposed Action; acid or ammonia-based lixiviant would introduce additional nonradiological health risks.
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Similar to Proposed Action, since the same types of chemicals would be stored and used.
	Arsenic and Selenium Recovery	Similar to Proposed Action; arsenic and selenium processing would introduce additional nonradiological health risks.

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Radiological Health Impacts	Proposed Action	Modeling shows no impact to the public.
	No Action	None
	Alternative Wellfield Layout	None
	Conventional Mining/Milling including Heap Leaching	Conventional mining, particularly underground, presents more risk of exposure to radiation than ISR recovery. Tailings from conventional milling or heap leaching would constitute 11e.(2) byproduct material that would be a permanent feature of the landscape.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Similar to Proposed Action; potential impacts could be reduced slightly with smaller CPP and lined retention ponds.
	Arsenic and Selenium Recovery	Same as Proposed Action

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Waste Management Impacts	Proposed Action	Slight risk of exposure to public by transporting wastes to approved disposal site. Risk will be minimized by employing BMPs.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Conventional mining and milling creates considerably more waste than ISR, including tailings, which would be 11e.(2) byproduct material, and residue (salts and minerals) left over from treatment of the large amount of water that would be produced to allow access by open pits or underground tunnels.
	Alternate CPP Location	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Use of evaporation to dispose of liquid wastes would leave a residue of solids that would require disposal in a licensed facility as 11e.(2) byproduct material. If that facility were off site, there would be additional impacts from hauling the material to the disposal site. If that facility were created on site, it would be a permanent impact on the site.
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Similar to Proposed Action; potential impacts would be slightly reduced if a smaller CPP were constructed.
	Arsenic and Selenium Recovery	Similar to Proposed Action; slightly more waste could be generated during selenium and/or arsenic processing.

Table 2.3-1. Comparison of Potential Environmental Impacts for Various Alternatives (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Mineral Resource Recovery Impacts	Proposed Action	Applicant will coordinate with oil producer on the property to assure that the operation does not interfere with oil recovery. No other minerals will be impacted.
	No Action	None
	Alternative Wellfield Layout	Same as Proposed Action
	Conventional Mining/Milling including Heap Leaching	Any existing oil wells would represent a conflict with development of an open-pit mine and would have to be plugged and abandoned.
	Alternate CPP Location	Similar to Proposed Action; potential impacts would depend on proximity to mineral resource development.
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action
	Alternate Size of CPP	Same as Proposed Action
	Arsenic and Selenium Recovery	Same as Proposed Action

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3.0 DESCRIPTION OF THE AFFECTED ENVIRONMENT

The proposed Ross ISR Project is located in northeastern Wyoming. The proposed project area encompasses approximately 1,721 acres in portions of Sections 7, 17, 18, and 19, Township 53 North, Range 67 West, and portions of Sections 12, 13, and 24, Township 53 North, Range 68 West. This area is in western Crook County, within the Nebraska-South Dakota-Wyoming Uranium Milling Region defined in the ISR GEIS (NRC 2009a).

Nearby towns include Moorcroft (21.5 miles south), Pine Haven (17 miles southeast), Gillette (33 miles southwest), and Sundance (30 miles southeast). The proposed project area is adjacent to the unincorporated ranching community of Oshoto. There are 11 residences within 2 miles (3.2 km) of the proposed project area, but no residences within the proposed site boundary. Existing land uses include livestock grazing, oil production, crop production, communication and power lines, transportation, recreation, reservoirs, and wildlife habitat.

This chapter describes the existing site conditions at the proposed Ross ISR Project. The area of review includes the approximately 1,721 acres within the proposed site boundary plus additional potentially affected area that varies according to resource as described in the following sections. This section describes 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 information in this chapter forms the basis for assessing the potential impacts (see Chapter 4) of the Proposed Action and No Action Alternative (see Chapter 2).

3.1 Land Use

3.1.1 General Setting

The proposed Ross ISR Project is located in western Crook County. The proposed project area is 21.5 miles north of Moorcroft (2009 population est. 926), 17 miles northwest of Pine Haven (2009 population est. 396), 33 miles northeast of Gillette (2009 population est. 28,726), and 30 miles northwest of Sundance (2009 population est. 1,339). Nearby hospitals include the Crook County Memorial Hospital in Sundance and the Campbell County Memorial Hospital in Gillette. Nearby schools are described in Section 3.10. The general location of the proposed project area is shown in Figure 1.2-2. The proposed project area is located in the northwest quadrant of the Nebraska–South Dakota–Wyoming Uranium Milling Region (ISR GEIS).

Surface ownership within the proposed project area is primarily private, with intermingled State and federal (BLM) surface. This is consistent with the description of the land ownership for portions of Crook County within the Nebraska-South Dakota-Wyoming Milling Region in the ISR GEIS. The ISR GEIS (pg. 3.4-4) notes that land ownership is predominantly private, generally consisting of less than 10% BLM-administered lands. The distribution of surface ownership within the proposed project area is summarized in Table 3.1-1 and shown on Figure 1.2-4. Mineral ownership is also depicted on Figure 1.2-4 and summarized in Table 3.1-1. Of the approximately 1,367 acres of private surface ownership within the proposed project area, the federal government (BLM) manages the subsurface mineral rights under 160.9 acres (12%). As described in the ISR GEIS (pg. 3.1-8), BLM policy directives provide the authority and direction for administering the development of federal mineral resources beneath privately owned surface. These 160.9 acres represent the only occurrence of split estate within the proposed project area; all State-owned surface overlies State-owned subsurface mineral rights, and all Federal-owned surface overlies Federally owned subsurface mineral rights.

Areas of existing disturbance within the proposed project area include roads, utilities, oil wells, and activities associated with agriculture (including livestock and hay production). There are several maintained roads and three power lines that currently pass through the proposed project area. County roads that border or traverse the proposed project area and provide access to the proposed project area include D Road (CR 68), the New Haven Road (CR

164), Deadman Road (CR 211), the Oshoto Connection (CR 193), and Cabin Creek Road (CR 116). Refer to Figure 3.2-1 for nearby roads. D Road and the New Haven Road will be the primary access routes to the proposed project area. Several unnamed local access roads also provide private access within the proposed project area. For a complete description of the regional and local transportation corridors see Section 3.2 in this ER.

3.1.2 Land Use Classification

Existing land uses within 5 miles of the Ross ISR Project are shown on Figure 3.1-1. Within the proposed project area, existing land uses include: livestock grazing on rangeland, oil production, crop production, communication and power lines, transportation, recreation, reservoirs, and wildlife habitat. The mapped land use categories within 5 miles of the proposed project area include the following (Anderson et al. 1976):

- ♦ Mixed Rangeland: The Mixed Rangeland category is used when more than one-third intermixture of either herbaceous or shrub and brush rangeland species occur in a specific area.
- ♦ Herbaceous Rangeland: The Herbaceous Rangeland category encompasses lands dominated by naturally occurring grasses and forbs as well as those areas of rangeland which have been modified to include grasses and forbs as their principal cover. Most of the Herbaceous Rangeland in Wyoming consists of short grass.
- ♦ Cropland and Pasture: This category groups cropland and pasture together due to the difficulty in identifying the separate land uses from imagery alone. These areas include cropland harvested and pasture on land more or less permanently used for that purpose.
- ♦ 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.
- ♦ Evergreen Forest Land: The Evergreen Forest Land category includes all forested areas in which the trees are predominantly those which remain green throughout the year. Both coniferous and broadleaved evergreens are included in this category.
- ♦ Reservoirs: Reservoirs are artificial impoundments of water used for irrigation, flood control, municipal water supplies, recreation, hydroelectric power generation, and so forth.

Table 3.1-2 presents the percentage of land use in each category within the proposed project area and within 5 miles of the proposed project area. Note that this table also includes one land use category within the proposed project area not mapped on Figure 3.1-1 due to the mapping resolution: the combined category of transportation, communications, and utilities. Land use within the proposed project area is depicted on Figure 3.1-2. Approximately 80% of the proposed project area is currently used for livestock grazing. This is consistent with the analysis of this region in the ISR GEIS (pg. 3.4-4), which notes that cattle and sheep grazing represent the primary land use on private and federal lands within Crook County.

Historic land use is closely tied to historic water use as described in Section 3.4. From the beginning of the 20th century until the late 1970s, the proposed project area was primarily used for livestock production. Additional land uses included crop production (dry land and irrigated) recreation (hunting) and transportation (county roads). In the late 1970s, a portion of the proposed project area was used for a uranium ISR pilot project as described in Section 1.2.1. Also in the late 1970s, a producing oil field was developed. Future land use within the proposed project area is anticipated to remain the same as current land use for the foreseeable future as described in Section 3.1.12 below.

3.1.3 Livestock Production

In 2007 Crook County generated $39.6 million from the sale of livestock, poultry and their products, up from $36.7 million in 2002 (USDA-NASS 2010) Table 3.1-3 provides the 2009 livestock inventory for Crook County. According to the most recent agricultural census data (2007), there are also about 3,000 horses in Crook County.

The rangeland within the proposed project area is currently used for cattle and horse grazing. Future livestock production will likely continue to include cattle, horses and, potentially, sheep.

3.1.4 Crop Production

Wheat, hay and oats were the only crops commercially grown within Crook County in 2008 (USDA-NASS 2010). Table 3.1-4 shows agricultural yields for croplands in Crook County. Seventy acres of land contain irrigation water rights within the proposed project area, but crop production is currently

limited to dry land farming. There is a small portion (42 acres) of land in the southeast corner of the proposed project area used for commercial crop production. According to the vegetation study conducted for this project, in 2010 the cropland was seeded to wheat, but it has also been used for the production of oats and barley in the past.

3.1.5 Residences

There are no residences within the proposed project area. Table 3.1-5 shows the distance to the nearest residence and to the nearest site boundary from the center of the proposed project area for each of the 22 ½ degree sectors centered on each of the 16 compass points. The centroid of the proposed project area is in the NWSW Section 18, T53N, R67W, at latitude 44.57464°N, longitude 104.95981°W (NAD83). There are 11 residences within a 2-mile (3.2-km) radius of the proposed project area. Based on landowner interviews conducted during regional baseline monitoring, there are approximately 30 residents currently living in the 11 residences. The nearest residence to the proposed project boundary is 690 feet north-northeast of the easternmost portion of the proposed project boundary. This residence is approximately 2,860 feet (0.51 mile) east-northeast of the proposed CPP. There is one residence slightly closer to the CPP (2,500 feet southeast). Figure 3.1-3 shows the locations of the nearby residences.

3.1.6 Recreation

Crook County offers a variety of recreation opportunities. Some of the major attractions include Devils Tower National Monument, the Black Hills National Forest (BHNF) and Keyhole State Park. Some of the recreational opportunities within these areas include hunting, camping, hiking, horseback riding, biking, boating and fishing. Table 3.1-6 lists some major attractions and their distances from the proposed project area. Nearby recreation areas are depicted on Figure 3.1-4 as obtained from the Public Lands Information Center (PLIC 2010).

There is limited opportunity within the proposed project area for large game hunting, including mule deer, white-tailed deer and pronghorn. In general, publicly owned lands (i.e., State or BLM-administered federal lands) are open to hunting if legal access is available. State land can be accessed via County Road 193, but the BLM land cannot be accessed by public road. With

limited public land, large game hunting opportunities within the proposed project area are also limited.

Antelope Hunting

The Wyoming Game and Fish Department (WGFD) has classified the proposed project area as yearlong habitat for antelope (pronghorn). However, the proposed project area does not contain any crucial or enhancement habitat priority areas, which means that there are no special habitat protection and management activities in the proposed project area. The WGFD definitions of big game ranges are included in Section 3.5. The proposed project area is within pronghorn Hunt Areas 3 (east of D Road) and 18 (west of D Road), which are contained in the North Black Hills Herd Unit (339). In post-season 2007, the population of this herd unit was estimated at 18,565, which was above the WGFD objective of 14,000. (WGFD 2010a)

Historical problems associated with the management of the North Black Hills Herd Unit include hunter access, quantifying landowner preferences and desires, uncertainties in weather, and disease. In the mid-1990s herd population declined below objective size, however the herd unit recovered in the late 1990s to near objective. Since early 2000s the herd unit population has been above the objective due to mild winters followed by summers of high fawn production. Hunt Areas 3 and 18 contain mostly privately owned surface lands with poor hunter access to limited publicly owned lands; therefore, the number of antelope is expected to steadily increase. When the population exceeds objective levels, more licenses are needed and these may be difficult to sell in this mostly private land area. Nearly all landowners charge access fees for hunting and private land access is based on the desires and perceptions of the landowners. Assuming most licenses would be sold and given the predicted harvest, the 2008 post-season population was expected to be 18,077 antelope. (WGFD 2010a)

Mule Deer Hunting

The WGFD has classified the proposed project area as winter/yearlong habitat for mule deer. Crucial mule deer habitat does not occur within the proposed project area. The proposed project area is located within WGFD mule deer Hunt Area 18, part of the Powder River Herd Unit (319), and Hunt Area 3, part of the Black Hills Herd Unit (751). In post-season 2007, the population of

the Powder River Herd Unit was estimated to be approximately 49,560, which was below the WGFD objective of 52,000. Management of the Powder River Herd Unit for mule deer experiences similar problems as those encountered for pronghorn. Private land restricts access and the CBNG industry reduces some land available for hunting, although there is no CBNG development in the proposed project area. The WGFD predicts the population in this herd will continue to be steady. The 2008 post-season population for the Powder River Herd Unit was estimated at 53,711, which was over the objective. The Black Hills Herd Unit has significantly lower population counts than the Powder River Herd Unit. The 2007 post-season population estimate for the Black Hills Herd Unit was 28,856, while the objective was 20,000. In the late 1990s the population of mule deer in the Black Hills Herd Unit grew rapidly. Although declining in 2001, the population continued to increase through 2006 and levels were projected to stabilize in 2008 at a population of 28,851. (WGFD 2010a)

White-Tailed Deer Hunting

The proposed project area is located within the WGFD white-tailed deer Hunt Area 3, part of the Black Hills Herd unit (706). The 2007 post-season population estimate for this herd unit was 44,125, which was above the WGFD objective of 40,000. Between 1997 and 1999 the population grew almost 40% and then dropped in the post season of 2001. In 2002 the population began to increase and the hunting seasons were structured to stabilize the population. The 2008 post-season population for white-tailed deer was expected to be 44,557. (WGFD 2010a)

Other Hunting Opportunities

Sage grouse, wild turkeys, and small game are present and may also be hunted in the general vicinity. There is a hunting season for sage grouse during the month of September. Sage grouse hunting within the proposed project area is limited to lands west of D Road subject to landowner permission. Two wild turkey seasons occur in the spring and fall during April, May, and November. During the spring, only male turkeys are allowed to be hunted. Small game includes cottontail rabbits, snowshoe hares, and red, gray and fox squirrels. The hunting season runs from September to March and has no limitations. (WGFD 2010b)

Fishing

Aquatic habitat is very limited by the ephemeral or intermittent nature of surface waters in the proposed project area. Public fishing opportunities are likewise very limited. The lack of deep-water habitat and extensive and persistent water sources limits the presence and diversity of fish and other aquatic species. There are currently no fisheries within the proposed project area. Oshoto Reservoir, an in-channel impoundment on the Little Missouri River, is partially located on State land. The WGFD does not stock the reservoir and it is not managed by any private agency, but native fish have been observed in the reservoir. Refer to Section 3.11 for a description of fish sampling conducted as part of radiological baseline monitoring.

3.1.7 Aesthetics

The proposed project area consists of gently rolling topography and large, open expanses of grassland, hayland, and shrubland. Located in the backdrop towards the east is a view of Devils Tower National Monument and the BHNF. The proposed project area is rural in character, with minor industrial development from oil activities. The color of the landscape varies from tan and green vegetation in the springtime to tan and gold during the later drier months as well as tan soils. As the proposed project area has been used historically for grazing, cropland, and oil development, it is unlikely that any undisturbed area exists within the proposed project area. Human influence is evident in existing grazing activities and facilities (e.g., stock tanks and fences), oil production facilities, transportation corridors, and infrastructure that supports these activities.

Ancillary facilities are needed to support oil production. These support facilities include well access roads, pump jacks, production equipment at the wellheads, well production casing (which extends from the surface to the zone of production), short underground pipelines (which gather the oil produced by the individual wells and carry it to a storage tank), central metering facilities, electrical power utilities, and storage tanks.

3.1.8 Mineral Resources

Wyoming is a state with active mineral development. Crook County has an abundance of mineral resources, including coal, oil, gas, bentonite, sand, gravel, gypsum, limestone, uranium, and vanadium (Crook County 1998). As

described in Section 2.2.7.3 of this ER, Crook County also has the potential for the development of a rare earth elements mine near Sundance. Both the proposed project area and the surrounding 2-mile area contain producing oil wells, which typically target the Minnelusa Formation. Table 3.1-7 describes producing and nonproducing oil wells located within the proposed project area and the surrounding 2 miles. The majority of the wells are plugged and abandoned. There are 3 producing oil wells within the proposed project area. Oil is produced from a depth of approximately 6,000 to 6,500 feet, which is approximately 5,400 feet deeper than the uranium mineralization found in the proposed project area. The locations of the oil wells within 2 miles of the proposed project area are shown on Figure 3.1-5. Currently oil is the only mineral actively being developed within 2 miles of the proposed project area.

There are no nuclear fuel cycle facilities located within 50 miles (80 km) of the proposed project area (NRC 2010a). The nearest uranium hexafluoride conversion facility is in Metropolis, Illinois, about 1,240 road miles away. There are also no operational uranium recovery facilities within 50 miles (80 km) of the proposed project area. The ISR GEIS (pg. 3.1-4) identified one potential future ISR uranium recovery facility near Aladdin, which is about 40 miles east-northeast of the Ross ISR Project. According to Powertech Uranium Corporation (2010), confirmation drilling on the Aladdin Project occurred in 2007, but the project has yet to be developed as licensing activities are currently focused on Powertech's Dewey-Burdock and Centennial projects. Three other potential uranium recovery projects have been identified within 50 miles of the Ross ISR Project. These include the Bayswater Uranium Corporation Elkhorn, Wyoming Project about 17 miles northeast; the Bayswater Alzada, Montana Project about 36 miles north-northeast; and the Ur-Energy/Bayswater Hauber Project about 13 miles north-northeast of the proposed project area (Bayswater 2010a and 2010b, Ur-Energy 2010). The potential Hauber ISR Project is near the historic Hauber Uranium Mine, which was operated by Homestake Mining Company between 1958 and 1966 and was one of Wyoming's first uranium mines (Crook County 1998, Ur-Energy 2010).

According to the NRC (2010b), letters of intent have not been filed to permit any ISR projects within 50 miles (80 km) of the Ross ISR Project. Figure 3.1-6 depicts existing, planned and potential future uranium recovery facilities in the region.

3.1.9 Abandoned Wells and Drill Holes

Addendum 2.6-B in the TR lists the exploration drill holes within 0.25 mile of the proposed project area. Abandoned drill holes include those associated with historic uranium exploration prior to implementation of the Nubeth R&D ISR uranium recovery project, which is described in Section 1.2.1 in this ER. The pilot project was located within the proposed project area and was operated from 1978 to 1979. Exploration drilling continues in the proposed project area today, and the list of exploration drill holes provided in Addendum 2.6-B to the TR is current through October 2010. Many of the exploration drill holes have been abandoned with heavy bentonite grout, cement or plug gel. Prior to ISR uranium recovery, the remaining drill holes within the perimeter monitor well ring and beneath the central plant area will be plugged from the bottom of the hole to the surface with low hydraulic conductivity materials such as cement or heavily mixed bentonite grout. Additional details about well and drill hole plugging and abandonment procedures are provided TR Addendum 2.6-B.

Wells associated with the Nubeth R&D site include 47 injection, recovery and monitor wells. As described in TR Section 2.6.4, all wells associated with the Nubeth R&D site were abandoned in accordance with WDEQ/LQD requirements except five wells, two of which were transferred to an oil production company to be used as water supply wells for EOR, two of which were abandoned with grout from the bottom up by a drill rig due to casing integrity issues, and one monitor well which was turned over to a landowner but is no longer in use.

3.1.10 Surface and Groundwater Use

Surface and groundwater use in and around the proposed project area provides insight into historical and current land use. Detailed information is provided in Section 3.4 in this ER. Water use within the proposed project area was historically limited to livestock watering and occasionally irrigation. Groundwater is also used as drinking water nearby, but not within the proposed project area. Beginning in the late 1970s, water was put to use for industrial purposes, for ISR uranium production in the late 1970s, and for oil and gas operations beginning in 1978. Current surface and groundwater uses within the proposed project area include livestock watering, wildlife, and industrial use, primarily in EOR operations using water flooding.

3.1.11 Land Use Plans

Land use within the proposed project area is affected by two land use plans. Federal surface and mineral leases within the proposed project area are managed by the BLM according to the Newcastle Resource Management Plan (BLM 2000a). The Resource Management Plan includes planning and management decisions related to resource protection and mineral leasing. Some of the key resources and land uses that could potentially be affected by the Ross ISR Project include livestock grazing, air quality, cultural resources, minerals, recreation, and wildlife habitat. Crook County has also implemented a land use plan with the purpose of establishing "a process for Crook County to coordinate with federal and state agencies on their proposed actions that may potentially affect the management of private and public land and natural resource use" (Crook County 1998). In addition to these two land use plans, State-owned lands and minerals within the proposed project area are subject to the rules and regulations of the Office of State Lands and Investments (OSLI).

Crook County is a key stakeholder in the proposed Ross ISR Project. Based on pre-application meetings with Crook County officials, including county commissioners and members of the Land Use Planning & Zoning Commission, two primary concerns have been expressed. These include road maintenance and emergency services. Section 5.2 of this ER addresses Strata's plan to address road maintenance, including developing a maintenance agreement with the Crook County Road & Bridge Department. Various sections of this ER (e.g., Section 4.2.1.2) describe how Strata will commit to training local emergency response personnel in the specific hazards and spill control procedures associated with ISR operations and material transport. Strata will continue to identify and address Crook County concerns through ongoing meetings with elected officials and County staff.

3.1.12 Future Land Use

Future land use within the proposed project area, whether under the No Action Alternative or following decommissioning and release of the area for unrestricted use under the Proposed Action, is expected to be the same as current land use for the foreseeable future. Current land use includes livestock grazing, dry land crop production, oil production, transportation, and recreation. The primary land uses, livestock production and dry land crop

production, have been dominant since the beginning of the 20th century and will likely continue to be the dominant land uses of the future.

Oil production will also likely continue, but to a lesser extent than existing levels. Based on monthly production records available from the Wyoming Oil and Gas Conservation Commission (WOGCC 2010), oil production from the three producing wells within the proposed project area peaked in 1985 to 1986 and has generally declined since then. Since oil production is declining and since all oil has historically been produced from the only formation in the vicinity with proven reserves (Minnelusa), the potential for significant future oil and gas development is low. The potential for tight shale oil and gas development within the proposed project area is unknown. The Niobrara Shale Formation is currently being explored in southeastern Wyoming, and there may be potential for similar exploration and development in Crook County depending on the results. The proposed project area does not overlie any coal seams targeted for CBNG production, so there is no potential for future CBNG development. Sand or gravel extraction might occur within the proposed project area.

Future residential development will likely be limited within the proposed project area. Large land tract size, a distance of approximately 20 miles to the nearest public water and sewer service areas, and sparse residential development over the past 100 years suggest that residential development will likely be minor or nonexistent.

Table 3.1-1. Distribution of Surface Ownership and Subsurface Mineral Ownership

	Surface Ownership		**Subsurface Mineral Ownership**	
	Acres	**Percent**	**Acres**	**Percent**
Private	1,367.2	79.4	1,206.3	70.1
State	314.1	18.2	314.1	18.2
Federal	40.0	2.3	200.9	11.7
Total	1,721.3		1,721.3	

Table 3.1-2. Land Use within 5 Miles of the Proposed Project Area

Land Use Classification	Approximate Area and Percent of Total			
	Project Area		Study Area (5-mile buffer)	
Mixed Rangeland	1,019.4 ac	(59.2%)	46,620.5 ac	(63.1%)
Herbaceous Rangeland	369.0 ac	(21.4%)	15,465.6 ac	(20.9%)
Cropland and Pasture	244.0 ac	(14.2%)	7,123.9 ac	(9.6%)
Reservoirs	47.7 ac	(2.8%)	197.3 ac	(0.3%)
Transportation, Communications, and Utilities	28.0 ac	(1.6%)	794.2 ac	(1.1%)
Industrial	13.2 ac	(0.8%)	33.5 ac	(0.05%)
Evergreen Forest Land	0 ac	(0%)	3,704.6 ac	(5.0%)

Source: USGS (2005) and USDA-FSA (2009)

Table 3.1-3. Livestock Inventory for Crook County, 2009

Type of Livestock	Number	Percent of Total	Animal Units[1] Pounds (000s)	Percent
All Cattle	65,000	81.8	65,000	95.7
Breeding Sheep and Lambs	14,500	18.2	2,900	4.3
Total Animals	79,500	100	67,900	100

Source: USDA-NASS 2010

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

Table 3.1-4. Agricultural Yields for Croplands in Crook County, 2008

	Harvested	Yield		Production	
Crop	**Acres**	**Per Acre**	**Units**	**Total**	**Units**
All Hay	89,200	1.21	Tons	108,300	Tons
Oats	2,400	31	Bushel	74,000	Bushel
All Wheat	7,500	26.5	Bushel	197,000	Bushel

Source: USDA–NASS (2010)

Table 3.1-5. Distance to 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	0.99	>2	>2.99
NNE	1.08	0.16	1.38
NE	1.17	0.24	1.39
		1.25	2.53
ENE	1.03	0.19	1.20
		1.29	2.27
E	0.70	1.82	2.88
ESE	0.76	0.28	1.03
SE	1.17	>2	>3.17
SSE	1.08	>2	>3.08
S	0.90	1.10	2.06
SSW	0.55	>2	>2.55
SW	0.73	>2	>2.73
WSW	0.75	>2	>2.75
W	0.70	>2	>2.70
WNW	0.76	>2	>2.76
NW	1.01	1.61	2.82
		1.73	2.95
NNW	1.07	1.40	2.61

Note: The distance from the project center to the site boundaries are measured along each 22½-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).

Table 3.1-6. Nearby Recreational Areas

Name of Recreational Facility	Type of Activities Available	Distance from Project Area (miles)	Direction
Devils Tower National Monument	Climbing, hiking/backpacking, picnicking, museum	11	E
Keyhole Reservoir State Park	Boating, camping, fishing, hiking/backpacking, picnicking, water sports, winter sports, wildlife viewing	11	SSE
Thunder Basin National Grassland	Biking, camping, fishing, hiking/backpacking, horseback riding, hunting, off highway vehicles	6 27	WNW SSE
Weston Hills Recreational Area	Camping, hiking/backpacking, horseback riding, hunting, off highway vehicles, wildlife viewing	19	W
Bearlodge Campground (BHNF)	Camping, biking, hiking/backpacking, hunting	31	ENE
Cook Lake Campground (BHNF)	Biking, boating, camping, fishing, hiking/backpacking, hunting, picnicking, scenic driving, wildlife viewing, winter sports	26	E
Reuter Campground (BHNF)	Camping, hiking/backpacking, hunting, winter sports	27	ESE
Sundance Campground (BHNF)	Biking, camping, hiking/backpacking, horseback riding	31	ESE

Source: PLIC (2010). See Figure 3.1-4 for locations.

Table 3.1-7. Oil and Gas Wells within 2 Miles of the Proposed Project Area

		Number of Wells	
	Type of Well or Status	**Proposed Project Area**	**Within 2 Miles**
Gas	Plugged & abandoned	1	1
Oil	Plugged & abandoned	10	144
	Producing	3	19
	Shut-in	0	3
	Other	1	9
Other	Source	2	4
	Injector	3	8
	Disposal	0	3
	Other	0	2
	Total	**19**	**192**

Source: WOGCC 2010

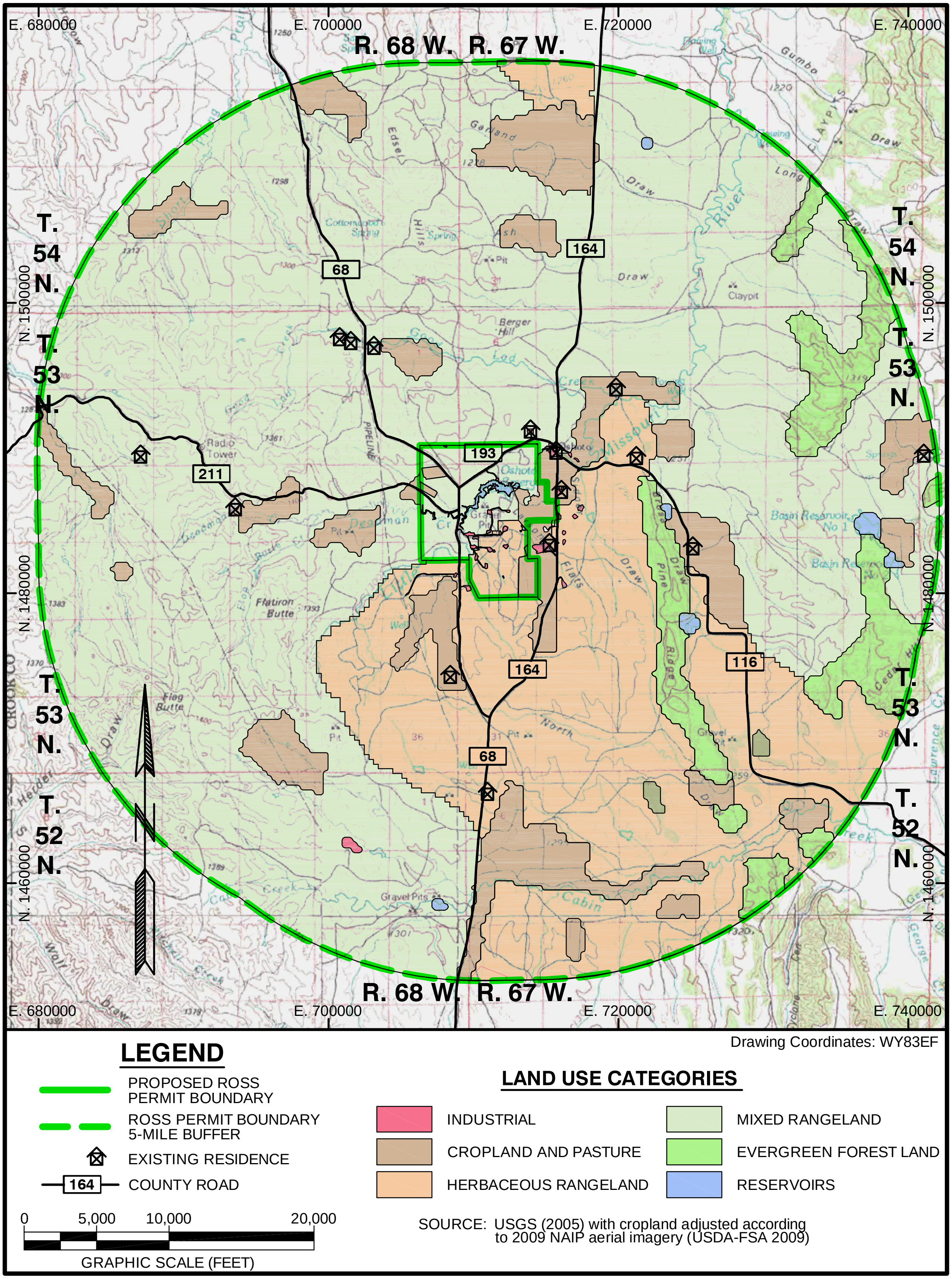

Figure 3.1-1. Land Use within 5 Miles of the Proposed Project Area

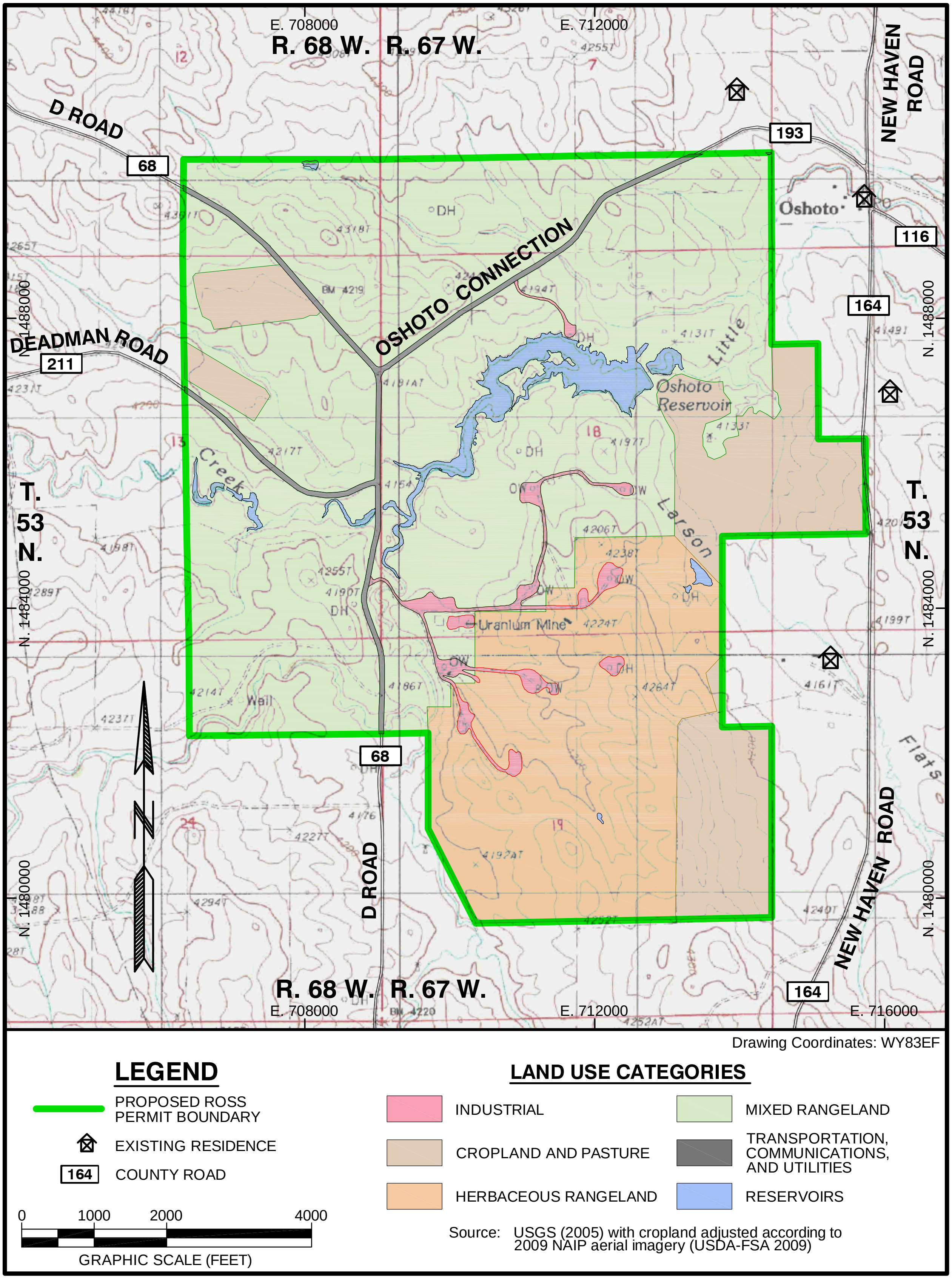

Figure 3.1-2. Land Use within the Proposed Project Area

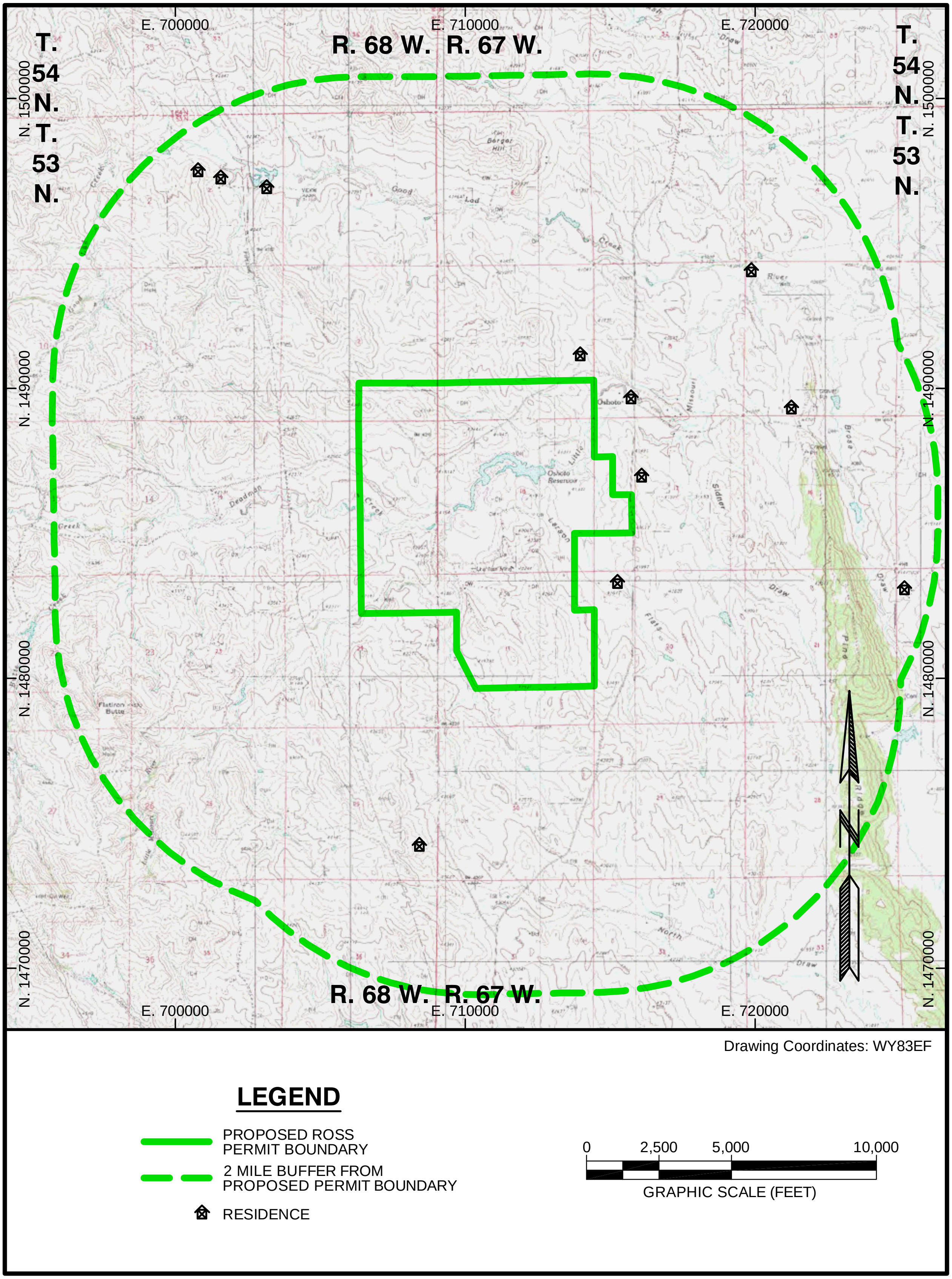

Figure 3.1-3. Residences within 2 Miles of the Proposed Project Area

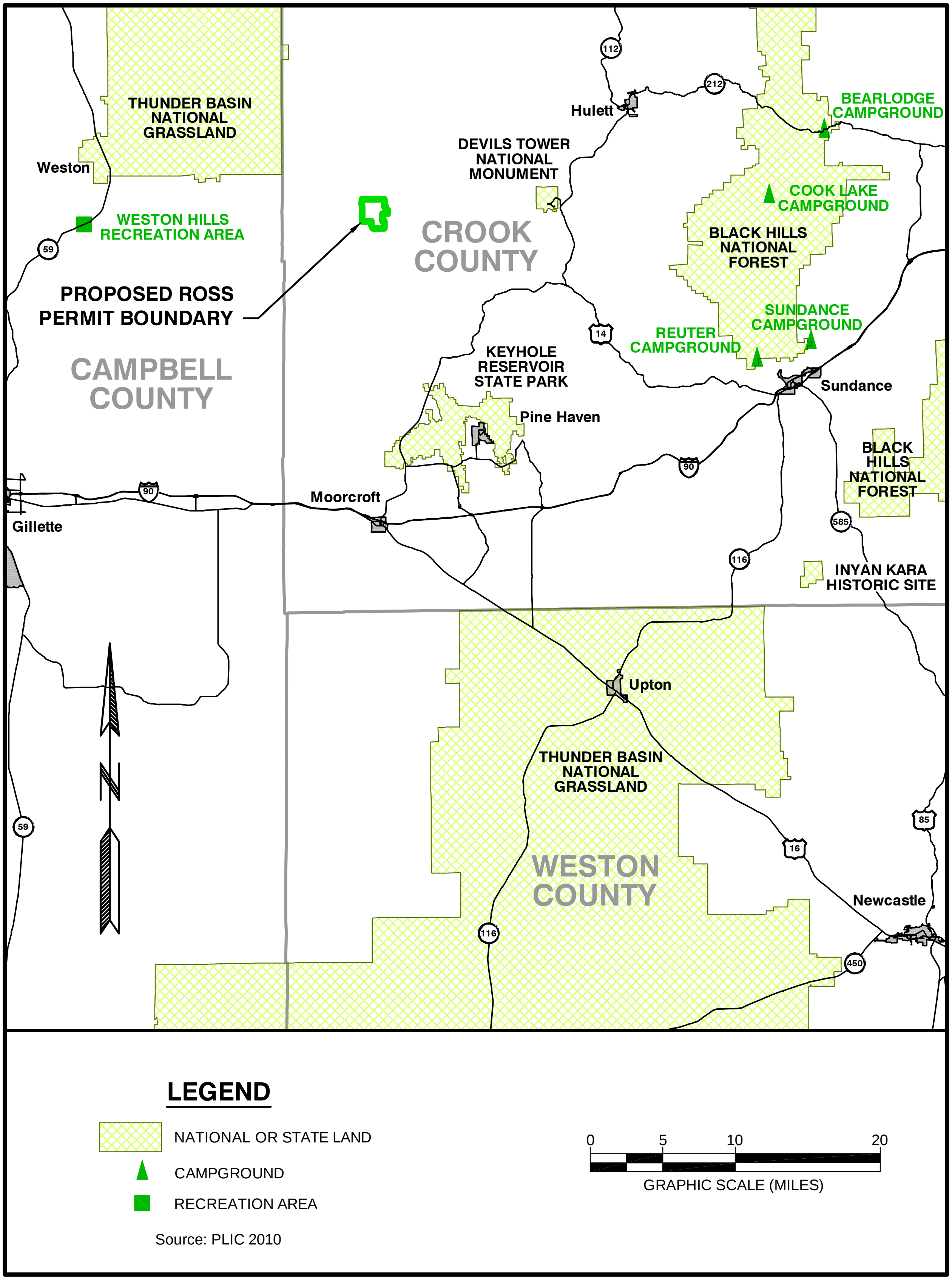

Figure 3.1-4. Nearby Recreation Areas

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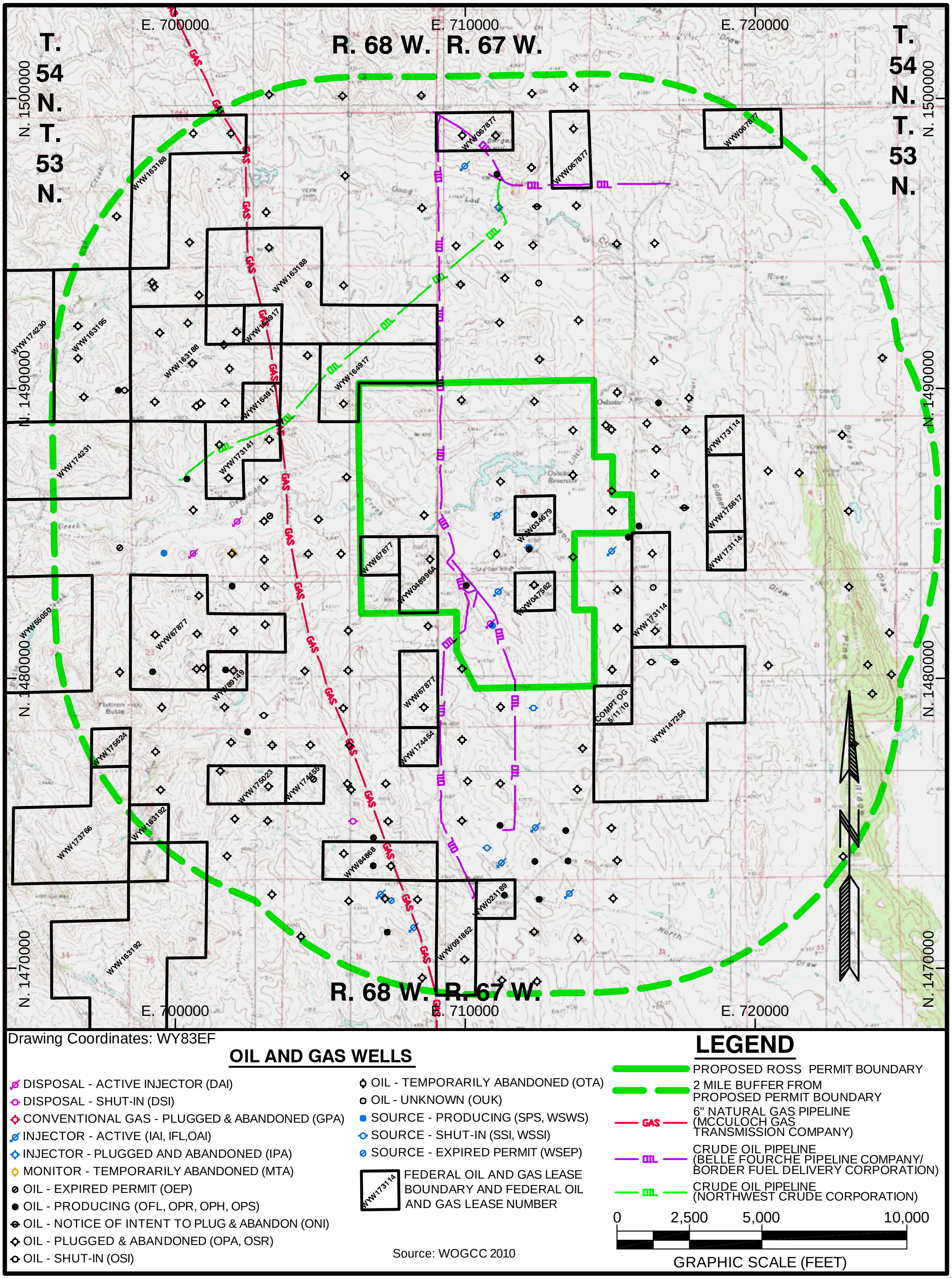
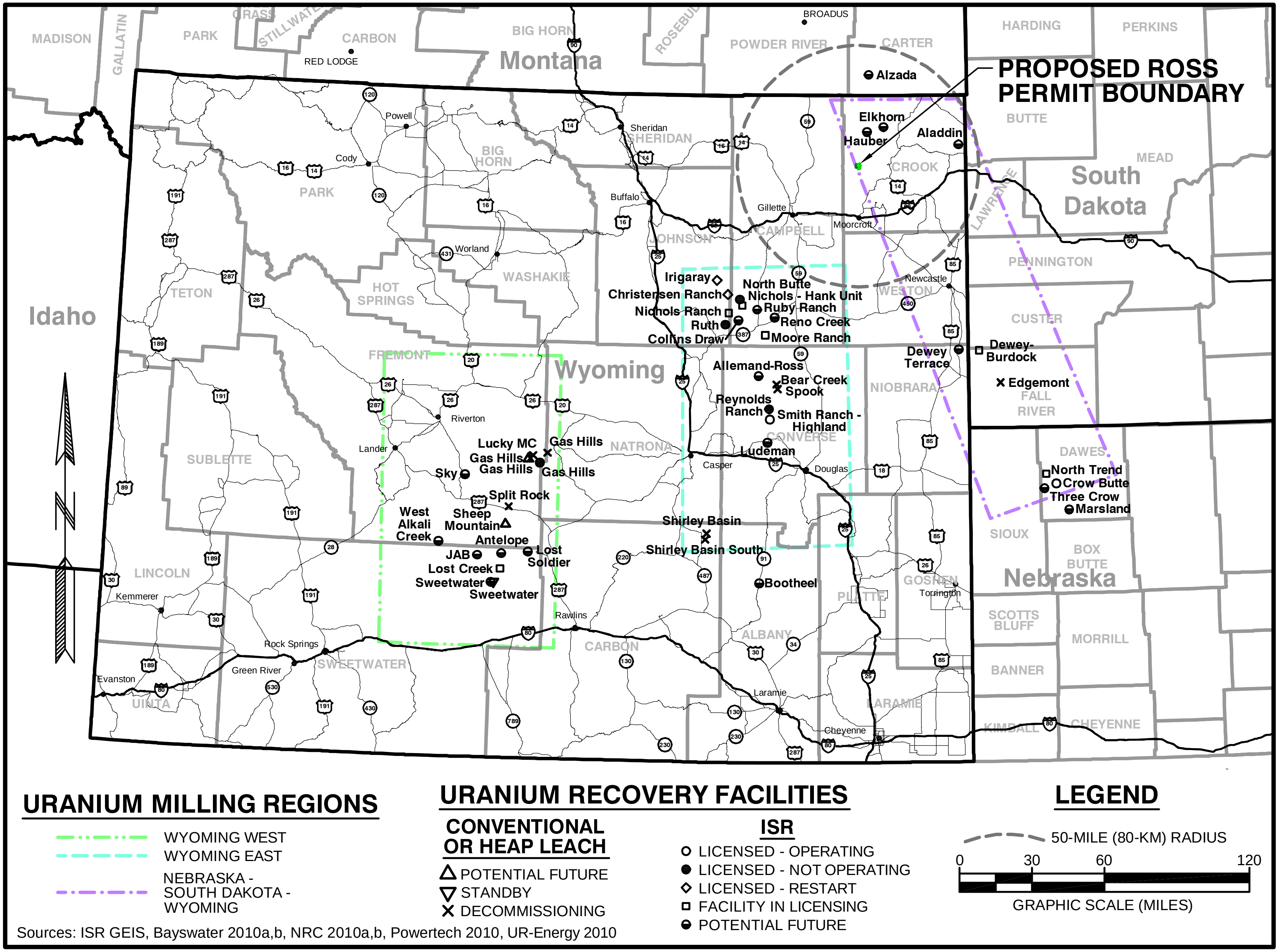


Figure 3.1-5. Oil and Gas Wells within 2 Miles of the Proposed Project Area

Figure 3.1-6. Regional Existing and Planned Uranium Recovery Facilities



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3.2 Transportation

3.2.1 Local Roads and Highways

Transportation routes within 50 miles (80 km) of the Ross ISR Project include Interstate highways, non-Interstate U.S. highways, state highways, county roads and local roads. The major corridors that could be used to access the proposed project area include Interstate 90 approximately 20 miles south, U.S. Highway 14 approximately 10 miles southeast, State Highway 59 approximately 20 miles west and U.S. Highway 212 approximately 40 miles northeast. Regional and local transportation routes are shown on Figure 3.2-1.

The primary access to the proposed project area is along D Road (CR 68) and the New Haven Road (CR 164) from the south. Beginning at I-90 exit 153, the primary access road will be reached by the following route:

- Drive south on U.S. 14/16 for 0.1 mile
- Turn right and drive west on Highway 51 for 1.4 miles
- Turn right and drive north on Bertha Road (CR 12) for 0.1 mile
- Turn right and drive north on D Road (CR 68) for 18.3 miles
- Turn right and drive north on the New Haven Road (CR 164) for 3.0 miles
- Turn left at the primary access road

U.S. 14, Highway 59 and U.S. 212 can be used as alternate routes to access the site. U.S. 14 is primarily accessed from I-90 exit 153 at Moorcroft or exit 185 near Sundance. Highway 59 runs in a north-south direction through the town of Gillette and can be accessed from I-90 exit 124. U.S. 212 is accessed from Belle Fourche, South Dakota. County roads connect these highways with the proposed project area. Cabin Creek Road (CR 116) begins at U.S. 14 just north of the town of Carlile and ends after 12 miles at the New Haven Road (CR 164), just northeast of the proposed project area. County roads that could be used to access the proposed project area from the west include Cow Creek Road (CR 26), Spring Creek Road (CR 91) and Deadman Road (CR 211). The total road distance from Highway 59 to the proposed project area is 29 miles. The Little Missouri Road (CR 200) follows the Little Missouri River 42 miles southwest from U.S. 212 near Alzada, Montana, to the New Haven Road 8 miles north of the proposed project area. The proposed

project area can also be accessed from Highway 112 at Hulett by driving west then south approximately 30 miles on CR 105 and the New Haven Road.

D Road is a 45-mile long north-south road which diverges from Bertha Road (CR 12) at 1-90 near Moorcroft and connects with Rocky Point Road (CR 85) 3 miles south of Rocky Point. It is a two-lane paved/gravel road about 30 to 35 feet wide with posted speed limits of 55 mph for cars and 45 mph for trucks. The pavement extends approximately 3 miles north from the intersection of D Road and Bertha Road, then the road surface consists of reclaimed asphalt pavement, which has been rotomilled and blended with the crushed base and subgrade for approximately 7.3 miles, after which D Road has a gravel type surface. The New Haven Road is a two-lane crushed shale road approximately 25 to 30 feet wide. The speed limit is posted at 45 mph; however, the posted sign is located about 2 miles north of the proposed project area. Therefore, northbound traffic traveling to the project area from D Road may not be aware of the change in speed limit. Strata assessed the existing condition of potentially affected segments of the D Road and the New Haven Road in October 2010 using the Gravel PASER Manual (University of Wisconsin 1989). The following conclusions were reached:

- The paved section of the D Road is in poor condition due to cracking, rutting, and potholes.
- The reclaimed asphalt pavement section of the D Road was recently upgraded and is in good condition.
- The gravel section of the D Road to the intersection of the New Haven Road is in good condition.
- The gravel (shale) section of the New Haven Road to the proposed primary access road is in good condition.

The complete results of the evaluation of existing road conditions are provided in Addendum 3.2-A.

Oshoto Connection (CR 193), a two-lane crushed shale road, connects the New Haven Road to D Road along the northern portion of the proposed project area. Deadman Road (CR 211), a two-lane gravel road, extends 13 miles from Bergreen Road (CR 10) to D Road and runs in a northwest to southeast direction. All of the access roads are maintained year-round by Crook County. Routine maintenance includes snow removal, debris removal, blading and grading operations, and miscellaneous road repairs.

3.2.2 Traffic

Table 3.2-1 presents the average annual daily traffic (AADT) on the major traffic corridors near the proposed project area. On an average annual basis, traffic on I-90 is about 10 times higher than the traffic on U.S. and state highways in the area. There are wide seasonal traffic variations on all area highways. For example, on I-90 east of Gillette (milepost 133.50), the monthly traffic varied from 78% of the average annual traffic in January 2008 to 135% in August 2008. The seasonal variation due to tourism near Devils Tower is even more pronounced. At U.S. 14 west of the Devils Tower Junction, January 2008 traffic was 46% and July 2008 traffic was 190% of the annual average. (WYDOT 2009)

The data obtained from WYDOT (Wyoming Department of Transportation) can be used as a baseline and to provide insight into seasonal variations in traffic volumes for the adjacent higher volume roadways. However, much less seasonal variation in traffic is expected on the county roads used to access the proposed project area. Observations of local traffic during more than 12 months of baseline data collection suggest that there is very little seasonal, tourist traffic on D Road or the New Haven Road.

Crook County completed traffic studies in 2009 that included four of the county roads near the proposed project area (Crook County 2010). The traffic study was conducted over 7 days at each traffic counter during the time period July 28 to August 18, 2009. The Crook County traffic study results are summarized in Table 3.2-2. Table 3.2-2 shows that summer 2009 average daily traffic (ADT) on county roads near the proposed project area varied from less than 10 to approximately 100 vehicles per day. The lowest traffic level occurred on Deadman Road, and the highest occurred on a portion of the New Haven Road. Crook County was unable to provide the locations of the traffic counters.

Strata conducted a 2-week traffic study in 2010 to further quantify existing traffic conditions of the local road network. The goal of the traffic study was to collect information about vehicle volumes, vehicle classifications and vehicle speeds. The 2010 traffic study results were compared to the data available from Crook County to help analyze baseline conditions. However, without knowing the locations of the traffic data collectors in 2009, comparison to the 2010 traffic data collected by Strata could only be made on a road-to-road comparison, not the same road segments.

Strata conducted a traffic study from May 20 to June 4, 2010 that included 10 traffic counters. Counters were placed within the proposed project area to collect traffic data along each roadway segment and at all points where traffic can access the area using public roadways. Figure 3.2-2 displays the traffic counter locations. Strata was conducting exploratory drilling during a portion of the 2-week traffic study, including May 20 and May 28 through June 4, 2010. Traffic levels during this time period were not representative of baseline conditions and were not included in the analysis.

It is also important to note that during the Strata traffic study, Crook County was performing construction operations along D Road from the New Haven Road intersection to the Deadman Road intersection. Construction activities and detours likely caused an increase in traffic volumes along the New Haven Road due to construction traffic and a decrease in traffic volumes on D Road due to detours.

The 2010 traffic study was conducted using Apollo portable classifier data collectors from Diamond Traffic Products. The data collectors were equipped with solar panels and batteries, which allowed the units to function continuously during the study. Each data collector recorded the lane, time, axles, speed, length, gap and headway for each vehicle. Using computer algorithms the data were sorted into separate categories of vehicle classification using the Federal Highway Administration (FHWA) standard vehicle classification system, which includes 13 vehicle classes. This method allowed Strata to determine the relative amount of truck traffic for each counter location.

Each traffic counter included two road tubes, which were installed perpendicular to the traffic flow at a fixed distance apart. This installation method allowed the processor to classify the vehicle according to the time each axle contacted each road tube and to determine the direction of travel.

The 2010 traffic study results are presented in Table 3.2-3. The results show that the traffic volumes were higher on all roads in 2010 than 2009. The increase was likely attributed to growth in other industries such as bentonite hauling and not associated with the proposed Ross ISR Project, since the days during which exploratory drilling occurred were omitted from the 2010 results. The results reported in Table 3.2-3 provide the most accurate existing data available to quantify baseline traffic and provide a benchmark for estimating future growth at known locations of the roadway network.

There were no road segments in or adjacent to the proposed project area with an ADT greater than 250 vehicles per day in the 2009 or 2010 traffic studies. Research on the safety of unpaved roads has been addressed by the National Cooperative Highway Research Program (NCHRP 1994). NCHRP Report 362 established that crash rates are generally higher for unpaved roads than for paved roads for traffic volumes of 250 vehicles per day or more. Additional information is available from the American Association of State Highway and Transportation Officials. The risk assessment conducted to develop the AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400) found that roads in rural areas generally reach the threshold at which paving the road would be expected to result in one less severe crash every 10 to 15 years in the traffic volume range between 300 to 350 vehicles per day (AASHTO 2001).

The 2010 traffic study also provided data on truck traffic on each segment. The roadway network near the proposed project area was experiencing 5% to 13% truck traffic. The highest percentage of truck traffic was on the Oshoto Connection, between the New Haven Road and D Road. Most of the trucks were attributed to bentonite hauling on the New Haven Road.

Speeds were also analyzed during the study and are shown to be relatively high for unpaved surfaces. The speeds reported in Table 3.2-3 include the 50th percentile (median) and 85th percentile speeds, or the speeds at which 85% of the drivers drove at or below. Relatively high speeds are likely a result of drivers' familiarity with the roadway, low traffic volumes, and lack of enforcement. As volumes increase the speeds will likely decrease. Decreased speed would help prevent deterioration of the gravel roadway surfaces, reduce dust and noise, and reduce the risk of accidents.

Traffic projections based on the 2010 Strata traffic study are provided in Table 3.2-4. Historical traffic data were available along Interstate 90, permitting linear regression analysis of the traffic volumes and truck volumes along the interstate. The linear regression equations were used to project traffic volumes and truck volumes to 2010, 2015, 2020 and 2030. See Figure 3.2-3 for historical Interstate 90 traffic levels. Traffic projections along D Road and the New Haven Road were calculated using a 2% annual rate of increase, which is considered standard practice among transportation officials. WYDOT typically uses a 2% annual traffic growth rate unless more site-specific traffic

data are available (Brown 2010). The traffic projections do not take into consideration additional traffic from the proposed Ross ISR Project. Traffic projections during the various project phases are provided in Section 4.2. The 20-year projected traffic volumes along D Road and the New Haven Road are all well below the range of 300 vehicles per day. The 2010 traffic volumes were used in the traffic volume projection instead of the results from the 2009 traffic study because the 2009 data were collected at unknown locations and may not be representative of the segments near the proposed project area. The existing gravel surfaces with some mitigation measures such as grading should provide adequate roadways for the local residents, ranchers, livestock haulers, bentonite transport, oil and gas operators, and recreational users.

3.2.3 Railroads

There are several railroads within 50 miles (80 km) of the proposed project area. These include two BNSF railroads that serve the coal mines around Gillette, Wyoming. The nearest of these is approximately 23 miles south, adjacent to U.S. 16. It connects Gillette with destinations ranging from Seattle, Washington to Chicago, Illinois. Another BNSF railroad is about 28 miles southwest of the proposed project area. It runs north-south from Gillette to Denver, Colorado. Regional railroads are shown on Figure 3.10-1 in Section 3.10.

Another railroad originates in northwest Crook County, about 43 miles (70 km) east-northeast of the proposed project area. DM&E uses this railroad to ship bentonite from mines in northeast Wyoming and southeast Montana to Rapid City, South Dakota and Midwestern cities.

Railroads are not planned for use in transporting materials, equipment or products to or from the proposed project area.

3.2.4 Navigable Rivers

The Ross ISR Project is located in the upper reaches of the Little Missouri River Basin. The Little Missouri River flows north through Montana, South Dakota and into North Dakota where it empties into the Missouri River. In Wyoming and in Montana above the confluence with Cottonwood Creek (see Figure 3.4-1 in Section 3.4), the Little Missouri River is not considered a navigable river (Montana Department of State Lands 1987). There are no navigable rivers within the proposed project area.

Table 3.2-1. Traffic Counts on Area Highways

Highway	2008 AADT (veh/day)	
	All Vehicles	**Trucks**
I-90 at Moorcroft	5,260	1,030
U.S. 212 at Wyoming/Montana State Line	590	20
U.S. 14 at Carlile	630	120
WY 112 at Seely	150	50
WY 59 at CR 26	540	100

Source: WYDOT 2009

Table 3.2-2. 2009 Crook County Traffic Study Results

Site	County Road Number	Site Description	ADT (veh/day)
C1	116	Cabin Creek South	44
C2	68	D Road	22
C3	211	Deadman Road	7
C4	164	New Haven 1	35
C5	164	New Haven 2	97
C6	164	New Haven North	17

Source: Crook County 7/28/2009 – 8/18/2009 traffic studies (Crook County 2010)

Table 3.2-3. 2010 Strata Traffic Study Results

Site	County Road Number	Site Description	ADT (veh/day)	Trucks (%)	50th Percentile Speed (mph)	85th Percentile Speed (mph)
1	68	D Road (South of New Haven Road Intersection)	114	7%	50.8	59.2
2	164	New Haven Road (South of Proposed Facilities Site)	108	10%	49.3	57.7
3	116	Cabin Creek Road (East of New Haven Road Intersection)	63	9%	37.6	46.4
4	164	New Haven Road (South of Oshoto Connection Intersection and North of Cabin Creek Road Intersection)	138	8%	26.1	37.7
5	164	New Haven Road (North of Oshoto Connection Intersection)	58	12%	38.3	48.3
6	68	D Road (North of Oshoto Connection Intersection)	62	10%	42.0	51.9
7	68	D Road (South of Oshoto Connection Intersection and North of Deadman Road Intersection)	49	5%	38.8	47.9
8	68	D Road (South of Deadman Road Intersection)	25	6%	36.1	46.5
9	211	Deadman Road (West of D Road Intersection)	19	9%	32.1	39.6
10	193	Oshoto Connection (Just West of Center between D Road and New Haven Road)	87	13%	39.9	49.0

Note: See Figure 3.2-2 for traffic study site locations.

Table 3.2-4. Projected Traffic Volumes

		2010			2015			2020			2030		
Route	**Route Description**	**All Vehicles (veh/day)**	**Trucks (veh/day)**	**%**	**All Vehicles (veh/day)**	**Trucks (veh/day)**	**%**	**All Vehicles (veh/day)**	**Trucks (veh/day)**	**%**	**All Vehicles (veh/day)**	**Trucks (veh/day)**	**%**
I-90	I-90 at JCT Route 44 (West Moorcroft Int)	5,943	1,083	18%	6,537	1,192	18%	7,131	1,300	18%	8,319	1,517	18%
CR 68	D Road (I-90 to New Haven Road Intersection)	114	8	7%	126	9	7%	139	10	7%	169	12	7%
CR 164	New Haven Road (D Road Intersection to Primary Access Road)	108	11	10%	119	12	10%	132	13	10%	160	16	10%

Note: Traffic projections for I-90 were performed using the linear regression analysis shown in Figure 3.2-3. The other two routes, CR 68 and CR 164, were projected using a 2% growth rate.

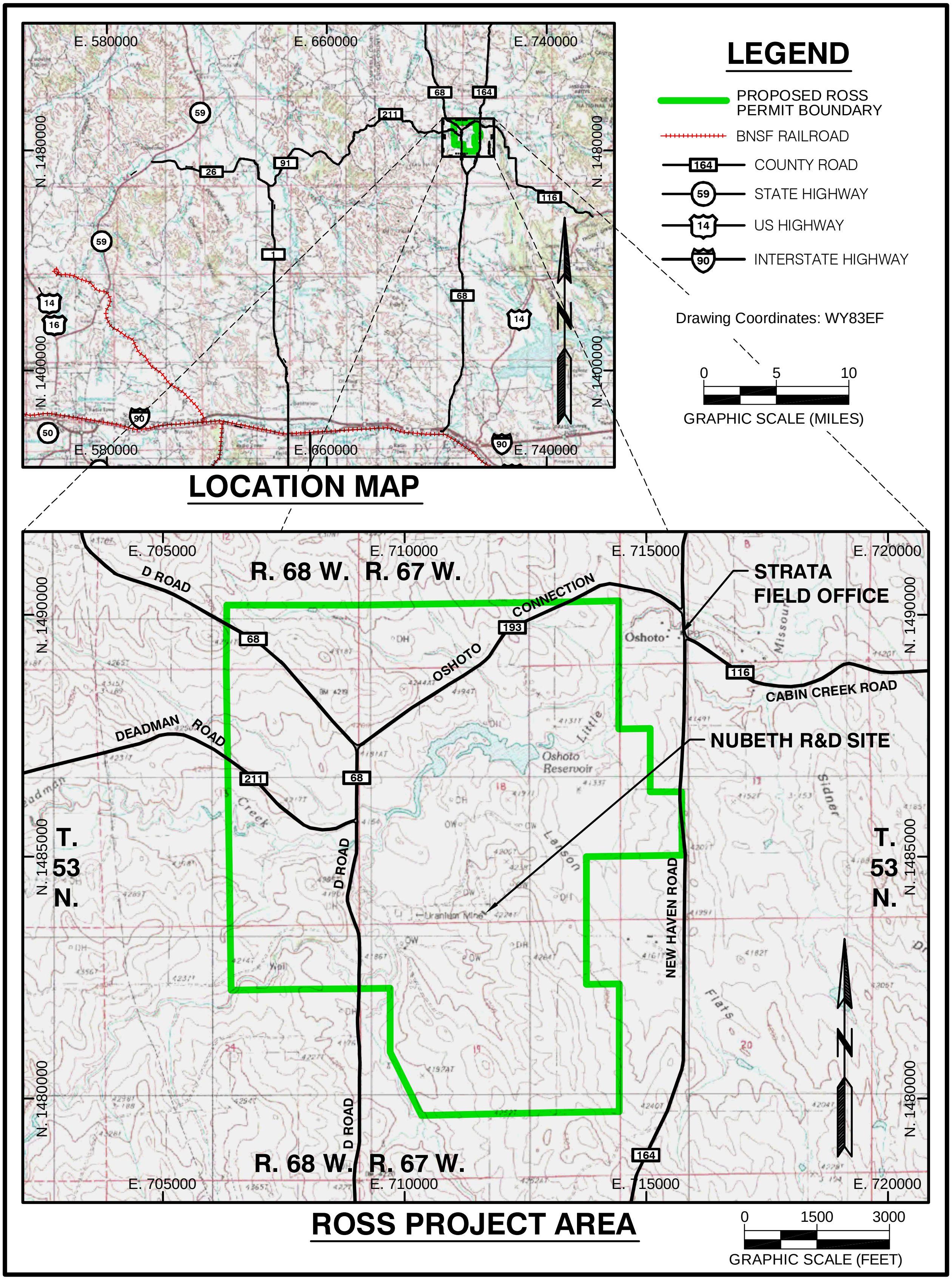


Figure 3.2-1. Existing Transportation Network

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ER_TRANSPORTATION.dwg, ER_FIGURE_3.2-1, 12/18/2010 12:32:50 PM

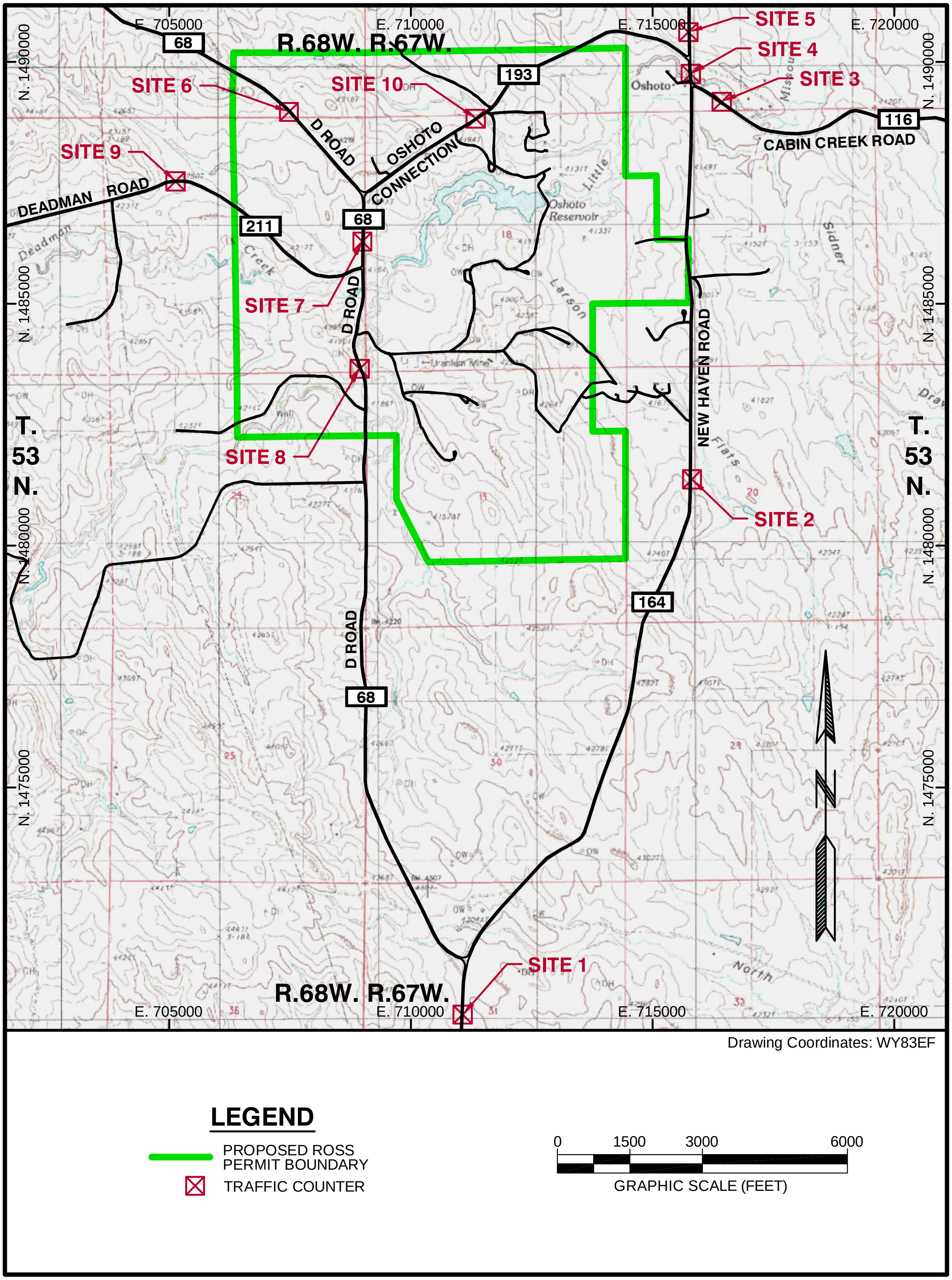


Figure 3.2-2. Strata 2010 Traffic Study Counter Locations

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ER_TRAF_COUNTERS.dwg, ER_FIGURE_3.2-2, 12/18/2010 12:34:44 PM

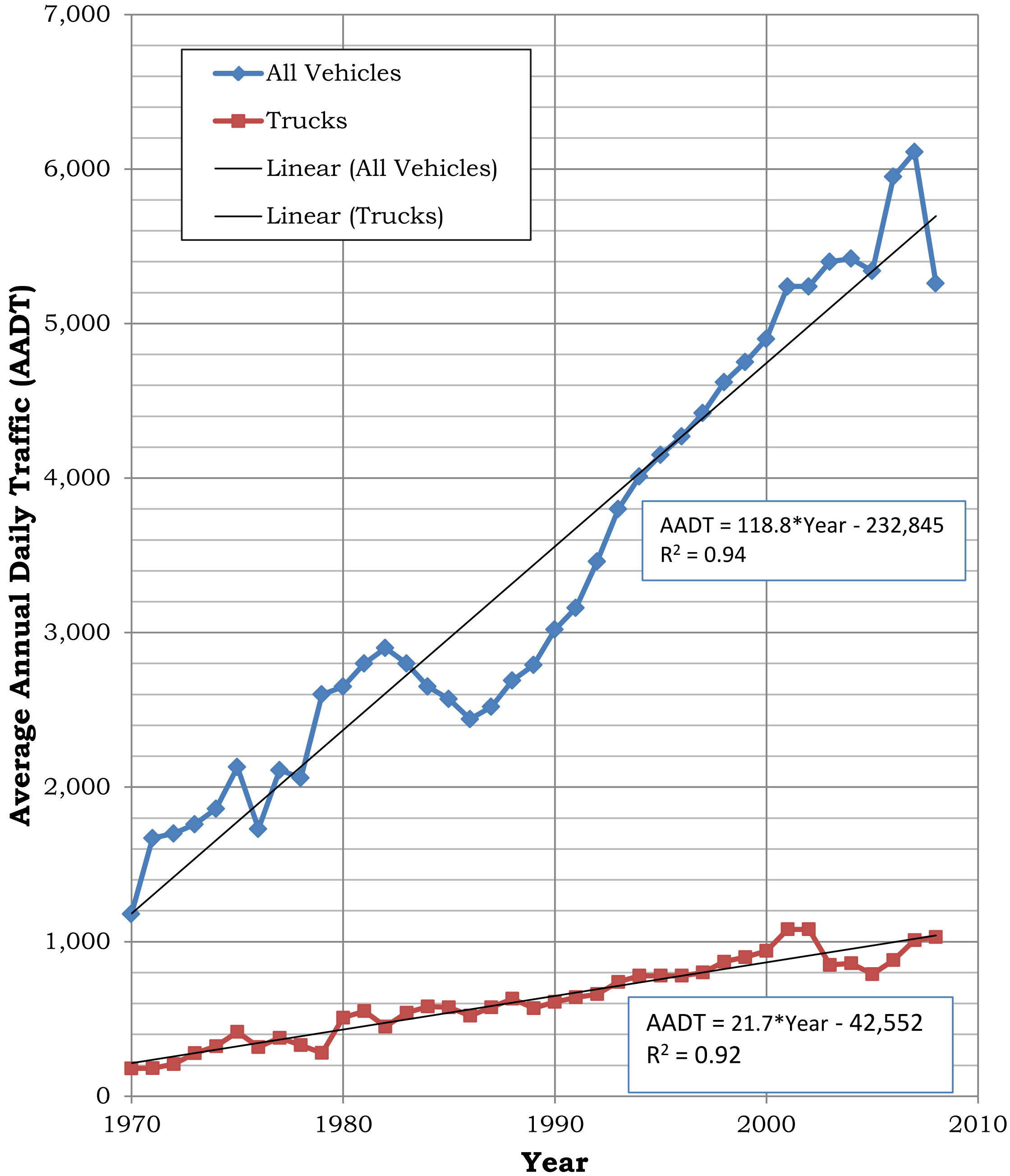


Figure 3.2-3. Historical I-90 Traffic Levels at Moorcroft
Source: WYDOT 2009, I-90 Junction Route 44 (West Moorcroft Interchange)

3.3 Geology and Soils

The regional geology and seismology related to the Lance District in general, and the local geology and seismology specifically related to the Ross ISR Project area are described in this section. Detailed information regarding the structure, stratigraphy, and ore mineralogy of the proposed project area are discussed to the extent that 10 CFR Part 40.32(e) allows Strata to obtain sufficient subsurface information by exploration drilling. Also included in this section is a detailed description of the soils characteristics of the proposed project area.

3.3.1 Regional Setting

<u>3.3.1.1 Structural Geology</u>

The Lance District is geographically located along the west side of Crook County in northeastern Wyoming. It is structurally situated between two major tectonic features: the Black Hills uplift to the east and the Powder River Basin to the west. Both of these structural features are related to the Laramide Orogeny (uplifts of the Rocky Mountain region). The Black Hills of South Dakota and Wyoming are commonly referred to as a classic example of doming of the basement (Lisenbee 1978). The Black Hills uplift is the easternmost and least deformed of the Laramide uplifts of the Rocky Mountain region (Lisenbee 1978). Figure 3.3-1 depicts the regional tectonic setting. The structural relief of this uplift is of a moderate nature compared to other uplifts of the Wyoming province (Lisenbee 1978).

Structural deformation that developed the Black Hills uplift and Powder River Basin was initiated in the Late Cretaceous and Early Tertiary (Paleocene) as Laramide crustal stresses. Erosion accompanied uplifting, and sediments stripped off from the growing uplift filled the structural basin that was synchronously developed to the west during the Laramide Orogeny. The depositional environments at that time consisted of near sea level low-relief streams, flood plains, sloughs, and swamps that were inland of the open sea that lay to the northeast. Through the Paleocene and into the Eocene, the Powder River Basin subsided intermittently, followed by periods of stability resulting in the accumulation of several thousand feet of interbedded sands, silts, clays and coal deposited in a near sea level environment. Deposition of the Paleocene Fort Union Formation and Eocene Wasatch Formation was

followed by the deposition of the Oligocene White River Group, which covered the Powder River Basin (Lisenbee 1988). The White River Group sediments were deposited with angular unconformity across most of the eroded roots of the uplift as well. During the Oligocene and Miocene Epochs, extensive volcanism to the west provided a source of thick accumulations of tuffaceous sediments that extended over much of the Powder River Basin and covered all but the highest mountain ranges (Mears 1993).

The age of the major regional uplift that resulted in the removal of most of the White River Group and formed the present-day Black Hills has been established as late Oligocene, or possibly as late as Pliocene (Whitcomb and Morris 1964 and Lisenbee 1988). Several erosional cycles in the stream valleys suggest that uplifting and exhumation has continued throughout the Tertiary Period. Uplifting may even prevail at the present time as streams in the Black Hills region apparently are downcutting (Whitcomb and Morris 1964). The north-northeast trending drainages in the Powder River Basin have continued their downcutting through recent time resulting in the present topography of the area (Mears 1993).

The Black Hills uplift is a broad north-trending domal structure approximately 180 miles long and 75 miles wide with its core comprised of Precambrian basement rocks. The intrusion of several large igneous masses into the rocks underlying the area accompanied the uplifting. The tectonic map of the Black Hills uplift and eastern Powder River Basin is depicted in Figure 3.3-2. In detail, the uplift is not a simple fold, but rather consists of two primary, north-trending en-echelon structural blocks, the western block and the eastern block. The flanks of the uplift display different characteristics, with a sharp monoclinal break on the west side of the western block and a broad arch on the east side of the eastern block (Lisenbee 1988). The structurally highest part of the uplift is on the eastern block centered on the exposed Precambrian core. The western block is bounded on the west by the Black Hills monocline. The north-trending monocline separates the gently west-dipping strata of the Powder River Basin from the uplift for a strike length of approximately 150 miles. The maximum values of westerly dips in the rotated limb range from 15 degrees west to vertical along strike (Lisenbee 1988).

The Powder River Basin, which borders the western flank of the Black Hills uplift, is a structurally asymmetric Tertiary intermontane basin having primarily Tertiary-age rocks exposed at the surface. The synclinal axis of the

basin is located along and near its western margin. Along the basin's eastern margin the structural dip of the sedimentary units is 1-2 degrees basinward. As described by Lisenbee (1988), the resistant Paleozoic strata are dramatically exposed in the monoclines along the western margin of the Powder River Basin and form an impressive topographic front at the eastern flank of the Big Horn Mountains approximately coincident with the uplift margin. In contrast, the eastern basin margin is undistinguished topographically. The Cretaceous units are only rarely reflected in topography at the Black Hills monocline, so the uplift and basin are at roughly the same elevation for much of their shared length.

3.3.1.2 Stratigraphy

The regional stratigraphy of the Black Hills uplift and adjacent Powder River Basin includes Precambrian crystalline basement rocks, Paleozoic, Mesozoic and Cenozoic sediments, along with some localized occurrences of igneous intrusive rocks. The regional stratigraphic column is depicted in Figure 3.3-3. The rocks of western Crook County are predominantly clastic and range from claystone to fine-grained sandstone. Some coarse and conglomeratic sandstone and massive limestone occur near the base of the stratigraphic sequence at great depth below land surface. This sedimentary series is underlain by igneous and metamorphic rocks of Precambrian age (Whitcomb and Morris 1964). Figure 3.3-4 depicts the regional bedrock geologic map. Sedimentary rocks of Mississippian age and older are not exposed on the surface along the northern and western flanks of the Black Hills uplift, nor are the Precambrian age crystalline basement rocks (Robinson et al. 1964). Sediments exposed in the Lance District are primarily limited to Lower (or Early) and Upper (or Late) Cretaceous and Quaternary age with the vast majority of the Tertiary age sediments being eroded away.

The Lower Cretaceous sedimentary units include the Lakota and Fall River Formations of the Inyan Kara Group. These sediments represent a transitional environment with terrestrial fluvial sequences grading into marginal marine sediments as the Cretaceous Interior Seaway inundated a stable land surface. Sandstone deposits of the Fall River Formation are known to be uraniferous both locally and regionally (Robinson et al. 1964). Uranium occurrences in the Carlile, Hulett Creek, and Elkhorn Creek areas were mined by a number of companies during the 1950s and 1960s from sandstones of the Fall River Formation.

Following deposition of the near-shore Fall River sediments, the Cretaceous Interior Seaway inundated large portions of present day North America. The resulting thick sequence of marine intervals are comprised of the Skull Creek Shale, Muddy Formation, Mowry Shale, Belle Fourche Shale, Greenhorn Formation, Carlile Formation, Niobrara Formation and Pierre Shale. Total thickness of these Lower and Upper Cretaceous intervals in the Lance District can exceed 5,000 feet.

As the Cretaceous Period drew to a close, the seas of the Interior Seaway were in retreat (Lisenbee 1988). In the area of the future Black Hills uplift and the Powder River Basin, offshore marine deposits of the Pierre Shale grade upward into transitional marine sediments of the near shore Fox Hills Formation. The Fox Hills Formation is an erratic near-shore sand development deposited during regression of the Upper Cretaceous sea (Dunlap 1958). It has been divided by Dodge and Spencer (1977) into lower and upper units. Sediments of the lower Fox Hills were deposited in marginal marine, foreshore, and shore-face environments (Dodge and Spencer 1980). Unconformably overlying the lower Fox Hills rocks are estuarine sediments of the upper Fox Hills Formation (Dodge and Spencer 1977 and 1980). Dominated by near-shore, fine-grained sandstones, the Fox Hills Formation is a primary uranium host in the Lance District and portrays initiation of Laramide Orogenic events in the region. The transition from marginal marine to terrestrial sedimentation patterns is apparent in the Fox Hills, with a generally fining upward sequence typical of the Powder River Basin.

Continued Laramide Orogenic activity resulted in deposition of the Lance Formation, which lies conformably upon the Fox Hills Formation. The Lance records the deposition of continental deposits following the withdrawal of the Upper Cretaceous sea in the Powder River Basin (Dunlap 1958). Marine influence on sediment distribution terminated with the sandstones and mudstones of the Lance Formation. The Lance was deposited on a relatively stable platform located in what is now northeastern Wyoming. Resulting depositional environments have been interpreted as being fluviodeltaic in origin Dodge and Powell 1975, Dodge and Spencer 1977, Dodge and Spencer 1980). The Lance Formation consists of fluvial channel sandstones that make up about one-third of the formation (Connor 1992); the rest of the formation is composed of interchannel mudstone and sandstone (Dodge and Powell 1975). The Lance channel sandstones are pale yellowish- or greenish-brown, fine-

grained to very fine-grained elongate sand bodies, ranging from 3 feet to over 150 feet in thickness with a source area from uplifts in western Montana (Dodge and Powell 1975). The interchannel sediments are finer grained and composed of medium- to dark-gray, sandy clay that swells when wet, and pale-reddish-brown to gray, tuffaceous mudstones (Dodge and Powell 1975). Thin interchannel muddy sandstones are interlayered with the thicker sandstones, and the mudstones commonly contain degraded plant debris but lignite and coaly shales are conspicuously absent.

Paleontological data also represent a change from near-shore marine conditions of the Fox Hills Formation to fluviodeltaic conditions of the Lance Formation. The Fox Hills rocks contain marine type fossils and the Lance rocks contain numerous disarticulated bones of dinosaurs and other terrestrial reptiles (Dodge and Powell 1975). Robinson et al. (1964) used the lowest brown carbonaceous shale or swelling clay bed as the Fox Hills-Lance contact. Within the Powder River Basin, the combined Lance and Fox Hills thicken from less than 700 feet in the north to more than 3,300 feet in the south; there is little change in thickness from east to west (Connor 1992). Deposition of the Lance Formation ended at the Cretaceous-Tertiary boundary. Studies have indicated that rainfall amounts increased dramatically, accompanied by greater amounts of sandy sediments and eventually by the development of widespread peat accumulating swamps in the upper part of the Paleocene (Connor 1992). Deposition of fluvial sandstones, floodplain mudstones and coals document a continued continental influence on sedimentation through the overlying Fort Union Formation.

The Fort Union Formation of Paleocene age consists primarily of fluvial lenticular siltstones and sandstones and floodplain claystones and mudstones that contain subbituminous coal and carbonaceous shale. The Fort Union-Lance contact is unconformable throughout the Rocky Mountain area and marks the break between Cretaceous and Tertiary time (Dunlap 1958). The general lithology of the Fort Union-Lance is similar and no consistent marker denoting the contact can be identified over the Powder River Basin. Some geologists pick the contact at the first coal bed encountered (Dunlap 1958). The upper two-thirds of the Lance contains no coal seams (Brown 1958). The upper parts of the Fort Union Formation (the Tongue River Member) host the very rich coal seams mined near the center of the Powder River Basin north and south of the city of Gillette, Wyoming.

3.3.2 Proposed Project Area

<u>3.3.2.1 Structural Geology</u>

Due to the Black Hills monocline, there is a steepening of the regional stratigraphic dip, which is essentially horizontal, to nearly vertical along the eastern edge of the proposed Ross ISR Project area. The rocks in this area have been rotated as a result of the flexure on the steeply inclined limb of the monocline (Buswell 1982). As indicated on the bedrock geologic map (Figure 3.3-4), the entire proposed project area lies within the outcrop of the Lance Formation, while the other two formations of interest (Fox Hills and Pierre Shale) crop out within ½ mile of the proposed project area's eastern boundary. A generalized geologic cross-section depicting the Black Hills monocline in the vicinity of the proposed project area is shown in Figure 3.3-5. An 85 degree dip to the west was measured at an outcropping of the Pierre Shale located approximately ¼ mile east of the proposed project area, while structural dips within the proposed project area were measured at 1 to 2 degrees (basinward) at outcrops of the Lance Formation.

With the obvious exception of the Black Hills monocline, there are no significant structural features in the proposed project area. No faults of major displacement exist within the proposed project area; however, minor localized slumps, folds and differential compaction features are common. Lineal features originally interpreted by Buswell (1982) as structural faults are now believed by Strata to actually be depositional rather than structural in origin. Strata conducted a rigorous analysis of the data utilized by Buswell and, as explained below, concluded that depositional irregularities and differential compaction of dissimilar textures account for the minor changes in dip and/or thicknesses of beds.

In 1982, M.D. Buswell completed his M.S. Thesis on the subsurface geology of the Oshoto Uranium District for the South Dakota School of Mines and Technology. The study area for Buswell's thesis is roughly the same area as the Ross ISR Project. Buswell's thesis presents a map of the structural contours on the base of the Upper Fox Hills, which illustrates the locations of six, roughly east-west trending structural faults in the currently proposed project area (Figure 3.3-6). Displacement on these suspected subsurface faults was estimated to range between 10 and 30 feet. To support his interpretation, Buswell stated that, "slickensides were present on the fault surface" in a core

sample that intersected a fault, and that, “sandstone was displaced against shale.” In addition, he cited the results of an aquifer pumping test conducted near suspected faults that suggested the “presence of hydrologic barriers in the area,” and “that the barrier is fault related.” Buswell’s observation of what he thought was a fault surface in a single core sample is considered conjectural and a subjective judgment call. As for the aquifer test cited by Buswell, the groundwater hydrologist (P.A. Manera) who conducted and analyzed the test stated in his report (Manera 1978) that the changing permeability and lateral discontinuity in the stratigraphy was the more probable reason for some observation wells to be hydrologically isolated rather than structural faulting causing no-flow boundary conditions.

In an effort to verify the existence of the faults that Buswell suspected, and to identify and quantify the displacement of those faults, Strata developed a series of detailed geologic cross sections drawn normal to the fault traces. Only recently surveyed drill holes from the Nubeth R&D project database that was developed in the 1970s by Nuclear Dynamics (later ND Resources) were used to construct the cross sections. A review of the historic information regarding the drilling program contained in the Nubeth database indicated that the original drill holes were never surveyed. A great majority of the historic Nubeth holes were capped with a cement plug containing a metal tag that identified the old hole number. Utilization of a metal detector was successful in locating these old holes, and once identified, they were surveyed by Bearlodge Ltd. Inc. of Sundance, Wyoming. Many of the Nubeth holes posted on the historic maps in the database were mislocated and had erroneous collar elevations. As of June 18, 2010, approximately 300 of the Nubeth project holes had been surveyed in the proposed Ross Project area.

The effort by Strata to verify the existence of the structural faults interpreted by Buswell also included a review of structure contour maps of distinctive stratigraphic horizons across the proposed project area. The top and bottom elevations of specific horizons (e.g., base of the upper Fox Hills sandstone) having distinct geophysical log signatures were calculated only from drill holes having correct surveyed collar elevations, and were used to prepare the structure contour maps. The structure contour map for each respective stratigraphic interval of importance with respect to the proposed Ross ISR Project area is addressed within Section 3.3.2.2.

A detailed review of the cross sections along with the structure contour maps indicate that the east-west faults as mapped by Buswell in the proposed project area are not perceptible. What do appear to exist, however, are localized slumps and differential compaction features overprinted on an undulating or rolling terrain. In the sections where there is an apparent dip change and an indicated displacement in the range of 10 to 12 feet, these minor displacements most likely relate to undulating or rolling terrain, common in the Pierre Shale and overlying basal Fox Hills, and/or differential compaction of sandstone versus shale. These local features do not consistently carry through more than one to two cross sections, further evidence for lack of faulting.

Buswell, in his thesis, acknowledged that he had access to ND Resources' drill hole database for his analysis. Buswell presumably would have used the USGS topographic map to visually locate and estimate drill hole collar elevations because the Nubeth holes had not been surveyed. The original USGS topographic map for this area was the Oshoto 15-minute quadrangle, which was issued in 1954 and had a contour interval of 40 feet. Minor fault displacement of 10 to 30 feet, as suspected by Buswell, could be accounted for by erroneous drill hole collar elevations. The use of stratigraphic information from unsurveyed drill holes within a very complex stratigraphic section is problematic and discredits any subsurface geologic structural interpretation. Therefore, Strata does not consider Buswell's structural fault interpretations to be valid. A copy of M.D. Buswell's M.S. Thesis is included in Addendum 2.6-A in the TR.

3.3.2.2 Stratigraphy

Detailed analysis of the subsurface stratigraphy and mineralogy of the proposed Ross Project area began in the early 1970s with the first uranium exploration and development efforts in the Oshoto area. Beginning in 1971, Nuclear Dynamics began a multi-phased drilling program in the Lance District. The initial, wide-spaced drilling phase provided information on stratigraphic correlations of the Lance Formation and the first identification of oxidation-reduction boundaries and mineral intercepts. From 1971 to 1975, thousands of exploration holes were drilled to delineate roll front uranium deposit boundaries and provide information for the economic evaluation of uranium deposits. From 1975 to 1977, exploration efforts emphasized the development of a mineable ore deposit in the Oshoto area. In 1978, Nuclear Dynamics formed a joint venture with Bethlehem Steel called the Nubeth Joint Venture.

That year Nubeth developed and briefly operated a pilot ISR plant within the proposed project area. All exploration efforts in the Oshoto area ended in 1979 upon completion of an initial test of the leach chemistry, concurrent with a sharp decrease in interest in nuclear energy following the Three Mile Island Incident. Nubeth discontinued their Oshoto project in 1983.

In 2007 and 2008, Strata initiated mineral acquisition in the Lance District and acquired a portion of the Nubeth drill hole database. Strata subsequently began confirmation drilling and exploration drilling for the Ross ISR Project in September 2008. Strata continued with exploration and development drilling in 2009 and also acquired the complete historic Nubeth database that same year. As of June 18, 2010, there were 1,115 surveyed drill holes and 962 unsurveyed drill holes within a ½-mile radius of the proposed Ross Project area. Core samples were collected from 14 of the surveyed holes.

The main objective of Strata's program of rotary mud and core drilling was to confirm the presence of the historic uranium mineralization and enhance the understanding of the area's geology. A geophysical log (resistivity, spontaneous potential and gamma radioactivity) of each hole is used to help interpret the subsurface stratigraphy in parallel with lithologic logging of drill cuttings. Core samples also provide detailed lithologic data for stratigraphic correlations. Unsurveyed Nubeth holes have been and continue to be located by Strata and surveyed. Strata has also completed 27 monitor wells in the proposed project area, which are included in the total number of surveyed drill holes. Addendum 2.6-B in the TR includes a tabulation of all drill holes and core holes located within the proposed project area that provide valid subsurface information.

Specific to the proposed Ross ISR Project area, the stratigraphic sequence of importance is, in descending order: recent unconsolidated surficial deposits including residual soils, colluvium and alluvium, Lance Formation, Fox Hills Formation, and Pierre Shale. Figure 3.3-7 depicts the stratigraphic nomenclature that is used within the proposed project area. This figure illustrates the geophysical log and corresponding lithology obtained from exploration drill hole number RMR008, the location of which is shown on Figure 3.3-4. This particular drill hole was chosen as the "type log" for the proposed project area due to the clarity of the geophysical logs and the associated stratigraphic descriptions from land surface to the top of the Pierre Shale. The Pierre Shale conformably underlies the Fox Hills Formation, which

is divisible into upper and lower units (Dodge and Spencer 1980). Upper Fox Hills strata comprise the lower mineralized horizon (designated herein as the FH horizon having uranium roll fronts **A** through **D**). Overlying the Fox Hills is the Lance Formation. The boundary between these formations is conformable. Mineralization also occurs in the lower Lance (designated herein as the LT horizon having roll front uranium deposit **E**). Recent unconsolidated surficial deposits (i.e., residual soils, colluvium and alluvium) lie unconformably upon the Lance Formation.

A total of 371 geophysical logs that were of sufficient resolution and considered most representative of the stratigraphy were selected for the preparation of six geologic cross sections that are used to illustrate the subsurface stratigraphy of the proposed project area. These cross sections, which are constructed both parallel and perpendicular to the local dip, are included in Addendum 2.6-C in the TR as Figures 2 through 34. Due to the large number of geophysical logs that were used to construct the cross sections, each one was broken up into segments for illustration purposes. For example, Figures 2 through 13 are Segments 1 through 12, respectively, of cross section A-A'. Figure 1 in Addendum 2.6-C in the TR illustrates the locations of the cross sections and the individual segments that make up each section.

Descriptions of each of these stratigraphic units and the important implications they have from groundwater hydrological and ISR operational perspectives are discussed below in ascending order.

3.3.2.2.1 Sub-Pierre Shale

Formations older than the Upper Cretaceous Pierre Shale are listed on the Regional Stratigraphic Column (Figure 3.3-3). The eastern edge of the proposed Ross ISR Project area lies essentially along the trace of the Black Hills monocline, as depicted on the bedrock geology map (Figure 3.3-4). As such, the outcrops of seven Upper and Lower Cretaceous formations (Niobrara, Carlile Shale, Greenhorn Formation, Belle Fourche, Mowry, Newcastle, and Skull Creek) underlying the Pierre Shale occur within roughly 2 miles of the proposed project area. The Pierre Shale in this area is a massively thick marine shale that is considered a regional confining layer. The older, underlying formations are therefore sufficiently separated by the Pierre from the overlying Fox Hills and Lance formations so as to not be of interest here, with the following

exception. An analysis of the geology and water quality of potential injection zones was performed to evaluate the optimum targets available at the proposed project area for Class I wastewater injection wells. As such, the Cambrian-age Deadwood and Flathead formations were selected as the optimum target injection interval. The Class I UIC permit application for the proposed Ross ISR Project was prepared by Petrotek and is included in Addendum 4.2-A in the TR. Based on Petrotek's geologic analysis, the Deadwood and Flathead formations will likely be encountered at depths of approximately 8,163 and 8,565 feet below land surface, respectively.

3.3.2.2.2 Pierre Shale

The Pierre Shale, of Upper Cretaceous age, is the oldest formation of interest for the Ross ISR Project. As indicated on Figure 3.3-7, the stratigraphic horizon nomenclature for the Pierre Shale is "KP" within the proposed project area.

As indicated on the bedrock geology map (Figure 3.3-4), the Pierre Shale crops out approximately ¼ mile east of the proposed project area. Outcrops of Pierre Shale are poorly exposed, but are distinguishable in the subsurface by electric logs and core (Buswell 1982). Typically, historic Nubeth and recent Strata drill holes have been terminated in the top of the Pierre Shale. Therefore, the description of the full Pierre Shale section included herein is based on information obtained from other sources. The Pierre Shale is comprised of massive, dark grey to black silty shales with relatively uniform composition. *Siphonites*, trace fossils identified in core samples, give indication of a marine environment of deposition (Dodge and Spencer 1980).

Based upon the thickness of the outcrop on the bedrock geology map (Figure 3.3-4) and geophysical logs from oil wells located in the general area, the Pierre Shale appears to be approximately 2,200 feet thick in the proposed project area. Depths to the top of the Pierre Shale within the proposed project area range from roughly 500-650 feet in the northeastern quadrant, 690-870 feet in the southeastern quadrant, 740-920 feet in the southwestern quadrant, and 860-980 feet in the northwestern quadrant. Spontaneous potential (SP) and resistivity (R) logs for drill holes that penetrated the Pierre Shale, such as drill hole RMR008 (Figure 3.3-7), and logs for oil wells typically indicate the absence of water-bearing zones. Locally, the upper Pierre Shale is void of any permeable water-bearing strata. Due to its thickness and low permeability, the

Pierre Shale is considered the lower groundwater confining unit within the proposed Ross ISR Project area. The Pierre provides a significant hydraulic barrier between water bearing intervals within the older, underlying Cretaceous, Mesozoic, and Paleozoic formations and the younger, overlying Upper Cretaceous Fox Hills/Lance formations. Additional discussions on the hydraulic characteristics of the Pierre Shale are included in Section 3.4 in this ER.

3.3.2.2.3 Fox Hills Formation

The bedrock geology map, Figure 3.3-4, depicts the Upper Cretaceous Fox Hills Formation cropping out along the eastern boundary of the proposed Ross Project area. In the vicinity of Oshoto, Dodge and Spencer (1980) divided the Fox Hills Formation into lower and upper units, based on differences in color, bedding, trace fossils, lithology and texture.

3.3.2.2.3.1 Lower Fox Hills Formation

The lower Fox Hills Formation, as described by Buswell (1982), consists of two sand members separated by interbedded shales and silts. The lower of the two, or basal, sand horizons is comprised of sandstones with thin interbeds of shale and siltstone, capped by a calcareous-cemented sandstone. The contact between the underlying Pierre Shale and the lower Fox Hills Formation basal sand horizon is gradational, with the basal sandstone typically exhibiting a coarsening upward with a very sharp upper contact with overlying shales and siltstones. As indicated on Figure 3.3-7, the stratigraphic horizon nomenclature for the basal sandstone in the lower Fox Hills is “FS,” and its thickness is generally found to be around 20 to 35 feet.

Overlying the FS horizon is an interval comprised of dark gray to black shale, claystone and mudstone. This interval is described herein as the basal Fox Hills Lower Confining Unit (or aquitard). The stratigraphic horizon nomenclature used herein for this shale unit in the lower Fox Hills is “BFH,” and its thickness is generally around 30 to 50 feet within the proposed project area (Figure 3.3-7).

The upper of the two sand horizons in the lower Fox Hills consists of thin bedded sandstones and interbeds of shales, siltstones, and calcareous-cemented sandstones (Buswell 1982). Typical of this sand interval, the lower contact is sharp, then fining upward to a gradational upper contact. The

stratigraphic horizon nomenclature used herein for this upper sand horizon in the lower Fox Hills is "BFS" (Figure 3.3-7), and it is believed to be continuous throughout the proposed project area. With respect to this sand member's significance to the proposed Ross ISR Project, and in particular to the occurrence of groundwater in the Oshoto area, it is the first water-bearing interval that lies stratigraphically below the uranium ore-bearing sands in the upper Fox Hills Formation. Groundwater monitoring wells have been installed in this saturated interval, which demonstrates hydraulic continuity and the same basic lithologic characteristics throughout the proposed project area (refer to Section 3.4). This areally continuous sand interval is also referred to as the deep monitoring zone, or "DM" interval.

Structure contour maps that depict the elevations of the upper and lower surfaces of the DM interval (or BFS horizon), as well as an isopach map that depicts the DM interval's thickness within and near the proposed project area are included in Addendum 2.6-D in the TR as Figures 1, 2, and 3, respectively. The thickness of the DM interval ranges from around 10-30 feet and averages about 16.5 feet thick within the proposed project area. Within the proposed project area, depths to the top of the DM zone range from roughly 480-620 feet in the northeastern quadrant, 500-680 feet in the southeastern quadrant, 600-760 feet in the southwestern quadrant, and 550-790 feet in the northwestern quadrant.

Conformably overlying the BFS horizon (DM aquifer) is an interval comprised of thin interbeds of black to dark gray shales, siltstones and claystones. This shale unit contains the marine trace fossil *Thalassinoides*, which is the only trace fossil found in the lower Fox Hills (Dodge and Spence 1980). This shale interval is also described as the basal Fox Hills Lower Confining Unit. The stratigraphic horizon nomenclature used herein for this aquitard is "BFH" (Figure 3.3-7). The DM interval is separated from the upper Fox Hills sandstones by this shale unit. An isopach map that depicts the thickness of the BFH shale interval, which is also referred to as the Lower Confining Unit, within and near the proposed project area is included in Addendum 2.6-D in the TR as Figure 4. The thickness of this confining shale interval ranges from around 10-50 feet and averages about 32 feet thick within the proposed project area. Additional discussions on the confining properties of the BFH Lower Confining Unit shale aquitard, which is believed to be

continuous throughout the proposed project area, are included in Section 3.4 in this ER.

3.3.2.2.3.2 Upper Fox Hills Formation

Buswell (1982) determined that there are two types of sandstone deposits that are prevalent within the upper Fox Hills Formation in the Oshoto area: 1) thick-bedded, blocky sandstones, and 2) thin, interbedded sandstones, siltstones and shales.

The blocky sandstones are light gray to gray, well to moderately well sorted, and fine-grained. Intraformational shale pebble conglomerates commonly occur at, or slightly above, the basal contact between upper and lower Fox Hills. Shale clasts are well rounded and have been found in core to range up to 6 inches in diameter.

The thin, interbedded sandstones, siltstones, and shales represent either low percentage sands or high alternation rate areas. Sandstones range from olive green to gray, fine- to very fine-grained, and moderately to poorly sorted. Black shales to dark gray siltstones are slightly bioturbated (disturbed by organisms), and Dodge and Spencer (1980) identified brackish-water pelecypods in the same unit. Coalified leafy matter and small carbonaceous fragments are present in core samples.

Uranium mineralization occurs in the marginal marine sandstones of the upper Fox Hills Formation, which are primary production targets of the Ross ISR Project. The upper Fox Hills sandstones make up the lower portion of the mineralized zone, and as depicted on Figure 3.3-7, the stratigraphic horizon nomenclature used herein for the upper Fox Hills mineralized zone is "FH." Mineralization occurs in three to four discontinuous interbedded sandstones and the roll front uranium deposits have the letter designations of **A**, **B**, **C**, and **D**, in ascending order (Figure 3.3-7). Within the proposed project area, the FH horizon ranges in thickness from around 50 to 65 feet.

The FH horizon is also the lower portion of the ore zone aquifer, or what is referred to herein as the "OZ" monitoring interval. The upper portion of the mineralized zone, which also is the upper portion of the OZ aquifer, is within the overlying Lance Formation.

3.3.2.2.4 Lance Formation

The bedrock geology map, Figure 3.3-4, shows that the proposed Ross Project area lies virtually within the outcrop of the Upper Cretaceous Lance Formation. The Lance Formation sediments are poorly exposed at the surface, but are distinguishable in the subsurface core and electric logs (Buswell 1982). The Fox Hills-Lance contact is rarely exposed, but the marine beds of the Fox Hills are directly overlain by fluviodeltaic sandstone and mudstone of the Lance Formation. Only the lower section of the Lance Formation occurs in the proposed project area.

As described in Section 3.3.1.2, the Lance Formation on the eastern side of the Powder River Basin consists of a mixture of thicker fluvial channel sandstone and thinner floodplain interchannel clays, mudstones, and very fine-grained sandstones. The depositional environment of the Lance created a stratigraphy that is complicated and vertically heterogeneous. In general, the lower Lance Formation sediments are comprised of multiple sand bodies bounded by abundant shales and siltstones.

Buswell's investigation of the Lance Formation in the Oshoto area included the lower 100 to 150 feet of the formation above the Fox Hills boundary. Within this section of the formation, Buswell described two depositional sandstone packages with opposing sand body geometry. Both deposits are related in that deposition occurred in a continental setting, but were influenced by varied local processes active in a progradational coastal setting. Streamflow directions throughout Lance sedimentation in northeastern Wyoming are predominantly south to southeast (Dodge and Powell 1975). Sandstones were deposited as distributary channels and crevasse splays on a lower coastal or delta plain.

The following description of the Lance Formation sediments is taken from M.D. Buswell's 1982 M.S. Thesis on the subsurface geology in the Oshoto area:

> The lowest sand package of the Lance Formation is comprised of narrow, rejoining fluvial channel deposits. Channel sandstones form sharp upper and lower contacts and display abrupt boundaries with laterally equivalent interchannel sediments. The sandstone deposits in the lowest section are divided into thick bedded sandstones and thin, interbedded sandstone, siltstone, and shale. Thick-bedded sandstones are gray to light gray, fine- to very fine-grained, and often have clasts of carbonaceous fragments and coalified woody materials. Interbedded

sediments have dark brown and gray organic-rich shales, black lignitic shales, and dark gray, very fine-grained sandstones and siltstones. Basal Lance distributaries formed a complex rejoining channel pattern that probably resulted from rapid and repeated channel diversions. Sandstones form a net of north-south oriented sand bodies within this section. These sand bodies are typically narrow and straight, rejoining channels trending roughly north-south that extend out of the Oshoto area.

Located above the lower Lance channel-interchannel deposits are sediments comprised of small, east-west-trending sandstones, which are fine- to very fine-grained. The types of sand bodies occurring within this section are multiple narrow east-trending shoestring sandstones and a singular, broad, wedge-shape sandstone that grades easterly into multiple shoestring sand channels. Sand trends extend west out of the Oshoto area. Lateral boundaries for individual sand bodies are abrupt. These sand bodies are bounded by abundant dark gray shales and siltstones. (Buswell 1982)

The Lance Formation is of particular importance to the Ross ISR Project. Uranium mineralization occurs in the fluvial sandstones of the basal Lance Formation, which, combined with the uranium mineralization of the upper Fox Hills sandstones (FH horizon), are primary production targets of the Ross ISR Project. The basal Lance sandstones comprise the upper portion of the mineralized zone, and as depicted on Figure 3.3-7, the stratigraphic horizon nomenclature used herein for the lower Lance mineralized zone is "LT." Mineralization occasionally occurs in the LT horizon as roll front uranium deposits having the letter designation of **E** (Figure 3.3-7). Within the proposed project area, the LT horizon ranges in thickness from around 30 to 40 feet. The uranium ore-bearing sands of the upper Fox Hills Formation (FH horizon) and lower Lance Formation (LT horizon) are saturated and capable of transmitting groundwater. Monitoring wells have been installed in this saturated interval, which demonstrates hydraulic continuity and is referred to as the ore zone aquifer, or the "OZ" monitoring interval, throughout the proposed project area (refer to Section 3.4).

Structure contour maps that depict the elevations of the upper and lower surfaces of the OZ interval, as well as an isopach map that depicts the OZ interval's thickness within and near the proposed project area are included in Addendum 2.6-D in the TR as Figures 5, 6, and 7, respectively. The thickness of the OZ interval ranges from around 100-180 feet and averages about 136 feet thick within the proposed project area. Within the proposed project

area, depths to the top of the OZ interval range from roughly 250-430 feet in the northeastern quadrant, 300-500 feet in the southeastern quadrant, 410-660 feet in the southwestern quadrant, and 400-650 feet in the northwestern quadrant.

Overlying the OZ aquifer is a sequence of thinly interbedded, gray to dark gray mudstones, claystones, siltstones, and very fine-grained sandstones. As depicted on Figure 3.3-7, the stratigraphic horizon nomenclature used for the Ross ISR Project for these predominantly floodplain deposit intervals are, in ascending order, “LC,” “LS,” “LR,” “LQ,” “LP,” “LO,” and “LN.” Overall, the thickness of this entire sequence typically ranges from about 55 to 145 feet. These very fine-grained sediments that lie directly above the OZ aquifer have been determined to be areally continuous throughout the proposed project area and impermeable to groundwater flow (refer to Section 3.4). An isopach map of the LC horizon aquitard, which is also referred to as the Upper Confining Unit (Figure 3.3-7), within the proposed project area is included in Addendum 2.6-D in the TR as Figure 8. The thickness of this confining unit ranges from around 20-80 feet and averages about 43 feet thick within the proposed project area. Additional discussions on the confining properties of the LC horizon Upper Confining Unit aquitard are included in Section 3.4 in this ER.

A stratigraphic sequence of fine-grained fluvial sandstones and interbedded claystones and siltstones lies directly above the very fine-grained mudstones and claystones that are described in the preceding paragraph. This interval of saturated permeable material will yield enough water to wells that can be put to beneficial use to be considered an aquifer. As depicted on Figure 3.3-7, the stratigraphic horizon nomenclature used for the Ross ISR Project for this saturated fluvial sandstone interval is, in ascending order, “LM,” “LL,” and “LK.” With respect to this sandstone interval’s significance to the proposed Ross ISR Project, and in particular to the occurrence of groundwater in the Oshoto area, it is the first water-bearing interval that lies stratigraphically above the targeted uranium ore-bearing sands of the upper Fox Hills/lower Lance (OZ aquifer). This sandstone interval is the first areally consistent saturated zone encountered when drilling in the Oshoto area. Monitoring wells have been installed throughout the proposed project area in this saturated interval, which demonstrates hydraulic continuity and is referred to as the shallow monitoring zone, or “SM” aquifer (refer to Section 3.4). Structure contour maps that depict the elevations of the upper and lower

surfaces of the SM interval, as well as an isopach map that depicts the SM interval's thickness within and near the proposed project area are included in Addendum 2.6-D in the TR as Figures 9, 10, and 11, respectively. The thickness of the SM interval ranges from around 60-170 feet and averages about 112 feet thick within the proposed project area. Within the proposed project area, depths to the top of the SM interval range from roughly 100-250 feet in the northeastern quadrant, 150-350 feet in the southeastern quadrant, 300-450 feet in the southwestern quadrant, and 250-450 feet in the northwestern quadrant. Additional discussions on the SM interval is included in Section 3.4 in this ER.

Overlying the SM aquifer is a sequence of interbedded floodplain deposits of mudstones, claystones and siltstones and fluvial channel sandstones. As depicted on Figure 3.3-7, the stratigraphic horizon nomenclature used for the Ross ISR Project for these predominantly floodplain deposit intervals are, in ascending order, "LG," "LF," "LE," "LD," "LB," and "LA." These very fine-grained sediments act to confine the SM aquifer. A structure contour map that depicts the elevations of the upper surface of the confining unit (aquitard) above the SM interval, and an isopach map that depicts its thickness within and near the proposed project area are included in Addendum 2.6-D in the TR as Figures 12 and 13, respectively. The thickness of the confining unit above the SM interval ranges from around 20-120 feet and averages about 60 feet thick within the proposed project area.

Sandy units within the LB and LA horizons are locally saturated. With adequate recharge and permeability, groundwater occurs locally within some of the fluvial sandstones of the upper-most Lance Formation within the proposed project area. Monitoring wells have been installed in these horizons within the proposed project area to monitor the surficial aquifer, or what is referred to as the "SA" interval. Additional discussion on the SA interval is included in Section 3.4 in this ER.

3.3.2.2.5 Stratigraphic Continuity

The uninterrupted connection or persistence of the various stratigraphic units/intervals throughout the proposed Ross Project area is clearly depicted on the geologic cross sections contained in Addendum 2.6-C in the TR. A fence diagram that graphically illustrates the spatial relationships of the various geologic units/intervals that demonstrate hydraulic continuity and exhibit

similar lithologic characteristics within the proposed project area is shown on Figure 3.3-8. Only drill holes located along geologic cross sections A-A', B-B', and D-D' that penetrated the DM interval were used in the construction of the fence diagram. The top of the reference sections are located from the existing ground surface and the depths to the contacts between the various intervals coincide with those depicted on the respective geologic cross sections. Due to the three-dimensional projection of the reference sections, the vertical and horizontal scales are not consistent throughout the diagram.

The cross sections and fence diagram demonstrate that the upper Fox Hills/lower Lance production zone (referred to as the OZ aquifer) is stratigraphically continuous and hydraulically isolated from the overlying upper Lance by areally continuous and impermeable mudstones and claystones (referred to as the LC horizon aquitards or the Upper Confining Unit). The geologic cross sections and the fence diagram not only demonstrate the continuity of the confinement provided by the overlying units but also the continuity of the confinement provided by the basal Fox Hills siltstone-claystone unit (referred to as the BFH horizon aquitards or the Lower Confining Unit) and the underlying Pierre Shale.

3.3.3 Ore Mineralogy and Geochemistry

The following description is from the Wyoming State Geological Survey on the origin of uranium deposits:

> "Uranium occurs nearly everywhere on the planet, even in sea water, but may become concentrated in ore deposits under the right geological conditions and processes. Uranium is usually found in porous sedimentary rocks such as sandstones or conglomerates, but some large deposits are associated with igneous and metamorphic rocks. Uranium atoms are similar in size and chemical properties to calcium atoms, so as rocks form, uranium often substitutes for calcium in minerals such as plagioclase (very common in granites). Thus, calcium-rich rocks such as granite typically contain more uranium than other rocks, and are thought to be the source of many uranium ore deposits. Particles ejected from ancient volcanoes – particles often chemically similar to granitic rocks – are another possible source of uranium ore deposits. These two possibilities are still the center of debate among scientists trying to determine the source of uranium deposits.
>
> Groundwater carries the leached uranium from the source rock – either Precambrian igneous and/or metamorphic basement rock or large-volume volcanic ash fall deposits – and re-deposits it upon migrating into

a reducing environment within the aquifer. In-situ leach mining reverses that process to recover uranium." (WSGS 2010a)

C-shaped roll fronts and tabular ore bodies in the proposed project area developed when Upper Cretaceous sediments were uplifted in the early Tertiary and exposed to oxidizing, uranyl-bearing groundwater. Groundwater entering the system initially migrated down the stratigraphic dip. When strike-oriented sand channels were encountered, groundwater was diverted primarily northward. The source of the uranium in the Upper Cretaceous rocks may have been the uranium-rich tuffaceous rocks of the Oligocene age White River Formation that covered the whole northeastern Wyoming area to a depth of several hundred feet (Buswell 1982).

Uranium targeted for production within the proposed project area is located in permeable sandstones of the Upper Cretaceous Lance and Fox Hills formations. Briefly, the epigenetic roll fronts deposited in the Oshoto area demonstrate patterns similar to those across the Powder River Basin. The uranyl-bearing groundwater moved downdip with emplacement of uranium as a coating on sand grains primarily due to factors such as permeability, reducing groundwater conditions, and groundwater flow (Buswell 1982).

The roll front geometry at the proposed project area is complex due to the variability of the depositional environment of the host sandstones and hence controls on groundwater movement. Active, passive, and stagnant roll fronts formed in response to the differential migration of groundwater through a heterogeneous aquifer. Active alteration tongues coincide with thick, permeable, transmissive channel sands of the Fox Hills and Lance formations. Passive and stagnant fronts tend to be associated with channel flanks or low-permeability, organic-rich interchannel sediments (Buswell 1982).

Uranium grade and thickness of roll front deposits are dependent upon the rate and volume of uranyl-bearing groundwater crossing the geochemical interface. Both the orientation of the roll front to groundwater flow and the size of the channel sand have a direct bearing on uranium deposition. The richest ore deposits are found at the terminus of alteration projections associated with large channel systems (Buswell 1982).

The alteration process not only changes the color, but also alters the mineralogy of the host sandstones. The color of unaltered reduced sandstone is light to dark gray; the darkening agents consist of organic material, dark

accessories and fine-grained pyrite. Altered oxidized sandstone contains subtle iron oxide staining where former carbonaceous matter and pyrite were present. Kaolinized feldspar is typically a greenish-gray to bleached and occasionally has a pink to tan-buff appearance. The presence of pyrite and carbonaceous material along with rapid facies changes of the sandstone host to silty clayey sediments are the major controls on uranium precipitation. Thinning of sandstones and diminished grain size (siltstones-claystones) likely slowed the advance of the uranium-bearing solutions and further enhanced the chances of precipitation (Buswell 1982).

The two horizons targeted for ISR uranium production in the proposed project area, one in the upper Fox Hills (FH horizon) and one in the Lower Lance (LT horizon), vary from thick, fine-grained cut and fill argillaceous sandstones to fine-grained sandstones with numerous facies changes (marginal marine environment) occurring within short distances. Uranium mineralization occurs in depositional environments as both roll fronts and tabular ore bodies.

Based on drilling to date, the two main mineralized horizons are found at depths ranging from 410 to 700 feet below the surface within the proposed project area. The main mineralized horizons trend in a north-south to northeast-southwest direction. The average dimensions of the mineralized roll fronts and tabular bodies are 115 feet wide by 14 feet thick and 2,000 to 3,000 feet long. The mineralization grade averages 500 ppm eU_3O_8. Historically, the horizons were broken out into numerous sub-horizons. Because of the complexity of correlating these narrow, discontinuous zones the decision was made to group the horizons. The richest mineralized zone occurs in the middle part of the FH horizon sand; it is about 70 feet thick and contains the most significant portion of the total resources within the proposed project area. The LT horizon, approximately 30 to 40 feet thick, is an interbedded sandstone-siltstone-mudstone zone and contains minor mineralization.

A petrographic analysis of a core sample from the 1977 push-pull test hole SP758R was completed by Rocky Mountain Geochemical Corporation (1977). The composition of the core ranged from fine- to medium-grained sandstone to very fine-grained siltstone with lenses of clay and minor calcite throughout. The core is typical of many Wyoming uranium deposits. The composition of the sandstone consists of the following:

- 60% quartz

- ♦ 35% feldspar (50% plagioclase and 50% orthoclase)
- ♦ 5% clay (montmorillonite)
- ♦ approximately 1% organic material
- ♦ <1% pyrite
- ♦ <1% carbonate

According to the petrographic analysis performed by Rocky Mountain Geochemical Corporation, the principal uranium minerals are uraninite, a uranium oxide, and coffinite, a uranium silicate. Vanadium in the form of vanadinite (a lead chlorovanadate [$Pb_5(VO_4)_3Cl$]) and carnotite (a hydrated potassium uranyl vanadate [$K_2(UO_2)_2(VO_4)_2\ 3H_2O$]) is also found in association with the uranium at an average ratio of 0.6 (vanadium) to 1.0 (uranium).

Petrographic analyses were completed by Core Laboratories of Houston, Texas in September 2009, on three thin sections from core samples obtained from two borings, RMRD0003 and RMRD0004. The following was revealed from those analyses:

> "The composition of the ore zone sandstones are predominantly fine grained, moderately well sorted, argillaceous sandstone (>10% matrix). Sand grains are typically subangular to sub rounded. Compaction appears to be light in the sandstones to moderate in the argillaceous sandstone, as point-to-point contact areas are more common than the long grain contacts.
>
> The argillaceous sandstone has a subarkose composition with abundant monocrystalline quartz and moderate to common feldspar and minor lithic components. Trace to minor amounts of polycrystalline quartz, metamorphic rock fragments, carbonate rock fragments, sandstone rock fragments, argillaceous rock fragments, clay-replaced grains, kaolinite-replaced grains, and chert. Accessory grains include micas, heavy minerals and plant fragments and clay pellets.
>
> Syntaxial quartz overgrowths and clay (kaolinite chlorite) are the primary authigenic minerals observed in the argillaceous sandstone; these are rare to minor in other samples. The authigenic chlorite appears to be more grain-coating than grain replacing; kaolinite is more commonly observed as grain-replacement.
>
> Other authigenic minerals noted include calcite, pyrite and titanium oxides. Both the detrital clay and some of the authigenic clay have very similar composition (illitic); they are distinguished by their distribution and their morphology. The clay in the argillaceous sandstone

has a reddish color in reflected and transmitted light suggesting partial replacement/precipitation to hematite.

The two sandstone samples contain abundant primary intergranular pores and are of excellent reservoir quality. The argillaceous sandstone contains moderate amounts of primary pores and fair reservoir quality; detrital and authigenic clay are the primary causes of the reduced reservoir quality. Secondary pores are of minor abundance in all samples and do not significantly affect the reservoir quality."

Section 1.7 in the TR describes the ISR uranium recovery and processing of uranium at the proposed Ross ISR Project.

3.3.4 Historic Uranium Exploration/Development Activities

Historic exploration activities in the proposed Ross ISR Project area can be summarized as follows:

- ♦ 1971 - Nuclear Dynamics begins exploration drilling in the Lance Project Area.
- ♦ 1978 - Nuclear Dynamics forms a Joint Venture with Bethlehem Steel (Nubeth Joint Venture) to develop the Project.
- ♦ 1978 - Nubeth Joint Venture develops and briefly operates a pilot plant ISR in the south-central portion of what will become the proposed Ross Project area.
- ♦ 1983 - The Project is discontinued by Nubeth.
- ♦ 2008 - Strata acquires mineral rights covering most of the proposed Ross Project area and begins confirmation drilling of historic resources plus exploration drilling. Strata also acquires a portion of the historic Nubeth database.
- ♦ 2009 - Strata continues with exploration and development drilling and also acquires the original complete Nubeth database.
- ♦ 2010 - Exploration and development drilling is ongoing by Strata in the proposed Ross Project area and expansions of the known mineralized zones are progressing.

3.3.5 Soils

Soils within the proposed project area were evaluated by BKS Environmental Associates, Inc. (BKS) of Gillette, Wyoming in 2009 and 2010. All 1,721.3 acres of the proposed project area were included in the final soil

mapping of the Ross ISR Project. 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 Aridic Argiustolls, Ustic Haplargids, or Ustic Torrifluvents. The physical and chemical properties of topsoil and subsoil were compared to WDEQ/LQD suitability standards. The primary limiting factors included high sodium adsorption ratio (SAR), high clay texture, alkaline pH, and calcareous soils.

Following is a description of the soil survey methodology and a summary of the survey results. Complete results are provided in addenda. Refer to Addendum 3.3-A for tables, Addendum 3.3-B for soil mapping unit descriptions, Addendum 3.3-C for sampled soil series descriptions, Addendum 3.3-D for soil laboratory analysis, Addendum 3.3-E for prime farmland designation and Addendum 3.3-F for photographs.

3.3.5.1 Soil Survey Methodology

Baseline soils inventories for the proposed project area consisted of refinement of the current USDA Natural Resources Conservation Service (NRCS) mapping for Crook County, Wyoming. The soils in Crook County were studied and mapped to an Order 3 scale by the NRCS between 1960 and 1977.

Field mapping was conducted according to techniques and procedures outlined in the National Cooperative Soil Survey. WDEQ/LQD Guideline 1 (August 1994 Revision) was used as a guide during all phases of the study (WDEQ/LQD 1994).

A reconnaissance of the proposed project area was done by field personnel during in 2009. Soil profiles were examined on a widely scattered basis according to physiographic configuration. Information derived from these profiles was used to determine which soils are likely to occur on specific landscape positions. Following the reconnaissance survey, a higher intensity Order 1-2 soil survey was conducted during June and August 2010. Actual soil boundaries were identified in the field by exposing additional soil profiles to determine the nature and extent of soil series in the proposed project area. The soil boundaries were delineated on a 1:6,000 orthophoto.

For purposes of the soil survey, the major disturbance of the Proposed Action was assumed to be the plant site. Soils were evaluated for two plant site options. The primary plant site option is located in the NE¼, SE¼ of Section

18, T53N, R67W. Intensive sampling was conducted on the primary plant site option. The alternate plant option is located in the S½, SW¼ of Section 7, T53N, R67W.

WDEQ/LQD approved the soil sampling methodology during a meeting in Sheridan, Wyoming on December 9, 2009. Intensive sampling was conducted on the primary plant site option and 10 samples were sent to the lab. The alternate plant site option was sampled at one pedon per series for a total of five samples sent to the lab. Soil series located outside of the plant site options were also sampled at one pedon per series for a total of 11 samples sent to the lab. Due to the close proximity of the alternate plant site, one sample location (No. 42) was used to represent both the entire proposed project area and the alternate plant site option.

All soil samples were collected with a Giddings truck mounted auger or hand auger to paralithic contact or a maximum depth of 60", whichever was shallower. Sampled profiles were described in the field, to the extent possible, by the physical and chemical nature of each profile horizon. Backhoe pits were not utilized for soil sampling. Sample locations were identified on a base map and global positioning system (GPS) locations were collected with hand-held Garmin GPS units. Soil samples were placed in clean, labeled, polyethylene plastic bags, and sealed to limit sample drying. Samples were kept as cool as possible, but were not stored on ice. Samples were analyzed for pH, SAR, electrical conductivity (EC), saturation %, texture, coarse fragments, boron, selenium, and organic matter.

3.3.5.2 Soil Survey Results

The following provides a summary of the soil survey results for the proposed project area. Detailed results are summarized in Addenda 3.3-A through 3.3-F. General topography of the area ranged from nearly level uplands to steep hills, ridges, and breaks. The soils occurring in the proposed project area were generally a sandy or coarse texture on hills, ridges, and breaks with clayey or fine-textured soils occurring on nearly level uplands and near drainages. The proposed project area contains moderate and deep soils on level upland areas and drainages with shallow soils located on hills, ridges, and breaks. Figure 3.3-9 depicts the baseline soils within the proposed project area, and Table 3.3-1 summarizes the soil mapping results.

The primary purpose of the 2009 and 2010 fieldwork was to characterize the soils within the proposed project area in terms of topsoil salvage depths and physical and chemical properties. Of the 98 sites within the proposed project area that were evaluated in the field, 26 sites were evaluated in detail through written profile descriptions and laboratory analysis. Laboratory analyses are included in Addendum 3.3-D. 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. In several of the pedestal sampling locations, laboratory analysis yielded finer or coarser than expected textures (based upon field observations). Where textures are not typical for the series, it is noted in the Range of Characteristics (according to field observations and lab analysis) in the soil series descriptions.

Approximate topsoil salvage depths of the map unit series ranged from 0.42 to 5.0 feet. Within the proposed project area, suitability of soil as a plant growth medium is generally affected by physical factors such as high clay texture and high saturation percentages. Chemical limiting factors included SAR, selenium, EC, pH, and calcium carbonate. Table 3.3-2 provides the criteria that WDEQ/LQD use to establish the suitability of topsoil. This table is reproduced from WDEQ/LQD Guideline 1, which notes that these are guidelines and not enforceable suitability standards. Based on comparison with WDEQ/LQD Guideline 1, marginal material was found in 16 of the 26 sampled profiles. Unsuitable material was found in 7 of the 26 sampled profiles. Based on laboratory analysis and field observations, marginal and unsuitable material parameters primarily consisted of texture, selenium, SAR, and pH.

Based on the 2009 and 2010 fieldwork with associated field observations and subsequent chemical analysis, the recommended topsoil average salvage depth over the Ross ISR proposed project area was determined to be 1.74 feet.

The hazard for wind and water erosion within the proposed project area varies from negligible to severe, based on the soil mapping unit descriptions. 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 slightly coarser texture of the surface horizons throughout the majority of the proposed project area, the soils are slightly more susceptible to erosion from wind than water.

Prime farmland was assessed by Jason Nehl, NRCS Resource Specialist in Sundance, Wyoming. No prime farmland was indicated within the proposed project area.

3.3.6 Seismology

3.3.6.1 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. 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). The closest capable faults to the site are located in central Wyoming, 270 km (168 miles) to the west-southwest. Section 3.3.2.1 describes how faults previously mapped in the area by Buswell (1982) were the result of limited survey data.

3.3.6.2 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 for Crook County (Case, Toner and Kirkwood 2002), and 100 Years of Earthquakes in the Wyoming Region (WSGS 2010b).

Earthquakes are common in Wyoming and have occurred in every county in the State over the past 120 years. Most of these have occurred in the

northwestern part of the State (see Figure 3.3-10). Only two earthquakes with a magnitude greater than 2.5 (Richter Magnitude Scale) or intensity greater than III (Modified Mercalli Intensity Scale) have been recorded in Crook County and only nine in Campbell County. Magnitude is an instrumentally determined measure of the size of an earthquake and the total energy released. Each one-step increase in magnitude equates to a 32 times increase in associated seismic energy (e.g., a magnitude 7.5 earthquake releases approximately one thousand times more energy than a magnitude 5.5 earthquake, or 32 times 32). Intensity is a qualitative measure of the degree of shaking an earthquake imparts on people, structures, and the ground. For a given earthquake, intensities can vary depending upon the distance from the epicenter. Table 3.3-3 presents a summary of the Modified Mercalli Intensity Scale, equivalent Richter magnitude, and approximate peak ground acceleration associated with each scale category.

Natural earthquakes in Wyoming occur because of movements on existing or newly created faults or movements of (or in) the magma chamber beneath Yellowstone National Park. Most historical earthquakes have occurred as a result of movements on faults not exposed at the surface. These deeply buried faults, which are not expected to generate earthquakes with magnitudes greater than 6.5, have not been studied in detail. A series of Quaternary (within the past 1.65 million years) faults exposed at the surface in Wyoming, however, have activated and generated earthquakes from hundreds to thousands of years ago. Future earthquakes with magnitudes from 6.75 to 7.5 are expected to occur along those exposed Quaternary faults. As discussed in the preceding section, no Quaternary faults have been mapped within 270 km of the proposed Ross license area.

As shown in Table 3.3-3, earthquakes generally do not result in ground surface rupture unless the magnitude of the event is greater than 6.5. Because of this, areas of the state that do not have active faults exposed at the surface, such as the proposed project area, are generally thought not to be capable of having earthquakes with magnitudes over 6.5. See Figure 3.3-11 which shows the probability of an earthquake with magnitude greater than or equal to 6.5 in the vicinity of the proposed project area. This figure was prepared using the USGS Probabilistic Seismic Hazard Analysis (PSHA) model (USGS 2009b). Earthquakes with magnitudes less than 6.5 would cause little damage in specially built structures but could cause considerable damage to ordinary

buildings and severe damage to poorly built structures. Some walls could collapse. Underground pipes would generally not be broken and ground cracking would not occur or would be minor.

3.3.6.3 Historic Seismicity Near Proposed Project Area

Only three magnitude 3.0 and greater earthquakes have been recorded in or around Crook County (Case, Toner, and Kirkwood 2002, WSGS 2010b). One occurred near Sundance on February 3, 1897. The intensity IV-V earthquake severely shook the Shober School on Little Houston Creek southwest of Sundance. Many residents of Sundance reported hearing three loud reports resembling the explosion of a boiler or a great blast (Case, Toner and Kirkwood 2002). The other recorded Crook County earthquake occurred near Moorcroft in November 2004. It had a magnitude of 3.7, which corresponds to an intensity level of III (WSGS 2010b).

On February 18, 1972 a magnitude 4.3 earthquake occurred approximately 18 miles east of Gillette near the Crook-Campbell County line. No damage was reported (Case, Toner, and Kirkwood 2002).

3.3.6.4 Seismic Risk

The Uniform Building Code (UBC) contains information and guidance on designing buildings and structures to withstand seismic events. The current (1997) UBC Seismic Zone Map divides Wyoming into five zones (Zones 0 to Zone 4) defined in part by the probability of having a certain level of ground shaking (horizontal acceleration) in 50 years (See Figure 3.3-12). Horizontal acceleration in the UBC Seismic Zone Map is provided in terms of percent of gravitational acceleration (%g).

The UBC criteria are as follows:

Zone	Effective Peak Acceleration (%g)
0	<5
1	5 to 10
2	10 to 20
3	20 to 30
4	>30

The UBC based these criteria on the assumption that there was a 90% probability that the above values would not be exceeded in 50 years, or roughly a 100% probability that the values would be exceeded in 475 to 500 years.

Crook County is in UBC Seismic Zone 0, which suggests that there is a 90% probability that an earthquake with an acceleration of 5%g would not occur within any 50-year period. Such acceleration, however, is less than would be suggested through newer building codes. Recently, the UBC has been replaced by the IBC, which is based on probabilistic analyses (Case, Toner, and Kirkwood 2002), as discussed below.

Some regulations require an analysis of the earthquake potential in areas where active faults are not exposed (such as the area around the Ross ISR Project area), 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. The USGS 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).

Within a tectonic province, earthquakes associated with buried faults are assumed to occur randomly and are sometimes referred to as "floating earthquakes" (Case, Toner, and Kirkwood 2002). Sometimes regulations or prudent design requires that a floating earthquake be used for design of 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, NRC requires that a floating earthquake be placed 15 km from the site, and that earthquake is then used to determine what horizontal accelerations may occur at the site. A magnitude 6.25 floating earthquake placed 15 km from any structure in Crook County would generate horizontal accelerations of approximately 15%g at the site. That acceleration is about three times what would be found from the UBC Seismic Zone Map and would be adequate for designing certain facilities at a uranium mill tailings site but may be too conservative for less critical sites, such as a landfill (Case, Toner, and Kirkwood 2002). Critical facilities, such as dams, usually require a more detailed probabilistic analysis of random earthquakes.

3.3.6.5 Probabilistic Seismic Hazard Analysis

The USGS publishes probabilistic acceleration maps for 500-, 1000- and 2500-year time frames. The maps show what accelerations may be met or exceeded in those time frames by expressing the probability that the accelerations will be met or exceeded in a shorter time frame. For example, a

10% probability that a peak ground acceleration may be met or exceeded in 50 years is roughly equivalent to a 100% probability of exceedance in 500 years. The IBC uses a 2,500-year map as the basis for building design, vs. the 500-year map used for the UBC zone map. The IBC maps reflect current perceptions on seismicity in Wyoming (Case, Toner, and Kirkwood 2002). In many areas of Wyoming, ground accelerations shown on the USGS maps can be increased due to local soil conditions. 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 occur 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.

Based on the 500-year map (10% probability of exceedance in 50 years) (Figure 3.3-13a), the estimated peak horizontal acceleration in the proposed project area is about 2.7%g. This relates to an intensity IV earthquake (see Table 3.3-3) which would be felt by many people indoors, few outdoors, and would feel similar to a heavy truck passing nearby. Based on the 1000-year map (5% probability of exceedance in 50 years) (Figure 3.3-13b), the estimated peak horizontal acceleration at the site is about 4%g. This relates to an earthquake at the low end of intensity V, which would be felt by almost everyone, would awaken some people, move small objects, may shake trees and poles, and could crack plaster and break dishes. For the 2,500-year map (2% exceedance probability in 50 years) the estimated peak horizontal acceleration at the site is about 7.5%g, which according to Table 3.3-3 would still relate to an intensity V earthquake.

With a limited historic record, it is nearly impossible to determine when a 2,500-year event last occurred in Crook County. Because of the uncertainty involved, and based on the fact that the new IBC utilizes 2,500-year events for building design, the Wyoming State Geologic Survey (WSGS) suggests that the 2,500-year probabilistic map (Figure 3.3-13c) be used for seismic analysis in design of critical facilities in this part of Wyoming. This conservative approach is in the interest of public safety (Case, Toner, and Kirkwood 2002). The CPP and other Ross ISR Project buildings will be conservatively designed on the basis of the 2,500-year probabilistic map (2% probability of exceedance in 50 years) in accordance with WSGS recommendations.

Table 3.3-1. Soil Mapping Unit Acreages

Map Symbol	Map Unit Description	Acreage	% Proposed Project Area	Salvage Depth[1] (ft)	Total Volume of Topsoil[2] (ac-ft)
AB	Absted very fine sandy loam	262.7	15.3	0.83	218.9
AS	Ascalon fine sandy loam	265.9	15. 5	0.83	221.6
BI	Bidman loam	226.0	13.1	1.92	433.2
BO	Bone loam	113.8	6.6	5.00	569
CU	Cushman very fine sandy loam	47.2	2.7	1.83	86.4
FO	Forkwood loam	336.6	19.6	1.67	561.0
NU	Nunn clay loam	219.6	12.8	3.00	658.8
SH	Shingle clay loam	58.8	3.4	0.92	53.9
TA	Tassel fine sandy loam	43.3	2.5	0.42	18.0
TE	Terro sandy loam	87.0	5.1	1.50	130.5
VO	Vona fine sandy loam	40.3	2.3	1.25	50.4
WATER	Water	20.1	1.2	0.00	0.0
Average Salvage Depth of Project Area[3]		**---**	**---**	**1.74**	**---**
	Total	**1721.3**	**100.0**	**---**	**3001.8**

[1] Found in Addendum 3.3-B of this report, under Topsoil Suitability. These salvage depths take in account all 26 sample locations.
[2] Calculated by multiplying permit acreage by salvage depth in feet, as shown in Table II-1 (Topsoil Volume Summary) of WDEQ/LQD Guideline 1.
[3] Calculated as the average of the weighted average salvage depths found in Addendum 3.3-B

Table 3.3-2. WDEQ/LQD Topsoil Suitability Criteria

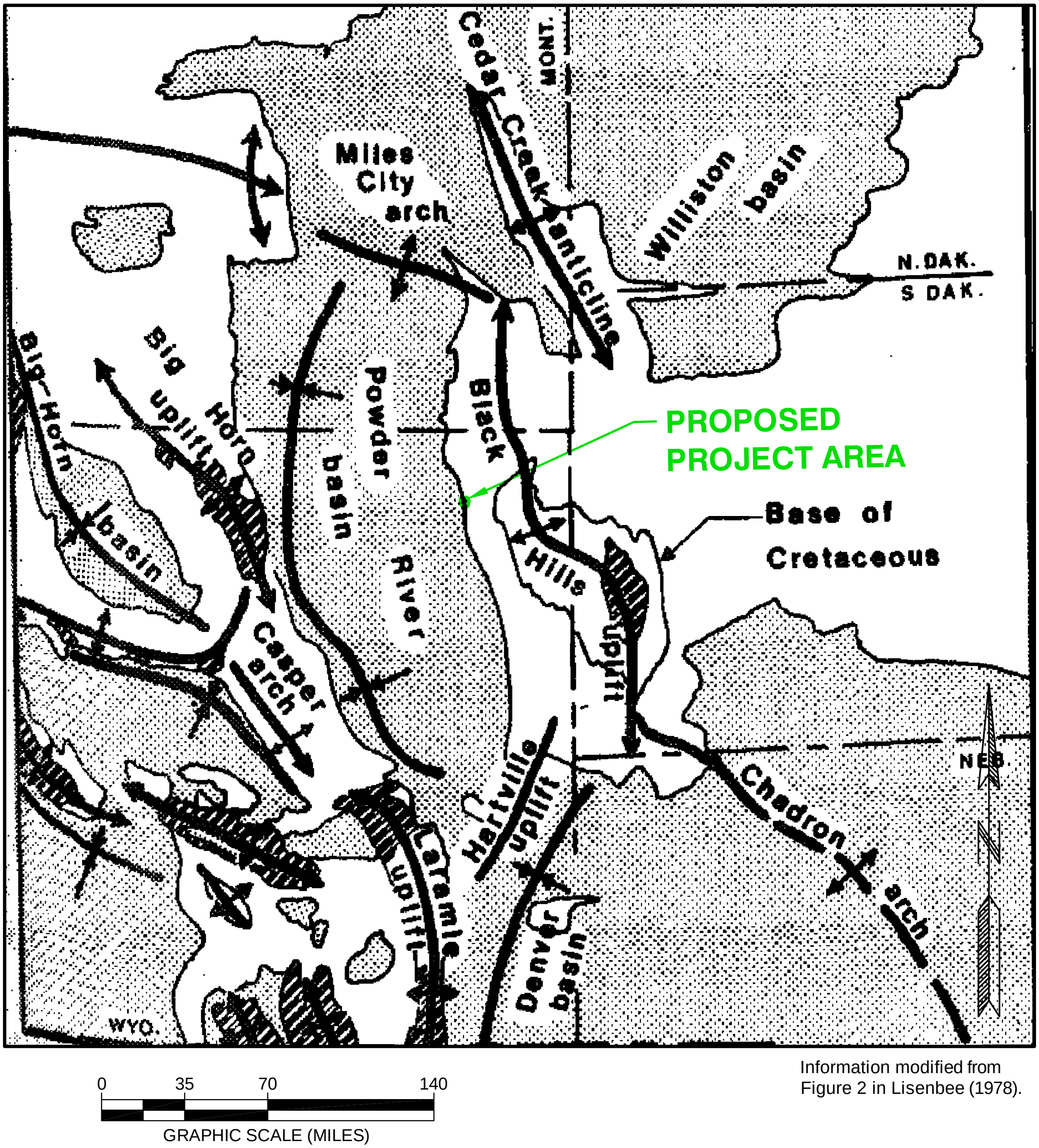
Parameter	Suitable	Marginal[1]	Unsuitable
pH	5.5-8.5	5.0-5.5 8.5-9.0	<5.0 >9.0
EC (Conductivity) mmhos/cm	0-8	8-12	>12
Saturation Percentage	25-80	<25 >80	
Texture		clay, silty clay, sand	
SAR[2]	0-10	10-12[3] 10-15	>12[3] >15
Selenium	<0.1 ppm	>0.1 ppm	
Boron	<5.0 ppm		>5.0 ppm
Coarse Frag (% vol)	<25%	25-35	>35%

[1] Evaluated on an individual basis for suitability.
[2] As an alternative to SAR calculations, ESP (exchangeable sodium percentage) can be determined. ESP should be determined if suitable SAR value is exceeded.
[3] For fine textured soils (clay >40%)
Source: WDEQ/LQD Guideline 1, Table I-2

Table 3.3-3. General Terms Regarding Earthquake Intensity and Magnitude

Intensity	Equivalent Richter Magnitude	Description	Peak Ground Acceleration (%g)
I	1.0 – 2.0	Felt by very few people; barely noticeable.	< 0.17
II	2.0 – 3.0	Felt by a few people, especially on upper floors.	0.17 – 1.4
III	3.0 – 4.0	Noticeable indoors, especially on upper floors, but may not be recognized as an earthquake.	0.17 – 1.4
IV	4.0	Felt by many indoors, few outdoors. May feel like heavy truck passing by.	1.4 – 3.9
V	4.0 – 5.0	Felt by almost everyone, some people awakened. Small objects moved. Trees and poles may shake.	3.9 – 9.2
VI	5.0 – 6.0	Felt by everyone. Difficult to stand. Some heavy furniture moved, some plaster falls. Chimneys may be slightly damaged.	9.2 - 18
VII	6.0	Slight to moderate damage in well built, ordinary structures. Considerable damage to poorly built structures. Some walls may fall.	18 - 34
VIII	6.0 – 7.0	Little damage in specially built structures. Considerable damage to ordinary buildings, severe damage to poorly built structures. Some walls collapse.	34 - 65
IX	7.0	Considerable damage to specially built structures, buildings shifted off foundations. Ground cracked noticeably. Underground pipes broken. Wholesale destruction. Landslides.	65 - 124
X	7.0 – 8.0	Most masonry and frame structures and their foundations destroyed. Ground badly cracked. Landslides. Wholesale destruction.	> 124
XI	8.0	Total damage. Few, if any, structures standing. Bridges destroyed. Wide cracks in ground. Waves seen on ground.	> 124
XII	8.0 or greater	Total damage. Waves seen on ground. Objects thrown up into air	> 124

Case and Green 2000; Case, Toner, and Kirkwood 2002; and Michigan Tech University 2010.



Regional tectonic setting of the Black Hills uplift at the easternmost margin of the Wyoming province. Diagonal pattern indicates Precambrian basement, dotted pattern indicates Tertiary deposits. Approximate location of axes of uplifts and basins shown with heavy line.

Figure 3.3-1. Regional Tectonic Setting

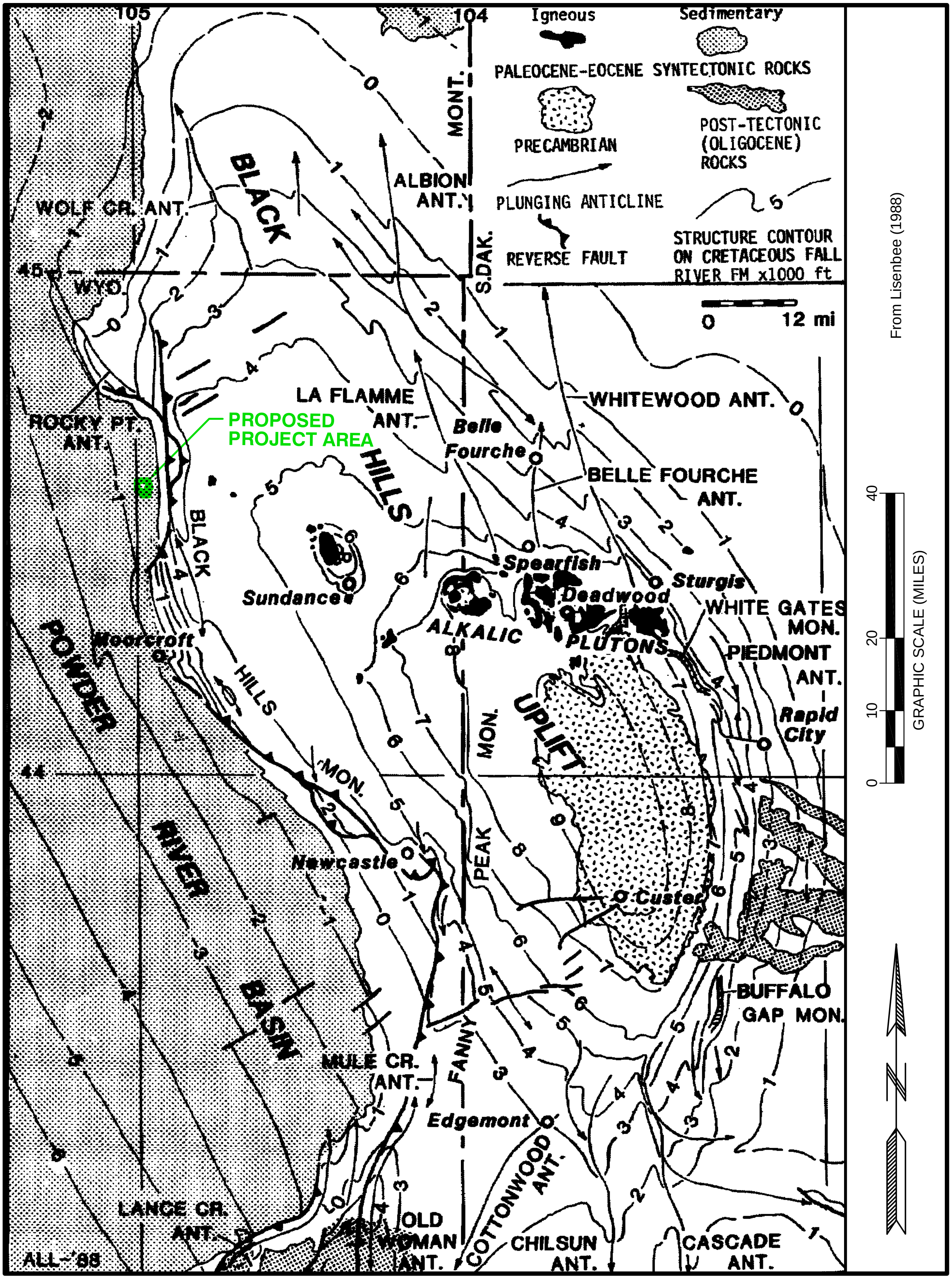
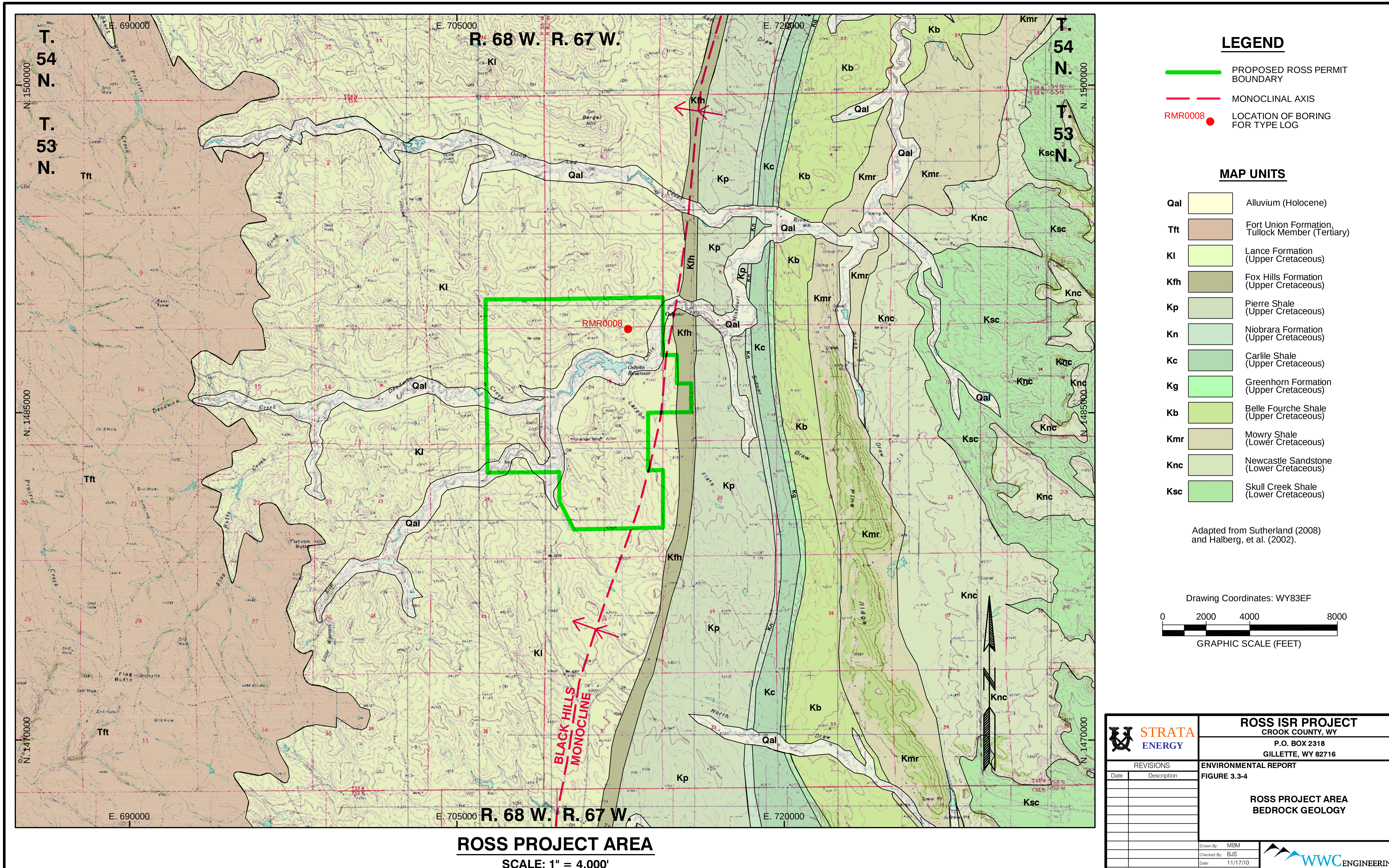


Figure 3.3-2. Tectonic Map of the Black Hills Uplift and Eastern Powder River Basin

GENERAL OUTCROP SECTION OF THE BLACK HILLS AREA

	FORMATION	THICKNESS IN FEET	DESCRIPTION
QUATERNARY	SANDS AND GRAVELS	0-50	Sand, gravel, and boulders.
TERTIARY – PLIOCENE	OGALLALA GROUP	0-100	Light colored sands and silts.
TERTIARY – MIOCENE	ARIKAREE GROUP	0-500	Light colored clays and silts. White ash bed at base
TERTIARY – OLIGOCENE	WHITE RIVER GROUP	0-600	Light colored clays with sandstone channel fillings and local limestone lenses
TERTIARY – PALEOCENE	FORT UNION FORMATION – TONGUE RIVER MEMBER	0-425	Light colored clays and sands, with coal-bed farther north.
TERTIARY – PALEOCENE	FORT UNION FORMATION – CANNONBALL MEMBER	0-225	Green marine shales and yellow sandstones, the latter often as concretions.
TERTIARY – PALEOCENE	FORT UNION FORMATION – LUDLOW MEMBER	0-350	Somber gray clays and sandstones with thin beds of lignite.
?			
CRETACEOUS – UPPER	HELL CREEK FORMATION (Lance Formation)	425	Somber-colored soft brown shale and grey sandstone, with thin lignite lenses in the upper part. Lower half more sandy. Many loglike concretions and thin lenses of iron carbonate.
CRETACEOUS – UPPER	FOX HILLS FORMATION	25-200	Grayish-white to yellow sandstone
CRETACEOUS – UPPER	PIERRE SHALE	1200-2000	Principal horizon of limestone lenses giving teepee buttes Dark-gray shale containing scattered concretions. Widely scattered limestone masses, giving small tepee buttes
CRETACEOUS – UPPER	Sharon Springs Mem.		Black fissile shale with concretions
CRETACEOUS – UPPER	NIOBRARA FORMATION	100-225	Impure chalk and calcareous shale
CRETACEOUS – UPPER	CARLILE FORMATION Turner Sand Zone Wall Creek Sands	400-750	Light-gray shale with numerous large concretions and sandy layers. Dark-gray shale
CRETACEOUS – UPPER	GREENHORN FORMATION	(25-30)	Impure slabby limestone. Weathers buff.
CRETACEOUS – UPPER	GRANEROS GROUP	(200-350)	Dark-gray calcareous shale, with thin Orman Lake limestone at base.
CRETACEOUS – UPPER	GRANEROS GROUP – BELLE FOURCHE SHALE	300-550	Gray shale with scattered limestone concretions. Clay spur bentonite at base.
CRETACEOUS – LOWER	GRANEROS GROUP – MOWRY	150-250	Light-gray siliceous shale. Fish scales and thin layers of bentonite
CRETACEOUS – LOWER	GRANEROS GROUP – MUDDY – DYNNESON / NEWCASTLE	20-60	Brown to light yellow and white sandstone.
CRETACEOUS – LOWER	GRANEROS GROUP – SKULL CREEK SHALE	170-270	Dark gray to black shale
CRETACEOUS – LOWER	INYAN KARA GROUP – FALL RIVER [DAKOTA (?)] ss	10-200	Massive to slabby sandstone.
CRETACEOUS – LOWER	INYAN KARA GROUP – LAKOTA FM Fuson Shale Minnewaste ls	10-188 0-25 25-485	Coarse gray to buff cross-bedded conglomeratic ss, interbedded with buff, red, and gray clay, especially toward top. Local fine-grained limestone.
JURASSIC	MORRISON FORMATION	0-220	Green to maroon shale. Thin sandstone.
JURASSIC	UNKPAPA SS	0-225	Massive fine-grained sandstone.
JURASSIC	SUNDANCE FM Redwater Mem Lak Member Hulett Member Stockade Beaver Canyon Spr. Mem	250-450	Greenish-gray shale, thin limestone lenses Glauconitic sandstone; red ss. near middle
JURASSIC	GYPSUM SPRING	0-45	Red siltstone, gypsum, and limestone
TRIASSIC	SPEARFISH FORMATION	250-700	Red sandy shale, soft red sandstone and siltstone with gypsum and thin limestone layers.
?	Goose Egg Equivalent		Gypsum locally near the base.
PERMIAN	MINNEKAHTA LIMESTONE	30-50	Massive gray, laminated limestone.
PERMIAN	OPECHE FORMATION	50-135	Red shale and sandstone
PERMIAN / PENNSYLVANIAN	MINNELUSA FORMATION	350-850	Yellow to red cross-bedded sandstone, limestone, and anhydrite locally at top. Interbedded sandstone, limestone, dolomite, shale, and anhydrite. Red shale with interbedded limestone and sandstone at base.
MISSISSIPPIAN	PAHASAPA (MADISON) LIMESTONE	300-630	Massive light-colored limestone. Dolomite in part. Cavernous in upper part.
DEVONIAN	ENGLEWOOD LIMESTONE	30-60	Pink to buff limestone. Shale locally at base.
ORDOVICIAN	WHITEWOOD (RED RIVER) FORMATION	0-60	Buff dolomite and limestone.
ORDOVICIAN	WINNIPEG FORMATION	0-100	Green shale with siltstone
CAMBRIAN	DEADWOOD FORMATION	10-400	Massive buff sandstone. Greenish glauconitic shale, flaggy dolomite and flatpebble limestone conglomerate. Sandstone, with conglomerate locally at the base.
PRE-CAMBRIAN	METAMORPHIC and IGNEOUS ROCKS		Schist, slate, quartzite, and arkosic grit. Intruded by diorite, metamorphosed to amphibolite, and by granite and pegmatite.

Figure 3.3-3. Regional Stratigraphic Column.
Modified from WGA Guidebook for 20th Annual Field Conference (1968)



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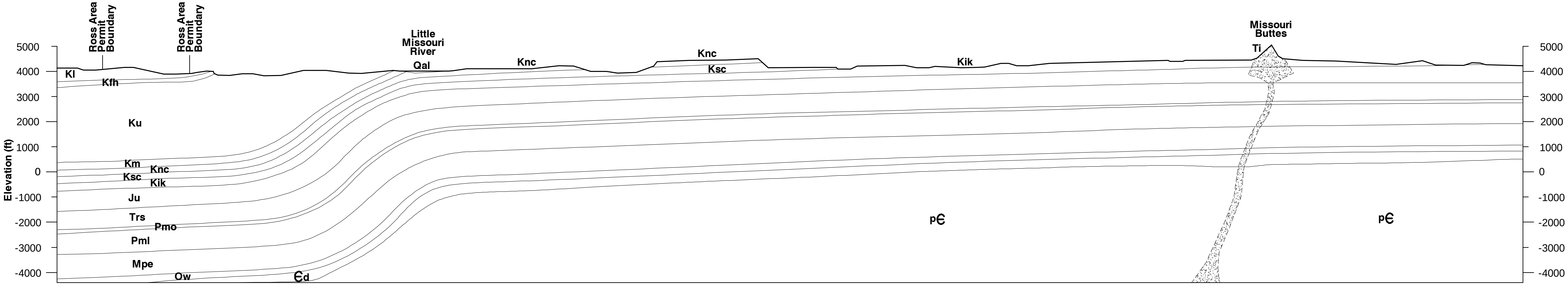
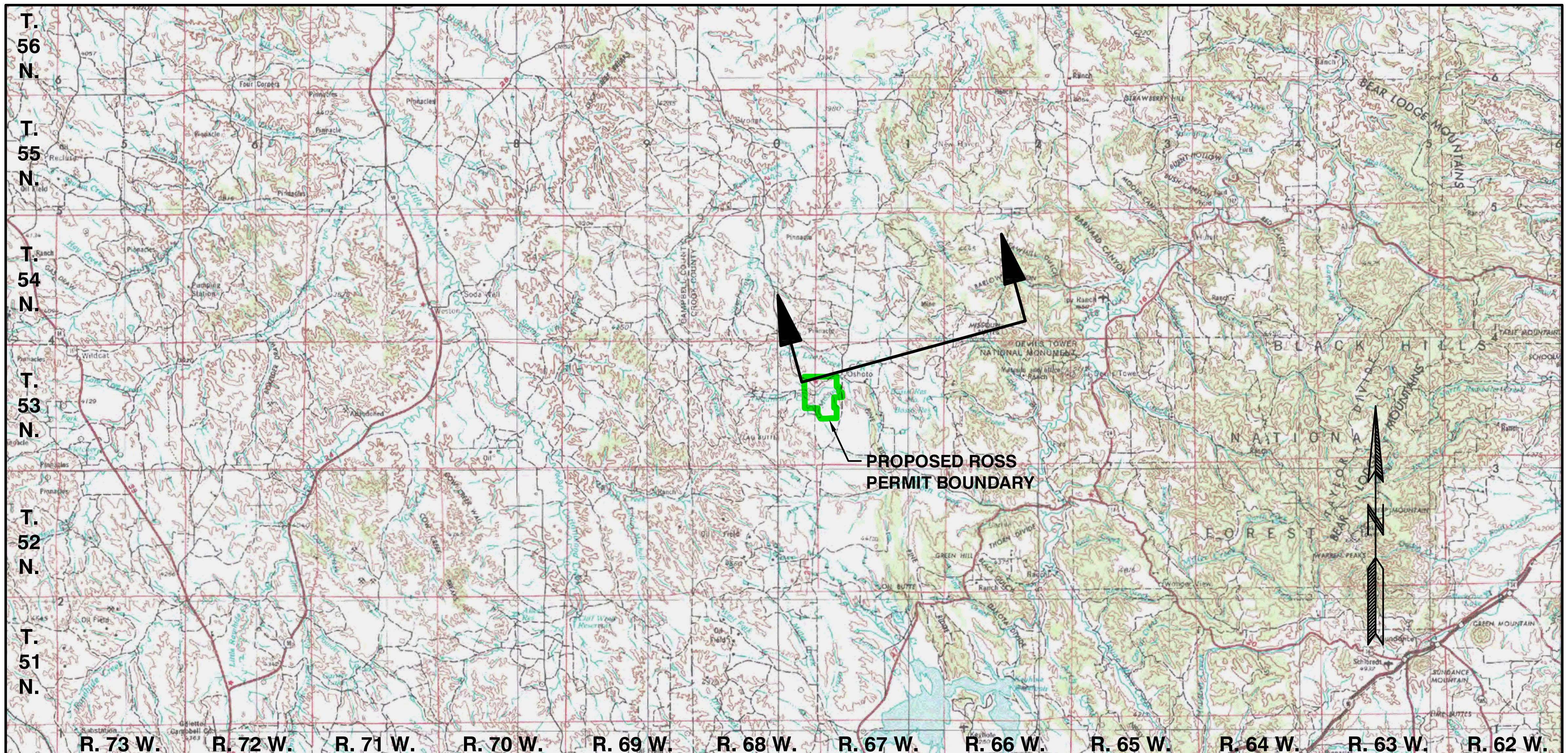


Modified from: Whitcomb et.al., 1958
Occurence of Ground Water in the Eastern Powder River Basin and Western Black Hills
N.E. Wyoming WGA Thirteenth Annual Field Conference



CROSS SECTION LOCATION

LEGEND

Qal	Quaternary Alluvium
Ti	Tertiary Intrusives
Kl	Lance Formation
Kfh	Fox Hills Formation
Ku	Upper Cretaceous, undivided
Km	Mowry Shale
Knc	Newcastle Sandstone
Ksc	Skull Creek Shale
Kik	Inyan Kara Group
Ju	Jurassic, undivided
Trs	Spearfish Formation
Pmo	Minnekahta Limestone and Opeche Formation
Pml	Minnelusa Sandstone
Mpe	Pahasapa and Englewood Limestones
Ow	Whitewood Limestone
Ꞓd	Deadwood Formation
pꞒ	Precambrian

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS

Date	Description

ENVIRONMENTAL REPORT
FIGURE 3.3-5

GENERALIZED GEOLOGIC CROSS SECTION DEPICTING BLACK HILLS MONOCLINE IN THE OSHOTO AREA

Drawn By: MBM
Checked By: MJE
Date: 11/22/10

WWC ENGINEERING
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FILE: ROSS_ER_GEO_XS_PRB

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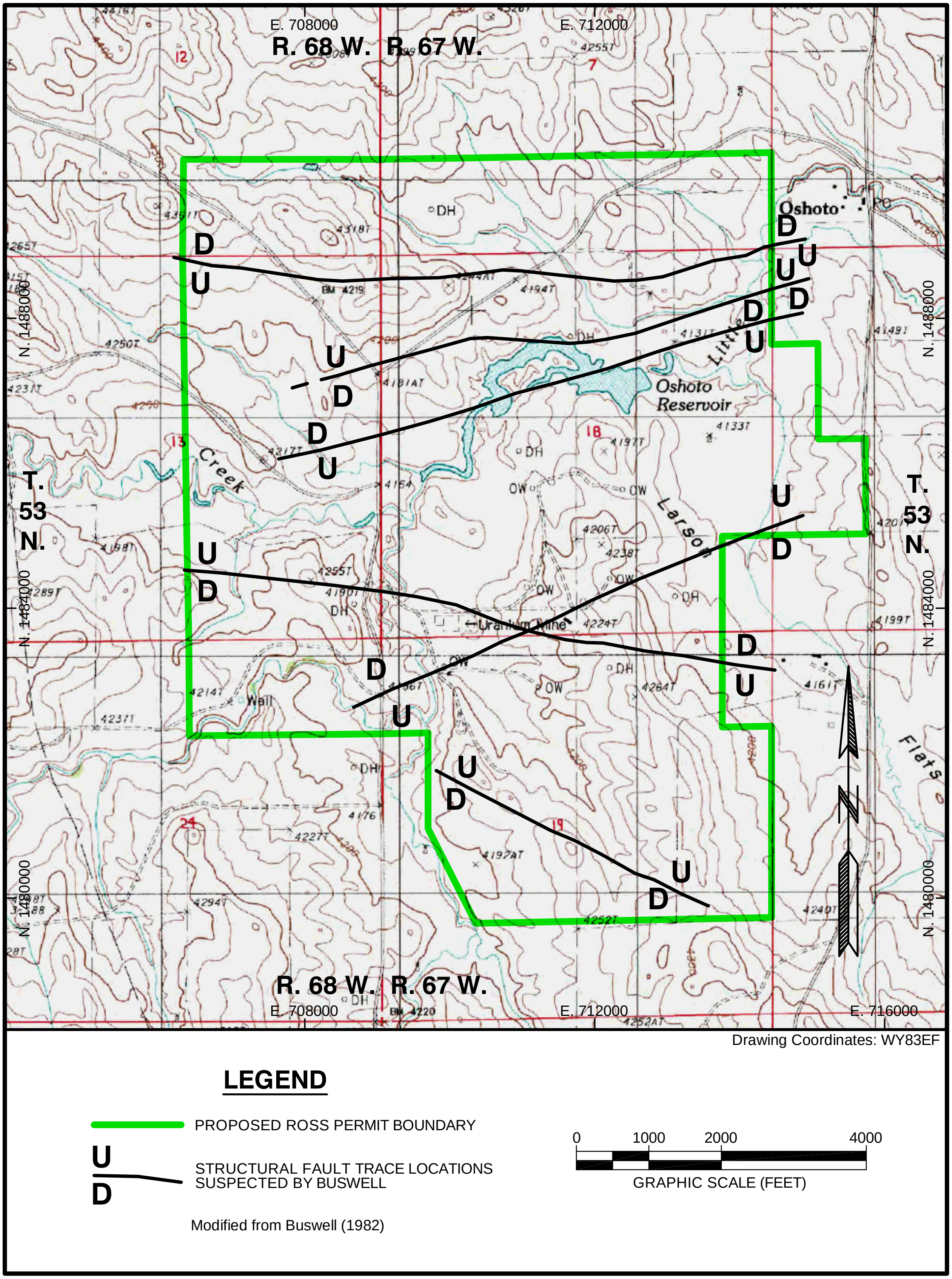
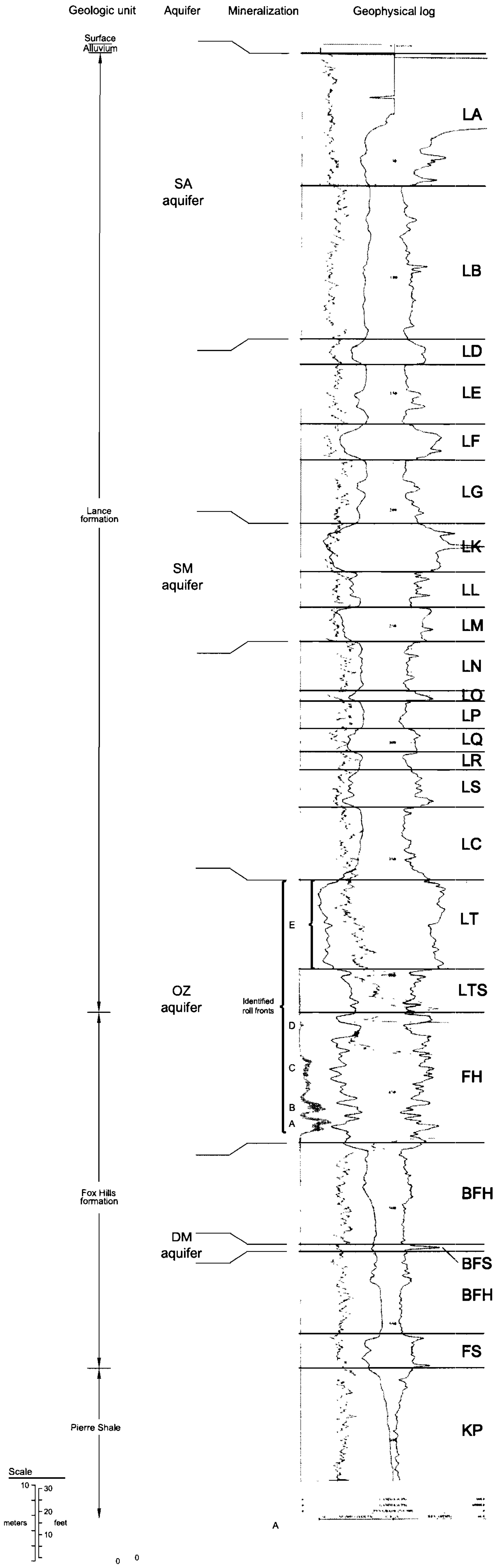


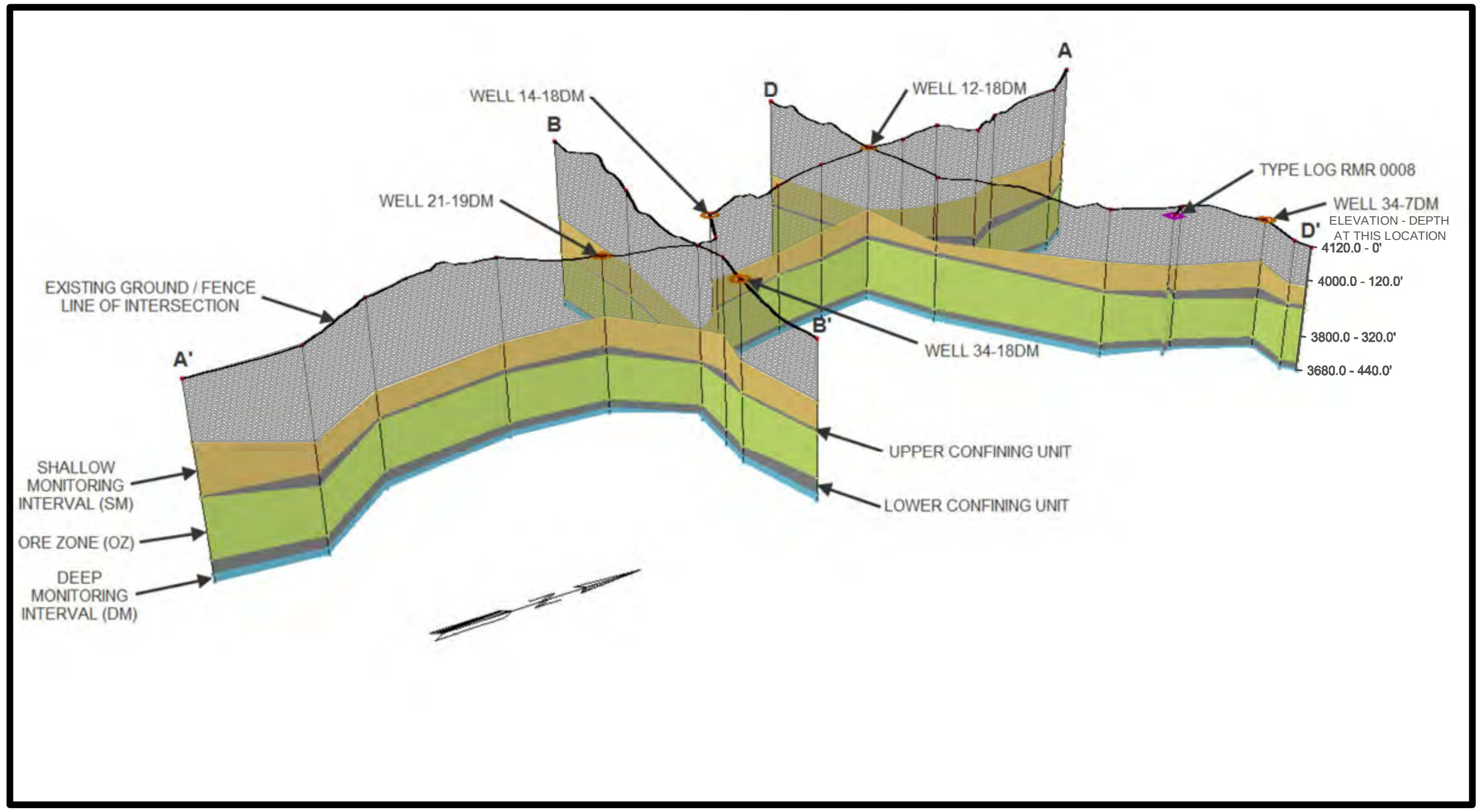
Figure 3.3-6. Buswell Interpreted Faults



Thickness	Description
>10' variable	Unconsolidated alluvium, weathered bedrock and soil
>40' variable	Sandstone (fluvial)
40'–60'	Mudstone and claystone
5'–20'	Sandstone (fluvial)
10'–30'	Mudstone and claystone
10'–20'	Sandstone (fluvial)
10'–25'	Siltstone and claystone
10'–20'	Sandstone (fluvial)
10'–20'	Interbedded sandstone, claystone and siltstone
5'–25'	Sandstone (fluvial)
10'–30'	Claystone and siltstone with interbedded sandstone
0'–10'	Sandstone (fluvial)
5'–15'	Siltstone and claystone
5'–15'	Sandstone (fluvial)
5'–15'	Siltstone and claystone
10'–25'	Sandstone with interbedded siltstone and claystone
20'–35'	Mudstone/claystone (Upper Confining Unit)
30'–40'	Sandstone (fluvial), occasional mineralization
0'–20'	Sandstone, laterally variable and shaley in areas
50'–65'	Sandstone (marine) with interbedded mudstone
30'–50'	Claystone (marine) (Lower Confining Unit)
10'–30'	Sandstone, often silty and clayey
30'–50'	Claystone (marine) (Lower Confining Unit)
20'–35'	Basal sandstone, often silty and clayey
2000'+	Claystone (marine)

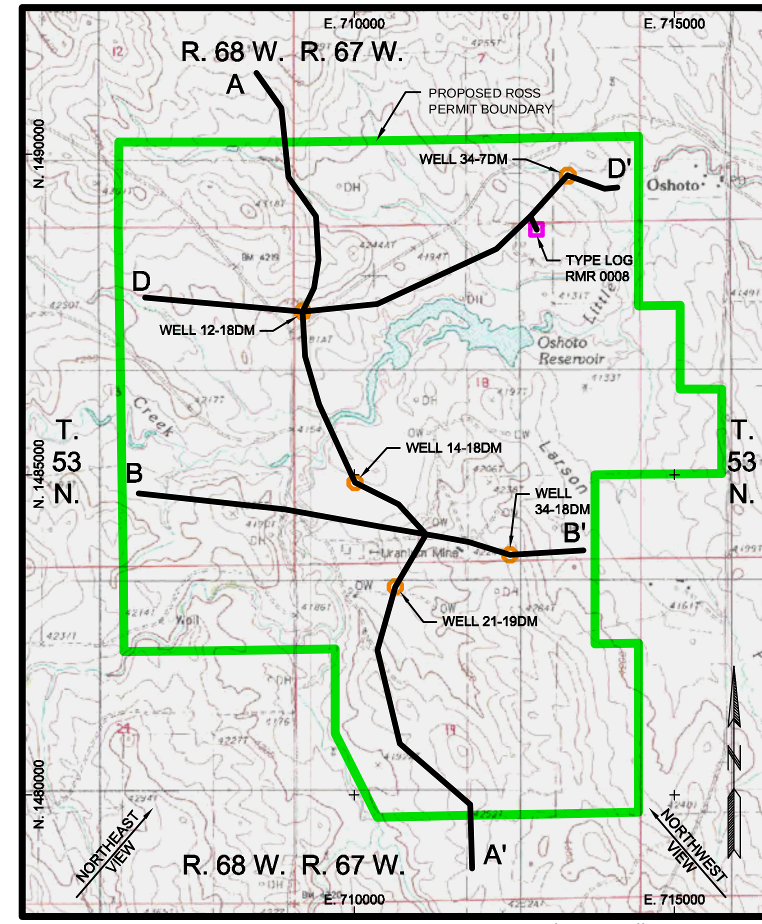
STRATA ENERGY

STRATIGRAPHIC NOMENCLATURE
Used within Proposed Ross Permit Area
Figure 3.3-7



FENCE DIAGRAM - LOOKING NORTHWEST

NOT TO SCALE

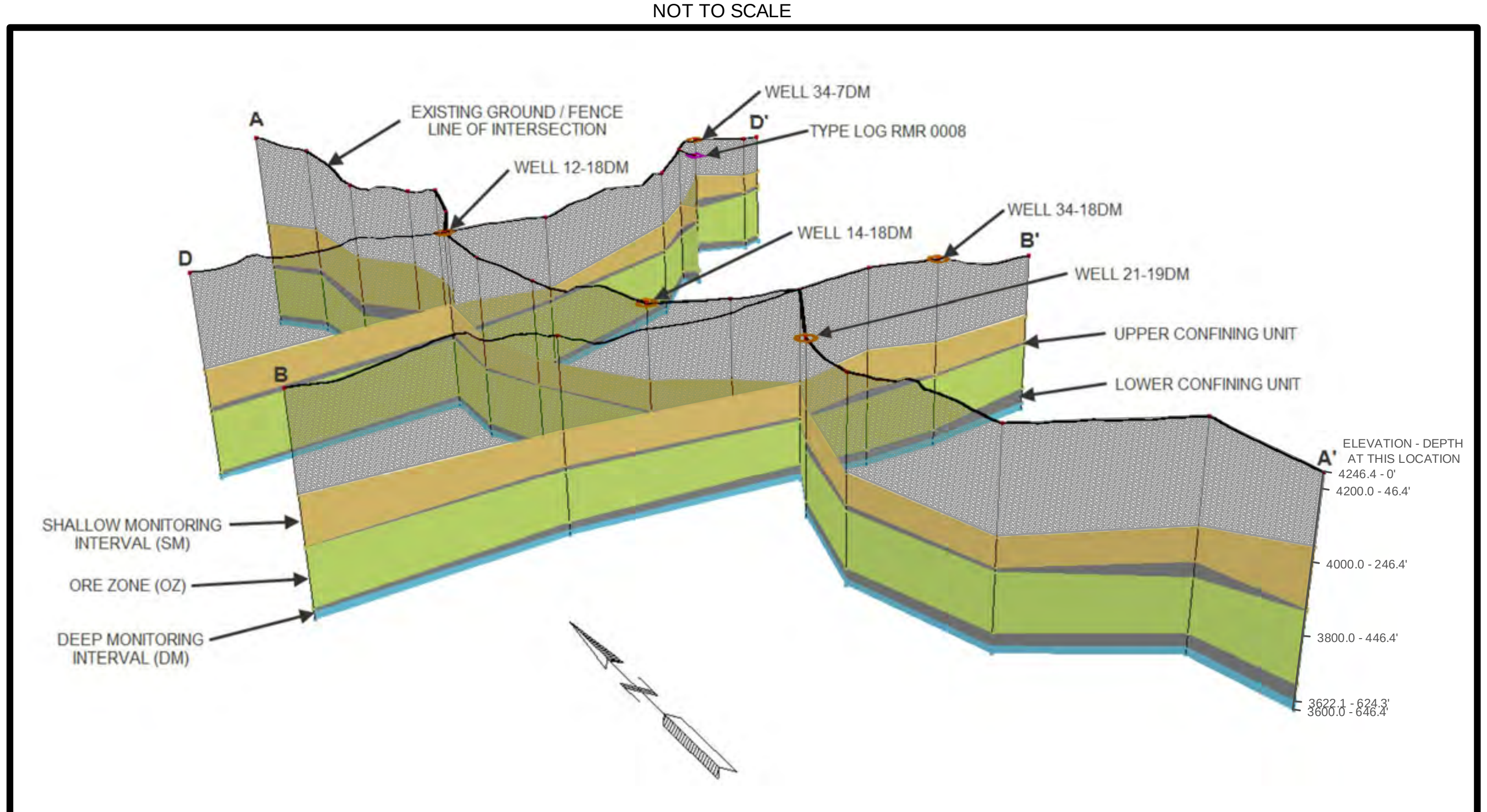


Drawing Coordinates: WY83EF

FENCE DIAGRAM KEY

0 1500 3000 6000

GRAPHIC SCALE (FEET)

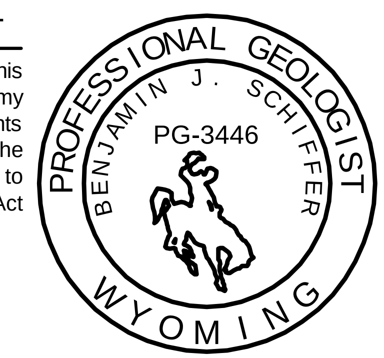


FENCE DIAGRAM- LOOKING NORTHEAST

NOT TO SCALE

CERTIFICATE OF GEOLOGIST

I, Benjamin J. Schiffer, hereby certify that this drawing was prepared by myself or under my direct supervision and that it correctly represents the geologic conditions described in the accompanying application which is provided to meet the requirements of the Atomic Energy Act and its accompanying regulations.



NOTES:

1. THE FENCE DIAGRAM IS A GRAPHIC PERSPECTIVE OF THREE OR MORE GEOLOGIC SECTIONS SHOWING THE LATERAL EXTENT AND CORRELATION OF SUBSURFACE FORMATIONS. TO GIVE PROPER PERSPECTIVES, SCALES DIMINISH WITH DISTANCE FROM THE FOREGROUND. A FENCE-LIKE ENCLOSURE IS FORMED WHEN SEVERAL SECTIONS ARE USED TOGETHER, HAVING THE ADVANTAGE OF THREE-DIMENSIONALITY. THE TOP OF THE REFERENCE SECTIONS ARE LOCATED FROM THE EXISTING GROUND SURFACE.
2. THE FENCE DIAGRAM IS DISPLAYED WITH A 3V:1H EXAGGERATION FOR CLARITY.

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS	
Date	Description

ENVIRONMENTAL REPORT
FIGURE 3.3-8

ROSS PROJECT AREA
GEOLOGIC FENCE DIAGRAM

Drawn By: RAM
Checked By: BJS
Date: 11/21/10

FILE: ROSS_GEO_FENCE

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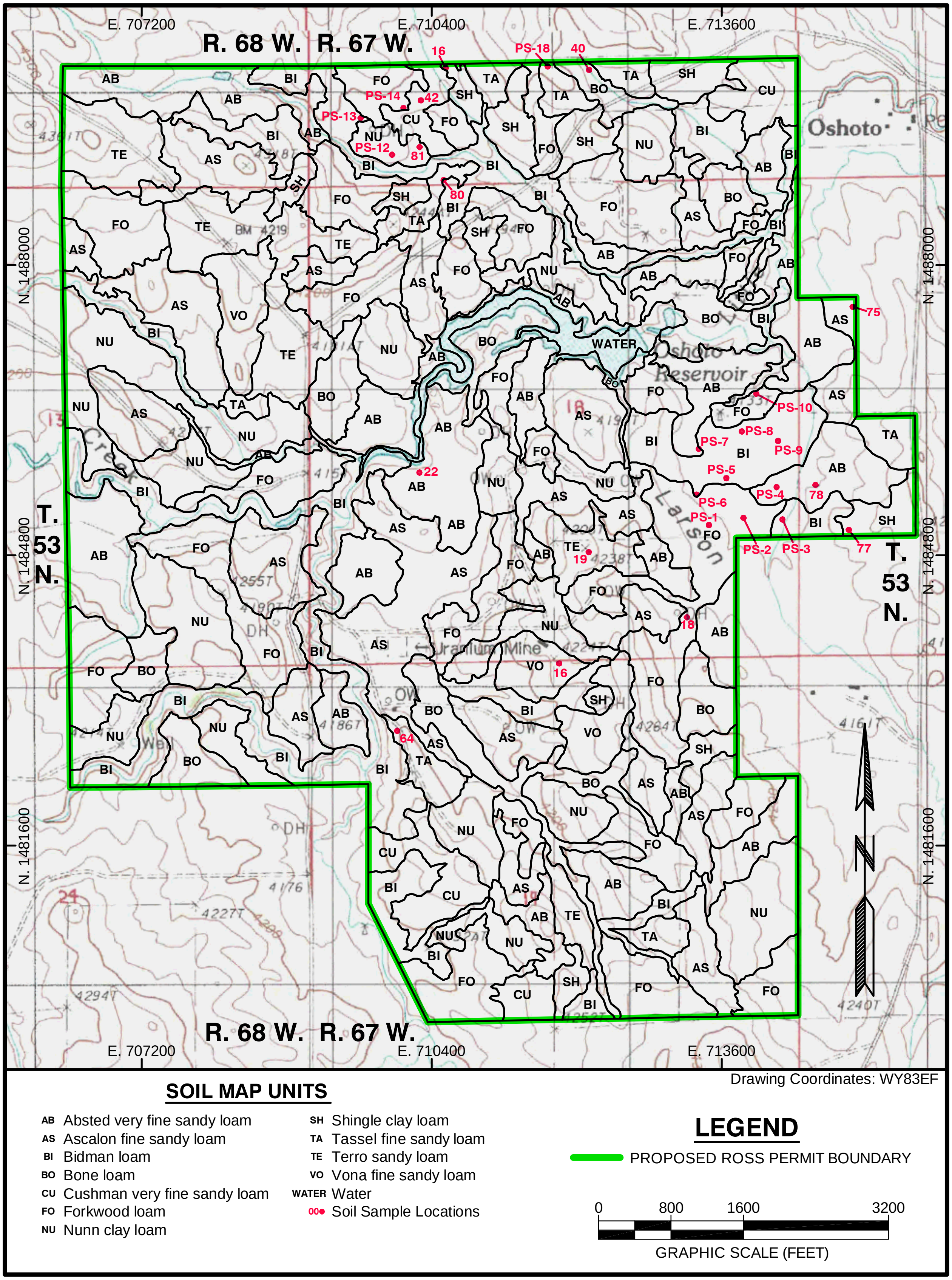


Figure 3.3-9. Baseline Soils

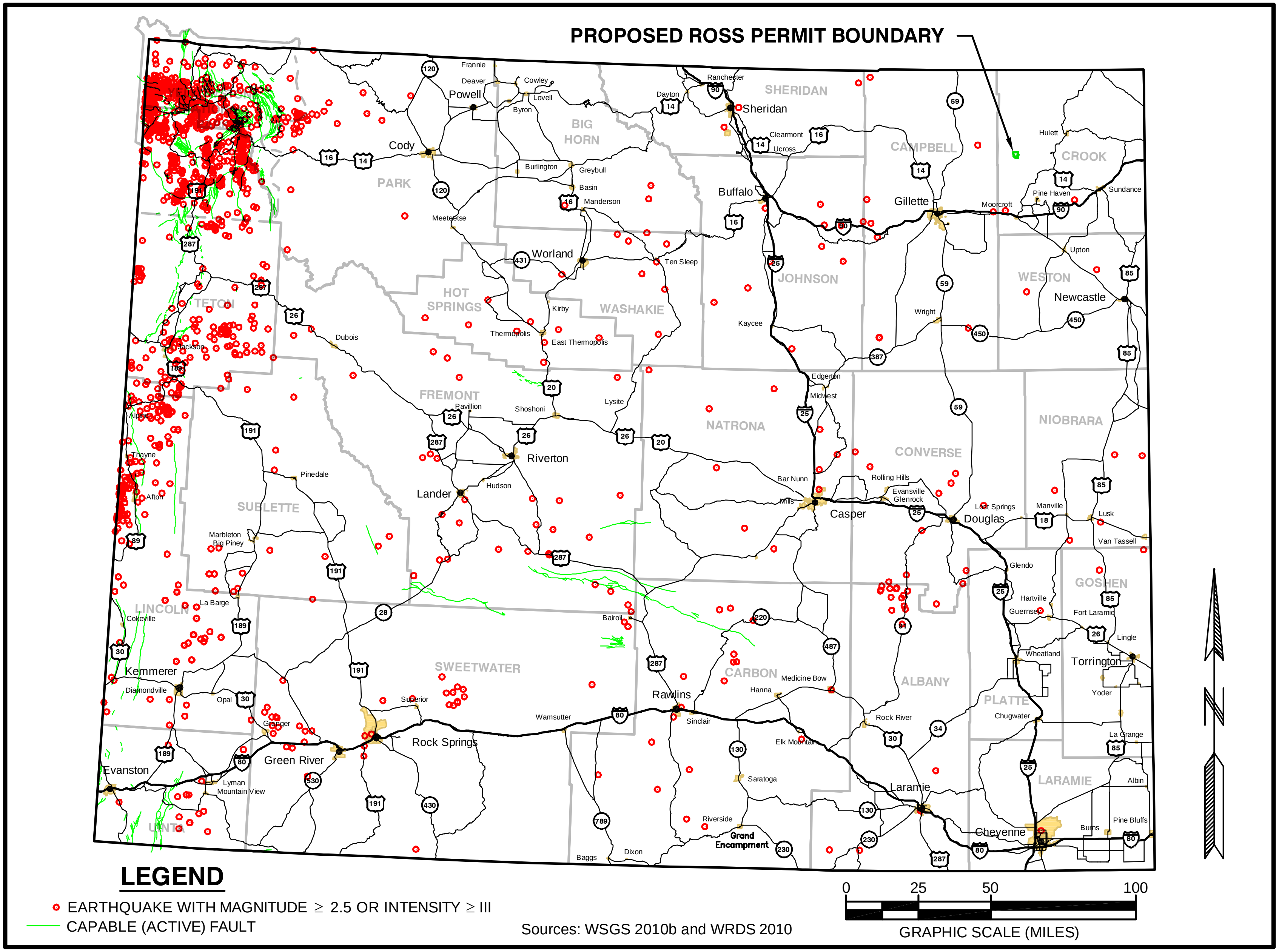


Figure 3.3-10. Historic Earthquakes in Wyoming

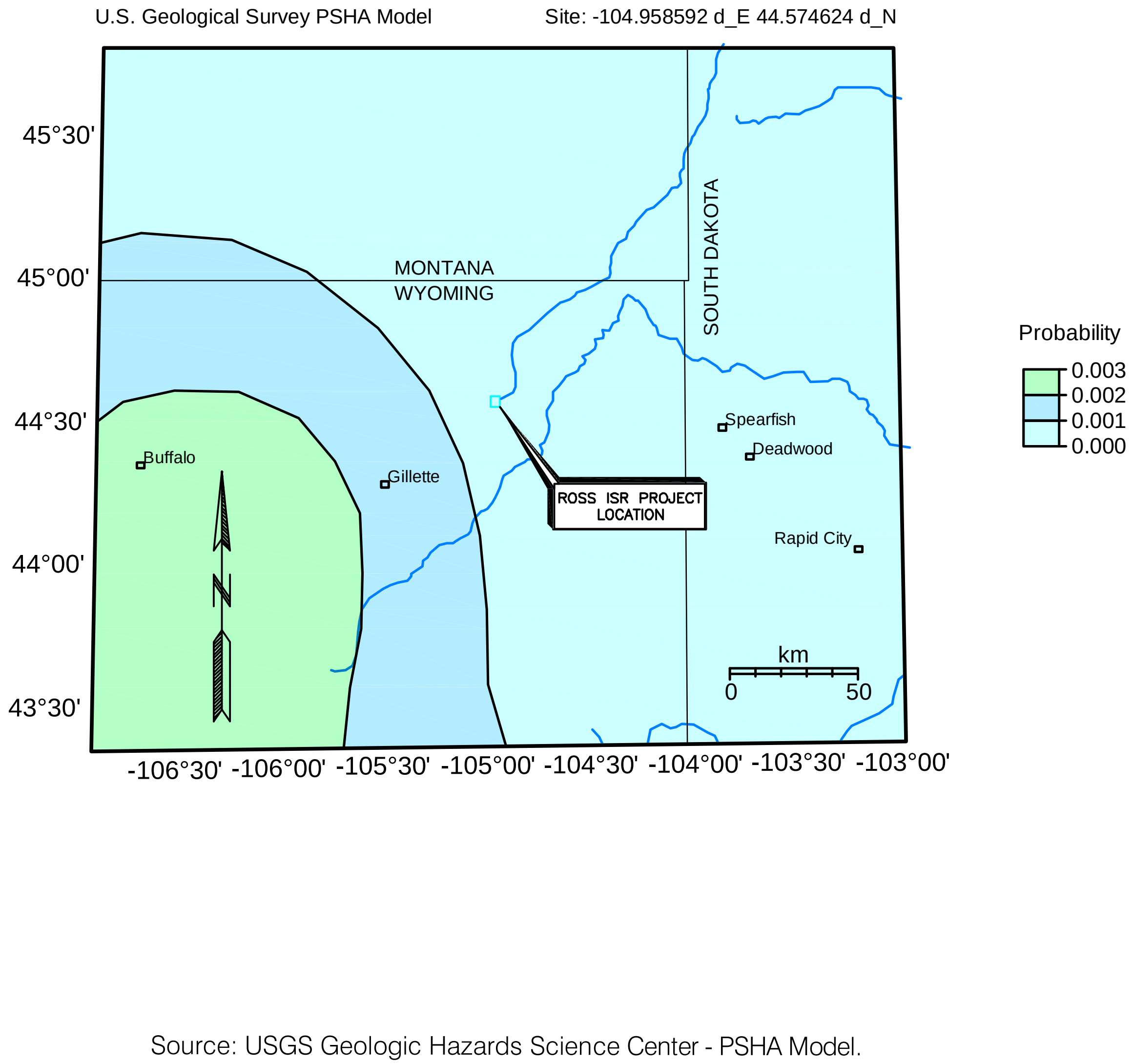


Figure 3.3-11. Probability of Earthquake with Magnitude ≥ 6.5 within 50 Years

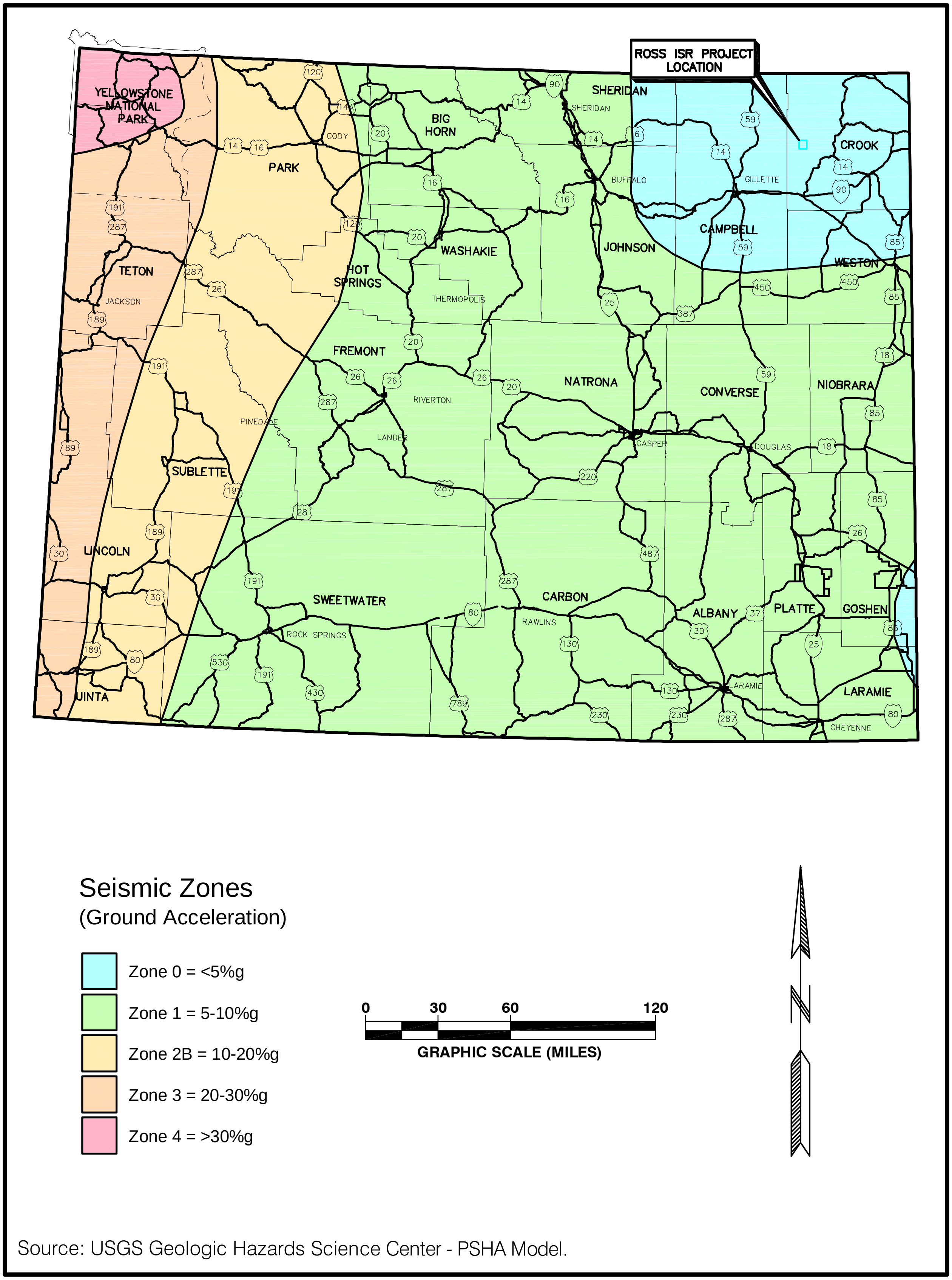


Figure 3.3-12. UBC Seismic Zone Map

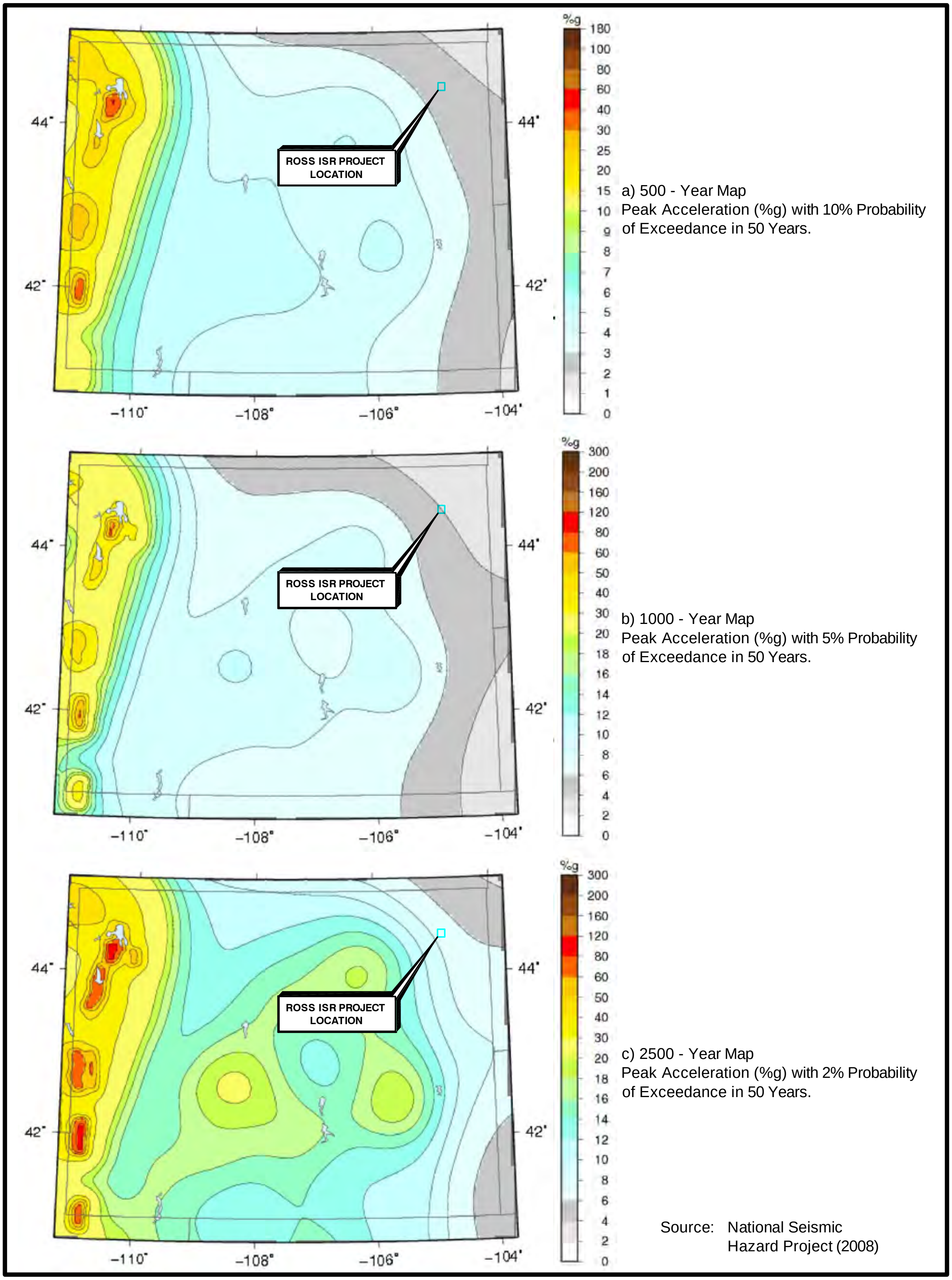


Figure 3.3-13. Seismic Hazard at the Proposed Project Area

3.4 Water Resources

The following sections describe the characterization of the hydrology at the Ross ISR Project in accordance with NUREG-1748 and NUREG-1569 (NRC 2003a and 2003b, respectively). These sections address surface water features, groundwater characteristics, and surface and groundwater quality.

3.4.1 Surface Water Hydrology

3.4.1.1 Regional Description

The Ross ISR Project is located in the upper reaches of the Little Missouri River Basin (Hydrologic Unit Code 101102). The Little Missouri River originates in northeastern Wyoming, flows through southeastern Montana, through northwestern South Dakota, and into North Dakota where it empties into the Missouri River at Lake Sakakawea. The total stream length is 405 miles, and the total drainage area is approximately 9,470 square miles. Figure 3.4-1 depicts the Little Missouri River Basin.

The proposed project area is located within the semi-arid West where evaporation exceeds annual precipitation. Evaporation and precipitation amounts for the site are discussed in Section 3.6. The area streams are in large part ephemeral, and flow only in direct response to snow melt and precipitation.

Five USGS gaging stations are located on the Little Missouri River downstream of the proposed project area (USGS 2010a). The mean annual discharge ranges from 77 cfs or 55,782 ac-ft/yr at the most upstream gaging station to 533 cfs or 386,130 ac-ft/yr at the most downstream gaging station (see Table 3.4-1). According to the University of Wyoming College of Agriculture (UW 2000), the average annual Little Missouri River discharge where it exits Wyoming is 31,000 ac-ft/yr (42.8 cfs).

Figure 3.4-2 displays the mean monthly discharge rate at the two nearest gaging stations, one of which is located in Montana and one in South Dakota. The discharge is typically lowest from November through January and highest during the months of March through June.

Table 3.4-2 presents the observed peak annual flows at the two nearest gaging stations. During the period of record for the Alzada, Montana gaging station the peak flow took place in April 1944 with an estimated discharge of

6,000 cfs. The peak flow at the Camp Crook, South Dakota gaging station took place in March 1978 with a flow of 9,420 cfs. The timing of these peak flows indicates that snow melt and spring run-off typically result in the highest flows for this portion of the Little Missouri River.

3.4.1.2 Drainage Basin Description

Surface water hydrology adjacent to and within the proposed project area is dominated by the northeastward flowing Little Missouri River and associated tributaries. The drainage basins are depicted on Figure 3.4-3. The drainage area of the Little Missouri River at the downstream boundary (Junction 10) of the proposed project area is approximately 18.2 square miles. Drainage basin geomorphology for the Little Missouri River and tributaries are presented in Table 3.4-3.

3.4.1.3 Surface Runoff Estimates

There are no long-term streamflow records within or adjacent to the proposed project area. Therefore, a U.S. Army Corps of Engineers (USACE) HEC-HMS model was developed to estimate the peaks and volumes of floods for various recurrence intervals within the proposed project area. This program was selected due to the size of the drainage area, the watershed routing functions offered by HEC-HMS, and the universal acceptance of HEC-HMS within the hydrologic sciences community. The HEC-HMS model uses a form of the NRCS (formerly SCS) Triangular Hydrograph Method, and is a parametric method of estimating flood peaks and runoff volumes from site-specific data, in addition to providing watershed routing parameters. The NRCS method was utilized for the evaluation of individual watershed hydrology, while the Muskingum method was used for routing procedures.

Procedures followed in applying these methods may be found in the HEC-HMS Users Manual (USACE 2001), HEC-HMS Technical Reference Manual (USACE 2000) and the U.S. Bureau of Reclamation Design of Small Dams (USBR 1977).

The precipitation values were determined from the National Oceanic and Atmospheric Administration (NOAA) Atlas No. 2 for Wyoming (Miller et al. 1973) and are presented in Table 3.4-4 for various return periods and frequencies. The runoff curve numbers were calculated by area-weighting the drainage basin soil types according to hydrologic soil group as determined from the soil

survey information obtained from the NRCS soil survey geographic database for Crook County, Wyoming. An antecedent moisture condition (AMC) of two (average) was used.

The input parameters and results of the HEC-HMS analyses can be found in Addendum 2.7-A in the TR, while the surface water runoff estimates are summarized in Table 3.4-5.

Miller (2003) regression equations were also applied to the watershed to compare peak discharge to the HEC-HMS analyses. Miller's equations were developed through the use of refined analytical techniques to interpret data from 364 selected continuous and partial-records streamflow gaging stations that were minimally influenced by anthropogenic activities and had at least 10 years of annual peak data. Instantaneous peak flow data through the year 2000 were also utilized in the analysis. The data were used to provide a correlation between flow and basin characteristics. The resulting information was transformed into regression equations that provide an analytical tool for estimating peak flow events where no gaging data are available. The regression calculations are shown in Addendum 2.7-B in the TR. A comparison of peak flow estimates using the method of Miller and HEC-HMS for the Little Missouri River where it exits within the proposed project area is provided in Table 3.4-6. The HEC-HMS peak flow estimates are higher than the estimates using Miller's method due in part to existing reservoirs. The Miller method is based on empirical measurements of Wyoming streams, most of which are affected by existing reservoirs. Flood inundation was calculated using the conservatively higher peak flow estimates obtained from the HEC-HMS model.

3.4.1.4 Flood Inundation Study

Peak flood levels were modeled for stream channels within the proposed project area during the 100-yr, 24-hr storm event. Cross sections were first generated at the upper and lower ends of the main stream channels within the proposed project area. Additional cross sections were added near various confluence points along the Little Missouri River within the proposed project area. Longitudinal profiles were then generated for the major channels. Cross sections and profiles were developed from the light detection and ranging (LiDAR) aerial flight topography data collected by Aero-Graphics of Salt Lake City. Then using the peak runoff values calculated from the HEC-HMS model, Manning's equation was used to estimate the peak flow depth at each cross

section. The calculated flow depths were then averaged throughout the length of the channel, and used to generate the inundation surface shown in Figure 3.4-4. The cross sections, cross section locations, channel profiles, and flow depths are provided in Addendum 2.7-C in the TR. A Manning's n of 0.030 was used in the evaluation. Cowan's method (Chow 1959), which accounts for channel materials, irregularity, cross section variance, obstructions, vegetation, and meandering, was used to estimate Manning's n.

The Oshoto Reservoir was included in the HEC-HMS model and was assumed to be full prior to the start of the 100-yr, 24-hr storm event. The storm was then routed through the reservoir and the back water during this event was used as the inundation boundary.

Flooding will be routed around the facilities area by the construction of a diversion channel, which is described in Section 3.1.9 of the TR. Flood and erosion protection for the wellfields are also described in Section 3.1.9 of the TR.

3.4.1.5 Surface Water Use

A surface water rights search was completed within the proposed project area and adjacent 2 miles using the WSEO database (WSEO 2010). The search of the database indicates that 43 surface water rights exist within and adjacent to the proposed project area. A summary of each right is presented in Table 3.4-7 and shown on Figure 3.4-5. In addition to the permitted surface water rights there are at least 17 additional reservoirs within or adjacent to the permit that could not be found in the WSEO water rights database. The table shows that nearly half of the permits have been cancelled, while the remaining permits are complete, fully adjudicated, or unadjudicated.

Surface water within the proposed project area and surrounding 2-mile area is primarily used for livestock watering, with lesser amounts used for irrigation and industrial uses (primarily as a temporary water supply for oil and gas construction activities). The number and age of surface water rights provide insight into the historical water and land use in the area. Stock reservoirs account for about half of the total water rights in the search area, but if cancelled rights are neglected and stock reservoirs not listed in the WSEO database are included, the proportion climbs to about 90%. Most of the stock reservoirs were constructed before 1970 with the majority still in use today. Irrigation water rights only account for a relatively small portion (less

than 10%) of the surface water rights. All of the irrigation rights were permitted 50 to 100 years ago for relatively small areas (70 acres or less). One water right for the Nubeth R&D facility evaporation reservoir signified the rise of uranium exploration in the late 1970s. Following this, there were some 15 temporary water haul permits for oil and gas activities from 1980 to 1991. Finally, the two most recent water rights were appropriated by Strata for exploration activities associated with the proposed Ross ISR Project.

3.4.1.6 Surface Water Features

The surface water features located within the proposed project area are depicted on Figure 3.4-6 and consist of several reservoirs and minor stream channels. Oshoto Reservoir (WSEO Permit No. P6046R) is the main hydrologic feature. It is located in the channel of the Little Missouri River. The only potential springs identified within the proposed project area are associated with field delineated wetlands (see Section 3.4.2.2 in this ER) or with the Little Missouri River in the vicinity of the Oshoto Reservoir (see Section 3.4.1.7.1 in this ER). Although several springs were identified on the USGS 7.5-minute topographic quadrangles covering the groundwater model domain, their locations are more than 0.5 mile from the proposed project area and their presence was therefore not verified. The closest springs or seeps that are believed to be in hydrologic communication with the ore zone aquifer at the proposed project area occur at the Lance/Fox Hills outcrop approximately 7 miles north of the site. These features are shown and discussed in more detail in Addendum 2.7-H in the TR.

3.4.1.6.1 Surface Water Monitoring Network

A surface water monitoring network was implemented to characterize surface water quantity and quality in the potentially affected area in accordance with requirements established by federal and state regulations and guidelines. The network was designed to monitor the major drainages, identify any unique hydrologic features within the proposed project area and establish baseline surface water quality.

3.4.1.6.2 Surface Water Monitoring Stations

Strata established three surface water monitoring stations within the proposed project area in March 2010. The sites were identified during a preliminary field investigation. Criteria for each station location included: 1)

straight reach of stream channel, 2) proximity of the channel to an elevated bank that has a fairly steep grade; this ensured the instruments were placed at a location where they would not be flooded, 3) the distance from the center of the channel to the instruments had to be less than 50 feet due to sensor cable length constraints, and 4) submerged channel reaches (pools) were avoided.

The stations were located at two sites on the Little Missouri River and one site on Deadman Creek, tributary to Little Missouri River. The locations of the monitoring stations are depicted on Figure 3.4-7. Station locations are summarized in Table 3.4-8.

In June 2010, Strata installed continuous stage recorders and pump samplers at each station. The stage recorders are designed to continuously measure discharge and are integrated with designated pump samplers. During installation of each stage recorder the cross section and profile of the stream channel at each station was surveyed. The survey data were used to develop a rating curve, which was programmed into the flow/sampler instrument to calculate flow rates. The pump samplers were installed to collect water quality samples during runoff events. Each pump sampler was initiated by flow stage at each station based on stream geomorphology. The water sample was automatically collected in a single container located in the instrument. Following the runoff event the water was manually transferred from the container to sample bottles and submitted to the contract laboratory for analysis.

3.4.1.6.3 Surface Water Quantity

The average and peak daily flow rates for the surface water monitoring stations are presented in Figures 3.4-8 and 3.4-9, respectively. The three surface water monitoring stations were operated continuously from June 15 to September 25, 2010. Although not decommissioned for the winter until November 2, 1010, the batteries failed and no data were recovered between September 26 and November 2, 1010. Following is a description of the surface water flows measured at the three monitoring stations.

The continuous stage recorder at SW-1 (Little Missouri River, downstream) recorded continuous flow from June 15, 2010 (the first day of continuous monitoring) through August 8, 2010. During this time the average daily flow rate ranged from 0.00 to 0.56 cfs and averaged 0.30 cfs. The peak daily flow rate during the same time interval ranged from 0.00 to 0.94 cfs and

averaged 0.38 cfs. The maximum flow corresponded with a late June precipitation event that was also observed at SW-2 and SW-3. When the 1Q10 water sample was collected from SW-1 (March 9, 2010), the flow rate was estimated at 2.5 cfs and the source of the flow was believed to be snow melt. During the 2Q10 water sample event (April 13, 2010), the flow rate had reduced to an estimated 0.25 cfs. No flow was recorded at SW-1 from August 9 through September 25, 2010.

SW-2 (Little Missouri River, upstream) was generally dry during the June 15 through September 25 time interval during which the continuous stage recorder was operated. One small flow event was recorded between June 23 and June 25. During this flow event, the average daily flow rate ranged from 0.01 to 0.63 cfs and the flow peaked at 2.5 cfs on June 24. Two other minor flow events registered at SW-2. The peak flow measured on July 6 was 0.02 cfs, and the peak flow on August 3 was 0.01 cfs. These flow events were short enough in duration that the average daily flow on these two days was 0.00 cfs. On March 9, the flow rate at SW-2 was estimated at 2.5 cfs, and on April 13 it was estimated at 0.25 cfs.

SW-3 (Deadman Creek) was dry during continuous stage recording except for the late June precipitation event. Between June 23 and June 25 the daily flow rate averaged 0.01 to 0.09 cfs and peaked at 0.20 cfs on June 24. The estimated March 9 and April 13 flow rates at SW-3 were 1.5 and 0.25, respectively.

The results of the monitoring indicate that where the streams flow into the proposed project area (SW-2, SW-3) flow is only in response to snow melt or precipitation events, indicating that both the Little Missouri and Deadman Creek at the upstream proposed permit boundary are ephemeral. The other minor tributaries within the proposed project area are also ephemeral, since no discharges other than in responses to snow melt or precipitation events were observed. The Little Missouri at the downstream proposed permit boundary (SW-1) does have flow for an extended period of the year. This is downstream of the Oshoto Reservoir. Figure 3.4-10 shows the average daily flow observed at SW-1 in relationship to the water surface elevation in Oshoto Reservoir. There appears to be some correlation between the increased flow in the Little Missouri River downstream of Oshoto Reservoir and the amount of head in the reservoir. This would indicate that some of the flow could be attributed to the stored capacity in Oshoto Reservoir. It appears that directly downstream of the

reservoir the Little Missouri River is intermittent. Stream classification is depicted on Figure 3.4-6.

3.4.1.6.4 Reservoirs

In addition to the surface water monitoring stations, Strata identified 12 existing reservoirs within or just outside the proposed project area using aerial photography, WSEO permits, and landowner interviews. Information about reservoir capacities and use is presented in Table 3.4-9. The reservoirs are depicted in Figure 3.4-6. Oshoto Reservoir (WSEO Permit No. P6046R) is the main hydrologic feature within the proposed project area. It is located in the channel of the Little Missouri River and was constructed by a compacted earth fill embankment across the channel. All other reservoirs are relatively small. Most have maximum capacities less than 2 ac-ft, and all have maximum capacities less than 10 ac-ft. As discussed previously, Oshoto Reservoir has potential to affect streamflow characteristics downstream of the reservoir. Also, based on the relationship between reservoir stage and surficial aquifer (SA) monitoring well water levels, the reservoir stage appears to influence water table elevations in its proximity (see Section 3.4.3.3.5.4).

3.4.1.7 Surface Water Quality

The surface water monitoring network included the collection of water quality samples from surface water monitoring stations and existing reservoirs. The surface water quality analysis results are reported in a format consistent with WDEQ/LQD Uranium Mining Data Submission Spreadsheets. The following sections provide a summary of the monitoring results, while complete results are included in Addendum 2.7-D in the TR, and the lab data are provided in Addendum 2.7-E in the TR.

3.4.1.7.1 Surface Water Monitoring Stations

All streams within the proposed project area, including the Little Missouri River and Deadman Creek, are classified by WDEQ/WQD as 3B streams. A Class 3B stream is defined by the WDEQ/WQD as an intermittent or ephemeral stream incapable of supporting fish populations or drinking water supplies. About 40 miles below the project the Little Missouri River becomes a class 2ABWW stream at its confluence with Government Canyon Creek. This classification signifies that it is protected as a drinking water source (2AB) and

warm-water (WW) fishery. Table 3.4-10 presents the use designations for the various surface water classifications in Wyoming streams.

Surface water sample collection began in March 2010 at the three stations described above and continued quarterly through 2010. Samples were collected in bottles provided by the contract laboratory and analyzed for constituents listed in Table 3.4-11.

Samples collected at the three surface water monitoring stations indicate that the quality of surface water within the proposed project area is relatively consistent from one sample location to the next and at different times during the year. Monitoring results from the surface water stations are summarized in Table 3.4-12, while a piper diagram of the average major ion chemistry for each station is presented in Figure 3.4-11.

The results indicate that TDS concentrations in the Little Missouri River and Deadman Creek are low to moderate, ranging from 220 mg/L to 940 mg/L. The water type of both streams is sodium bicarbonate, which is uncommon in Wyoming streams. Streams originating in the lowlands are typically dominated by sodium sulfate, while mountain streams are generally calcium bicarbonate (Miller et. al. 2004). Since streams are influenced by the geologic formations through which they flow, the results were compared to the surficial aquifer (SA zone) wells constructed by Strata as part of the regional baseline monitor well network. The results confirmed that water quality in the SA zone wells was similar to the surface water in the Little Missouri River and Deadman Creek. This indicates that there is potential communication between surface and shallow groundwater in the proposed project area.

Metal and radionuclide concentrations measured at the surface water monitoring stations were near or below detection limits, with the exception of uranium. Concentrations of uranium above the detection limit of 0.001 mg/L were measured at all three stations. Overall, the concentrations were the highest in the 2nd quarter 2010 when discharge rates in the streams were very low.

3.4.1.7.2 Reservoirs

Strata began reservoir sampling in the 3rd quarter 2009. Samples were collected on a quarterly basis through the 4th quarter 2010, when possible (i.e., when the reservoirs were not dry or frozen and when Strata had landowner permission). Reservoir samples were collected with a telescoping

dipper and transferred to sample bottles provided by the contract laboratory. Samples analyzed for dissolved constituents were filtered and preserved in the field. Table 3.4-13 provides the sample history for each reservoir.

The water quality in the reservoirs sampled within the proposed project area varied significantly. The water quality analytical results, summarized in Table 3.4-14, indicate that reservoirs constructed on the channel of the Little Missouri River and Deadman Creek had increased salinity and hardness compared to more upland reservoirs. The water quality within the main channel reservoirs was similar to that of the surface water monitoring stations. The remaining reservoirs, located away from the main channels, contained water with lower TDS. The water in all reservoirs was mildly to moderately basic, with pH generally ranging from 8 to 10 standard units.

The major ion chemistry of the water contained in each reservoir is depicted in Figure 3.4-12. The figure shows that water within the reservoirs located on Deadman Creek and the Little Missouri River (R-2 and R-6 through R-10) contained sodium bicarbonate type water, while the water type in the remaining reservoirs was calcium bicarbonate.

Total metals and radionuclide concentrations were low to undetectable for all reservoirs. The highest concentrations of uranium were measured in the reservoirs located along the Little Missouri River and Deadman Creek. Concentrations were similar to those measured at surface water monitoring stations. Few radiological constituents were measured above the detection limit. Reservoirs R-1 and R-10 measured lead-210, while radium-226 was detected in all but four reservoirs.

3.4.1.8 WYPDES Outfalls

Upstream from the proposed project area there are two WYPDES permitted outfalls (permit numbers WY0044296 and WY0033065). Downstream from the proposed project area there is one WYPDES outfall (permit number WY0034592). All three permits are associated with oil production facilities. The discharge points are shown in Figure 3.4-3. The facility names and operators of these permits are shown in Table 3.4-15, while the effluent limits are presented in Table 3.4-16. The effluent limits were updated when all three permits were renewed in 2009. Prior to 2009, monitoring was required for oil and grease, chloride, radium-226 and flow rate. Following the permit renewals WDEQ/WQD updated the permitting

requirements to include pH, EC, and sulfate. Additionally, the effluent limit for chloride was revised from 230 to 2,000 mg/L.

Discharge monitoring reports from 2007 through 2009 are summarized in Table 3.4-17 for the three WYPDES-permitted outfalls. Discharge rates from the outfalls are relatively low (0 – 0.04 MGD). Chloride and radium-226 concentrations were below permit limits. The radium levels were generally above the EPA MCL of 5 pCi/L, but drinking water standards are not applicable to these discharges. In addition, some samples from permits WY0034592 and WY0033065 exceeded the oil and grease limit. Sulfate and EC concentrations were reported for permit WY0044296 in 2009. The results indicate that these parameters are below the WDEQ/WQD permitted limits.

3.4.2 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 12 (utility line activities);
- NWP 14 (linear transportation projects); and
- NWP 44 (non-coal mining activities).

NWP 12, NWP 14, and NWP 44 activities cannot result in the loss of greater than 0.5 acre of WoUS per NWP permit. Impacts to Other Waters of the U.S. are not considered under the acreage limit. Final determination of jurisdictional decision lies with the USACE.

3.4.2.1 Wetland Survey Methodology

The initial step of the wetland survey was to obtain and review all pertinent, available environmental information within the proposed project

area. Existing data included USDA-NRCS soil mapping (NRCS 2010), U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) mapping (USFWS 2010), and May 2010 aerial photography. All sources of information provided relevant information on the potential occurrence and distribution of wetlands. Wetland determination sites identified in this initial step, including all NWI mapped wetland areas, were visited during the field investigation to verify if wetland characteristics were present.

Site-specific field investigations were conducted within the proposed project area by John Berry of WWC Engineering (WWC) on June 22 and 28 and July 8 and 21, 2010 in accordance with the Interim Regional Supplement to the U.S. Army Corps of Engineer's Wetland Delineation Manual: Great Plains Region (USACE 2008). Wetland determination sites were examined for hydrophytic vegetation, hydric soils, and wetland hydrology during the June and July 2010 field investigations. The locations of sample sites were determined during on-site visits to obtain the most relevant and optimal information possible. Initial assessments at each sample site began with a vegetative cover inventory. The *North American Range Plants Field Guide-Fifth Edition* (Stubbendieck et al. 1997) and the *Western Wetland Flora Field Office Guide to Plant Species* (USDA-NRCS 1988) were used to assist in vegetation species identification. Vegetative species indicator status, with respect to wetland or non-wetland, was recorded along with its percent composition within the sample area. The indicator status was obtained using the National List of Plant Species that Occur in Wetlands: Region 4 (Resource Management Group, Inc. 1994). Where possible, soil observation pits were dug to a depth of 20 inches. A Munsell Color Chart (Kollmorgan Corporation 1975) was used to record soil color, texture, and other distinguishing characteristics for each sample site. Wetland hydrology indicators were assessed. Each sample point was assessed and recorded on a site-specific wetland determination field form.

A Trimble® GeoXH GPS unit was used to delineate the boundaries of the potential wetland areas. This GPS unit is accurate to ±1 meter. Portions of the boundaries of the larger delineated areas were determined by observing distinctions in vegetation and hydrology, although soils were examined at varying intervals along the boundaries to verify the ocular delineations. Due to the similarities between potential wetland areas, it was not considered necessary to complete wetland determinations forms for all areas. Addendum 3.4-A contains photos of potential wetland areas.

The shallow, open water type was delineated using recent (May 2010) high quality aerial photography to determine areas with no apparent emergent, floating, or submergent vegetation. Other Waters of the U.S. were determined using USGS 1:24,000 quadrangle maps. Drainages (dashed lines adjusted to fit the aerial photography) were delineated as Other Waters of the U.S. if not delineated as a wetland type.

3.4.2.2 Wetland Survey Results

Table 3.4-18 and Figure 3.4-13 depict the wetland survey results. The complete wetland survey results, photographs, and correspondence with the USACE are provided in Addenda 3.4-A and 3.4-B. The 13 wetland sites indicated on the NWI mapping within the proposed project area were investigated during the 2010 field surveys. All but two of these NWI areas were included in field delineated wetlands (Figure 3.4-13). The two sites not included did not have the three characteristics for wetlands. Many of the potential wetland areas delineated during the 2010 field surveys were small (<0.1 acre) depressions that were in close proximity to each other but were distinct depressions separated by upland vegetation. A significant number of these small depression areas appeared to be influenced by groundwater, receiving seepage from the Lance Formation, which outcrops in the area.

The potential wetland areas were classified according to Cowardin et al. (1979) to more accurately describe the types of potential wetlands present within the proposed project area (Figure 3.4-13 and Table 3.4-18). Most (approximately 93%) of the potential wetland areas were man-made (diked or excavated). The vast majority of these were preliminarily classified as Palustrine, Aquatic Bed, Seasonally Flooded, Diked (PABFh). Of the areas designated as PABFh, about half were areas of open water. There were approximately 5.1 acres (22,130 linear feet x average 10-foot wide channel) of Other Waters of the U.S. identified within the proposed project area (see Figure 3.4-13).

3.4.2.2.1 Wetland Delineation and Jurisdictional Determination

A wetlands delineation report for the proposed project area was submitted to the USACE, Omaha District in Cheyenne, Wyoming in September 2010. A copy of the report is included in Addendum 3.4-A. The

USACE verification letter will be provided to NRC and WDEQ/LQD when available.

USACE jurisdictional determination of specific wetland areas will not occur until Strata applies for coverage under an appropriate NWP for specific construction activities such as pipeline installation and access road stream channel crossings. At that time, Strata will provide a site-specific mitigation plan for disturbance of jurisdictional wetlands.

3.4.3 Groundwater

This section presents a synopsis of the regional and local hydrostratigraphy, including the direction of groundwater flow and recharge/discharge characteristics. Information on the local groundwater uses, hydraulic characteristics and groundwater quality in the vicinity of the proposed Ross Project area is also presented in detail within this section. Comprehensive information on the regional and local geology, particularly structure and stratigraphy, is presented in Section 3.3.

3.4.3.1 Regional Hydrogeology

The proposed Ross ISR Project area is located on the eastern margin of the Powder River Basin and the western margin of the Black Hills Uplift. This discussion will focus on the eastern Powder River Basin. In the vicinity of the proposed project area, rocks of Upper Cretaceous age are exposed. East of the proposed project area, older rocks through Mississippian age are exposed along the western flank of the Black Hills Uplift. Quaternary-age deposits of unconsolidated alluvium and colluvium are also present. In addition to saturated alluvium and colluvium, there are a number of water-bearing bedrock strata present in the eastern Powder River Basin, ranging in age from Precambrian to Paleocene. Near the Black Hills uplift, Paleozoic strata dip rather steeply into the basin, so water supply wells completed within these rocks are typically near the outcrop. Table 3.4-19 presents the hydrostratigraphic relationships of the strata occurring in the eastern Powder River Basin.

Due to lack of major surface water sources, municipalities within the northeast corner of Wyoming rely on groundwater. Regionally, there are a number of water-bearing intervals exploited by municipalities and industrial users, depending on location. In the vicinity of the Black Hills Uplift, the

principal aquifer for municipalities is the Mississippian Madison Limestone. The city of Gillette operates a wellfield consisting of 10 wells north of the town of Moorcroft. The water is piped some 40 miles to Gillette and blended with locally-produced groundwater from the Fort Union Formation and to a lesser degree from wells completed in the Lance and Fox Hills formations. Other towns in the vicinity (Moorcroft, Sundance, Upton, Newcastle, and Hulett) utilize the Madison for municipal supply (WWDC 2010). In the vicinity of Gillette, the Fox Hills and Lance formations are typically targeted by industrial users, while smaller municipalities, subdivisions and improvement districts use wells completed within the shallower Fort Union Formation.

Regionally, recharge occurs in the outcrop areas, with groundwater moving away from the outcrop into the basin. Due to the geologic dip of the strata, horizons that are accessible near the Black Hills Uplift are deeply buried in the basin center. Dissolved solids concentrations increase with depth and distance from the recharge sources.

3.4.3.2 Site Hydrogeology

3.4.3.2.1 Introduction

The proposed project area is situated on the Lance Formation outcrop. With the exception of the recent alluvium located in the valley floors of the Little Missouri River and Deadman Creek, and a small portion of Fox Hills Formation in the extreme eastern portion of the proposed project area, the entire proposed Ross ISR Project area is located on the Lance Formation outcrop. Underlying the Lance Formation is the Fox Hills Formation and the Pierre Shale. The Pierre Shale is a thick marine shale that yields very little water and is considered regionally as a confining unit (Langford 1964). The Fox Hills Formation is a sequence of marginal marine to estuarine sand deposits that were deposited during the eastward regression of the Upper Cretaceous Interior Seaway. In the Ross area, the Fox Hills Formation consists of an upper (FH horizon) and a lower unit (FS/BFS horizons) separated by 10 to 50 feet of intervening shale, claystone and mudstone (BFH horizon). The FS and BFS sandstone units consist of offshore-marine and transitional-marine shale, siltstone, and fine grained sandstone and are not known to contain uranium. The FH horizon sand consists of uranium-bearing, organic, thinly-bedded claystone, siltstone, and sandstone (Dodge and Spencer 1977). Within the proposed project area, mineralization primarily occurs within the FH horizon

sand, although in localized areas mineralization occurs within the overlying Lance interval (LT horizon) sandstone.

3.4.3.2.2 Monitoring/Testing Program

The Ross ISR Project regional baseline groundwater monitoring program consists of six monitoring well clusters located across the proposed project area as shown on Figure 3.4-14. The six well clusters consist of at least four wells, each completed in a separate, consistent stratigraphic horizon intended to provide a portion of the data necessary for hydrogeologic characterization of the proposed Ross ISR Project area. The horizons/zones monitored consist of (beginning with the deepest): 1) the BFS horizon sandstone, operationally termed the deep monitor or DM unit; 2) the FH/LT horizon ore-bearing sandstone, operationally termed the ore zone or OZ unit; 3) overlying the ore zone is a persistent confining unit (LC horizon aquitard or Upper Confining Unit) 20 to 80 feet thick, and above this confining unit are the LM through LK horizon sandstones, operationally termed the shallow monitoring or SM unit; and 4) the surficial water table aquifer is operationally termed the SA unit. The DM and SM units will monitor vertical isolation of the ore zone.

The location of the monitoring well clusters was based on a number of factors, including:

- Regulatory considerations (as detailed in WDEQ/LQD Guideline 4, In Situ Mining, WDEQ/LQD Guideline 8, Hydrology, WDEQ/WQD Chapter 8, and NRC Regulatory Guide 4.14),
- Consistent/continuous water-bearing interval above and below mineralization,
- Satisfactory thickness of confining intervals,
- Proximity to existing drilling data, and
- Landowner considerations, including minimization of surface disturbance and access to sufficient aerial coverage to develop potentiometric surfaces of aquifers for characterization, to characterize spatial (both horizontally and vertically) variations in water quality.

Completion details of the wells used in the monitoring program are presented in Table 3.4-20.

Each well cluster is depicted in detail on Figures 3.4-15 through 3.4-20. Each of these figures shows the distances between wells and a cluster type log

with respective completion intervals and water level elevations. Geologic cross sections A-A' through F-F' (excepting E-E') are drawn through each of the six well clusters (see Addendum 2.6-C in the TR).

All baseline monitoring wells were constructed using conventional mud-rotary drilling techniques. At each of the six well clusters a 6¼-inch diameter pilot was drilled to a depth through the DM interval, and geophysical logs consisting of natural gamma ray (GR), resistivity (R), and spontaneous potential (SP) were acquired. Following logging, the target completion intervals for the deep monitor (DM), ore zone (OZ), shallow monitor (SM), and surficial aquifer (SA) were selected. This information was used to ensure that the regional baseline monitor wells did not over-penetrate beneath the target zone.

Each well consisted of a pilot hole drilled to the top of the target interval and reamed to 8¾ inches to allow installation of casing and screen assembly. The wells were constructed with 5-inch diameter, SDR-17 PVC well casing. PVC well centralizers were placed at 60-foot intervals to the top of the target aquifer interval. The annular space between the casing and the borehole wall was then filled with cement slurry consisting of a 14.8 to 15.0 pounds per gallon mixture of Type I cement and 2% bentonite, using positive displacement to fill the annular space from the bottom to the ground surface. After allowing the cement to cure for at least 72 hours the target intervals were underreamed to 7 inches in diameter across the entire aquifer interval. The underream intervals were again logged with a caliper tool to verify the integrity of the target interval for accepting the screen assembly and sand pack material.

The intake interval consists of 3-inch diameter, 0.010-inch slot rod-based PVC V-wire well screen with a 10-20 silica sand filter pack. Following filter pack placement, air-lift development was conducted until turbidity readings stabilized. The wells were again logged to assess the completeness of the filter pack installation. Figures 1.2-8 through 1.2-10 depict the typical monitoring well completions employed by Strata. Section 1.2.5.1 includes a detailed description of well construction materials, methods, development and integrity testing.

Dedicated submersible pumps, sounding tubes and recording pressure transducers were installed in the SM, OZ and DM wells to expedite groundwater sample collection and document groundwater elevations. Well completion data are presented in Table 3.4-20. Well locations and measuring point elevations were surveyed by Bearlodge Engineering (Sundance, Wyoming)

under the direction of a Wyoming Professional Land Surveyor. Initial and quarterly water levels are manually measured with a Waterline™ water level indicator with accuracy to ± 0.01 ft.

In July 2010 an aquifer pumping test was conducted at each well cluster, with two tests conducted at the 12-18 well cluster. The details of the aquifer testing program are presented in Addendum 2.7-F in the TR. The test results are summarized in Table 3.4-21.

3.4.3.2.3 Hydrostratigraphy

A detailed discussion of the stratigraphy within the proposed Ross ISR Project area is presented in Section 3.3. Table 3.4-22 presents the relationships between the areal geologic units and the Ross ISR Project stratigraphic horizon and aquifer/confining unit nomenclature. A description of each of the various aquifer/confining units, in ascending order, follows.

Pierre Shale

The Pierre Shale is roughly 2,200 feet thick in the proposed project area. Locally, the Pierre Shale is relatively uniform and void of any water-bearing strata. Site-specific hydraulic conductivity tests have not been performed for the Pierre Shale, but vertical hydraulic conductivity has been estimated on the order of 2.6×10^{-10} to 2.6×10^{-9} ft/day by Neuzil (1993) outside of the region. Other estimates of the vertical hydraulic conductivity outside of the region for the Pierre Shale are in the range of 5×10^{-8} to 5×10^{-4} ft/day (Kansas Geological Survey 1991). The Pierre Shale is described as a regional aquitard in the literature (e.g., Langford 1964, Domenico and Swartz 1990) and in the Ross area. On the east side of the proposed project area, the Pierre Shale outcrop marks the eastern extent the overlying Ross area aquifers. No wells are known to be completed within the Pierre Shale within the proposed project area.

Fox Hills Formation Aquifers

Within the proposed project area, the water-bearing sandstone intervals within the Fox Hills Formation consists of the FH, BFS and FS horizons. The BFS and FS sandstone horizons are separated by interbedded shales and silts and represent the only water-bearing strata within the lower Fox Hills Formation. Both sand units are believed to be continuous throughout the proposed project area, although in places they are relatively thin. The BFS

horizon is the nearest aquifer below the uranium-bearing sandstone (the FH horizon) in the upper Fox Hills Formation, and in terms of ISR uranium recovery operations it is referred to as the deep monitoring zone, or DM interval. The DM unit is separated from the FH sand by 10 to 50 feet of shale, claystone and mudstone. The DM unit is deeply confined, with confining heads ranging from 320 to 430 feet across the proposed project area. The upper Fox Hills mineralized zone is the FH horizon and is the lower portion of the ore zone aquifer, or what is referred to herein as the OZ monitoring interval/unit. The hydrostatic heads in the DM unit are lower than the OZ heads in some locations and higher than the OZ heads in others, but remain in close proximity across the proposed project area. Aquifer tests performed in July 2010 indicate that the DM interval is generally isolated from overlying water-bearing units. Furthermore, the water quality in the DM unit compared to that in the overlying OZ unit is distinctly different, supporting hydraulic isolation of the DM unit from overlying units. No aquifer tests have specifically been performed to determine the hydraulic conductivity of the DM unit (or BFS sandstone horizon). Based on the exceedingly low rate of recovery of the DM wells following pumping to obtain water quality samples (see DM hydrograph analysis in Addendum 2.7-G in the TR), the hydraulic conductivity of the DM zone is much lower than that of the overlying OZ units. Due to the thickness (10 to 50 feet) of the shale, claystone and mudstone interval (BFH horizon) separating the DM unit from the FH horizon, this low permeability unit is considered to be a confining interval. The BFH interval is also referred to as the basal Fox Hills Lower Confining Unit. Although vertical hydraulic conductivities are not available for this basal confining shale aquitard, vertical hydraulic conductivity is expected to be comparable to that of the Pierre Shale, i.e., 5 x 10^{-4} ft/day or less.

The FH horizon sandstones within the upper Fox Hills Formation contain uranium and are the primary uranium recovery target of the Ross ISR Project. The ore zone comprises these sandstones along with the overlying lower Lance Formation sandstones (LT horizon). Monitor wells have been installed in this saturated interval, which demonstrates hydraulic continuity and is referred to as the ore zone aquifer, or the OZ monitoring interval. The thickness and lithologies of the FH sandstones can vary significantly over short distances. As described in Section 3.3, the upper Fox Hills Formation ranges from thick-bedded, blocky sandstones to thin, interbedded sandstones, siltstones and shales. Within the proposed project area the gross sand thickness of the Fox

Hills Formation is approximately 150 feet, although local variations of up to 50 feet or more are not unusual. The FH sandstones, shales, and silts have been studied extensively through both core analysis and aquifer tests. Addendum 2.7-F in the TR presents the results of the 2010 aquifer testing program. A summary of past tests, both field and laboratory, conducted within the proposed project area is included in Addendum 2.7-F as well.

Lance Aquifers

The Lance Formation depositional environment has been interpreted as being fluvio-deltaic in origin (Tschudy 1975). The Lance Formation consists of a mixture of non-marine deposited sandstones and floodplain mudstones with thin beds of coal (Connor 1992). The depositional environment of the Lance Formation created a stratigraphy that is complicated and vertically heterogeneous. Within the proposed Ross ISR Project area the LT horizon sandstones of the lower Lance Formation are of particular interest because they make up the upper portion of the ore zone (OZ unit), which is saturated and demonstrates hydraulic continuity throughout the proposed project area. The basal Lance Formation uranium-bearing LT sand ranges in thickness from 30 to 40 feet within the proposed project area. Above the LT sand is a shale layer varying in thickness from 20 feet to 80 feet, locally called the LC horizon aquitard or Upper Confining Unit. The LC horizon aquitard serves as a confining unit that separates the mineralized sandstones of the FH and LT horizons (OZ aquifer) from the water bearing zone above. Information about the confining properties of the Upper Confining Unit can be found in the groundwater model in TR Addendum 2.7-H. The model-calibrated vertical hydraulic conductivity of the Upper Confining Unit is 6.5×10^{-6} ft/day. The water-bearing sand above the ore zone is also referred to as the shallow monitoring zone or SM aquifer comprised of the LM through LK horizon sandstones, and will be monitored during uranium recovery operations. Above the SM unit is a sequence of thin sands, shales, and silts. Many of the thin sandstones contain water; however, these sandstones are generally discontinuous, and while they may be used locally for stock and domestic wells, they are not regional.

Hydraulic parameters for the Lance Formation have not been extensively studied. Pumping tests performed on the uranium-bearing sandstone in the upper Fox Hills Formation detected no hydraulic communication between the Fox Hills uranium-bearing sandstone and the SM unit (Manera 1977 and

1978, Hamilton 1977, and Addendum 2.7-F in the TR). While the SM unit was monitored during aquifer testing, neither testing of core samples nor pumping tests have been conducted within this portion of the Lance Formation. Based on lithology, however, the hydraulic properties of the SM unit within the Lance Formation are expected to compare to those of the Fox Hills Formation.

Surficial Aquifer

The surficial aquifer (SA) within the proposed project area consists of the uppermost water-bearing interval within the upper Lance Formation and the alluvium of the Little Missouri River and Deadman Creek. The surficial aquifer is under water table conditions.

3.4.3.3 Potentiometry, Gradients, and Recharge/Discharge Areas

Using head data from the monitoring well clusters, potentiometric surfaces for the DM, OZ, SM and SA aquifer units were developed.

3.4.3.3.1 DM Unit

The DM potentiometric surface is presented on Figure 3.4-21. As stated above, the DM unit is a confined aquifer with potentiometric heads ranging from 320 to 430 feet above the top of the interval across the proposed project area. The direction of groundwater flow within the DM unit is generally from the northeast to the southwest in the northern portion of the proposed project area. Proceeding south, the direction of flow shifts to the east, and takes on a northerly component in the southeast portion of the proposed project area. Hydraulic gradients vary slightly, but are typically on the order of 50 feet per mile (approximately 0.009 ft/ft). There is a distinct trough in the DM potentiometry in the vicinity of the 21-19 well cluster. This trough is due to abstractions from an oil field water supply well (22X-19) in this area that is completed in both the DM and OZ intervals. Pumpage from over the last 30 years has apparently depressed the heads from background conditions, resulting in the trough-like feature that is readily apparent in the DM potentiometry.

Groundwater within the DM unit moves into the proposed project area from the northeast and east, and moves to the south and west from recharge areas along the Fox Hills Formation outcrop, particularly where the Little Missouri River crosses the outcrop. Groundwater flow direction within the DM

unit is generally downdip, westward into the Powder River Basin. Based on the length of time it takes for the DM monitoring wells to recover following pumping for sample collection and the chemical quality of the DM groundwater (sodium-chloride type - see Section 3.4.3.5.2.2), flow within the DM aquifer is relatively sluggish.

3.4.3.3.2 OZ Unit

The OZ potentiometric surface is presented on Figure 3.4-22. The current shape of the OZ potentiometry has been affected by some 30 years of groundwater withdrawals by oil field water source wells completed in the OZ interval, with development of a distinct cone of depression near the 21-19 well cluster. This pumping has changed the hydraulic gradient and the direction of groundwater flow throughout most of the proposed project area. The potentiometry near the 34-7 well cluster has been least affected by pumping, and has southwesterly flow direction under a gradient of approximately 50 feet per mile.

Based on estimates that are presented in Addendum 2.7-H (Groundwater Model) in the TR, approximately 150 feet of drawdown in the OZ unit has occurred in the vicinity the 21-19 well cluster since pumping began in 1980 for local oil field water flood operations. Vertical gradients have been reversed from background conditions, resulting in OZ unit potentiometric surface elevations that are now lower than DM unit potentiometric surface elevations in the southern portion of the proposed project area. The OZ unit is, however, a confined aquifer across the entire proposed project area, with potentiometric heads ranging from around 150 feet to more than 400 feet above the top of the ore zone interval. Figure 3.4-23 is an isopachous map depicting the currently available hydrostatic head above the top of the OZ aquifer across the proposed project area.

As can be seen on Figure 3.4-22, within the proposed project area groundwater in the ore zone generally moves from recharge areas along the Fox Hills Formation outcrop toward the cone of depression near the 21-19 well cluster.

3.4.3.3.3 SM Unit

The configuration of the SM potentiometry does not conform with the typical confined aquifer potentiometric surfaces for other aquifers that emanate

from the Black Hills Uplift, such as the Dakota Formation or Madison Formation confined aquifers. Typically, these aquifers possess uniformly spaced potentiometric contours that are parallel to geologic strike, with a basin-ward gradient. Based on the water surface elevations from the SM wells within the regional baseline well clusters, the potentiometry is somewhat convoluted and difficult to interpret into a cohesive surface. The difficulty in preparing a comprehensive surface using the hydrostatic heads from the six SM cluster wells is due to at least two reasons. First, the SM unit's hydrostatic pressure heads have likely declined over the last three decades as result of pumping the local oil field water source wells completed in the underlying OZ interval. Based on the modeling results (Addendum 2.7-H in the TR), nearly 30 years of pumpage has lowered SM heads roughly 10 feet in the vicinity of the 21-19 well cluster. Second, the lithology of the SM interval is discontinuous, making correlation within this unit somewhat difficult over long distances across the proposed project area. Although the SM wells are typically completed in the first sand overlying the ore zone interval, this interval may not necessarily correlate between distantly spaced well clusters. This is most apparent upon comparison between the 34-7 and 42-19 well clusters, which are located near the northern and southern borders of the proposed project area, respectively, and some 8,500 feet apart. These two well clusters, which are roughly in the same position relative to the Fox Hills Formation outcrop, show some 50 feet of head difference in the SM unit. Inspection of geologic cross section C-C' (Addendum 2.6-C in the TR) indicates that the completion interval of well 34-7SM is not exactly correlative with the completion interval of well 42-19SM. The difference in hydrostatic head between these two wells suggests that the SM unit does not behave as a single aquifer and vertical gradients are present, making preparation of a potentiometric surface for this unit problematic. For this reason, the potentiometric surface depicted on Figure 3.4-24 includes some speculation.

3.4.3.3.4 SA Unit

The surficial aquifer or SA unit is the water table aquifer within the proposed project area, and includes the alluvium of the Little Missouri River and Deadman Creek. In addition to the SA well completions at the various monitor well clusters, shallow piezometers were installed in the SA unit for a geotechnical study, one of which is dry. Well logs and completion details for these piezometers are included in Addendum 3.1-A in the TR. The increased

number of monitoring sites for the SA unit provides more detail in the SA potentiometry than in the underlying units. The SA potentiometric surface is presented on Figure 3.4-25.

The direction of groundwater flow in the surficial aquifer in the proposed project area is generally from the highlands to the lowlands, moving from both the north and south and converging on the Little Missouri River valley. Groundwater in the SA aquifer leaves the proposed project area in a northeasterly direction as alluvial underflow. Gradients within the SA aquifer are approximately 35 feet per mile, with flow converging on the Little Missouri River and its tributary, Deadman Creek.

3.4.3.3.5 Hydrograph Analysis

Water level data collection began in the proposed project area with installation of the regional baseline monitor well clusters in the fourth quarter of 2009. In March 2010, each of the DM, OZ, and SM monitor wells were fitted with recording pressure transducers, as was well 12-18SA, and continuous groundwater level hydrographs were prepared for each well starting April 1, 2010. At the five remaining SA wells, of which two were dry, manual water level measurements were collected. In June 2010, four piezometers were installed in the NW SW of Section 18, T53N, R67W as part of a geotechnical investigation. Water level data collection is ongoing.

The recording pressure transducers are non-vented, and do not compensate for water level changes in the aquifer that are the result of barometric pressure fluctuations. Therefore, the hydrographs prepared using the data from these transducers show the aquifer head fluctuations affected by changes in the barometric pressure. Barometric pressure data were collected at Strata's field office in Oshoto.

Hydrographs for each of the monitor wells and piezometers were prepared and are housed in Addendum 2.7-G in the TR. Including manual measurement, the period of record is January through October 2010. A graph of barometric pressure with a period of record from March through October 2010 is also included. A discussion of the hydrographic response during the period of record for each respective aquifer and individual well, where appropriate, follows.

3.4.3.3.5.1 DM Unit

The DM well hydrographs all have similar attributes. Due to the low permeability of this unit, each hydrograph depicts the long water level recovery period following water quality sampling events, which occurred in March, June, July-August, and October 2010. Full recovery of the DM aquifer water levels generally takes 45 to 60 days following a sampling event. To a varying extent, all DM hydrographs show minor perturbations on the order of 0.1 foot due to variation in barometric pressure. During the May-June 2010 period, water levels were more variable in the 12-18DM well, with a spike of almost 3 feet occurring in late April with another spike occurring in late May. These spikes are imprinted on the general water level increase following the March sampling event. With the exception of the 34-7DM well, all of the DM wells show a "blip" during this time frame. The cause of these spikes is unknown. The 12-18 well cluster is approximately 4,000 feet away from the oil field water supply wells located in the southern portion of Section 18. It is therefore unlikely that the hydrograph variation recorded in the 12-18DM well is due to pumpage, although the hydrograph from the 21-19DM well, which is located closer to the oil field water supply wells, depicts a very recognizable spike in the same mid- to late-April time period, although not on the same day.

3.4.3.3.5.2 OZ Unit

The amount of variability in the OZ well hydrographs is a function of the well locations relative to the oil field water supply wells in Sections 18 and 19. The wells located closest to this area (21-19OZ, 34-18OZ, 14-18OZ, and 42-19OZ) display water level fluctuations that are clearly related to pumpage. Obvious on these four hydrographs are pumping starts and stops that occurred in the late June, early July 2010 time frame. Also apparent on these four hydrographs is a rapid water level rise (over 15 feet in the 21-19OZ well) in late September 2010 that is attributed to a temporary cessation of pumping. A rapid decline in water level following this rise can be noted in the 42-19OZ, 34-18OZ and 21-19OZ well hydrographs. This decline is an indication of resumption of pumping.

The 34-7OZ well is furthest from the water supply wells, and its hydrograph displays the least variation. Other than the aquifer testing that took place over the period of record, the only obvious perturbations are related to sampling events and barometric fluctuations. The barometric fluctuations

are less than 0.5 foot. During the January through October 2010 time frame, the 34-7OZ hydrograph shows a steady increase of approximately 2 feet. Steady variations of this type are not discernable on the remaining OZ well hydrographs.

The 12-18OZ hydrograph varies within a window of approximately 2.5 feet. Based on the magnitude of the water level changes in this well, the majority of observed water level change can be ascribed to barometric pressure fluctuations, with the exception of the fluctuations in the late June, early July time period, which coincide with pumping-related water level changes in the same time frame observed in the group of four wells discussed above.

3.4.3.3.5.3 SM Unit

The hydrographs of the SM wells show much less variation than the DM and OZ units. Other than changes related to sampling events, the SM hydrographs typically vary less than 1 foot over the period of record, with the variations coinciding with changes in barometric pressure. The only exception to this observation is the 12-18SM well, the hydrograph for which shows over 3.5 feet of change from January through October 2010. Following roughly 2 feet of decline during May through June 2010, the 12-18SM hydrograph remained relatively flat during June through October 2010. The SM well hydrographs show no resemblance to the OZ well hydrographs, which is another verification that these two units are hydraulically isolated from one another.

3.4.3.3.5.4 SA Unit

For the period of April 1 through August 10, 2010, the 12-18SA well was equipped with a recording pressure transducer. The continuous groundwater level hydrograph from the 12-18SA well is presented in Addendum 2.7-G in the TR. The hydrographs for the remaining SA wells and piezometers were prepared from manual measurements. In August 2010, the transducer in the 12-18SA well was moved to the SA43-18-3 piezometer. The 12-18SA hydrograph shows approximately 5 feet of water level increase from January to June 2010. A seasonal increase in water level of this type is common in shallow, water table aquifers and indicates recharge from snow melt and spring precipitation. Of the remaining SA well hydrographs, well 14-18SA shows an increase of a little more than 2 feet from January to June 2010, with a decline

of similar magnitude from June through October. The other SA well hydrographs show general declines and increases of varying magnitude, typically of no more than 1 foot.

As discussed in Section 3.4.3.3.4, the direction of groundwater flow in the surficial aquifer generally follows the topography, moving from the highlands to the lowlands and converging on the Little Missouri River valley. As discussed in Section 3.4.1, extended periods of streamflow and increased streamflow rates observed downstream of the Oshoto Reservoir appear to correlate with higher water level elevations in the reservoir. By the same token, groundwater level elevations observed in the SA unit at monitoring sites located in the lowland areas appear to correlate with higher water level elevations in the reservoir as well.

3.4.3.4 Groundwater Use

In order to assess historical and current groundwater use, groundwater rights and unregistered water wells were evaluated within the proposed project area and within the surrounding 2-mile (3.2-km) area. Sources of data include wells registered with the WSEO (WSEO 2010), landowner interviews, and field investigations. The search revealed 119 groundwater rights and unregistered wells, the locations of which are depicted on Figure 3.4-26.

Table 3.4-23 breaks down the groundwater rights by use. Historical groundwater use began with the first domestic and livestock well in 1918. From about 1918 to 1977, groundwater was used primarily domestically and for livestock consumption, with lesser amounts of water used for irrigation. In 1977, Nuclear Dynamics permitted 14 monitor and industrial use wells associated with the Nubeth R&D site, which is described in Section 1.2.1. Between 1980 and 1991, many industrial and miscellaneous wells associated with oil and gas production were permitted in and around the proposed project area. These include three wells within the proposed project area (P50917W, P67746W and P67747W) that are currently used as water supply wells for EOR operations (water flooding). Addendum 2.7-H in the TR presents more detail on industrial water use within the proposed project area. In 1981, International Minerals & Chemical Corporation permitted five pits (P58895W, P58896W, P58899W, P58902W and P58905W) for dewatering and dust suppression associated with bentonite mining. According to WSEO records, the water rights were cancelled prior to 2001 at the request of the applicant. Since 1991, the

only groundwater rights that have been filed within the search area are for domestic and livestock use until 2009, when Strata obtained groundwater rights for the regional baseline monitor wells.

Table 3.4-24 summarizes the groundwater rights within the proposed project area. Groundwater use within the proposed project area follows a similar pattern to that observed within the 2-mile (3.2-km) search area, except that historical use has been livestock only (no domestic or irrigation use). More recent uses including monitoring and industrial use associated with the Nubeth R&D site and water supply for oil and gas operations.

Most of the groundwater rights represented in Table 3.4-24 have been cancelled or are no longer active. Current groundwater use is limited to 4 livestock wells, Strata's regional baseline monitor wells, and 3 industrial wells (water supply for oil and gas operations). The stock wells are completed at total depths ranging from 128 to 265 feet, which is considerably above the OZ aquifer. The currently operating industrial water use wells are completed at total depths of 536 to 750 feet. Together these wells withdraw an average of about 30 gpm from the OZ aquifer as described in Addendum 2.7-H in the TR.

A complete list of groundwater rights and unregistered water wells within the proposed project area and the surrounding 2-mile (3.2-km) area is provided in Table 3.4-25.

3.4.3.5 Groundwater Quality

Strata evaluated both regional and site specific groundwater quality to assess baseline conditions prior to ISR uranium recovery. The following sections include a description of the regional groundwater quality and a summary of baseline groundwater quality from the constructed regional baseline monitoring network wells and existing water supply wells in the vicinity of the proposed project.

3.4.3.5.1 Regional Groundwater Quality

The following sections briefly describe the regional groundwater quality in alluvial/colluvial aquifers, the Lance-Fox Hills formations, and deeper formations.

Alluvial Aquifers

Alluvial groundwater quality in the PRB is highly variable spatially but generally suitable for livestock and wildlife use. Based on the analyses of 793 alluvial groundwater samples collected in the southern PRB, the median concentration of TDS was 2,110 mg/L and the predominant chemical constituents were calcium and sulfate, although significant quantities of sodium, magnesium and bicarbonate were also present (Ogle and Calle 2006).

The proposed project area is located on the eastern flank of the PRB, near the Black Hills uplift. According to the BLM (2003), alluvial water quality tends to be better near the Black Hills than within the central part of the PRB. Based on a review of field water quality measurements from 10 alluvial wells in Crook County (USGS 2010b), the median EC was 2,100 μmhos/cm, indicating that the alluvial water quality in the vicinity is somewhat better than the average PRB alluvium. Using a conversion factor of TDS ≈ 0.65 EC, the average TDS of the Crook County alluvial wells is estimated to be about 1,400 mg/L, or about two-thirds that in the PRB as a whole.

Lance-Fox Hills Aquifers

Rankl and Lowry (1990) describe water quality in the Lance Formation as being highly variable according to well depth. Shallow Lance Formation wells typically yield water of similar quality to surficial material (i.e., significant contributions of calcium and magnesium), while deep wells tend to exhibit strong sodium dominance. Some wells contain large concentrations of sulfate, while others are strongly dominated by bicarbonate and carbonate. According to Rankl and Lowry, the dominant reactions that control the chemical quality of water in the Lance Formation are cation-exchange softening and sulfate reduction.

Regional water quality data for the Lance-Fox Hills aquifers were obtained from 16 wells in Crook and Campbell counties identified as being completed in Upper Cretaceous aquifers (USGS 2010b). Table 3.4-26 summarizes the median water quality from the 16 sample results. Data from these wells indicate that the Lance-Fox Hills aquifers generally have slightly alkaline pH, moderate TDS, low hardness, strong sodium dominance, and relatively strong bicarbonate dominance, with sulfate levels ranging from very low to approximately equal to bicarbonate.

Deeper Aquifers

The deep disposal well application for the Ross ISR Project (Addendum 4.2-A in the TR) contains estimates of water quality in deeper formations, from the Minnelusa to basement. The Minnelusa and Deadwood/Flathead Formations are both expected to have TDS concentrations greater than 10,000 mg/L, while the Madison Formation likely has a TDS concentration around 1,000 mg/L in the project vicinity. These are based on calculations presented in Addendum 4.2-A in the TR.

3.4.3.5.2 Site Groundwater Quality

Baseline groundwater quality information within and near the proposed project area was obtained from three sources: the construction and sampling of a regional baseline monitoring network, sampling of existing water supply wells and an evaluation of historical data from the Nubeth R&D site. The following sections provide a detailed analysis of groundwater quality obtained from each source. Groundwater quality results are provided in Addenda 2.7-I through 2.7-L in the TR.

3.4.3.5.2.1 Regional Baseline Monitoring Network

Strata constructed a regional baseline groundwater monitoring network within the proposed project area in 2009 and 2010. The monitoring network, depicted in Figure 3.4-14, comprises six well clusters and four piezometers. Each well cluster includes four monitoring wells targeting the SA, SM, OZ and DM units. Construction details for the cluster wells are presented in Tables 3.4-20 and 3.4-27, and construction techniques are presented in Section 3.4.3.2.2.

Dedicated submersible pumps, sounding tubes and pressure transducers were installed in the SM, OZ and DM wells to expedite groundwater sample collection and document fluctuations in the groundwater systems. Because the SA wells are shallow and easily accessible with a portable pump, dedicated pumps were not installed in these wells. Cross-contamination was prevented by decontaminating the portable pump between uses. Cluster well sampling commenced in the first quarter 2010 and continued quarterly throughout the year. Prior to sample collection each well was purged using a dedicated sample pump to ensure representative samples were collected. During each well purge field parameters (pH, EC, water temperature, turbidity

and dissolved oxygen) were measured at set intervals. When field measurements became stable and/or least three casing volumes had been evacuated, sample collection was initiated. All samples were collected in bottles provided by the contract laboratory and analyzed for constituents listed in Table 3.4-11.

Immediately following well construction and development, preliminary samples were collected by air lifting water from each well. A comparison of the air lifted sample analysis with results from subsequent quarterly sample results indicated that the preliminary sample results were not representative of the regional baseline groundwater quality. Therefore, the preliminary results obtained by air lifting samples were not included in the baseline groundwater quality analysis. The air lifted sample results are included with all groundwater quality analyses in Addendum 2.7-I in the TR.

3.4.3.5.2.2 Regional Baseline Monitoring Network Results

The groundwater quality results for the regional baseline monitoring network wells indicate that each zone has distinct water quality. The lower zone (DM) is characterized by elevated chloride concentrations, while increased radionuclides distinguish the ore zone (OZ). Groundwater quality in the SM and SA aquifers is similar; however there are distinguishing characteristics.

The major ion chemistry and TDS concentrations of each aquifer provide a general indication of water quality within each zone. The three deeper zones (DM, OZ and SM) exhibited complete sodium dominance, while the surficial aquifer (SA) contained varying amounts of calcium and magnesium. The anions vary significantly. Table 3.4-28 shows that SA zone is characterized by the bicarbonate ion, with increasing sulfate levels in the SM and OZ zones followed by chloride dominance in the DM zone.

TDS generally increases with depth, from the SA zone to the OZ zone, then declines between the OZ and DM zones. The general trends in TDS and major ion chemistry are consistent with the three main zones of sedimentary basins discussed by Freeze and Cherry (1979):

1) The upper zone: active groundwater flushing with bicarbonate as the dominant anion.
2) The intermediate zone: less active groundwater circulation, with higher TDS concentrations. Sulfate is typically the dominant anion.

3) The lower zone: groundwater is increasingly sluggish. Highly soluble minerals are present due to minimal flushing. High chloride concentrations are characteristic of this zone.

Piper diagrams illustrate the variations in major ion chemistry for the wells within the regional baseline monitoring network. Figure 3.4-27 presents the average major ion chemistry of each well, while Figure 3.4-28 presents the average major ion chemistry within each zone.

The piper diagrams illustrate the differences in major ion water chemistry between zones. The SM and OZ wells have similar cation chemistry (complete sodium dominance), but the OZ wells have significantly higher sulfate than the SM wells. The SA wells appear scattered on Figure 3.4-27, demonstrating greater variability in major ion chemistry and notably in the concentrations of magnesium and calcium. As a group, the most distinct wells on the piper diagrams occur in the DM zone, since these wells are dominated by chloride.

In addition to major ion chemistry and TDS, other constituent concentrations vary between aquifers. Table 3.4-29 provides the range of concentrations for each zone. All groundwater quality results are included in Addendum 2.7-I in the TR.

The OZ zone is distinguishable from the other three zones by higher concentrations of sulfate, TDS, gross alpha, uranium and elements of the uranium decay series, including lead-210, polonium-210, radium-226 and 228, and radon-222. Further information on the water quality within each zone is provided below.

In addition to water quality characteristics of the different zones, Strata also evaluated the up- and down-gradient well water quality based on the location of the wells in relation to the potential wellfield modules, the CPP and lined retention ponds as recommended by NRC Regulatory Guide 4.14. The potentiometric surfaces for each aquifer were used to determine the up- and down-gradient wells. The qualitative comparison indicates that overall water chemistry did not differ significantly between the up- and down-gradient wells for each zone. The following provides a summary of water quality well gradient comparisons for each zone.

- SA zone: While the water quality varied considerably between some SA zone wells, no correlation was observed with the location of the wells in relation to the potentiometric surface (Figure 3.4-25). The

most upgradient (21-19SA) and downgradient (37-7SA) SA wells had very similar water quality in terms of major ion chemistry (both sodium bicarbonate) and TDS (both wells had TDS concentrations of about 600 to 800 mg/L).

- SM zone: Trends toward increasing TDS and a transition from sulfate to bicarbonate were observed in the downgradient direction in the SM wells. For instance, the most upgradient SM well (42-19SM) measured TDS of 830 to 1,040 mg/L and sulfate levels of about 55% of the total anions. By comparison, the most downgradient SM well (34-7SM) measured TDS levels of 1,150 to 1,260 mg/L and sulfate levels less than 35% of the total anions. One of the other upgradient SM wells (34-18SM) also measured significantly higher sulfate levels than the remaining SM wells. The two most upgradient wells also measured the lowest concentrations of radionuclides, specifically radon-222.

- OZ zone: Because of the influence of the water supply wells used for enhanced oil recovery, the most upgradient OZ well is 34-7OZ, and the most downgradient well is 21-19OZ. A comparison between water quality in these two wells reveals no apparent spatial trends. The TDS in each ranges from 1,500 to 1,700 mg/L, and they are virtually indistinguishable on a piper diagram. The radionuclide concentrations including radon-222 and gross alpha were also very similar.

- DM zone: Some variation in DM zone water quality was observed in relation to potentiometric surface. The most upgradient well (34-7DM) had the highest TDS (1,600-1,900 mg/L) and chloride concentrations (539-818 mg/L), while the most downgradient well (21-19DM) had much lower TDS (1,200-1,250 mg/L) and chloride (425-535 mg/L). No variation was observed in radionuclide concentrations as a function of location in the DM zone.

The average groundwater quality within each zone was compared to WDEQ class of use standards in Chapter 8 of the Wyoming Water Quality Rules and Regulations. Class I groundwater is suitable for domestic use, Class II groundwater is suitable for agricultural (i.e., irrigation) use, Class III groundwater is suitable for livestock, and Class IV groundwater is suitable for industrial use. Table 3.4-30 summarizes the probable classifications of groundwater within each zone. (Strata acknowledges that only WDEQ can formally classify groundwater within Wyoming.) A discussion of constituents exceeding the class of use standards is presented in the subsections below.

On average, the SA zone has the lowest TDS concentrations of the four zones. The groundwater in the SA zone would likely be classified as Class II or

III depending on pH, sulfate and manganese concentrations. Groundwater in the lower and upper zones (DM and SM) appears to meet Class III standards, while groundwater in the OZ zone is likely Class IV (industrial use only) due to elevated concentrations of radionuclides.

Following are detailed summaries of the water quality within each zone.

SA Zone

Groundwater quality in the four SA wells demonstrated the greatest variability of the regional baseline monitor wells. Throughout the monitoring period the 34-18SA and 42-19SA wells remained dry.

Major ion chemistry indicates that each well in the SA zone has somewhat distinct water chemistry. While all wells were dominated by sodium bicarbonate, additional ions in varying concentrations were present in the groundwater. A summary of the monitoring results for the SA zone wells is presented in Table 3.4-31.

The piper diagram of the SA wells, Figure 3.4-29, illustrates the variation in water chemistry. All of the wells exhibited sodium dominance, but two of the four also contained significant contributions from magnesium and calcium. Similarly, all four wells exhibited bicarbonate dominance, but sulfate was significant at about 30% to 40% of anions and one well measured about 12% chloride (14-18SA). TDS also varied by a factor of two among SA wells.

Few radiological constituents above detection limits were measured in the SA zone. Three of the four sampled SA wells had uranium and radium-226 concentrations slightly above the detection limits of 0.001 and 0.2 mg/L, respectively.

The groundwater in the SA wells is likely Class II or III based on a comparison with WDEQ standards as summarized in Table 3.4-32. TDS concentrations exceed the Class I standard for all wells, while sulfate and manganese concentrations exceed both Class I and II standards in two of the four wells.

A comparison of the SA zone groundwater quality to EPA drinking water standards indicates that all wells meet the primary MCLs, while few exceedances of the secondary MCLs are evident. Table 3.4-33 presents the EPA standards and exceedances for the SA wells.

SM Zone

The SM wells exhibited similar water chemistry with minor exceptions. Most SM wells were dominated by bicarbonate, while the 34-18SM and 42-19SM wells had a slight sulfate dominance. The data show that in the SM zone, sulfate makes up about 30% to 55% of the anionic concentration, while bicarbonate/carbonate make up about 40% to 70%. Monitoring results for the SM wells are presented in Table 3.4-34.

The piper diagram of the SM wells, Figure 3.4-30, shows consistent sodium dominance, variable bicarbonate/sulfate dominance and very low concentrations of calcium, magnesium and chloride.

The SM wells measured non-detect to low concentrations of selenium, uranium and radiological constituents. None of the SM wells measured detectable selenium concentrations, while two of six wells measured uranium concentrations slightly above the detection limit of 0.001 mg/L. Similarly, measurable but relatively low radium-226 and 228 concentrations were observed in five of six wells. One well (34-7SM) also measured a detectable lead-210 concentration (about 1.3 pCi/L).

Based on a comparison with WDEQ standards, the groundwater in the SM wells is likely Class III (suitable for livestock). Table 3.4-35 shows that the sulfate concentration in the SM zone is above Class I and II standards. Additional parameters not meeting Class I standards include TDS and ammonia.

Groundwater quality in the SM zone was also compared to EPA drinking water standards. Table 3.4-36 shows that arsenic in the four of the six wells does not meet the primary MCL of 0.01 mg/L. Fluoride, TDS, aluminum and sulfate exceeded the secondary standards.

OZ Zone

The groundwater quality of the individual OZ wells did not vary during the four quarters of monitoring; however, there was some minor variation in OZ zone water quality across the proposed project area. Five of the six OZ wells were characterized by sodium sulfate type water, while the 12-18OZ well exhibited sodium bicarbonate type water. Overall, the 12-18OZ well also had the lowest concentrations of major ions, while the 14-18OZ well measured the

highest concentrations of dissolved salts. Table 3.4-37 presents the quarterly groundwater monitoring results for the OZ wells.

Major ion water chemistry of the OZ wells is illustrated in Figure 3.4-31. The piper diagram shows that the 12-18OZ well was slightly dominated by bicarbonate, while the majority anion in the remaining wells was sulfate. Generally, sulfate contributes about 45% to 65% of anions, while bicarbonate/carbonate contribute 35% to 55%. Cations comprise almost exclusively sodium.

As previously discussed, groundwater quality in the OZ zone is distinct from the other zones due to elevated concentrations of radionuclide constituents. While all OZ wells measured increased concentrations of uranium and constituents in the uranium decay series, the highest concentrations were measured in the 12-18OZ, 14-18OZ and 34-18OZ wells. These wells measured the greatest concentrations of radon-222, lead-210, polonium-210, and radium-226.

A comparison of OZ zone groundwater quality to WDEQ standards indicates that the water is likely suitable only for industrial use (Class IV). A summary of the constituents exceeding the class of use standards is presented in Table 3.4-38. The WDEQ Class I, II and III standard for gross alpha is 15 pCi/L. The table shows that all wells exceeded the gross alpha standard. Additionally, wells 12-18OZ and 34-18OZ also exceeded the Class I, II and III combined radium-226 and 228 standard of 5 pCi/L.

The groundwater in the OZ wells was also compared to EPA drinking water standards, as summarized in Table 3.4-39. The EPA MCLs for gross alpha and combined radium-226 and 228 are the same as the WDEQ standards. Therefore, all wells exceed the gross alpha MCL. Additionally, four of the six wells exceeded the uranium MCL and two of the six wells exceeded the radium-226 and 228 MCL. In 1999, the EPA proposed a drinking water standard for radon of 300 pCi/L. The radon-222 measured in all of the OZ wells exceeds the proposed EPA standard. In two of six wells, the measured radon-222 concentration was higher than 30,000 pCi/L, or more than 100 times the proposed EPA Standard.

<u>DM Zone</u>

With two exceptions, water quality within each of the six DM wells did not vary significantly during the four quarters of monitoring. The exceptions

occurred in the 1Q10 samples from two of the six DM wells (34-18DM and 42-19DM), where the water quality (especially chloride) varied from the latter three quarterly sampling events in 2010. In 1Q10, the chloride concentration in 34-18DM was 139 mg/L, while the range in 2Q10 through 4Q10 was 371 to 523 mg/L). A similar difference was observed in 42-19DM. Based on the slow recovery of the DM wells (see Section 3.4.3.3.5.1) it is believed that an insufficient quantity of water could be withdrawn from these two wells during the 1Q10 sample event to obtain a truly representative sample of the formation water. This is supported by consistency in the latter three samples collected in 2010. Of the six DM wells, the highest levels of dissolved constituents were measured in well 34-7DM, including TDS, sodium, chloride, arsenic and selenium. Well 42-19DM yielded the lowest TDS and chloride concentrations. Quarterly groundwater monitoring results are presented in Table 3.4-40.

The water quality of the DM zone wells is distinct from other zones due to relatively high concentrations of chloride. The piper diagram of the DM wells, presented in Figure 3.4-32, illustrates that chloride is the dominant anion. Bicarbonate and carbonate make up the balance of anions, with less than 10% sulfate in all DM wells. The elevated chloride in the DM zone could complicate detection of potential vertical excursions of recovery solutions, which are anticipated to contain relatively high concentrations of chloride. To address this concern, sulfate is proposed as an alternate excursion indicator for the DM zone, as discussed in Section 6.2.

Radiological water quality results for the DM wells indicate concentrations near or below detection limits, with a few exceptions. Radium-226 and radon-222 were measured in three of the six wells, while low concentrations of lead-210 and thorium-230 were measured in two of the six wells.

A comparison of DM zone water quality to the WDEQ groundwater class of use standards indicates that the groundwater in all DM zone wells is likely suitable for livestock (Class III) or industrial use (Class IV). Constituents exceeding Class I (domestic), II (agriculture), and III (livestock) standards are summarized in Table 3.4-41. In some samples, wells 14-18DM and 34-7DM measured gross alpha in excess of the WDEQ Class I-III standard; however, the average gross alpha concentrations in these wells for the monitoring period were below the class of use standard of 15 pCi/L.

Water quality results for the DM wells were also compared to EPA drinking water standards as presented in Table 3.4-42. Gross alpha and arsenic were the only constituents exceeding a primary MCL in one or more DM wells. All DM wells exceeded the secondary standards for TDS, chloride and aluminum. Additionally, well 34-7DM exceeded the secondary standard for manganese.

Plant Area Piezometers

Strata installed four piezometers in and around the proposed central plant area in May 2010, as depicted in Figure 3.4-14. The piezometers, completed in the alluvium at depths ranging from 8.7 to 28.8 feet (see Table 3.4-20), were constructed to assess baseline groundwater in the proposed central plant area. Groundwater samples were collected from the piezometers beginning in the 2nd quarter 2010. Monitoring results are presented in Table 3.4-43.

Piezometer SA13-17-1 was dry during all sample events. Water quality varied significantly between the other three piezometers. SA43-18-3 yielded water quality typical of the SA wells of the regional baseline monitoring network, while SA43-18-1 and SA43-18-2 yielded high concentrations of dissolved salts, sulfate, selenium, uranium and gross alpha. For example, the TDS concentration in SA43-18-3 ranged from 420 to 510 mg/L, while TDS levels in SA43-18-1 and SA43-18-2 ranged from 4,190 to 7,280 mg/L.

The gross alpha concentrations were also significantly higher in SA43-18-1 (66 to 84 pCi/L) and SA43-18-2 (115 to 218 pCi/L) than SA43-18-3 (8 to 18 pCi/L). However, the average gross alpha concentration in all three piezometers exceeds the Class I-III WDEQ class of use standard. Additional parameters exceeding WDEQ Class III standards include sulfate and selenium in SA43-18-1 and SA43-18-2. Based on a comparison with WDEQ class of use standards, the water in all three plant area piezometers is likely Class IV (industrial use only) due to gross alpha and, in some cases, selenium and sulfate. The water sampled in all three piezometers exceeds the EPA primary MCL for gross alpha, and water sampled from SA43-18-1 and SA43-18-2 also exceeds the EPA primary MCLs for selenium and uranium.

The difference in water quality in the plant area piezometers is attributed to the piezometer locations in relation to the Little Missouri River and Oshoto Reservoir. As described in Section 3.4.3.3.5.4, groundwater levels in the SA

unit at monitoring sites located in the lowland areas appear to correlate with water levels in Oshoto Reservoir. Piezometer SA43-18-3 is located near Oshoto Reservoir, where the surficial aquifer appears to be influenced and routinely flushed by infiltrating surface water. SA43-18-1 and SA43-18-2 are located upgradient and significantly further from Oshoto Reservoir and the Little Missouri River. The water in these wells is likely relatively stagnant, contributing to the higher dissolved solids.

3.4.3.5.2.3 Existing Water Supply Wells

As part of the baseline groundwater inventory, Strata identified all of the currently operable water supply wells within the proposed project area and surrounding 2 km (1.2 mi) area. The wells, depicted in Figure 3.4-33 and summarized in Table 3.4-44, were identified through the groundwater rights search, landowner interviews and field investigations.

A total of 29 existing water supply wells were identified and sampled including 2 industrial wells, 15 stock wells and 12 wells used for domestic use. No domestic wells are located within the proposed project area; all sampled domestic wells were in the surrounding area. The industrial wells were permitted in the early 1980s and completed at depths of 536 and 750 feet. The majority of the stock wells were permitted through the WSEO with permit dates ranging from 1953 to 2010. According to the WSEO (2010), completion depths of permitted stock wells range from 40 to 304 feet. According to WSEO records, the completion depths for the domestic wells range from 150 to 600 feet.

The wells were sampled on a quarterly basis with sample commencement between 3rd quarter 2009 and 1st quarter 2010. Samples were collected in bottles provided by the contract laboratory and analyzed for constituents listed in Table 3.4-11. Sample results are summarized below.

Industrial Wells

Two industrial wells, 19XX18 and 22X-19, were sampled as part of the existing water supply well baseline groundwater monitoring. A third industrial well (789V) could not be accessed. These three wells provide water for enhanced oil recovery within the proposed project area. The 19XX18 and 789V wells are permitted as two separate wells; however, water from well 19XX18 is piped to well 789V and comingled for injection. All samples were collected from a water spigot on the line from the 19XX18 well, while water from well 789V

could not be accessed. As previously stated, the 19XX18 well was utilized as the recovery well at the Nubeth R&D site prior to being converted to a water supply well for oil and gas operations in the 1980s. A discussion of the 19XX18 water quality while under ownership of Nuclear Dynamics is presented in Section 3.4.3.5.2.4.

The 19XX18 and 22X-19 wells, located within the proposed project area, have water chemistry similar to the OZ wells of the regional baseline monitoring network. This similarity in water quality would be expected since these two wells are completed in the OZ unit, although the 22X-19 is also completed in the DM zone as described in Section 3.4.3.3.1. The water in the industrial wells is dominated by sodium and sulfate ions and has moderate concentrations of TDS, as presented in Table 3.4-45.

Radiological constituents were detected in both wells, with the highest concentrations measured in the 19XX18 well. Overall, the results were consistent with the OZ wells in the regional baseline monitoring network.

Water quality in the industrial wells was compared to WDEQ class of use standards. The results indicate that the water is likely suitable for industrial use only (Class IV), due to high concentrations of radium-226, radium-228, and gross alpha. Similarly, the combined radium-226 and radium-228 and gross alpha concentrations exceed the EPA MCLs. The WDEQ and EPA standards for combined radium-226 and radium-228 and gross alpha are 5 and 15 pCi/L, respectively.

Stock Wells

Fifteen stock wells were sampled within and surrounding the proposed project area. The analytical results indicate variation in water chemistry similar to that found in the SA unit characterized in the regional baseline monitoring network.

The piper diagram presented in Figure 3.4-34 illustrates the major ion chemistry of the stock wells. The piper diagram shows that 10 of the wells are dominated by sodium, 1 is calcium dominant, and the remaining 4 have incomplete cation dominance, with a blend of sodium, calcium, and magnesium. Additionally, the figure shows that most of the wells are bicarbonate dominant, while four contain at least 30% sulfate and one is sulfate dominant. The variability in water chemistry is reflective of the variability in stock well depth, which ranges from about 40 to 300 feet.

Stock well water quality results are provided in Table 3.4-46. The sample results indicate relatively higher concentrations of selenium, uranium and/or radiological constituents in about half of the wells. Two wells measured higher uranium and selenium levels than the regional baseline OZ wells. All of the wells measured near or below detection limits for lead-210, polonium-210, radium-228, and thorium-230. Increased concentrations of radium-226 were measured in several wells as were relatively high levels of gross alpha.

The groundwater quality of the stock wells was compared to WDEQ and EPA standards. A comparison with WDEQ class of use standards is presented in Table 3.4-47. The table illustrates the broad range of stock well water quality. About half of the stock wells do not meet the Class I, II, or III suitability criteria for gross alpha. In contrast, one well met Class I class of use standards. The remaining wells appear to meet all agricultural (Class II) or livestock (Class III) class of use standards.

The groundwater quality of the stock wells was also compared to the EPA drinking water standards. The results, presented in Table 3.4-48, indicate that the water produced by half of the wells exceeds at least one primary standard (most often uranium and gross alpha), while all but one well yielded water samples that exceed one or more secondary standards (TDS, sulfate, and/or manganese). This table is presented for comparison with other wells only, since these wells are not used as a domestic drinking water supply.

<u>Domestic Wells</u>

Strata sampled 12 domestic wells near the proposed project area. As shown on Figure 3.4-33, the closest domestic well (DWWELL01) is about 0.12 mile outside the proposed project area. The monitoring results are presented in Table 3.4-49.

The piper diagram of the average water quality in domestic wells, Figure 3.4-35, shows that the water in all domestic wells is sodium dominant, while four wells had calcium plus magnesium levels of about 15% to 40%. Anion dominance was divided between bicarbonate and sulfate. TDS concentrations ranged from about 500 to 2,000 mg/L.

All of the domestic wells measured near or below the detection limit for selenium, while several wells had measurable concentrations of uranium and radiological constituents, including radium-226 and 228 and gross alpha.

The groundwater quality in nearby domestic wells was compared to WDEQ class of use standards. The results, presented in Table 3.4-50, indicate the water generally meets class of use standards for livestock and industrial uses. In the majority of domestic wells, TDS and sulfate exceed Class I (domestic) and II (agriculture) class of use standards. Four of the wells measured gross alpha in excess of the WDEQ standard (15 pCi/L) in at least one sample.

The monitoring results for the domestic wells were also compared to EPA drinking water standards, as presented in Table 3.4-51. One well exceeded MCLs for uranium and gross alpha, and another exceeded the MCL for arsenic. Three more exceeded the MCL for gross alpha in at least one sample, although the average concentrations were less than the MCL. Based on the very limited construction information available for the nearby domestic wells and the limited availability of geologic information near the Fox Hills Formation outcrop where most of the wells are completed, it was generally not possible to assign the domestic wells to a particular completion interval.

3.4.3.5.2.4 Nubeth R&D Groundwater Quality

As part of the Nubeth R&D site, Nuclear Dynamics monitored groundwater quality during all phases of the ISR uranium recovery process, including baseline, uranium recovery, and aquifer restoration. Prior to initiating uranium recovery operations, Nuclear Dynamics developed a "five spot" wellfield including recovery, injection, buffer, sampling and monitor wells. Records for the Nubeth R&D site indicate that groundwater samples were collected from nine wells, as summarized in Table 3.4-52.

Records indicate that Nuclear Dynamics began uranium recovery operations in August 1978. Groundwater monitoring results from April 4, 1978 were used to assess baseline monitoring water quality. Key constituent concentrations for each well are summarized in Table 3.4-53.

The major ion chemistry of the wells indicates that groundwater was dominated by sodium, sulfate and bicarbonate. The majority of the wells yielded significant concentrations of gross alpha, radium-226 and uranium. The highest radionuclide concentrations were measured in well 19X, which was utilized by Nuclear Dynamics as the recovery well for the ISR pilot project. This well is completed in the ore zone and remains in use today, as discussed in

previous sections. Overall, the groundwater in the wells, with the exception of 7X and 20X, exceeded Class I-III class of use standards for gross alpha.

In mid-1979, restoration activities were initiated. During restoration and decommissioning the wells were sampled on a regular basis. The results of the last samples reported by Nuclear Dynamics are presented in Table 3.4-54. The four wells used to determine restoration success were 3X, 4X, 19X and 20X. The results show that, due to elevated gross alpha concentrations, the restored water remained suitable for industrial use only.

Table 3.4-1. Little Missouri River Mean Annual Streamflow

Parameter	USGS Gaging Stations				
	06334000	**06334500**	**06335500**	**06336000**	**06337000**
	Near Alzada, MT	**At Camp Crook, SD**	**At Marmarth, ND**	**At Medora, ND**	**Near Watford City, ND**
Drainage Area (mi^2)	904	1,970	4,640	6,190	8,310
Mean Annual Discharge (cfs)	77	125	307	443	533
Mean Annual Flow (ac-ft)	55,782	90,556	222,405	320,930	386,130
Period of Record	1912-1969	1904-1906 1956-2009	1939-2009	1904-1908 1924-1975 2002-2009	1935-2009

Source: USGS (2010a)

Table 3.4-2. Annual Peak Streamflow for the Little Missouri River

USGS Gage 06334000 near Alzada, MT			USGS Gage 06334500 at Camp Crook, SD		
Water Year	**Date**	**Streamflow (cfs)**	**Water Year**	**Date**	**Streamflow (cfs)**
1912	Apr. 06, 1912	4,550	1956	Jul. 05, 1956	3,210
1913	Apr. 01, 1913	4,250	1957	Aug. 31, 1957	2,080
1914	Aug. 03, 1914	2,630	1958	Jul. 03, 1958	1,200
1915	Jun. 13, 1915	3,600	1959	Mar. 21, 1959	2,350
1916	Mar. 12, 1916	1,490	1960	Mar. 22, 1960	3,360
1917	Apr. 11, 1917	3,250	1961	Sep. 24, 1961	359
1918	Mar. 15, 1918	2,770	1962	May 28, 1962	7,600
1919	Jul. 30, 1919	1,360	1963	Jun. 16, 1963	3,420
1920	May 12, 1920	1,740(e)	1964	Jun. 11, 1964	1,440
1921	Jun. 29, 1921	915	1965	Apr. 07, 1965	4,000
1922	Jun. 16, 1922	4,100	1966	Mar. 16, 1966	1,850
1923	Sep. 30, 1923	4,090	1967	May 8, 1967	5,600
1924	Apr. 08, 1924	4,420	1968	Mar. 04, 1968	1,570
1925	Jun. 17, 1925	4,540	1969	Mar. 25, 1969	3,660
1929	May 30, 1929	4,000	1970	Apr. 13, 1970	1,370
1930	Feb. 21, 1930	2,160	1971	Jun. 05, 1971	4,440
1931	May 28, 1931	164	1972	Mar. 09, 1972	3,720
1932	Apr. 24, 1932	4,210	1973	Jun. 21, 1973	1,790
1935	Jul. 22, 1935	1,080	1974	Apr. 24, 1974	904
1936	Mar. 07, 1936	1,320	1975	May 7, 1975	8,460
1937	Jun. 14, 1937	2,780	1976	Jun. 16, 1976	4,800
1938	May 31, 1938	794	1977	Apr. 10, 1977	1,830
1939	Mar. 24, 1939	1,420	1978	Mar. 24, 1978	9,420
1940	Aug. 19, 1940	1,600	1979	Mar. 27, 1979	2,590
1941	Jun. 11, 1941	2,820	1980	Jun. 17, 1980	58
1942	Jun. 06, 1942	3,000	1981	Jul. 28, 1981	692
1943	Mar. 27, 1943	2,500	1982	May 21, 1982	6,810
1944	Apr. 04, 1944	6,000(e)	1983	Feb. 18, 1983	3,020
1945	Mar. 14, 1945	1,100(e)	1984	May 5, 1984	3,000
1946	May 24, 1946	3,040	1985	Mar. 19, 1985	3,660
1947	Jun. 23, 1947	2,850	1986	May 10, 1986	5,430
1948	Jun. 18, 1948	3,690	1987	Apr. 06, 1987	2,240
1949	Mar. 22, 1949	2,230	1988	Mar. 27, 1988	147
1950	Apr. 12, 1950	1,860	1989	May 4, 1989	1,530
1951	Jun. 17, 1951	490	1990	May 26, 1990	2,220
1952	Apr. 01, 1952	1,400	1991	May 18, 1991	307
1953	May 29, 1953	1,630	1992	Jul. 15, 1992	563
1954	Apr. 06, 1954	792	1993	Jun. 10, 1993	3,970
1955	May 19, 1955	1,780	1994	Mar. 09, 1994	2,000
1956	Mar. 22, 1956	1,000(e)	1995	May 15, 1995	7,380
1957	Jun. 24, 1957	639	1996	May 28, 1996	3,560
1958	Apr. 30, 1958	670	1997	Apr. 21, 1997	2,800
1959	Mar. 20, 1959	929	1998	Mar. 28, 1998	1,900
1960	Mar. 24, 1960	2,130	1999	Jun. 10, 1999	1,860
1961	Sep. 23, 1961	475	2000	Feb. 26, 2000	79
1962	May 27, 1962	2,940	2001	Jun. 11, 2001	2,150
1963	Jun. 17, 1963	1,320	2002	Mar. 28, 2002	46(e)
1964	Jun. 26, 1964	846	2003	Mar. 20, 2003	750
1965	Apr. 05, 1965	2,000(e)	2004	Aug. 06, 2004	1,020
1966	Jul. 29, 1966	299	2005	May 16, 2005	834
1967	Jun. 07, 1967	2,070	2006	Apr. 22, 2006	5,350
1968	Feb. 28, 1968	800	2007	Jun. 10, 2007	1,810
1969	May 4, 1969	2,420	2008	May 7, 2008	4,700

Note: (e) estimated value
Source: USGS (2010a)

Table 3.4-3. Drainage Basin Geomorphology

Drainage Basin Designation (Subwatersheds)	Drainage Area (mi^2)	Basin Length (mi)	Valley Length (mi)	Channel Length (mi)	Basin Relief (ft)	Valley Relief (ft)	Channel Relief (ft)	Total Stream Length (mi)	Basin Relief Ratio (ft/ft)	Valley Slope (ft/ft)	Channel Slope (ft/ft)	Channel Sinuosity (ft/ft)	Drainage Density (mi/mi^2)
Deadman Creek to confluence with Little Missouri River (B1-B3, B7-B8)	8.01	4.87	5.28	6.92	648	480	480	26.6	0.0252	0.0172	0.0131	1.31	3.32
Little Missouri River to confluence with Deadman Creek (B4-B6)	6.23	3.78	4.06	5.31	480	370	370	15.3	0.0240	0.0173	0.0132	1.31	2.45
Little Missouri River (total basin to project boundary, B1-B20)	18.2	6.08	6.81	8.83	668	500	500	52.2	0.0208	0.0139	0.0107	1.30	2.87
Draw 5 (B5)	2.14	1.83	2.07	2.31	225	265	225	4.39	0.0233	0.0243	0.0184	1.12	2.06
Draw 7 (B7)	0.19	0.56	0.46	0.48	159	47	47	0.48	0.0538	0.0194	0.0185	1.04	2.53
Draw 9 (B9)	0.90	2.14	1.94	2.26	296	206	206	2.26	0.0262	0.0201	0.0173	1.16	2.51
Draw 13 (B13)	1.65	2.61	2.42	2.94	224	134	134	3.51	0.0163	0.0105	0.0086	1.21	2.13
Draw 14 (B14-B16)	0.60	1.86	1.81	1.98	294	206	206	1.98	0.0299	0.0216	0.0197	1.06	3.30
Draw 15 (B15)	0.16	0.66	0.53	0.56	158	88	88	0.56	0.0453	0.0314	0.0230	1.06	3.50
Draw 18 (B18)	0.13	0.80	0.54	0.56	178	72	72	0.56	0.0421	0.0253	0.0244	1.04	4.31

Note: Subwatersheds are depicted on Figure 3.4-3.

Table 3.4-4. Precipitation Frequency

Storm Event	Precipitation (in)	Storm Event	Precipitation (in)	Storm Event	Precipitation (in)
2yr - 24hr	1.8	2yr - 6hr	1.4	2yr - 1hr	1.0
5yr - 24hr	2.4	5yr - 6hr	1.8		
10yr - 24hr	2.8	10yr - 6hr	2.2		
25yr - 24hr	3.4	25yr - 6hr	2.6		
50yr - 24hr	3.8	50yr - 6hr	3.0		
100yr - 24hr	4.2	100yr - 6hr	3.4	100yr - 1hr	2.6

Source: Miller et al. (1973)

Table 3.4-5. HEC-HMS Peak Flow and Runoff Volumes

Stream Designation	Precipitation Distribution	Parameter (Units)	Recurrence Interval (yr) 2	5	10	25	50	100
Little Missouri River at confluence with Deadman Creek (J3)	SCS Type II, 24-hr General Storm	Peak (cfs)	274	632	924	1413	1763	2128
		Vol. (acre-ft)	98	195	271	396	485	578
Confluence of Deadman Creek and Little Missouri River (J4)	SCS Type II, 24-hr General Storm	Peak (cfs)	775	1714	2469	3732	4633	5583
		Vol. (acre-ft)	267	521	717	1038	1267	1505
Little Missouri River at Eastern Project Boundary (J10)	SCS Type II, 24-hr General Storm	Peak (cfs)	457	1214	2143	3719	4832	5975
		Vol. (acre-ft)	327	643	887	1289	1577	1877
Draw 5 (B5)	SCS Type II, 24-hr General Storm	Peak (cfs)	117	288	428	668	840	1020
		Vol. (acre-ft)	33	68	95	141	173	208
Draw 7 (B7)	SCS Type II, 24-hr General Storm	Peak (cfs)	9	34	56	97	127	160
		Vol. (acre-ft)	2	4	6	10	12	15
Draw 9 (B9)	SCS Type II, 24-hr General Storm	Peak (cfs)	22	72	118	201	263	331
		Vol. (acre-ft)	8	20	29	46	58	70
Draw 13 (B13)	SCS Type II, 24-hr General Storm	Peak (cfs)	102	219	311	462	570	681
		Vol. (acre-ft)	33	64	87	125	152	180
Draw 14 (Reach 8)	SCS Type II, 24-hr General Storm	Peak (cfs)	63	142	204	305	287	457
		Vol. (acre-ft)	11	22	30	44	41	64
Draw 15 (B15)	SCS Type II, 24-hr General Storm	Peak (cfs)	17	43	65	100	126	152
		Vol. (acre-ft)	3	5	7	11	13	16
Draw 18 (B18)	SCS Type II, 24-hr General Storm	Peak (cfs)	3	15	26	46	62	80
		Vol. (acre-ft)	1	2	4	6	8	9

Note: Subwatersheds are depicted on Figure 3.4-3.

Table 3.4-6 Peak Flow Estimate Comparison

Method		Recurrence Interval (yr)					
		2	5	10	25	50	100
HEC-HMS AMC II	Peak (cfs)	457	1,214	2,143	3,719	4,832	5,975
Miller (2003)	Peak (cfs)	112	303	490	804	1,096	1,445

Table 3.4-7. Surface Water Rights within 2 Miles of Proposed Project Area

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Permitted Area (ac)	Uses	Status	Appropriator	Permitted Capacity (ac-ft)	Project Area
P732S	BERGER STOCK RESERVOIR	1/25/1954	53-67-6-SESE		STO	Fully Adjudicated	MINNIE BERGER	5.90	
P11959D	SYDNOR DITCH	8/7/1913	53-67-17-NWSE	25	IRR_SW	Unknown	THOMAS C. SYDNOR	0.36	
P2512R	SYDNOR RESERVOIR	8/4/1913	53-67-17-NWSE		IRR_SW	Unadjudicated	THOMAS C. SYDNOR	3.40	
P128R	LITTLE MISSOURI RESERVOIR	10/31/1898	53-67-18-SWNW		STO	Cancelled	GRAND ISLAND & NORTHERN RAILROAD CO.		X
P15509S	BUTTE #1 STOCK RESERVOIR	8/22/2003	53-67-18-SENE		STO	Cancelled	ANTONE SWANDA		X
P17592S	BUTTE #1 STOCK RESERVOIR	2/1/2006	53-67-18-SWSW		STO	Unadjudicated	ANTONE SWANDA** WYO STATE OFFICE OF LANDS & INVESTMENTS	1.24	X
P21242D	OSHOTO SPRINKLER IRRIGATION SYSTEM	7/15/1953	53-67-18-SWNE	70	IRR_SW	Fully Adjudicated	HARRY BERGER	1.00	X
P27819D	#1-15 SUN FEDERAL WATER HAUL	11/1/1982	53-67-18-SWSW		DRI; IND_SW; OIL; TEM	Cancelled	RAYMOND T. DUNCAN		X
P30061D	#31-14-53-68 WATER HAUL	10/17/1988	53-67-18-SWNE		DRI; IND_SW; OIL; TEM	Cancelled	PRENALTA CORP.		X
P34374D	STRATA ENERGY #3 WATER HAUL	6/28/2010	53-67-18-SESE		TEM	Complete	STRATA ENERGY		X
P6046R	OSHOTO RESERVOIR	7/15/1953	53-67-18-SWNE		IRR_SW; IND_SW	Fully Adjudicated	HARRY BERGER	172.70	X
P7913R	EVAPORATION RESERVOIR	5/16/1978	53-67-18-SWSW		IND_SW; MIS_SW	Cancelled	NUCLEAR DYNAMICS**WYO BOARD OF LAND COMMISSIONERS	17.20	X
P15506S	BUTTE #2 STOCK RESERVOIR	8/22/2003	53-67-19-NWNW		STO	Unadjudicated	ANTONE SWANDA	0.96	X
P2704S	BRISLAWN #2 STOCK RESERVOIR	2/3/1959	53-67-21-SWSW		STO	Unadjudicated	FRANCIS BRISLAWN	1.35	
P1159S	BRISLAWN #1 STOCK RESERVOIR	2/9/1955	53-67-32-NENW		STO	Unadjudicated	FRANCIS J. BRISLAWN	2.54	
P1630S	BRISLAWN NO. 1 STOCK RESERVOIR, FIRST ENLARGEMENT OF	10/24/1956	53-67-32-NENW		STO	Unadjudicated	FRANCIS J. BRISLAWN	19.07	
P6222S	BIGGERS #1 STOCK RESERVOIR	8/12/1968	53-67-32-NENE		STO	Fully Adjudicated	C. A. BIGGERS	1.92	

Table 3.4-7. Surface Water Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Permitted Area (ac)	Uses	Status	Appropriator	Permitted Capacity (ac-ft)	Project Area
P5255S	KEVIN STOCK RESERVOIR	7/21/1965	54-67-31-SESW		STO	Unadjudicated	MAX EVANS	3.92	
P34373D	STRATA ENERGY #1 WATER HAUL	6/28/2010	53-68-1-NESE		TEM	Complete	STRATA ENERGY		
P26760D	PRAIRIE WATER HAUL #1	9/8/1980	53-68-2-SWNE		IND_SW; OIL; TEM	Cancelled	DAVIS OIL CO.		
P28140D	KEE WATER PIPELINE #1 WATER HAUL	8/22/1983	53-68-2-SENE		DRI; IND_SW; OIL; TEM	Cancelled	KEE EXPLORATION, INC.		
P28776D	KISSACK WATER HAUL #31	12/10/1984	53-68-2-SENE		DRI; IND_SW; OIL; TEM	Cancelled	KISSACK WATER & OIL, INC.		
P30666D	SPIRIT #3 WATER HAUL	7/3/1991	53-68-2-SENE		DRI; IND_SW; TEM	Cancelled	APACHE CORP.		
P27555D	FEDERAL #33-11 WATER HAUL	4/5/1982	53-68-10-NENE		DRI; IND_SW; OIL; TEM	Cancelled	BASIC EARTH SCIENCE SYSTEMS INC.		
P12824D	RUBY DITCH	11/9/1914	53-68-12-NENE	48.3	IRR_SW	Fully Adjudicated	RUBY WESLEY	0.69	
P2767R	RUBY RESERVOIR	11/9/1914	53-68-12-NENE		IRR_SW	Fully Adjudicated	RUBY WESLEY	6.60	
P15507S	DEADMAN #1 STOCK RESERVOIR	8/22/2003	53-68-13-NWSE		STO	Unadjudicated	ANTONE SWANDA	0.96	X
P15508S	DEADMAN #2 STOCK RESERVOIR	8/22/2003	53-67-18-NWSW		STO	Unadjudicated	ANTONE SWANDA	0.17	X
P17341S	ENL. DEADMAN #1 STOCK RESERVOIR	8/10/2005	53-68-13-NWSE		STO	Unadjudicated	ANTONE SWANDA	1.47	X
P26607D	SNYDER OIL ENERGY DRILLING WATER HAUL	6/4/1980	53-68-13-NESW		DRI; IND_SW; OIL; TEM	Cancelled	SNYDER OIL ENERGY DRILLING		
P26832D	SNYDER OIL WATER HAUL NO. 1	10/31/1980	53-68-13-NESW		DRI; IND_SW; OIL; TEM	Cancelled	SNYDER OIL ENERGY DRILLING		
P27242D	KISSACK PIPELINE #3	7/24/1981	53-68-13-NESW		DRI; IND_SW; OIL; TEM	Cancelled	KISSACK WATER & OIL SERVICE		
P27640D	#1 NORTH MOREL WATER LINE	5/24/1982	53-68-13-NESW		DRI; IND_SW; OIL; TEM	Cancelled	GALLAGHER DRILLING, INC.		
P28692D	33-23-53-68 GOV'T WATER HAUL	10/22/1984	53-68-13-NESW		DRI; IND_SW; OIL; TEM	Cancelled	PRENALTA CORP.		
P32841D	DEADMAN PASTURE STOCK PIPELINE	6/23/2003	53-68-13-NWSE		STO	Fully Adjudicated	ANTONE SWANDA	0.05	X

Table 3.4-7. Surface Water Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Area (ac)	Uses	Status	Appropriator	Capacity (ac-ft)	Within Project Area
P27596D	KISSACK PIPELINE #11	5/10/1982	53-68-25-NWSW		DRI; IND_SW; OIL; TEM	Cancelled	KISSACK WATER & OIL, INC.		
P514S	RAY NO. 2 STOCK RESERVOIR	11/18/1953	53-68-25-NWSW		STO	Unadjudicated	RAY KOTTRABA	1.36	
P29206D	SANTA FE FEDERAL 26-5	9/23/1985	53-68-26-NESE		DRI; IND_SW; OIL; TEM	Cancelled	CONLEY P. SMITH		
P29368D	HAHN FEDERAL 27-12 WATER HAUL	5/1/1986	53-68-26-NWNE		DRI; IND_SW; OIL; TEM	Cancelled	CONLEY P. SMITH		
P4866S	KOTTRABA #2 STOCK RESERVOIR	2/12/1963	53-68-26-NESE		STO	Unadjudicated	RAY W. KOTTRABA	2.20	
P4869S	KOTTRABA #1 STOCK RESERVOIR	2/25/1963	53-68-26-SENE		STO	Unadjudicated	RAY W. KOTTRABA	9.67	
P513S	RAY NO. 1 STOCK RESERVOIR	11/18/1953	53-68-26-NWSW		STO	Cancelled	RAY KOTTRABA	1.00	
P7939S	KOTTRABA NO. 3 STOCK RESERVOIR	1/20/1975	53-68-26-NWSW		STO	Unadjudicated	CHARLES KOTTRABA	2.70	
Unknown	TWRES01	Unknown	53-67-7-SESE		STO	Unknown	T.J. WESLEY		X
Unknown	HBRES03	Unknown	53-67-17-NENW		STO	Unknown	HARRY BERGER		
Unknown	CSRES03	Unknown	53-67-18-SESE		STO	Unknown	CAROL STRONG		X
Unknown	CSRES04	Unknown	53-67-18-SESE		STO	Unknown	CAROL STRONG		X
Unknown	CSRES01	Unknown	53-67-19-NENE		STO	Unknown	CAROL STRONG		
Unknown	CSRES02	Unknown	53-67-19-SWNE		STO	Unknown	CAROL STRONG		X
Unknown	CSRES10	Unknown	53-67-19-NENE		STO	Unknown	CAROL STRONG		
Unknown	CSRES07	Unknown	53-67-20-NWNW		STO	Unknown	CAROL STRONG		
Unknown	CSRES08	Unknown	53-67-20-NWNW		STO	Unknown	CAROL STRONG		
Unknown	CSRES09	Unknown	53-67-20-NWNW		STO	Unknown	CAROL STRONG		
Unknown	CSRES12	Unknown	53-67-20-NWNW		STO	Unknown	CAROL STRONG		
Unknown	CSRES11	Unknown	53-67-20-SWNW		STO	Unknown	CAROL STRONG		
Unknown	CSRES05	Unknown	53-67-30-NENE		STO	Unknown	CAROL STRONG		
Unknown	CSRES13	Unknown	53-67-30-NWNE		STO	Unknown	CAROL STRONG		

Table 3.4-7. Surface Water Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Permitted Area (ac)	Uses	Status	Appropriator	Permitted Capacity (ac-ft)	Within Project Area
Unknown	TWRES02	Unknown	53-68-12-SESE		STO	Unknown	T.J. WESLEY		X
Unknown	TSRES01	Unknown	53-68-13-NESW		STO	Unknown	ANTONE SWANDA		
Unknown	TSRES02	Unknown	53-68-13-NWSE		STO	Unknown	ANTONE SWANDA		X

Uses:

STO	Stock
IRR_SW	Irrigation
DRI	Drilling
IND_SW	Industrial
OIL	Oil Refining/Production
TEM	Temporary
MIS_SW	Miscellaneous

Source: WSEO (2010)

Table 3.4-8. Surface Water Monitoring Stations

Station	Stream	Latitude (WGS84)	Longitude (WGS84)	Legal Location (Tns-Rng-Sec-¼¼)
SW-1	Little Missouri River, Downstream	44.58801	-104.93767	53-67-6-SWSW
SW-2	Little Missouri River, Upstream	44.56989	-104.96164	53-67-19-NWNW
SW-3	Deadman Creek	44.57568	-104.96368	53-68-13-NESE

Table 3.4-9. Existing Reservoirs within the Proposed Project Area

Reservoir	WSEO Permit No.	Capacity Normal (acre-ft)	Capacity Maximum (acre-ft)	Surface Area Normal (acre)	Surface Area Maximum (acre)	Depth Normal (ft)	Depth Maximum (ft)	Shoreline Normal (ft)	Shoreline Maximum (ft)	Use Intended	Use Current
Deadman #1 Stock Reservoir[1]	P15507S	1.43	2.04	1.12	1.31	2.5	3	1,910	1,888	stock	stock
Deadman #2 Stock Reservoir[3]	P15508S		0.21		0.12		4		360	stock	stock
Oshoto Reservoir[2]	P6046R	103.37	172.7	21.2	28.1	16	18		25,547	irrigation/industrial/ stock	industrial/stock
Butte #1 Stock Reservoir[1]	P17592S	1.19	6.42	0.67	2.03	3.5	7.5	2,246	4,200	stock	stock
Butte #2 Stock Reservoir	P15506S						Removed				
TSRES01[3,4]			1.56		0.77		5		1,517	stock	stock
TSRES02[3]			1.21		1.19		3		2,006	stock	stock
TWRES01[1]		2.03	4	0.53	1.08	7.5	10	786	1,239	stock	stock
TWRES02[1]		0.49	1.53	0.27	0.54	3.5	6	568	810	stock	stock
CSRES02[1]		0.03	0.9	0.06	0.29	1	6	207	590	stock	stock
CSRES03[1]		2.68	9.46	1.31	2.48	4	7.5	1,494	1,631	stock	stock
CSRES04[1]		0.18	0.65	0.14	0.33	2.5	4.5	404	732	stock	stock

Notes:
[1] Values estimated using May 2010 LiDAR data.
[2] Values estimated using May 2010 LiDAR data and permitted area-capacity table.
[3] Water surface was at maximum capacity at the time of survey.
[4] TSRES01 is located just outside of the proposed permit area.

Table 3.4-10. Wyoming Surface Water Classes and Use Designation

	Drinking	Game Fish	Non-Game Fish	Fish Consumption	Other Aquatic Life	Recreation	Wildlife	Agriculture	Industry	Scenic Value
1	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	Yes	Yes	Yes	Yes	Yes
2AB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2A	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
2B	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2C	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3A	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3B	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3C	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
4A	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4B	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4C	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes

Source: WDEQ/WQD 2001

Table 3.4-11. Surface Water/Groundwater Monitoring Constituents

Constituent	Holding Time	Analytical Method
pH	At time of sample	SM 4500 H B
Electrical Conductivity	28 Days	SM 2510B
Total Dissolved Solids (180)	7 Days	SM 2540
Total Suspended Solids	7 Days	SM 2540
Alkalinity, Total (As $CaCO_3$)	14 Days	SM 2320B
Nitrogen, Ammonia (As N)	28 Days	EPA 350.1
Oxygen, Dissolved	8 Hours	SM 4500-O G
Oil & Grease	28 Days	EPA 1664A
Gross Alpha	6 Months	SM 7110B
Gross Beta	6 Months	SM 7110B
Radium 226	6 Months	SM 7500-Ra B
Radium 228	6 Months	Ra-05
Turbidity	48 Hours	SM 2130
Alkalinity, Bicarbonate as HCO_3	14 Days	SM 2320B
Alkalinity, Carbonate as CO_3	14 Days	SM 2320B
Chloride	28 Days	EPA 300.0
Fluoride	28 Days	SM 4500FC
Nitrogen, Nitrate-Nitrite (As N)	28 Days	EPA 353.2
Sulfate	28 Days	EPA 300.0
Calcium	180 Days	EPA 200.7
Magnesium	180 Days	EPA 200.7
Potassium	180 Days	EPA 200.7
Sodium	180 Days	EPA 200.7
Aluminum	180 Days	EPA 200.7
Arsenic	180 Days	EPA 200.8
Barium	180 Days	EPA 200.8
Boron	180 Days	EPA 200.7
Cadmium	180 Days	EPA 200.8
Chromium	180 Days	EPA 200.7
Copper	180 Days	EPA 200.8
Iron	180 Days	EPA 200.7
Lead	180 Days	EPA 200.8
Mercury	28 Days	EPA 245.1
Molybdenum	180 Days	EPA 200.8
Nickel	180 Days	EPA 200.7
Selenium	180 Days	EPA 200.8
Uranium	180 Days	EPA 200.8
Vanadium	180 Days	EPA 200.8
Zinc	180 Days	EPA 200.7
Manganese	180 Days	EPA 200.7
Polonium 210	6 Months	OTW01 (modified)
Lead 210	6 Months	OTW01 (modified)
Thorium 230	6 Months	ACW10 (modified)

Table 3.4-12. Stream Monitoring Results

Parameter	Units	SW-1	SW-2	SW-3
Field conductivity	µmhos/cm	933 - 1200	422 - 1348	909 - 1209
Field pH	s.u.	8.06 - 8.39	7.62 - 8.35	8.5 - 8.86
Field turbidity	NTUs	9.1 - 14.14	3.86 - 11.68	14.9 - 16.29
Temperature	Deg C	1.8 - 9.8	3.2 - 7.8	2.4 - 10
Dissolved oxygen	mg/L	6.92 - 7.28	7.59 - 10.46	7.89 - 8.77
General				
Alkalinity (as CaCO3)	mg/L	331 - 497	118 - 600	357 - 586
Ammonia	mg/L	<0.1	<0.1	<0.1
Fluoride	mg/L	0.2	<0.1 - 0.3	0.1 - 0.3
Laboratory conductivity	µmhos/cm	795 - 1110	283 - 1250	794 - 1120
Laboratory pH	s.u.	8.2 - 8.7	8.1 - 8.6	8.3 - 8.8
Laboratory turbidity	NTUs	7.7 - 12.7	2.3 - 8.9	12.8 - 14.4
Laboratory dissolved oxygen	mg/L	8	10	9
Nitrate/nitrite	mg/L	<0.1	<0.1	<0.1
Total dissolved solids	mg/L	580 - 790	220 - 940	580 - 800
Total suspended solids	mg/L	<5 - 7	6 - 7	14
Major Ions				
Calcium	mg/L	17 - 37	14 - 58	24 - 32
Magnesium	mg/L	12 - 24	6 - 29	25 - 35
Potassium	mg/L	11	6 - 7	10 - 11
Sodium	mg/L	154 - 204	37 - 216	129 - 196
Bicarbonate	mg/L	404 - 542	144 - 655	435 - 619
Carbonate	mg/L	<5 - 32	<5 - 38	<5 - 47
Chloride	mg/L	7 - 8	3 - 10	4 - 7
Sulfate	mg/L	98 - 147	26 - 168	92 - 102
Metals				
Aluminum, dissolved	mg/L	<0.1 - 0.2	<0.1 - 0.2	<0.1
Arsenic, dissolved	mg/L	<0.005	<0.005	<0.005
Barium, dissolved	mg/L	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	<0.1 - 0.1	<0.1	<0.1 - 0.1
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	0.08 - 0.33	0.14 - 0.26	0.07 - 0.34
Iron, total	mg/L	0.37 - 0.95	0.32 - 0.64	0.58 - 0.87
Lead, dissolved	mg/L	<0.02	<0.02	<0.02
Manganese, total	mg/L	0.05 - 0.17	0.05 - 0.11	0.17 - 0.21
Mercury, dissolved	mg/L	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005	<0.005	<0.005
Silver, dissolved	mg/L	NM	NM	NM
Uranium, dissolved	mg/L	0.008 - 0.011	0.003 - 0.02	0.009 - 0.014
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01
Radiological				
Ra-226, dissolved	pCi/L	<0.2	<0.2	<0.2
Ra-228, dissolved	pCi/L	<1	<1 - 1.3	<1
Gross Alpha	pCi/L	7.3 - 8.8	4 - 7.9	6 - 7.3
Gross Beta	pCi/L	8.6 - 9.7	6 - 7.4	9.8 - 11.2

NM – not measured

Table 3.4-13. Surface Water Samples of Existing Reservoirs within Proposed Project Area

Site ID	Reservoir Name	Legal Location (Tns-Rng-Sec-¼¼)	3Q09	4Q09	1Q10	2Q10	3Q10	4Q10
R-1	TWRES01	53-67-7-SESE	**X**	**X**	2	**X**	**X**	**X**
R-2	Oshoto Reservoir (P6046R)	53-67-18-SWNE	**X**	**X**	**X**	**X**	**X**	**X**
R-3	CSRES03	53-67-18-SESE	**X**	**X**	2	**X**	**X**	**X**
R-4	CSRES04	53-67-18-SESE	**X**	4	2	4	4	4
R-5	CSRES02	53-67-19-SWNE	**X**	**X**	2	**X**	**X**	2
R-6	Butte #1 Stock Reservoir (P17592S)	53-67-18-SWSW	1	1	1	1	1	**X**
R-7	TSRES01	53-68-13-NESW	1	**X**	3	3	3	3
R-8	Deadman #2 Stock Reservoir (P15508S)	53-67-18-NWSW	1	1	1	1	1	**X**
R-9	TSRES02	53-68-13-NWSE	1	4	2	4	4	4
R-10	Deadman #1 Stock Reservoir (P15507S)	53-68-13-NWSE	1	4	2	**X**	**X**	**X**
R-11	TWRES02	53-68-12-SESE	1	1	1	**X**	**X**	**X**

Notes:

X – Sample collected
1-4 – No sample collected due to:
1 – No landowner permission
2 – Dry or frozen
3 – Outside of proposed project area
4 – Reservoir located directly downstream of another reservoir; upstream reservoir sampled.

Table 3.4-14. Reservoir Monitoring Results

Parameter	Units	R-1	R-2	R-3	R-4	R-5	R-6	R-7	R-8	R-10	R-11
		TWRES01	HBRES04	CSRES03	CSRES04	CSRES02	P17592S	TSRES01	P15508S	P15507S	TWRES02
Field											
Field Conductivity	µmhos/cm	147.3 - 247	654 - 1265	307 - 985	153.7	127.5 - 359	2890	2720	2700	1413 - 3640	281 - 1801
Field pH	s.u.	8.99 - 10.64	8.1 - 9.46	9 - 10.19	9.85	7.36 - 10.24	9.29	8.87	9.68	9.2 - 10.2	9.03 - 10.46
Field turbidity	NTUs	6.05 - 64.4	4.32 - 26	4.8 - 101		49.6 - 620	23.4	63	86.9	31.4 - 596	3.22 - 26.5
Temperature	Deg C	9.2 - 20.5	1.7 - 23.9	8.2 - 26.6	24.2	7.5 - 30.4	19.2	5.5	18.4	10.7 - 25.2	15.5 - 21.8
Dissolved oxygen	mg/L	3.91 - 7.21	5.34 - 9.42	4.32 - 7.66		0.46 - 8	4.88	6.78	9.87	10.14 - 11.32	4.37 - 10.73
General											
Alkalinity (as CaCO3)	mg/L	55 - 116	301 - 507	117 - 346	72	47 - 147	1090	1080	1220	639 - 1700	107 - 732
Ammonia	mg/L	<0.1	<0.1 - 0.3	<0.1 - 0.6	<0.1	<0.1 - 5.6	0.1	<0.1	<0.1	0.1 - 0.2	<0.1 - 0.1
Fluoride	mg/L	<0.1 - 0.2	0.2	<0.1 - 0.2	<0.1	<0.1	0.5	0.3	0.5	0.3 - 0.7	<0.1 - 1.7
Laboratory conductivity	µmhos/cm	129 - 231	713 - 1090	296 - 1000	143	108 - 327	2270	2000	2130	1220 - 2910	273 - 1870
Laboratory pH	s.u.	8 - 9.2	8.3 - 9.2	8.5 - 10	9.5	7.5 - 8.1	9	8.6	9.4	8.9 - 9.9	8.6 - 10
Laboratory turbidity	NTUs	4.8 - 62	3.1 - 19.1	2.4 - 101	6.2	7.6 - 490	18.7	58.4	69.4	27.3 - 392	2.2 - 24.8
Laboratory Dissolved Oxygen	mg/L	9 - 13	5 - 13	10	10	<1 - 10		12			
Nitrate/Nitrite	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Dissolved Solids	mg/L	100 - 170	460 - 730	200 - 760	100	110 - 500	1710	1360	1560	970 - 2320	210 - 1190
Total Suspended Solids	mg/L	6 - 74	<5 - 24	6 - 134	<5	58 - 252	8	62	86	37 - 530	<5 - 8
Major Ions											
Calcium	mg/L	11 - 21	15 - 29	25 - 54	16	11 - 34	18	41	13	10 - 43	5 - 38
Magnesium	mg/L	3 - 5	17 - 25	8 - 26	4	2 - 7	33	60	36	42 - 46	5 - 18
Potassium	mg/L	9 - 14	10 - 14	8 - 29	7	9 - 23	18	24	16	11 - 31	5
Sodium	mg/L	7 - 15	123 - 226	22 - 119	4	<1 - 5	515	440	494	212 - 739	24 - 427
Bicarbonate	mg/L	49 - 137	292 - 539	56 - 398	64	58 - 179	1080	1190	1030	635 - 1130	51 - 363
Carbonate	mg/L	<5 - 9	<5 - 88	5 - 43	11	<5	123	66	226	71 - 548	7 - 261
Chloride	mg/L	<1 - 4	7 - 9	3 - 9	<1	3 - 20	20	10	8	7 - 21	2 - 3
Sulfate	mg/L	4 - 8	66 - 97	32 - 169	3	<1 - 3	224	136	90	54 - 163	27 - 235
Metals											
Aluminum, dissolved	mg/L	<0.1 - 0.2	<0.1	<0.1	<0.1	0.2 - 1.4	<0.1	<0.1	<0.1	<0.1	<0.1 - 1.5
Arsenic, dissolved	mg/L	<0.005 - 0.006	<0.005 - 0.01	<0.005 - 0.022	0.009	<0.005 - 0.028	0.013	0.005	0.015	0.006 - 0.052	<0.005 - 0.007
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	<0.1	<0.1 - 0.1	<0.1	<0.1	<0.1	0.2	0.3	0.2	0.1 - 0.4	<0.1 - 0.6
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	<0.05 - 0.35	<0.05 - 0.06	<0.05	0.1	0.2 - 8.32	0.18	0.07	0.08	0.06 - 0.13	<0.05 - 0.8
Iron, total	mg/L	0.43 - 2.62	0.07 - 0.25	0.08 - 1.32	0.46	1.68 - 19.7	0.77	1.95	1.3	1.06 - 6.28	0.06 - 1.29
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	0.02 - 0.12	0.03 - 0.16	<0.02 - 1.12	0.04	0.14 - 1.24	0.08	0.25	0.09	0.11 - 0.34	0.03
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02 - 0.06	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005 - 0.005	<0.005	<0.005	<0.005	<0.005 - 0.006	<0.005	0.005	<0.005	<0.005	<0.005
Silver, dissolved	mg/L	<0.003	<0.003	<0.003		<0.003	<0.003		<0.003	<0.003	<0.003
Uranium, dissolved	mg/L	<0.001 - 0.001	0.006 - 0.009	<0.001 - 0.005	<0.001	<0.001	0.02	0.028	0.027	0.019 - 0.087	0.002 - 0.006
Uranium, suspended	mg/L	<0.001	<0.001	<0.001		<0.001				<0.001 - 0.003	<0.001
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02 - 0.03	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01 - 0.05	<0.01	<0.01	<0.01	<0.01	<0.01
Radiological											
Lead 210, dissolved	pCi/L	<1 - 1.29	<1	<1		<1				<1 - 1.46	<1
Lead 210, suspended	pCi/L	<1	<1	<1		<1 - 3.26				<1 - 1.55	<1
Polonium 210, dissolved	pCi/L	<1	<1	<1		<1				<1	<1
Polonium 210, suspended	pCi/L	<1	<1	<1		<1				<1	<1
Ra-226, dissolved	pCi/L	<0.2	<0.2 - 0.2	<0.2 - 0.46	0.2	<0.2 - 1.35	<0.2	0.29	<0.2	<0.2 - 0.31	<0.2
Ra-226, suspended	pCi/L	<0.2	<0.2	<0.2		<0.2 - 1.12				<0.2 - 0.3	<0.2
Ra-228, Dissolved	pCi/L	<1 - 1.34	<1 - 1.1	<1 - 1.52	<1	<1 - 1.22	<1	<1	<1	<1	<1
Th-230, dissolved	pCi/L	<0.2	<0.2	<0.2		<0.2				<0.2	<0.2
Th-230, suspended	pCi/L	<0.2	<0.2	<0.2		<0.2 - 0.28				0.28 - 0.46	<0.2
Gross Alpha	pCi/L	<2 - 3.55	3.1 - 9.5	<2 - 11.1	<2	<2 - 7.4	16.3	23	15	13.6 - 48.7	3.61 - 5.6
Gross Beta	pCi/L	8.7 - 14.3	8.1 - 22.9	8.6 - 27.6	6.9	10.5 - 28.7	20	31.4	20	12.9 - 48.5	3.9 - 11.6
QA/QC											
Anion Sum	meq/L	1.21 - 2.45	7.63 - 12.39	3.09 - 10.72	1.48	1.02 - 3.21	27.01	24.76	26.58	16.38 - 36.47	2.75 - 19.69
Cation Sum	meq/L	1.33 - 2.48	8.02 - 12.96	3.02 - 10.72	1.49	0.93 - 3.09	26.44	26.69	25.55	15.48 - 36.87	2.79 - 19.37
Total Anion/Cation Balance	%	0.45 - 4.95	0.72 - 2.47	0.01 - 2.04	0.34	0.16 - 4.62	1.07	3.74	1.97	0.55 - 2.83	0.72 - 1.97
Total Dissolved Solids (calc)	mg/L	70 - 130	430 - 690	170 - 610	80	50 - 170	1480	1360	1390	870 - 1950	150 - 680

Table 3.4-15. Nearby WYPDES Permits

Permit	Facility Name	Operator
WY0034592	Hundahl 24x-8	Wellstar Corporation
WY0033065	Gov't 33-23 Tank Battery	True Oil, LLC
WY0044296	Lease WYW66387 Wildfire A	Wildfire Partners, Inc.

Source: WDEQ/WQD (2010)

Table 3.4-16. WYPDES Effluent Limits

Constituent	WY0034592		WY0033065		WY0044296	
	2004-2009	**2009 Renewal**	**2004-2009**	**2009 Renewal**	**2004-2009**	**2009 Renewal**
Oil and grease, mg/L	10	10	10	10	10	10
Radium-226, pCi/L	60	--	60	--	60	60
Chloride, mg/L	230	2,000	230	2,000	230	2,000
Sulfate, mg/L	--	3,000	N/A	3,000	--	3,000
EC, µmhos/cm	--	7,500	N/A	7,500	--	7,500

Source: WDEQ/WQD (2010)

Table 3.4-17. Discharge Monitoring Results for WYPDES Permits

Permit	Effluent Characteristic	Concentration
WY0034592	Oil and grease, mg/L	9.6 – **13.2**
	Chloride, mg/L	65 - 88
	Radium-226, pCi/L	9.6 – 13.2
	Flow, MGD	0 – 0.013
WY0033065	Oil and grease, mg/L	6 – **22**
	Chloride, mg/L	2 – 85
	Radium-226, pCi/L	4 – 7.5
	Flow, MGD	0.033 – 0.040
WY0044296	Oil and grease, mg/L	1.2 – 8.7
	Chloride, mg/L	119 – 222
	Radium-226, pCi/L	26.9 – 53
	Flow, MGD	0.007 – 0.009
	Sulfate, mg/L	2,380
	EC, µmhos/cm	4,540

Source: WDEQ/WQD (2010)
Note: Items in bold signify an exceedance of effluent limit

Table 3.4-18. Potential Wetlands within the Proposed Project Area

Wetland Classification[1]	Acres within Project Area
PABFh	56.5
PABFx	0.3
PEMC	1.8
PEMCh	1.1
PEMCx	0.1
PEMF	2.6
PEMFx	0.3
PUSCh	2.3
Total[2]	**65.0**
Other Waters of the U.S.	5.1

1 Cowardin, et al. (1979):
PABFh – Palustrine, Aquatic Bed, Semipermanently Flooded, Diked; **PABFx** – Palustrine, Aquatic Bed, Semipermanently Flooded, Excavated; **PEMC**- Palustrine, Emergent, Seasonally Flooded; **PEMCh** – Palustrine, Emergent, Seasonally Flooded, Diked; **PEMCx** – Palustrine, Emergent, Seasonally Flooded, Excavated; **PEMF** – Palustrine, Emergent, Semipermanently Flooded; **PEMFx** – Palustrine, Emergent, Semipermanently Flooded, Excavated; **PUSCh** – Palustrine, Unconsolidated Shore, Seasonally Flooded, Diked

2 Total wetland acres include Wetland and Reservoir/Stockpond Map Units as noted on Table 3.5-1

Table 3.4-19. Stratigraphic Relationships and Hydrologic Characteristics in Recent to Pre-Cambrian units of the eastern Powder River Basin

Age	Geologic Unit	Hydrologic Characteristics
Holocene	**Alluvium**-Unconsolidated silt, sand, and occasional gravel. Underlies flood plains and bordering terraces. Thickness is typically under 25 feet, up to 50 feet in major drainages. Alluvium overlying formation of Tertiary age is typically fine to medium grained, and coarse-grained close to uplifts.	Water producing capabilities are highly variable, depending on saturated thickness and grain size distribution. Water quality is also variable. TDS concentrations range from 100 to over 4,000 mg/L, with lower TDS on basin margins and higher TDS in interior. Water type is also variable.
Paleocene	**Fort Union Formation**-Sandstone, fine-grained, and interbedded shale, carbonaceous shale and coal. Thickness about 2,300 feet in east part of basin, and about 2,900 feet in southwest part. Outcrops west of Ross Area. Dips to the west.	Major aquifer in Campbell County. City of Gillette municipal wells produce from the Fort Union Formation, which is blended with water from the City's Madison Formation wellfield. Properly designed wells can produce over 200 gpm. In the Gillette area, Fort Union Formation groundwater has TDS concentrations ranging from 300 to 600 mg/L. Water is of the sodium-bicarbonate type.
Upper Cretaceous	**Lance Formation**-Sandstone, fine-to medium-grained and interbedded sandy shale and claystone. Thickness increases southward on east side of basin from about 500 feet in northeast Campbell County to about 1,600 feet in Weston County, and from about 2,500 feet in Niobrara County to as much as 3,000 feet in southern Converse County.	Well yields typically low, but can exceed 100 gpm if screened through entire interval. Most stock/domestic wells completed in the Lance Formation tap a small part of the formation. Within the Ross area TDS concentrations in Lance Formation wells are on the order of 1,000 mg/L of sodium-bicarbonate-sulfate water.
	Fox Hills Formation-Predominantly sandstone, fine- to medium-grained, containing thin beds of sandy shale; thickness is approximately 100 feet in Campbell County, and ranges from about 125 to 200 feet in Crook and Weston Counties, and from 400 to 500 feet in Niobrara County.	Numerous industrial production wells are completed in Fox Hills Formation and overlying Lance sequence, particularly in Campbell County. Properly designed wells can produce 500 gpm or more. Within the Ross area, a number of water-flood wells are completed in the Fox Hills Formation. Based on the monitoring wells completed at Ross, well yields are in the order of 20-40 gpm. TDS concentrations in the Ross monitoring wells completed in the Fox Hills Formation are on the order of 1,350 mg/L. The water is of the sodium-bicarbonate-sulfate type.

Table 3.4-19. Stratigraphic Relationships and Hydrologic Characteristics in Recent to Pre-Cambrian units of the eastern Powder River Basin (Continued)

Age	Geologic Unit	Hydrologic Characteristics
Upper Cretaceous	**Pierre Shale**-Shale, some sandy shale and sandstone, and many beds of bentonite. Contains the Groat Sandstone Bed of the Gammon Ferruginous Member (Shannon Sandstone equivalent) in Crook and Weston Counties. Formation thickens southward from about 2,100 feet in northernmost Crook County to about 2,900 feet in central Weston County to as much as 3,100 feet in Niobrara County. Grades westward in subsurface into Lewis Shale, Mesaverde Formation and upper part of Cody Shale on west side of basin.	The sequence consisting of the Pierre Shale, Niobrara Formation, Carlile Shale, Greenhorn Formation, and Belle Fourche Shale is predominantly shale with only local lenses of sand from which small amounts of water may be derived. The Groat Sandstone Bed might be an exception but yield above 20 gpm is unlikely.
	Niobrara Formation-Calcareous shale and marl with some noncalcareous shale near base; contains many thin beds of bentonite; thickness ranges from 150 to 225 feet.	
	Carlile Shale-Shale, sandy in middle part; thickness ranges from about 450 feet to about 600 feet in northwest Crook County. Contains Turner Sandy Member in Crook and Weston Counties which is about 185 thick near Upton.	
	Greenhorn Formation-Shale, limestone and marl. Thickness variable: 125 to 370 feet in northern Crook County, 70 to 80 feet in southwest Crook County, and about 270 feet in Newcastle Osage area.	
	Belle Fourche Shale-Shale, dark gray to bluish black; contains numerous concretions and few thin beds of bentonite. About 850 thick in northwest Crook County.	

Table 3.4-19. Stratigraphic Relationships and Hydrologic Characteristics in Recent to Pre-Cambrian units of the eastern Powder River Basin (Continued)

Age	Geologic Unit	Hydrologic Characteristics
Lower Cretaceous	**Mowry Shale**-Hard siliceous shale in upper part, soft slightly siliceous shale in lower part; contains a few silty and sandy beds. Thickness increases to north in eastern part of basin, to about 250 thick in northern Crook County.	Not considered an aquifer.
	Newcastle Sandstone-Variable lithology, but mostly fine-to medium grained lenticular sandstone, with lesser amounts of siltstone and shale; thickness at most places ranges from 20 to 60 feet. As much as 100 feet thick in Newcastle area. Muddy Sandstone equivalent.	Sandstone beds in the Newcastle Sandstone and Skull Creek Shale may yield small amounts locally, but other rocks not considered water-bearing.
	Skull Creek Shale-Dark gray to black; contains a few thin beds of sandstone and siltstone. About 200 feet thick in Osage-Newcastle area.	
Lower Cretaceous	**Inyan Kara Group**-Consists of the Fall River Formation (Dakota Sandstone) and the Lakota Formation.	Wells completed in Fall River and Lakota yield from 5 to 20 gpm, with occasional higher yields; Dakota sandstone a regional aquifer on east side of Black Hills Uplift. TDS concentrations generally range from 300-3,000 mg/L of sodium-sulfate type water.
	Fall River-Sandstone fine to medium grained, with interbedded shale and siltstone, thickness generally 120 to 150 feet thick.	
	Lakota-Sandstone, conglomeratic sandstone and shale; lenticular, with rapid composition changes both laterally and vertically; thickness ranges from about 100 to 300 feet.	

Table 3.4-19. Stratigraphic Relationships and Hydrologic Characteristics in Recent to Pre-Cambrian units of the eastern Powder River Basin (Continued)

Age	Geologic Unit	Hydrologic Characteristics
Jurassic	**Morrison Formation**-Typically consists of variegated shale, with interbedded fine grained sandstone in lower part. In an area north of Newcastle and east of Osage, the Morrison consists locally in part or all of fine-grained sandstone resembling the Unkpapa Sandstone which locally replaces the Morrison at the south end of the Black Hills.	Sand zones may yield water, but most of the formation does not contain water-bearing strata.
	Sundance Formation-Shale, greenish-gray, and interbedded yellowish-gray fine grained sandstone; thickness generally between 370 and 400 feet in east part of basin. Formation consists of five members in the Black Hills, which in ascending order are the Canyon Springs Sandstone, Stockade Beaver Shale, Hulett Sandstone, Lak, and Redwater Shale.	Hulett sandstone may produce water suitable for livestock. TDS concentrations on the order of 2,500 mg/L.
	Gypsum Spring Formation-Massive white gypsum, red claystone, and gray limestone. About 125 feet thick in northern Crook County.	Well yields are minimal. High TDS.
Triassic-Permian	**Spearfish Formation**-Red shale, siltstone, sandstone, and white gypsum; contains thick beds of gypsum in lower part. Up to 825 feet thick in Crook County.	Goose Egg Formation and equivalent rocks, Spearfish Formation, Minnekahta Limestone, and Opeche Shale, rocks consist mostly of shale, gypsum, and thin-bedded limestone with minor sand. Well yields are small with higher TDS (500-3,000 mg/L the norm).
	Minnekahta Limestone-Thin-bedded limestone and dolomitic limestone; about 40 feet thick.	
	Opeche Shale-Shale, fine-grained sandstone and gypsum; 70-120 feet thick in Black Hills area.	

Table 3.4-19. Stratigraphic Relationships and Hydrologic Characteristics in Recent to Pre-Cambrian units of the eastern Powder River Basin (Continued)

Age	Geologic Unit	Hydrologic Characteristics
Permo-Penn.	**Minnelusa Formation**-Interbedded sandstone, sandy dolomite and limestone. Some shale and siltstone, occasional beds of gypsum and anhydrite. Thickness ranges from 700 to 900 feet.	Well yields range from 20 to as much as several hundred gallons per minute. Only potable near outcrop, with TDS concentrations increasing with depth. City wells at Hulett are completed in Minnelusa. Reported yield is 300 gpm/well. Minnelusa produces oil in the eastern PRB; producing wells at Ross Area are completed in Minnelusa at approximately 6,100 feet. Target for disposal wells in eastern PRB.
Mississippian	**Pahasapa (Madison) Limestone**-White to light-gray limestone, fine grained massive; cavernous in places. Thickness ranges from 900 feet in northern Black Hills to approximately 300 feet near Weston-Niobrara County line.	Where fractured and cavernous, well yields can exceed 1000 gpm. The City of Gillette's Madison wellfield is located in T49N, R67W. Yield from the 10-wellfield is 9,300 gpm from approximately 2,500 feet. TDS concentrations at the Gillette wellfield range from 590-714 mg/L. TDS concentrations increase with distance from the outcrop. Near the outcrop, TDS concentrations are less than 500 mg/L and water is of the calcium-bicarbonate type. Further from the outcrop, TDS concentration of 3,000 mg/L can be expected, and sulfate concentration increases with depth.
Ordovician	**Winnipeg Formation**-Siltstone and shale; thins southward, likely absent south of Crook County. Whitewood Dolomite - massive bedded dolomite roughly 50 feet thick. Also thins to south and is likely absent south of Crook County.	Winnipeg Formation is confining layer above Deadwood Formation. Whitewood Dolomite may yield water in small quantities.

Table 3.4-19. Stratigraphic Relationships and Hydrologic Characteristics in Recent to Pre-Cambrian units of the eastern Powder River Basin (Continued)

Age	Geologic Unit	Hydrologic Characteristics
Cambrian	**Deadwood Formation**-Massive buff sandstone, coarse-grained, conglomeratic at base. Flaggy dolomite, and flat pebble limestone conglomerate. Also contains greenish-gray glauconiticic interbedded shaly siltstones and claystones.	Minor aquifers near outcrop. Well yields of approximately 20 gpm likely.
	Flathead Sandstone-Fine- to coarse-grained sandstone, roughly 190 feet thick in eastern portion of basin. Few well penetrations due to overlying productive aquifers.	
Pre-Cambrian	**Igneous and metamorphic rocks**. Chiefly granite gneiss and schist complex of igneous and metamorphic rocks that underlie sedimentary strata in the basin and form the core of the Bighorn Mountains. Also found associated with intrusive of Tertiary age in the Black Hills such as Bear Lodge Mountains and Mineral Hill.	Yields of as much as 20 gpm may be possible locally from fractures, joints and weathered zones in areas of outcrop, but rocks may not yield any water at many locations. Chances of obtaining water decrease as depth increases. TDS concentrations generally less than 100 mg/L; water is usually calcium bicarbonate type.

Sources: Hodson et al. 1973, HKM Associates 1993, WSEO 2010

Table 3.4-20. Strata Energy/Ross ISR Project Monitor Well Construction Summary

Regional Baseline Well ID	Stratigraphic Interval/Aquifer	Location Coordinates (NAD 83, WY-E)		Ground Surface Elevation (ft amsl)	Top of Casing Elevation (ft amsl)	Hole Diameter/Depth Interval	PVC Well Casing Diameter/Depth Interval	PVC Well Screen Diameter/Depth Interval	Screened/ Aquifer Thickness (ft)	Completion Date
		Northing	Easting							
12-18 SA	Surficial	1487482	709185	4184.8	4185.8	8.75" / 0' - 103'	5" / 0' - 63'	3" / 63' - 103'	40.0	11/20/09-12/20/09
12-18 SM	Shallow	1487516	709224	4185.9	4187.1	8.75" / 0' - 352'	5" / 0' - 342'	3" / 342' - 352'	10.0	11/22/09-12/18/09
12-18 OZ	Ore Zone	1487518	709154	4186.5	4187.9	8.75" / 0' - 584'	5" / 0' - 474'	3" / 474' - 584'	110.0	11/22/09-12/16/09
12-18 DM	Deep	1487549	709191	4188.4	4189.2	8.75" / 0' - 632'	5" / 0' - 612'	3" / 612' - 632'	20.0	11/20/09-12/17/09
34-7 SA	Surficial	1489603	713334	4134.2	4135.4	8.75" / 0' - 52'	5" / 0' - 42'	3" / 42' - 52'	10.0	11/18/09-12/12/09
34-7 SM	Shallow	1489636	713363	4133.6	4134.9	8.75" / 0' - 245'	5" / 0' - 210'	3" / 210' - 245'	35.0	11/19/09-12/11/09
34-7 OZ	Ore Zone	1489623	713271	4134.9	4136.8	8.75" / 0' - 378.5'	5" / 0' - 318.5'	3" / 318.5' - 378.5'	60.0	11/19/09-11/30/09
34-7 DM	Deep	1489669	713334	4133.8	4135.3	8.75" / 0' - 487'	5" / 0' - 472'	3" / 472' - 487'	15.0	11/17/09-12/05/09
42-19 SA	Surficial	1481283	713073	4283.3	4284.2	8.75" / 0' - 108'	5" / 0' - 98'	3" / 98' - 108'	10.0	12/16/09-01/09/10
42-19 SM	Shallow	1481249	713109	4284.8	4286.1	8.75" / 0' - 290'	5" / 0' - 260'	3" / 260' - 290'	30.0	12/12/09-01/05/10
42-19 OZ	Ore Zone	1481247	713038	4281.1	4282.5	8.75" / 0' - 560'	5" / 0' - 470'	3" / 470' - 560'	90.0	11/17/09-12/05/09
42-19 DM	Deep	1481210	713075	4283.2	4284.4	8.75" / 0' - 610'	5" / 0' - 600'	3" / 600' - 610'	10.0	12/05/09-12/30/09
34-18 SA	Surficial	1483816	712431	4246.1	4247.5	8.75" / 0' - 70'	5" / 0' - 50'	3" / 50' - 70'	20.0	11/23/09-01/14/10
34-18 SM	Shallow	1483780	712468	4246.7	4247.8	8.75" / 0' - 298'	5" / 0' - 278'	3" / 278' - 298'	20.0	11/24/09-01/14/10
34-18 OZ	Ore Zone	1483785	712397	4246.0	4247.5	8.75" / 0' - 565'	5" / 0' - 460'	3" / 460' - 565'	105.0	11/30/09-01/01/10
34-18 DM	Deep	1483748	712430	4247.0	4248.3	8.75" / 0' - 620'	5" / 0' - 600'	3" / 600' - 620'	20.0	11/23/09-01/12/10

Table 3.4-20. Strata Energy/Ross ISR Project Monitor Well Construction Summary (Continued)

Regional Baseline Well ID	Stratigraphic Interval/Aquifer	Location Coordinates (NAD 83, WY-E)		Ground Surface Elevation (ft amsl)	Top of Casing Elevation (ft amsl)	Hole Diameter/Depth Interval	PVC Well Casing Diameter/Depth Interval	PVC Well Screen Diameter/Depth Interval	Screened/ Aquifer Thickness (ft)	Completion Date
		Northing	Easting							
21-19 SA	Surficial	1483326	710648	4167.4	4169.0	8.75" / 0' - 30'	5" / 0' - 20'	3" / 20' - 30'	10.0	01/04/10-01/29/10
21-19 SM	Shallow	1483289	710685	4169.6	4170.7	8.75" / 0' - 315'	5" / 0' - 260'	3" / 260' - 315'	55.0	12/23/09-01/28/10
21-19 OZ	Ore Zone	1483283	710613	4167.0	4168.3	8.75" / 0' - 468'	5" / 0' - 433'	3" / 433' - 468'	35.0	12/28/09-01/26/10
21-19 DM	Deep	1483249	710642	4168.6	4169.9	8.75" / 0' - 565'	5" / 0' - 550'	3" / 550' - 565'	15.0	12/21/09-01/27/10
14-18 SA	Surficial	1484950	710006	4155.6	4156.8	8.75" / 0' - 65'	5" / 0' - 35'	3" / 35' - 65'	30.0	12/21/09-01/23/10
14-18 SM	Shallow	1484918	710044	4154.9	4156.2	8.75" / 0' - 327'	5" / 0' - 282'	3" / 282' - 327'	45.0	12/20/09-01/22/10
14-18 OZ	Ore Zone	1484910	709972	4155.1	4156.3	8.75" / 0' - 529'	5" / 0' - 499'	3" / 499' - 529'	30.0	12/29/09-01/15/10
14-18 DM	Deep	1484876	710013	4154.8	4156.0	8.75" / 0' - 585'	5" / 0' - 570'	3" / 570' - 585'	15.0	12/18/09-01/21/10
OW1B57-1	Ore Zone	1487589	709146	4190.9	4192.0	8.75" / 0' - 529'	5" / 0' - 529'	open hole / 529' - 536'	7.0	06/18/10-06/30/10
						12.00" / 529' - 536'				
OW1B58-1	Ore Zone	1487507	709084	4187.1	4187.9	8.75" / 0' - 531'	5" / 0' - 513'	3" / 513' - 531'	18.0	06/18/10-06/30/10
OW1B60-1	Ore Zone	1487449	709164	4183.4	4184.2	8.75" / 0' - 509'	5" / 0' - 509'	3" / 509' - 525'	16.0	06/24/10-07/01/10
						12.00" / 509' - 525'				
SA43-18-1	Surficial	1485568	713105	4146.7	4148.0	8.0" / 0 - 30.5'	2" / 0 - 8.8'	2" / 8.8 - 28.8'	20.0	05/18/10
SA43-18-2	Surficial	1485026	713633	4149.3	4150.7	8.0" / 0 - 20.5'	2" / 0 - 8.6'	2" / 8.6 - 18.6'	10.0	05/18/10
SA13-17-1	Surficial	1485559	714589	4138.7	4140.0	8.0" / 0 - 13.0'	2" / 0 - 3.7'	2" / 3.7 - 8.7'	5.0	05/17/10
SA43-18-3	Surficial	1486277	713755	4132.9	4134.8	8.0" / 0 - 27.0'	2" / 0 - 13'	2" / 13 - 23'	10.0	05/18/10

Table 3.4-21. Strata Energy/Ross ISR Project Aquifer Test Summary of Hydraulic Characteristics

Regional Baseline Well ID	Well Type	Interpretation Method	Transmissivity (ft^2/day)	Hydraulic Conductivity (ft/day)	Storativity (unitless)
34-7 OZ	Pumping	Cooper Jacob Straight Line Drawdown	367.60	6.13	n/a
		Theis Recovery	172.50	2.88	n/a
42-19 OZ	Pumping	Cooper Jacob Straight Line Drawdown	12.70	0.14	n/a
		Theis Recovery	13.40	0.15	n/a
34-18 OZ	Pumping	Cooper Jacob Straight Line Drawdown	26.20	0.25	n/a
		Theis Recovery	19.80	0.19	n/a
14-18 OZ	Pumping	Cooper Jacob Straight Line Drawdown	3.80	0.13	n/a
		Theis Recovery	23.80	0.79	n/a
21-19 OZ	Pumping	Cooper Jacob Straight Line Drawdown	34.70	0.99	n/a
		Theis Recovery	25.60	0.73	n/a
12-18 OZ	Pumping	Cooper Jacob Straight Line Drawdown	116.90	1.06	n/a
		Theis Recovery	70.80	0.64	n/a
OW1B57-1	Observation	Theis Drawdown (Confined)	100.90	14.40	1.50E-04
		Cooper Jacob Straight Line Drawdown	102.20	14.60	1.50E-04
		Theis Recovery	96.70	13.80	
OW1B58-1	Observation	Theis Drawdown (Confined)	88.10	4.90	5.80E-05
		Cooper Jacob Straight Line Drawdown	88.20	4.90	5.70E-05
		Theis Recovery	80.50	4.50	
OW1B60-1	Observation	Theis Drawdown (Confined)	88.20	5.50	6.20E-05
		Cooper Jacob Straight Line Drawdown	88.40	5.50	6.10E-05
		Theis Recovery	84.50	5.30	

Table 3.4-21 Strata Energy/Ross ISR Project Aquifer Test Summary of Hydraulic Characteristics (Continued)

Regional Baseline Well ID	**Well Type**	**Interpretation Method**	**Transmissivity (ft^2/day)**	**Hydraulic Conductivity (ft/day)**	**Storativity (unitless)**
OW1B57-1	Pumping	Cooper Jacob Straight Line Drawdown	81.00	11.60	
		Theis Recovery	80.30	11.50	
OW1B58-1	Observation	Hantush, 1961	111.00	6.90	3.50E-05
		Theis Drawdown (Confined)	110.00	6.20	3.50E-05
		Cooper Jacob Straight Line Drawdown	137.10	7.60	1.00E-05
		Theis Recovery	92.70	5.10	
OW1B60-1	Observation	Hantush, 1961	90.80	5.70	1.30E-05
		Theis Drawdown (Confined)	90.80	5.70	1.30E-05
		Cooper Jacob Straight Line Drawdown	113.60	7.10	4.00E-06
		Theis Recovery	96.20	6.00	
12-18 OZ	Observation	Theis Drawdown (Confined)	103.90	0.94	1.10E-04
		Cooper Jacob Straight Line Drawdown	105.60	0.96	1.00E-04
		Theis Recovery	93.20	0.85	
		Min	**3.80**	**0.13**	**4.00E-06**
		Max	**367.60**	**14.60**	**1.50E-04**
		Median	**89.60**	**5.00**	**5.75E-05**

Table 3.4-22. Ross Area Geologic/Hydrologic Nomenclature

Geologic Unit	Stratigraphic Horizon	Aquifer
Lance Formation and/or Recent Alluvium/Colluvium	LA/Qal	SA
Lance Formation	LB-LG	Lance Aquitards
	LK-LM	SM
	LC	Upper Confining Unit
	LT	OZ
Fox Hills Formation	FH	
	BFH	Lower Confining Unit
	BFS/FS	DM
Pierre Shale	KP	Regional Confining Unit/Aquitard

Table 3.4-23. Historical Groundwater Use within 2 Miles of Proposed Project Area

Use	Number of Wells	Percent of Total	Appropriation Dates
Domestic Only	5	4%	1943 - 1995
Domestic & Stock	15	13%	1918 - 2003
Domestic, Stock & Irrigation	1	<1%	1972 - 1972
Stock Only	34	29%	1933 - 2010
Stock & Irrigation	1	<1%	1961 - 1961
Monitor	39	33%	1977 - 2010
Industrial or Miscellaneous	24	20%	1977 - 1991
Total	119	100%	1918 - 2010

Source: WSEO (2010)

Table 3.4-24. Historical Groundwater Use within the Proposed Project Area

Use	Number of Wells	Percent of Total	Appropriation Dates
Stock Only	4	8%	1949 - 2010
Monitor	38	79%	1977 - 2010
Industrial or Miscellaneous	6	13%	1977 - 1984
Total	48	100%	1949 - 2010

Source: WSEO (2010)

Table 3.4-25. Groundwater Rights within 2 Miles of Proposed Project Area

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Total Depth (ft)	Uses	Status	Appropriator	Depth to Water (ft)	Yield (gpm)	Within Project Area
P7330P	MINNIE BERGER #1	4/22/1961	53-67-5-NWNE	222	STK	Complete	MINNIE B. BERGER		2	
P7325P	BERGER #8	8/10/1951	53-67-5-SESW	100	DOM_GW	Complete	HARRY J. BERGER		5	
P7324P	BERGER #7	9/10/1954	53-67-5-SWSW	160	STK	Complete	HARRY J. BERGER		3	
P7328P	BERGER #11	9/5/1954	53-67-6-NENE	207	STK	Complete	HARRY J. BERGER		4	
P7331P	MINNIE BURGER #2	9/14/1958	53-67-6-SESW	125	STK	Complete	MINNIE B. BERGER		3	
P7329P	BERGER #12	9/10/1918	53-67-6-SWNE	140	DOM_GW; STK	Complete	HARRY J. BERGER		3	
P55055W	NORTH WELL #5	12/15/1980	53-67-7-NESE	130	STK	Complete	S. ELMO WESLEY	30	10	
P74302W	YARD #1	3/23/1987	53-67-7-NESE	200	DOM_GW; STK	Complete	JOHN H. & RONDI L. YARD	120	10	
P191679W	DM 34-7	10/12/2009	53-67-7-SESE	487	MON	Complete	STRATA ENERGY INC	84		X
P191680W	SA 34-7	10/12/2009	53-67-7-SESE	52	MON	Complete	STRATA ENERGY INC	21		X
P191681W	SM 34-7	10/12/2009	53-67-7-SESE	245	MON	Complete	STRATA ENERGY INC	55		X
P191682W	OZ 34-7	10/12/2009	53-67-7-SESE	379	MON	Complete	STRATA ENERGY INC	84		X
P41438W	MH #2	3/16/1977	53-67-7-SESE		MON	Cancelled	NUCLEAR DYNAMICS			X
P7326P	BERGER #9	5/15/1954	53-67-8-NENW	100	STK	Complete	HARRY J. BERGER		5	
P17466W	BERGER #13	12/15/1972	53-67-8-NWSE		DOM_GW; IRR_GW; STK	Cancelled	HARRY J. BERGER		250	
P103666W	WESLEY #1	9/3/1996	53-67-8-SWSW	160	DOM_GW; STK	Complete	VESTA LOUISA WESLEY	22	25	
P55053W	BARN WELL #3	12/15/1980	53-67-8-SWSW	60	STK	Complete	S. ELMO WESLEY	15	5	
P55054W	HOUSE WELL #4	12/15/1980	53-67-8-SWSW	90	STK	Complete	S. ELMO WESLEY	10	25	
P58895W	IMC OSHOTO MINE PIT "L"	5/12/1981	53-67-9-NWNE		MIS	Cancelled	INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	
P58896W	IMC OSHOTO MINE PIT "M"	5/12/1981	53-67-9-SENE		MIS	Cancelled	INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	
P58899W	IMC OSHOTO MINE PIT "P"	5/12/1981	53-67-9-SESW		MIS	Cancelled	INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	

Table 3.4-25. Groundwater Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Total Depth (ft)	Uses	Status	Appropriator	Depth to Water (ft)	Yield (gpm)	Within Project Area
P62157W	OSHOTO CHURCH #1	10/4/1982	53-67-9-SESW	120	MIS	Cancelled	OSHOTO COMMUNITY BIBLE CHURCH	60	12	
P76190W	OSHOTO CHURCH #1	1/11/1988	53-67-9-SESW	120	MIS	Fully Adjudicated	OSHOTO COMMUNITY BIBLE CHURCH	60	15	
P77982W	ENL OSHOTO CHURCH #1	9/13/1988	53-67-9-SESW	120	DOM_GW; STK	Complete	OSHOTO COMMUNITY BIBLE CHURCH	60		
P78287W	O C B C #2	10/12/1988	53-67-9-SESW	560	DOM_GW; MIS; STK	Unknown	OSHOTO COMMUNITY BIBLE CHURCH	18	11	
P618W	ROBINSON #1	9/29/1961	53-67-10-SWSW	415	IRR_GW; STK	Unknown	RAY W. ROBINSON	390	25	
P58901W	IMC OSHOTO MINE PIT "R"	5/12/1981	53-67-16-NWNE		MIS	Cancelled	WY BOARD OF LAND COMMISSIONERS** INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	
P58902W	IMC OSHOTO MINE PIT "S"	5/12/1981	53-67-16-SESE		MIS	Cancelled	INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	
P58903W	IMC OSHOTO MINE PIT "T"	5/12/1981	53-67-16-SWSE		MIS	Cancelled	WY BOARD OF LAND COMMISSIONERS** INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	
P58900W	IMC OSHOTO MINE PIT "Q"	5/12/1981	53-67-16-SWSW		MIS	Cancelled	WY BOARD OF LAND COMMISSIONERS** INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	
P7430P	EVANS #1	8/1/1966	53-67-17-NENW	150	DOM_GW; STK	Complete	DELL B. EVANS	100	4	
P7323P	BERGER #6	8/10/1949	53-67-17-NWSW	150	STK	Complete	HARRY J. BERGER	2	3	X
P7431P	EVANS #2	6/25/1955	53-67-17-SWNE	50	DOM_GW; STK	Complete	DELL B. EVANS	10	4	
P55052W	WINDMILL WELL #2	12/15/1980	53-67-18-NENE	128	STK	Complete	S. ELMO WESLEY	25	10	X
P41440W	MH #4	3/16/1977	53-67-18-NESW	560	MON	Abandoned	NUCLEAR DYNAMICS	83		X

Table 3.4-25. Groundwater Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Total Depth (ft)	Uses	Status	Appropriator	Depth to Water (ft)	Yield (gpm)	Within Project Area
P41439W	MH #3	3/16/1977	53-67-18-NWSE		MON	Cancelled	NUCLEAR DYNAMICS			X
P41436W	WELL #1	3/16/1977	53-67-18-SESW	536	IND_GW; MIS	Cancelled	NUCLEAR DYNAMICS	145	10	X
P41447W	RECOVERY WELL #1	11/18/1977	53-67-18-SESW	566	IND_GW	Cancelled	NUCLEAR DYNAMICS	113	15	X
P41448W	WELL #3	11/18/1977	53-67-18-SESW		MIS	Cancelled	NUCLEAR DYNAMICS		50	X
P41449W	TEST SET #1	11/18/1977	53-67-18-SESW	550	MON	Complete	NUCLEAR DYNAMICS	150		X
P67746W	789V STATE	5/11/1984	53-67-18-SESW	566	IND_GW	Unknown	DEADMAN CREEK UNIT	113	15	X
P67747W	19XX STATE	5/11/1984	53-67-18-SESW	536	IND_GW	Unknown	DEADMAN CREEK UNIT	145	10	X
P191683W	DM 12-18	10/12/2009	53-67-18-NWNW	632	MON	Complete	STRATA ENERGY INC	175		X
P191684W	SA 12-18	10/12/2009	53-67-18-SWNW	103	MON	Complete	STRATA ENERGY INC	50		X
P191685W	SM 12-18	10/12/2009	53-67-18-SWNW	352	MON	Complete	STRATA ENERGY	88		X
P191686W	OZ 12-18	10/12/2009	53-67-18-SWNW	584	MON	Complete	STRATA ENERGY	169		X
P192703W	OW1B60-1	3/24/2010	53-67-18-SWNW		MON	Incomplete	STRATA ENERGY			X
P192704W	OW1B58-1	3/24/2010	53-67-18-SWNW		MON	Incomplete	STRATA ENERGY			X
P192705W	OW1B57-1	3/24/2010	53-67-18-NWNW		MON	Incomplete	STRATA ENERGY			X
P50243W	Unknown	9/25/1979	53-67-18-SWNW	580	MON	Complete	WY BOARD OF LAND COMMISSIONERS**INC. NUCLEAR DYNAMICS	28		X
P50244W	PHASE II-2	9/25/1979	53-67-18-SWNW	434	MON	Complete	WY BOARD OF LAND COMMISSIONERS**INC. NUCLEAR DYNAMICS	28		X
P50245W	PHASE II-3	9/25/1979	53-67-18-SWNW	565	MON	Complete	WY BOARD OF LAND COMMISSIONERS**INC. NUCLEAR DYNAMICS	32		X
P50246W	PHASE II-4	9/25/1979	53-67-18-SWNW	575	MON	Complete	WY BOARD OF LAND COMMISSIONERS**INC. NUCLEAR DYNAMICS	26		X
P50247W	PHASE II-5	9/25/1979	53-67-18-SWNW	548	MON	Complete	WY BOARD OF LAND COMMISSIONERS**INC. NUCLEAR DYNAMICS	27		X
P191691W	DM 34-18	10/12/2009	53-67-18-SWSE	620	MON	Complete	STRATA ENERGY	268		X

Table 3.4-25. Groundwater Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Total Depth (ft)	Uses	Status	Appropriator	Depth to Water (ft)	Yield (gpm)	Within Project Area
P191692W	SA 34-18	10/12/2009	53-67-18-SWSE	70	MON	Complete	STRATA ENERGY INC	70		X
P191693W	SM 34-18	10/12/2009	53-67-18-SWSE	298	MON	Complete	STRATA ENERGY INC	136		X
P191694W	OZ 34-18	10/12/2009	53-67-18-SWSE	565	MON	Complete	STRATA ENERGY INC	277		X
P191687W	DM 14-18	10/12/2009	53-67-18-SWSW	585	MON	Complete	STRATA ENERGY	156		X
P191688W	SA 14-18	10/12/2009	53-67-18-NWSW	65	MON	Complete	STRATA ENERGY	22		X
P191689W	SM 14-18	10/12/2009	53-67-18-SWSW	327	MON	Complete	STRATA ENERGY	66		X
P191690W	OZ 14-18	10/12/2009	53-67-18-SWSW	529	MON	Complete	STRATA ENERGY	157		X
P191695W	DM 21-19	10/12/2009	53-67-19-NENW	565	MON	Complete	STRATA ENERGY INC	195		X
P191696W	SA 21-19	10/12/2009	53-67-19-NENW	30	MON	Complete	STRATA ENERGY INC	9		X
P191697W	SM 21-19	10/12/2009	53-67-19-NENW	315	MON	Complete	STRATA ENERGY INC	84		X
P191698W	OZ 21-19	10/12/2009	53-67-19-NENW	468	MON	Complete	STRATA ENERGY INC	215		X
P41441W	MH #5	3/16/1977	53-67-19-NESE		MON	Cancelled	NUCLEAR DYNAMICS			X
P191699W	DM 42-19	10/12/2009	53-67-19-SWNE	610	MON	Complete	STRATA ENERGY INC	285		X
P191700W	SA 42-19	10/12/2009	53-67-19-SWNE	108	MON	Complete	STRATA ENERGY INC	108		X
P191701W	SM 42-19	10/12/2009	53-67-19-SENE	290	MON	Complete	STRATA ENERGY INC	154		X
P50917W	22X-19	1/17/1980	53-67-19-SENW	750	IND_GW	Unknown	BURLINGTON NORTHERN INC.	150	20	X
P191702W	OZ 42-19	10/12/2009	53-67-19-SWNE	560	MON	Complete	STRATA ENERGY INC	299		X
P22582P	PRAIRIE DOG #1	2/7/1973	53-67-19-SWSW	150	STK	Complete	GRACE I. REYNOLDS	20	6	
P132537W	STRONG # 1	2/8/2001	53-67-20-NWNW	330	DOM_GW; STK	Complete	GEORGE / CAROL STRONG	27		
P645W	ROBINSON #3	10/3/1961	53-67-20-NWNW	120	DOM_GW; STK	Complete	RAY W. ROBINSON	70	20	
P78474W	ROBINSON #4	11/9/1988	53-67-20-NWNW	600	DOM_GW; STK	Complete	GEORGE & CAROL STRONG	40	2	
P7318P	BERGER #1	12/30/1943	53-67-22-NWNW	300	DOM_GW	Complete	HARRY J. BERGER		5	
P7320P	BERGER #3	8/5/1961	53-67-22-NWNW	434	STK	Complete	HARRY J. BERGER	6	4	
P619W	ROBINSON #2	9/29/1961	53-67-30-NENE	120	STK	Complete	RAY W. ROBINSON	90	25	

Table 3.4-25. Groundwater Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Total Depth (ft)	Uses	Status	Appropriator	Depth to Water (ft)	Yield (gpm)	Within Project Area
P72048W	KIEHL WATER WELL #2	2/6/1986	53-67-30-NWSE	720	IND_GW	Unknown	PETROLEUM, INC.	272	20	
P65808W	KIEHL WATER WELL #1	10/26/1983	53-67-30-SESE		IND_GW	Unknown	PETROLEUM, INC.		50	
P70181W	KIEHL WATER WELL #1	11/19/1984	53-67-30-SESE	662	IND_GW	Unknown	PETROLEUM, INC.	220	30	
P72004W	KIEHL WATER WELL #1	2/24/1986	53-67-30-SESE	662	STK	Complete	PETROLEUM**ANTONE SWANDA	220	25	
P75737W	ENL KIEHL WATER WELL #1	10/5/1987	53-67-30-SESE	662	MIS	Unknown	PETROLEUM, INC.	220		
P22585P	REYNOLDS #2	2/7/1973	53-67-30-SESW	286	STK	Complete	GRACE I. REYNOLDS	100	2	
P84615W	KIEHL WATER WELL #3	3/11/1991	53-67-30-SESW		IND_GW	Cancelled	PETROLEUM, INC.		50	
P58905W	IMC OSHOTO MINE PIT "V"	5/12/1981	53-67-33-SWNW		MIS	Cancelled	INTERNATIONAL MINERALS & CHEMICAL CORPORATION		1200	
P17177W	BLATT #1	12/12/1972	53-68-1-NENW	180	STK	Complete	PHILENA M. BLATT		1	
P23418P	KOKESH #1	12/31/1952	53-68-1-SWSW	150	STK	Complete	GRACE ZIMMERSCHIED		1	
P71108W	GOODLAD #2	9/10/1985	53-68-2-SENE	220	STK	Complete	PHILENA BLATT	100	15	
P50113W	GOODLAD WELL #3	9/27/1979	53-68-2-SWNE	40	STK	Complete	HAROLD BURCH**PHILENA BALTT	8	5	
P84665W	GOODLAD #3	3/25/1991	53-68-2-SWNW	50	STK	Complete	PHILENA BLATT	20	5	
P23421P	WOODS E. #1	12/31/1943	53-68-10-NENE	189	STK	Complete	GRACE E. ZIMMERSCHIED	90	3	
P148750W	Z-1	1/8/2003	53-68-10-SESE	410	STK	Complete	GRACE ZIMMERSCHIED	200	8	
P146029W	EVERETT NO 1	7/25/2002	53-68-11-NESW	260	STK	Complete	GRACE ZIMMERSCHIED	120	3	
P23422P	WOODS WM. #3	12/31/1955	53-68-11-NWNE	150	STK	Complete	GRACE ZIMMERSCHIED		1	
P192896W	WESLEY 2010	5/4/2010	53-68-12-SESE		STK	Incomplete	T J WESLEY		25	X
P41437W	MH #1	3/16/1977	53-68-12-SESE		MON	Cancelled	NUCLEAR DYNAMICS			X
P68906W	MOREL #14	11/5/1984	53-68-13-SESW		STK	Cancelled	GERALD M. MOREL		25	
P42868W	BESS #1	4/17/1978	53-68-14-NWSE	243	DOM_GW; STK	Complete	JAMES & BESSIE HAHN	100	15	
P72178W	SOPHIA #1A	9/9/1985	53-68-14-SESW	1011	IND_GW	Unknown	FANCHER OIL COMPANY	250	8	

Table 3.4-25. Groundwater Rights within 2 Miles of Proposed Project Area (Continued)

Permit #	Facility Name	Priority Date	Location (Tns-Rng-Sec-¼¼)	Total Depth (ft)	Uses	Status	Appropriator	Depth to Water (ft)	Yield (gpm)	Within Project Area
P72542W	ENL SOPHIA 1A	5/13/1986	53-68-14-SESW	1011	IND_GW	Unknown	FANCHER OIL COMPANY	250		
P144030W	TOWER #2	4/23/2002	53-68-23-SESW	401	DOM_GW; STK	Complete	ANTONE SWANDA	200	12	
P41442W	MH #6	3/16/1977	53-68-24-NESE		MON	Cancelled	NUCLEAR DYNAMICS			
P99263W	REYNOLDS #2	5/22/1995	53-68-24-NESE	100	DOM_GW	Complete	DAVID A. OR BETTY J. REYNOLDS	60	10	
P50883W	MOREL #4	1/11/1980	53-68-24-NWNE	150	STK	Complete	GERALD M. MOREL	50	25	X
P21128P	KOTTRABA #5	12/31/1955	53-68-24-SESW	140	STK	Complete	CHARLES & ALTA KOTTRABA	60	8	
P21129P	KOTTRABA #6	12/31/1953	53-68-24-SWSW	200	STK	Complete	CHARLES & ALTA KOTTRABA	100	8	
P150688W	TOWER #3	5/2/2003	53-68-25-NESW	460	DOM_GW; STK	Complete	ANTONE SWANDA	205	10	
P21126P	KOTTRABA #3	12/31/1951	53-68-25-NWSW	140	DOM_GW; STK	Complete	CHARLES & ALTA KOTTRABA	60	3	
P21127P	KOTTRABA #4	12/31/1933	53-68-25-NWSW	140	STK	Complete	CHARLES & ALTA KOTTRABA	60	3	
P22584P	REYNOLDS #1	2/7/1973	53-68-25-SESE	386	DOM_GW; STK	Complete	GRACE I. REYNOLDS	100	10	
P21130P	KOTTRABA #7	12/31/1948	53-68-26-SWNE	250	STK	Complete	CHARLES & ALTA KOTTRABA	100	8	
P74677W	WSW #1 WEST KIEHL UNIT	4/27/1987	53-68-36-NWNE	997	IND_GW	Unknown	PACIFIC ENTERPRISES OIL CO (USA)	460	21	
Unknown	DWWELL01	Unknown	53-67-17-SENW		DOM_GW	Unknown	DALE WOOD	Unknown		
Unknown	HBWELL06	Unknown	53-67-22-NWNW		DOM_GW	Unknown	HARRY BERGER	Unknown		
Unknown	SBWELL01	Unknown	53-68-2-SWNE		STK	Unknown	STORMY BURCH	Unknown		
Unknown	SBWELL02	Unknown	53-68-1-NESE		STK	Unknown	STORMY BURCH	Unknown		

Uses:		
	DOM_GW	Domestic
	IRR_GW	Irrigation
	MIS	Miscellaneous
	IND_GW	Industrial
	MON	Monitoring

Source: WSEO (2010)

Table 3.4-26. Regional Lance-Fox Hills Water Quality

Parameter	**Unit**	**Median Concentration[1]**
pH	s.u.	8.4
TDS	mg/L	1,130
Hardness	mg/L as $CaCO_3$	16
Calcium	mg/L	6
Magnesium	mg/L	1
Sodium	mg/L	432
Bicarbonate	mg/L	803
Chloride	mg/L	34
Sulfate	mg/L	162

[1] USGS 2010b

Table 3.4-27. Regional Baseline Monitor Wells

Well ID	WSEO Permit	Northing[1] (ft)	Easting[1] (ft)	Completion Zone	Ground Surface Elevation (ft amsl)	Top of Casing Elevation (ft amsl)	Total Depth (ft)	Screen Interval (ft bgs)
12-18DM	P191683W	1487549	709191	DM	4188.4	4189.2	640	612 - 632
12-18OZ	P191686W	1487518	709154	OZ	4186.5	4187.9	600	474 - 584
12-18SM	P191685W	1487516	709224	SM	4185.9	4187.1	470	342 - 352
12-18SA	P191684W	1487482	709185	SA	4184.8	4185.8	115	63 - 103
14-18DM	P191687W	1484876	710013	DM	4154.8	4156.0	600	570 - 585
14-18OZ	P191690W	1484910	709972	OZ	4155.1	4156.3	530	499 - 529
14-18SM	P191689W	1484918	710044	SM	4154.9	4156.2	331	282 - 327
14-18SA	P191688W	1484950	710006	SA	4155.6	4156.8	70	35 - 65
21-19DM	P191695W	1483249	710642	DM	4168.6	4169.9	580	550 - 565
21-19OZ	P191698W	1483283	710613	OZ	4167.0	4168.3	470	433 - 468
21-19SM	P191697W	1483289	170685	SM	4169.6	4170.7	330	282 - 327
21-19SA	P191696W	1489326	710648	SA	4167.4	4169.0	40	20 - 30
34-7DM	P191679W	1489669	713334	DM	4133.8	4135.3	550	471 - 486
34-7OZ	P191682W	1489623	713271	OZ	4134.9	4136.8	382	321 - 376
34-7SM	P191681W	1489636	713363	SM	4133.6	4134.9	245	210 - 245
34-7SA	P191680W	1483603	71333	SA	4134.2	4135.4	60	42 - 52
34-18DM	P191691W	1483748	712430	DM	4247.0	4248.3	640	600 - 620
34-18OZ	P191694W	1483785	712397	OZ	4246.0	4247.5	570	460 - 565
34-18SM	P191693W	1483780	712468	SM	4246.7	4247.8	307	278 - 298
34-18SA	P191692W	1487816	712431	SA	4246.1	4247.5	80	50 - 70
42-19DM	P191699W	1481210	713075	DM	4283.2	4284.4	620	600 - 610
42-19OZ	P191702W	148127	713038	OZ	4281.1	4282.5	570	470 - 560
42-19SM	P191701W	148249	713109	SM	4284.8	4286.1	300	260 - 290
42-19SA	P191700W	1481283	713073	SA	4283.3	4284.2	115	97 - 107

[1] Coordinate system: Wyoming East State Plane NAD 83 U.S. Feet

Table 3.4-28. Regional Baseline Monitoring Network General Water Quality

Well Zone	Major Ion Chemistry	TDS (mg/L)
SA	Sodium bicarbonate	370 – 1,230
SM	Sodium bicarbonate-sulfate	830 – 1,330
OZ	Sodium sulfate-bicarbonate	1,140 – 2,070
DM	Sodium chloride	870 – 1,900

Table 3.4-29. Cluster Well Water Quality

Parameter	Units	Zone			
		SA	SM	OZ	DM
Field					
Field conductivity	µmhos/cm	725 - 2030	1436 - 3360	1654 - 3660	1525 - 4000
Field pH	s.u.	7.9 - 10.3	9.0 - 12.8	8.4 - 9.4	9.3 - 12.9
Field turbidity	NTUs	0.1 - 99.4	0.1 - 40.2	0 - 154	2 - 122
Depth to water	ft	10.6 - 50.9	56.1 - 155.7	84.0 - 303.9	85.3 - 287.9
Temperature	Deg C	9.3 - 20.2	10.2 - 18.4	10.1 - 14.4	10.5 - 21.7
ORP	millivolts	-185 - 193	-200 - 220	-233 - 257	-221 - 83
Dissolved oxygen	mg/L	1.7 - 6.1	0.8 - 8.2	0.9 - 6.7	1.1 - 7.9
General					
Alkalinity (as CaCO3)	mg/L	151 - 531	282 - 658	471 - 568	336 - 547
Ammonia	mg/L	<0.1 - 0.5	<0.1 - 2.8	0.2 - 0.8	0.2 - 3.9
Fluoride	mg/L	0.1 - 0.5	0.9 - 2.1	0.3 - 1.2	0.9 - 1.6
Laboratory conductivity	µmhos/cm	554 - 1860	1420 - 2240	1640 - 2810	1600 - 3220
Laboratory pH	s.u.	8.1 - 10	8.7 - 11.6	8.4 - 9	9 - 11.7
Nitrate/nitrite	mg/L	<0.1 - 1.1	<0.1	<0.1 - 0.3	<0.1
Total dissolved solids	mg/L	370 - 1230	830 - 1330	1140 - 2070	870 - 1900
Major Ions					
Calcium	mg/L	2 - 46	<1 - 3	4 - 9	1 - 8
Magnesium	mg/L	<1 - 33	<1 - 1	1 - 3	<1 - 2
Potassium	mg/L	7 - 22	5 - 47	4 - 17	10 - 48
Sodium	mg/L	84 - 400	275 - 451	368 - 644	302 - 722
Bicarbonate	mg/L	84 - 572	<5 - 682	478 - 662	<5 - 426
Carbonate	mg/L	<5 - 193	25 - 250	8 - 52	49 - 312
Chloride	mg/L	2 - 86	2 - 8	3 - 10	139 - 818
Sulfate	mg/L	91 - 343	179 - 414	295 - 937	<1 - 146
Metals					
Aluminum, dissolved	mg/L	<0.1	<0.1 - 0.2	<0.1 - 0.5	<0.1 - 0.6
Arsenic, dissolved	mg/L	<0.005	<0.005 - 0.023	<0.005	<0.005 - 0.014
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	<0.1 - 0.3	0.2 - 0.6	0.3 - 0.6	0.3 - 1
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01 - 0.02	<0.01	<0.01
Iron, dissolved	mg/L	<0.05 - 0.18	<0.05	<0.05 - 0.69	<0.05 - 0.21
Iron, total	mg/L	<0.05 - 5.68	<0.05 - 0.8	<0.05 - 3.38	<0.05 - 10.2
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	<0.02 - 0.36	<0.02 - 0.03	<0.02 - 0.06	<0.02 - 0.15
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02 - 0.06	<0.02 - 0.05	<0.02	<0.02 - 0.06
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005	<0.005	<0.005 - 0.009	<0.005 - 0.023
Silver, dissolved	mg/L	<0.003 - 0.006	<0.003 - 0.004	<0.003	<0.003
Uranium, dissolved	mg/L	<0.001 - 0.007	<0.001 - 0.004	0.005 - 0.109	<0.001 - 0.003
Uranium, suspended	mg/L	<0.001	<0.001	<0.001 - 0.003	<0.001 - 0.001
Vanadium, dissolved	mg/L	<0.02	<0.02 - 0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01 - 1.32	<0.01 - 0.03	<0.01 - 0.02	<0.01 - 0.09
Radiological					
Lead 210, dissolved	pCi/L	<1	<1 - 1.34	<1 - 4.89	<1 - 1.16
Lead 210, suspended	pCi/L	<1	<1	<1 - 32.2	<1 - 1.25
Polonium 210, dissolved	pCi/L	<1	<1	<1 - 22.9	<1
Polonium 210, suspended	pCi/L	<1	<1	<1 - 35	<1
Ra-226, dissolved	pCi/L	<0.2 - 0.5	<0.2 - 0.24	0.71 - 12.01	<0.2 - 0.4

Table 3.4-29. Cluster Well Water Quality (Continued)

Parameter	Units	Zone			
		SA	**SM**	**OZ**	**DM**
Ra-226, suspended	pCi/L	<0.2 - 0.24	<0.2 - 0.28	<0.2 - 4.24	<0.2 - 0.5
Ra-228, dissolved	pCi/L	<1 - 1.2	<1 - 2.27	<1	<1 - 1.56
Radon-222	pCi/L	NM	<28 - 443	4580 - 35100	<25-242
Th-230, dissolved	pCi/L	<0.2	<0.2	<0.2	<0.2 - 0.24
Th-230, suspended	pCi/L	<0.2	<0.2	<0.2 - 0.95	<0.2 - 0.325
Gross alpha	pCi/L	<2 - 13.8	<2 - 12.2	15.4 - 222	<2 - 28.3
Gross beta	pCi/L	5.3 - 15.8	<3 - 42.5	4.2 - 43.2	6.6 - 41

Table 3.4-30. Comparison of Probable WDEQ Classes of Use

Zone	Probable WDEQ Groundwater Class	Suitability
SA	II or III	Irrigation or livestock
SM	III	Livestock
OZ	IV	Industrial
DM	III	Livestock

Table 3.4-31. SA Zone Monitoring Results

Parameter	Units	12-18SA				14-18SA				21-19SA				34-7SA				34-18SA				42-19SA			
		1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10
Field																									
Field Conductivity	μmhos/cm	811	945	725	942	1791	1909	1834	2030	973	863	984	1084	1229	1325	1294	1348								
Field pH	s.u.	9.65	8.3	9.97	8.03	9.93	8.81	8.6	8.27	8.08	8.44	7.9	8.22	9.7	9.57	9.38	10.3								
Field turbidity	NTUs	4.94	74.9	6.08	8.54	0.49	0.61	0.1	3.29	0.27	99.4	1.47	13.07	0.66	0.6	0.37	6.67								
Depth to Water	ft	50.87	48.03	47.69	48	23.32	22.78	22.93	23.79	10.56	10.82	11.02	11.52	22.62	22.92	22.06	22.33	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Temperature	Deg C	11.8	13.9	20.2	17.6	10.6	12.4	12.7	16	10.2	9.3	13.3	19.6	10.4	12.8	15.9	18.7								
ORP	millivolts		-118	180	-185		-103	132	-122			162	-67		63	152	193								
Dissolved oxygen	mg/L	6.14		1.82	2.01	3.5		1.74	2.46	4.69		4.33	2.87	3.35		3.63	3.1								
Dissolved oxygen, pct	%	57.4		20.6	21.7	31.8		18.1	26	42.2		43.4	29.3	30.3		41.2	36.8								
General																									
Alkalinity (as CaCO3)	mg/L	201	303	151	290	453	471	463	478	374	374	367	399	497	511	531	506								
Ammonia	mg/L	0.4	0.3	0.5	0.4	<0.1	<0.1	0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4								
Fluoride	mg/L	0.2	0.2	0.1	0.2	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.5	0.5	0.4	0.4								
Laboratory conductivity	μmhos/cm	729	829	554	835	1690	1750	1800	1860	911	937	968	974	1160	1200	1270	1190								
Laboratory pH	s.u.	9.2	8.4	9.8	8.2	9.3	8.6	8.5	8.4	8.2	8.2	8.1	8.2	9.1	9.1	9.1	10								
Nitrate/Nitrite	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.1	<0.1	1	0.3	<0.1	<0.1	<0.1	<0.1								
Total Dissolved Solids	mg/L	500	550	370	490	1160	1230	1200	1220	620	640	620	610	770	810	820	690								
Major Ions																									
Calcium	mg/L	20	43	3	46	14	17	18	22	31	26	36	30	2	2	2	3								
Magnesium	mg/L	22	31	13	33	8	9	10	12	13	11	15	13	<1	1	2	2								
Potassium	mg/L	22	16	20	16	17	11	11	13	7	9	7	8	10	11	11	13								
Sodium	mg/L	101	97	89	84	393	361	391	400	160	171	165	177	274	266	299	259								
Bicarbonate	mg/L	172	352	84	354	368	526	544	572	456	456	447	487	484	516	513	223								
Carbonate	mg/L	36	8	49	<5	91	24	10	5	<5	<5	<5	<5	60	53	66	193								
Chloride	mg/L	12	12	24	11	80	86	68	67	19	17	18	17	3	3	2	2								
Sulfate	mg/L	163	142	94	130	314	343	315	327	112	107	118	91	134	133	137	98								
Metals																									
Aluminum, dissolved	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1								
Arsenic, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005								
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5								
Boron, dissolved	mg/L	<0.1	<0.1	<0.1	<0.1	0.2	0.2	0.2	0.2	<0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.2								
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002								
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01								
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01								
Iron, dissolved	mg/L	<0.05	<0.05	<0.05	0.18	<0.05	<0.05	0.09	<0.05	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05								
Iron, total	mg/L	0.33	0.34	0.42	0.37	0.1	0.14	0.14	0.15	0.08	5.68	0.16	0.37	<0.05	<0.05	<0.05	0.15								
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02								
Manganese, total	mg/L	0.04	0.06	0.03	0.08	0.02	0.04	0.04	0.07	0.19	0.36	0.18	0.2	<0.02	<0.02	<0.02	<0.02								
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Molybdenum, dissolved	mg/L	0.06	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02								
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01								
Selenium, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005								
Silver, dissolved	mg/L			0.006	<0.003			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003								
Uranium, dissolved	mg/L	0.003	<0.001	<0.001	<0.001	0.007	0.007	0.007	0.007	0.007	0.004	0.006	0.005	<0.001	<0.001	<0.001	<0.001								
Uranium, suspended	mg/L		<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001									
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02								
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.02	1.32	0.09	<0.01	<0.01	<0.01	<0.01	<0.01								
Radiological																									
Lead 210, dissolved	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1									
Lead 210, suspended	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1									
Polonium 210, dissolved	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1									
Polonium 210, suspended	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1									
Ra-226, dissolved	pCi/L	0.28	0.24	0.2	0.4	<0.2	0.27	0.26	0.5	0.41	0.24	0.23	0.3	<0.2	<0.2	<0.2	<0.2								
Ra-226, suspended	pCi/L		0.24	<0.2			<0.2	<0.2			0.24	<0.2			<0.2	<0.2									
Ra-228, Dissolved	pCi/L	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	1.2	<1	<1	<1	<1								
Radon-222	pCi/L																								
Th-230, dissolved	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2									
Th-230, suspended	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2									
Gross Alpha	pCi/L	<2	2.7	<2	4	5.1	7.4	7.33	13.8	6.5	6.4	6.16	6.7	<2	3.8	2.65	2.4								
Gross Beta	pCi/L	15.8	13	13.5	11.2	12.1	5.9	5.99	7.9	7.4	10	6.99	5.3	7.6	7.7	7.27	7.1								
QA/QC																									
Anion Sum	meq/L	7.73	9.33	5.66	8.83	17.86	19.01	17.76	18.26	10.36	10.18	10.3	10.35	12.82	13.09	13.55	12.24								
Cation Sum	meq/L	7.75	9.31	5.6	9.03	18.86	17.57	19.02	19.84	9.73	9.9	10.35	10.46	12.27	12	13.53	11.88								
Total Anion/Cation Balance	%	0.13	0.1	0.52	1.13	2.72	3.93	3.42	4.15	3.12	1.43	0.25	0.5	2.19	4.3	0.07	1.46								
Total Dissolved Solids (calc)	mg/L	460	520	330	490	1100	1110	1090	1130	570	570	580	580	720	720	770	680								

Table 3.4-32. SA Zone Comparison with WDEQ Class of Use Standards

Well ID	Probable WDEQ Class of Use	Parameters Exceeding Class I Standards[1]	Parameters Exceeding Class II Standards[1]
12-18SA	II	TDS, manganese	
14-18SA	III	TDS, sulfate, manganese	Sulfate
21-19SA	III	TDS, manganese	Manganese
34-7SA	II	TDS	
34-18SA	Dry		
42-19SA	Dry		

[1] pH and iron were not compared to class of use standards since these constituents are easily treatable

Table 3.4-33. SA Zone Comparison with EPA Standards

Well ID	Parameters Exceeding EPA Primary MCLs	Parameters Exceeding EPA Secondary MCLs[1]
12-18SA		TDS, manganese
14-18SA		TDS, sulfate, manganese
21-19SA		TDS, manganese
34-7SA		TDS
34-18SA		
42-19SA		

[1] EPA designates secondary standards as non-enforceable contaminants that may cause cosmetic or aesthetic effects in drinking water

Table 3.4-34. SM Zone Monitoring Results

Parameter	Units	12-18SM				14-18SM				21-19SM				34-7SM				34-18SM				42-19SM			
		1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10
Field																									
Field Conductivity	µmhos/cm	1487	1436	1657	1642	1569	1548	1611	1781	1874	1719	2300	2190	1788	1595	2060	2080	3360	2610	2470	2040	1897	1452	1642	1839
Field pH	s.u.	9.25	9.22	9.06	8.98	9.56	9.64	9.31	9.17	10.17	9.97	9.97	9.85	9.82	9.79	9.23	9.04	12.82	12.61	11.98	10.91	12.34	12.24	10.78	10.69
Field turbidity	NTUs	1.99	0.54	0.84	0.57	2.53	0.6	0.09	0.05	4.06	0.12	2.61	0.49	19.97	3.14	2.11	1.93	7.06	5.79	3.92	6.19	40.2	5.39	6.39	2.93
Depth to Water	ft	88.89	90.88	91.21	91.12	66.87	66.72	66.72	66.9	85.07	84.88	84.9	85.18	56.73	56.13	56.11	56.18	136.25	136.19	136.18	136.11	155.65	155.57	155.64	155.55
Temperature	Deg C	11	11.8	13.9	13.3	10.8	11.2	11.9	11.6	10.2	11.5	13	12.4	10.6	12.1	13.1	12.8	10.5	18.4	14.1	11.6	10.8	12	16.3	15.4
ORP	millivolts		-190	-10	26			-200	131		36	160	137		152	177	174		68	147	-166		34	188	220
Dissolved oxygen	mg/L		0.75	6.36	5.16	2.39	1.04	2.44	5.61	1.66	1.98	4.28	3.77	2.63	4.09	6.84	5.38	1.55	8.15	v	7.37	3.3	1.78	4.95	7.06
Dissolved oxygen, pct	%	32.1	16.9	63.4	53	21.3	10.2	22.8	51.6	15	18.7	42.9	35.6	23.1	39.3	69	53.4	14	85.2	v	69.5	30.2	18.2	54.3	73.8
General																									
Alkalinity (as CaCO3)	mg/L	531	528	532	534	551	556	581	582	572	602	647	633	595	628	647	658	521	486	484	458	420	282	303	319
Ammonia	mg/L	<0.1	<0.1	0.2	0.4	<0.1	<0.1	0.1	0.2	<0.1	0.2	1.1	0.6	<0.1	0.2	0.2	0.5	1.9	1.4	1.2	1	2.8	1.4	1.2	0.8
Fluoride	mg/L	2.1	1.7	1.9	2.1	1.6	1.5	1.6	1.5	1	1	1.1	1.1	0.9	1	0.9	0.9	1.4	1.3	1.2	0.9	1.6	1.5	1.5	1.4
Laboratory conductivity	µmhos/cm	1420	1440	1430	1450	1480	1520	1560	1560	1770	1970	2000	1960	1650	1840	1800	1830	2240	2190	2070	1800	1690	1540	1580	1620
Laboratory pH	s.u.	8.8	8.8	8.7	8.8	9.2	9.1	8.9	9	9.6	9.3	9.9	9.6	9.4	9	9	8.9	11.6	11.5	11.4	10.5	11.5	10.8	10.6	10.3
Nitrate/Nitrite	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Dissolved Solids	mg/L	970	980	980	970	1020	1040	1010	1000	1270	1330	1310	1300	1150	1200	1240	1260	1040	1100	1060	1140	830	970	990	1040
Major Ions																									
Calcium	mg/L	3	3	3	3	2	2	2	2	2	2	1	1	1	2	2	2	2	1	1	<1	3	1	1	1
Magnesium	mg/L	1	1	1	1	<1	<1	1	1	<1	<1	<1	<1	<1	1	1	1	<1	<1	<1	<1	<1	<1	<1	<1
Potassium	mg/L	8	5	6	6	6	8	7	8	32	31	47	37	14	13	10	10	31	28	26	20	17	11	10	11
Sodium	mg/L	341	328	354	371	350	352	373	360	426	439	451	447	426	417	426	431	359	342	360	383	275	325	342	323
Bicarbonate	mg/L	577	578	598	573	526	566	603	599	399	532	347	491	508	631	674	682	<5	<5	<5	51	<5	<5	12	64
Carbonate	mg/L	35	33	25	38	72	55	52	54	146	99	218	138	107	66	57	60	168	173	189	250	137	152	175	160
Chloride	mg/L	5	3	3	4	4	3	2	2	3	8	3	2	4	7	3	3	6	5	4	3	7	5	4	4
Sulfate	mg/L	236	218	212	216	232	241	238	230	383	396	336	335	312	312	298	300	293	295	304	367	179	405	371	414
Metals																									
Aluminum, dissolved	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.1	<0.1	<0.1
Arsenic, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	0.012	0.009	0.007	0.005	0.023	0.009	0.009	0.006	0.016	0.011	0.009	0.008	0.009	0.011	0.012	<0.005	0.007	<0.005	<0.005	<0.005
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.6	0.2	0.5	0.6	0.6	0.4	0.5	0.6	0.6	0.2	0.2	0.3	0.4	0.3	0.4	0.4	0.4
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron, total	mg/L	0.09	0.06	0.07	0.06	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.8	0.11	0.08	0.06	0.07	0.12	0.11	0.07	0.66	0.11	0.16	<0.05
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	0.02	0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	0.03	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Silver, dissolved	mg/L			0.004	<0.003			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003			0.004	<0.003			<0.003	<0.003
Uranium, dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.003	0.004	0.003	<0.001	0.001	0.002	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium, suspended	mg/L		<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001	
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Radiological																									
Lead 210, dissolved	pCi/L		<1	<1			<1	<1			<1	<1			1.34	<1			<1	<1			<1	<1	
Lead 210, suspended	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1			<1	<1			<1	<1	
Polonium 210, dissolved	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1			<1	<1			<1	<1	
Polonium 210, suspended	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1			<1	<1			<1	<1	
Ra-226, dissolved	pCi/L	<0.2	0.24	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.21	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	0.21	<0.2
Ra-226, suspended	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			0.28	<0.2			<0.2	<0.2			<0.2	<0.2	
Ra-228, Dissolved	pCi/L	<1	<1	<1	2.27	<1	1.29	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Radon-222	pCi/L	309				300				353				443				35				<28			
Th-230, dissolved	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Th-230, suspended	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Gross Alpha	pCi/L	<2	2.1	<2	<2	2.8	3.1	<3.5	11.2	3.1	5.4	6.6	12.2	4.7	6.2	4.1	10.1	<2	<2	<3.5	<2	<2	<2	2.78	2.8
Gross Beta	pCi/L	3.3	<6.8	<3	9.4	7.2	7	<6.8	12.4	22.2	19	29.8	42.5	8.7	10.3	5.8	9.7	18.7	17.3	16.5	11	10.8	6.8	6.9	6
QA/QC																									
Anion Sum	meq/L	15.76	15.29	15.23	15.38	16.03	16.29	16.71	16.56	19.54	20.55	20.06	19.75	18.55	19.3	19.26	19.51	16.74	16.08	16.19	16.93	12.41	14.28	13.97	15.18
Cation Sum	meq/L	15.26	14.67	15.77	16.5	15.48	15.6	16.61	16.02	19.45	19.97	20.88	20.43	18.95	18.64	18.98	19.2	16.48	15.66	16.4	17.16	12.53	14.49	15.18	14.41
Total Anion/Cation Balance	%	1.62	2.07	1.73	3.5	1.75	2.14	0.3	1.63	0.23	1.44	1.98	1.69	1.05	1.72	0.74	0.8	0.79	1.32	0.63	0.67	0.47	0.74	4.13	2.58
Total Dissolved Solids (calc)	mg/L	910	880	900	920	920	940	970	950	1190	1240	1230	1200	1110	1130	1130	1140	1000	960	990	1050	730	920	910	950

Table 3.4-35. SM Zone Comparison with WDEQ Class of Use Standards

Well ID	Probable WDEQ Class of Use	Parameters Exceeding Class I Standards[1]	Parameters Exceeding Class II Standards[1]
12-18SM	III	TDS	Sulfate
14-18SM	III	TDS	Sulfate
21-19SM	III	Ammonia, TDS, sulfate	Sulfate
34-7SM	III	TDS, sulfate	Sulfate
34-18SM	III	Ammonia, TDS, sulfate	Sulfate
42-19SM	III	Ammonia, TDS, sulfate	Sulfate

[1] pH and iron were not compared to class of use standards since these constituents are easily treatable

Table 3.4-36. SM Zone Comparison with EPA Standards

Well ID	Parameters Exceeding Primary MCLs	Parameters Exceeding Secondary MCLs[1]
12-18SM		Fluoride, TDS
14-18SM	Arsenic	TDS
21-19SM	Arsenic	TDS, sulfate
34-7SM	Arsenic	TDS, sulfate
34-18SM	Arsenic	TDS, sulfate
42-19SM		TDS, sulfate, aluminum

[1] EPA designates secondary standards as non-enforceable contaminants that may cause cosmetic or aesthetic effects in drinking water

Table 3.4-37. OZ Zone Monitoring Results

Parameter	Units	12-18OZ				14-18OZ				21-19OZ				34-7OZ				34-18OZ				42-19OZ			
		1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10
Field																									
Field Conductivity	µmhos/cm	1812	1654	2400	1934	3630	3660	3080	3070	3020	2630	2560	2620	2980	1992	2880	2430	2830	1930	2540	2510	2830	1876	2810	2410
Field pH	s.u.	8.99	9.02	8.56	8.44	9.42	9.07	8.77	8.75	9.11	8.99	8.78	8.6	9.2	9.29	8.77	8.85	9.39	9.18	8.77	8.62	9.12	9.14	8.97	8.5
Field turbidity	NTUs	1.18	0.97	0.23	0.13	154	25	1.61	14.08	9.07	1.3	0	1.04	2.94	0.8	0.93	0.21	45.8	3.26	0.15	1.57	4.41	2.43	0.7	0.5
Depth to Water	ft	169.93	169.79	170.74	169.31	158.1	155.17	155.4	152.45	216.63	218.18	214.35	208.04	85.54	84.88	84.94	84.02	278.31	282.71	279.99	278.2	299.9	303.94	301.31	300.62
Temperature	Deg C	11.1	12.4	13.8	14	11.1	14	12.7	11.9	10.6	12.1	12.6	12.5	10.1	11.6	12.5	11.6	10.4	12.7	13.2	13.2	10.9	12.1	13	14.4
ORP	millivolts		95	168	77			-45	16		94	76	-31		106	104	195		102	-233	-62		112	119	257
Dissolved oxygen	mg/L		1.83	2.71	6.11	1.93	1.44	2.76	2.89	2.31	2.52	1.73	2.55	4.26	3.77	1.43	3.75	2.4	2.47	2.21	3.26	2.29	6.65	0.94	2.6
Dissolved oxygen, pct	%	26.4	18.3	28.2	62.2	17.7	13.9	27	26.9	23	24.7	16.8	25.9	38.6	35.4	13.4	34	22	23.8	21.5	31.8	21.2	70	8.9	26.2
General																									
Alkalinity (as CaCO3)	mg/L	531	541	533	545	471	493	520	518	529	520	529	535	532	522	556	568	496	485	497	504	477	474	480	480
Ammonia	mg/L	0.3	0.2	0.4	0.6	0.4	0.5	0.6	0.6	0.3	0.5	0.4	0.5	0.4	0.5	0.5	0.8	0.4	0.4	0.4	0.7	0.3	0.3	0.5	0.4
Fluoride	mg/L	1.1	1.2	0.9	1.2	0.5	0.4	0.5	0.4	0.5	0.5	0.5	0.4	0.4	0.5	0.4	0.4	0.6	0.6	0.5	0.6	0.3	0.3	0.3	0.3
Laboratory conductivity	µmhos/cm	1900	1640	2160	1700	2620	2810	2780	2730	2190	2370	2280	2300	2130	2290	2250	2190	2070	2220	2260	2230	2080	1850	2200	2130
Laboratory pH	s.u.	8.6	8.6	8.6	8.7	8.9	8.6	8.6	8.6	8.7	8.6	8.5	8.6	8.7	8.7	8.4	8.8	9	8.7	8.4	8.7	8.6	8.8	8.7	8.7
Nitrate/Nitrite	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	<0.1
Total Dissolved Solids	mg/L	1340	1140	1490	1140	2020	2070	1980	1930	1600	1670	1620	1590	1590	1590	1640	1550	1530	1560	1620	1560	1500	1520	1650	1500
Major Ions																									
Calcium	mg/L	6	4	7	4	5	7	8	9	6	7	7	7	4	5	6	6	4	6	6	6	6	6	6	7
Magnesium	mg/L	2	1	2	1	2	3	3	3	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	3
Potassium	mg/L	5	4	4	4	17	11	7	6	5	6	5	6	7	12	5	8	8	6	5	6	6	6	5	7
Sodium	mg/L	438	416	516	368	624	639	644	600	537	531	574	516	533	520	546	512	542	486	557	481	499	532	547	541
Bicarbonate	mg/L	607	624	603	601	478	556	591	593	586	603	609	615	590	587	662	624	499	540	591	559	539	519	543	533
Carbonate	mg/L	20	18	24	31	48	23	21	19	29	16	18	19	29	24	8	34	52	26	8	28	21	29	21	26
Chloride	mg/L	7	4	6	4	10	10	10	9	7	9	8	7	5	5	4	4	8	8	8	6	5	4	3	3
Sulfate	mg/L	480	295	543	320	897	859	937	826	634	678	667	605	590	644	563	512	606	670	593	578	638	640	595	600
Metals																									
Aluminum, dissolved	mg/L	<0.1	<0.1	<0.1	<0.1	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	0.5	0.6	0.5	0.5	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.3	0.3	0.3	0.3
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	<0.05	<0.05	<0.05	<0.05	0.69	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron, total	mg/L	0.07	<0.05	<0.05	<0.05	3.38	0.33	0.1	0.52	0.18	0.07	<0.05	<0.05	0.09	0.1	<0.05	<0.05	1.02	0.1	<0.05	<0.05	0.11	0.05	<0.05	<0.05
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	<0.02	<0.02	<0.02	<0.02	0.06	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	0.009	<0.005	<0.005	<0.005	<0.005
Silver, dissolved	mg/L			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003
Uranium, dissolved	mg/L	0.07	0.033	0.069	0.033	0.096	0.109	0.109	0.085	0.017	0.008	0.024	0.005	0.041	0.038	0.044	0.028	0.062	0.059	0.046	0.041	0.011	0.01	0.01	0.009
Uranium, suspended	mg/L		<0.001	<0.001			<0.001	0.003			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001	
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Radiological																									
Lead 210, dissolved	pCi/L		4.83	4.89			<1	1.79			<1	1.35			1.17	<1			1.88	3.02			<1	1.4	
Lead 210, suspended	pCi/L		1.7	1.87			1.18	1.04			<1	32.2			1.94	1.44			3.88	1.66			1.35	1.86	
Polonium 210, dissolved	pCi/L		22.9	22.2			1.79	5.04			<1	3.74			<1	<1			4.77	8.73			<1	<1	
Polonium 210, suspended	pCi/L		35	17.2			1.05	<1			<1	25.4			<1	<1			13.38	6.93			<1	<1	
Ra-226, dissolved	pCi/L	8.16	5	12.01	5.8	2.31	3.74	4.03	4.9	0.89	0.93	0.71	0.8	1.38	0.94	2.35	1.5	5.97	9.06	9.68	8.8	1.38	1.36	1.46	1.4
Ra-226, suspended	pCi/L		<0.2	<0.2			0.28	4.24			<0.2	<0.2			<0.2	<0.2			0.49	<0.2			<0.2	<0.2	
Ra-228, Dissolved	pCi/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Radon-222	pCi/L	32900				13500				4580				5900				35100				6460			
Th-230, dissolved	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Th-230, suspended	pCi/L		<0.2	<0.2			<0.2	0.95			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Gross Alpha	pCi/L	222	157.5	177	93.9	173	191	165.3	183	33.5	19	47.7	18.4	69.1	46.1	56.8	48.1	175.7	111.1	76	93.8	19.4	15.4	18.7	19.6
Gross Beta	pCi/L	26.5	24.1	43.2	21.7	40.2	37.6	39.6	27.6	9.2	9.1	17.1	7.1	16.6	18.3	13.3	9.6	43.1	35.2	23.9	26.7	4.2	9.8	8.54	13.4
QA/QC																									
Anion Sum	meq/L	20.87	17.14	22.17	17.74	28.41	28.05	30.21	27.83	24.01	24.8	24.72	23.51	23.09	24.02	22.98	22.15	22.76	23.91	22.55	22.3	22.96	22.93	22.09	22.2
Cation Sum	meq/L	19.59	18.5	23.06	16.39	27.94	28.63	28.83	26.96	23.95	23.76	25.6	23.13	23.74	23.31	24.42	22.95	24.13	21.75	24.88	21.58	22.37	23.78	24.4	24.22
Total Anion/Cation Balance	%	3.17	3.82	1.96	3.95	0.83	1.02	2.34	1.57	0.11	2.14	1.75	0.81	1.38	1.48	3.04	1.78	2.92	4.72	4.92	1.64	1.29	1.81	4.96	4.34
Total Dissolved Solids (calc)	mg/L	1260	1050	1400	1030	1840	1820	1920	1760	1510	1550	1580	1460	1460	1500	1460	1380	1470	1470	1470	1380	1440	1470	1450	1450

Table 3.4-38. OZ Zone Comparison with WDEQ Class of Use Standards

Well ID	Probable WDEQ Class of Use	Parameters Exceeding Class I Standards[1]	Parameters Exceeding Class II Standards[1]	Parameters Exceeding Class III Standards[1]
12-18OZ	IV	Ammonia, TDS, sulfate, radium-226 & 228, gross alpha	Sulfate, radium 226- & 228, gross alpha	Radium-226 & 228, gross alpha
14-18OZ	IV	Ammonia, TDS, sulfate, manganese, gross alpha	TDS, sulfate, gross alpha	Gross alpha
21-19OZ	IV	TDS, sulfate, gross alpha	Sulfate, gross alpha	Gross alpha
34-7OZ	IV	Ammonia, TDS, sulfate, gross alpha	Sulfate, gross alpha	Gross alpha
34-18OZ	IV	Ammonia, TDS, sulfate, radium-226 & 228, gross alpha	Sulfate, radium-226 & 228, gross alpha	Radium-226 & 228, gross alpha
42-19OZ	IV	TDS, sulfate, gross alpha	Sulfate, gross alpha	Gross alpha

[1] pH and iron were not compared to class of use standards since these constituents are easily treatable

Table 3.4-39. OZ Zone Comparison with EPA Standards

Well ID	Parameters Exceeding Primary MCLs	Parameters Exceeding Secondary MCLs[1]
12-18OZ	Uranium, radium-226 & 228, gross alpha	TDS, sulfate
14-18OZ	Uranium, gross alpha	TDS, sulfate, aluminum, manganese
21-19OZ	Gross alpha	TDS, sulfate
34-7OZ	Uranium, gross alpha	TDS, sulfate
34-18OZ	Uranium, radium-226 & 228, gross alpha	TDS, sulfate
42-19OZ	Gross alpha	TDS, sulfate

[1] EPA designates secondary standards as non-enforceable contaminants that may cause cosmetic or aesthetic effects in drinking water

Table 3.4-40. DM Zone Monitoring Results

Parameter	Units	12-18DM				14-18DM				21-19DM				34-7DM				34-18DM				42-19DM			
		1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10	1Q10	2Q10	3Q10	4Q10
Field																									
Field Conductivity	μmhos/cm	3400	3080	2420	2420	2800	2860	2370	2410	2760	1874	2420	2390	4000	3370	3470	3430	3380	1779	2240	2540	2890	1525	1970	2260
Field pH	s.u.	12.64	12.23	10.2	9.85	10.57	10.06	9.48	9.32	10.32	10.01	9.3	9.31	10.85	10.92	10.52	10.24	12.91	10.9	10.32	9.29	12.66	11.49	9.71	9.47
Field turbidity	NTUs	21.7	6.54	3.35	2.43	122	31.2	14.03	3.31	32.4	35.4	5.02	4.2	45.2	48.9	60	69.6	23.3	5.29	2.02	2	6.99	31.2	11.67	2.26
Depth to Water	ft	175.99	175.54	176.08	175.91	157.17	156.65	158.16	156.48	196.48	196.09	196.39	196.12	85.33	87.81	89.04	89.42	269.85	272.57	272.64	273.63	286.01	286.32	287.28	287.9
Temperature	Deg C	10.5	12.4	16.3	15.9	11.5	12.1	13.7	12.6	10.8	14	14	14.8	11.6	13.7	15.7	14.3	11.2	15.9	13.8	14.7	10.9	21.7	16	14.5
ORP	millivolts		-221	-23	-106			-95	10		83	-140	14.8		49	-28	21		77	14	-70		21	-42	-11
Dissolved oxygen	mg/L	5.08	1.14	6.69	6.55	2.72	1.97	6.03	5.91	2.8	4.26	2.58	6.76	7.66	7.77	6.7	7.92	3.9	5.42	1.6	1.18	1.86		6.73	7.32
Dissolved oxygen, pct	%	48.5	10.9	70.2	67.8	25.1	18.6	59.3	55.7	25.2	42.6	26.7	66.2	76	74.9	67.9	77.8	36	57.4	16.1	12	17.4		71.5	74.8
General																									
Alkalinity (as CaCO3)	mg/L	466	415	418	411	439	422	416	422	408	413	429	431	463	449	547	447	498	336	360	427	481	352	386	443
Ammonia	mg/L	2.4	1.4	0.9	0.6	0.6	0.4	0.5	0.5	0.6	0.5	0.2	0.9	0.8	1.8	2.4	1.5	3.9	0.9	1.8	0.6	2.5	2.1	0.6	0.4
Fluoride	mg/L	1	0.9	1	1.2	1.1	1.1	1.2	1.1	1.2	1.1	1.2	1.2	0.9	1.1	0.9	0.9	1.2	1.1	1.2	1	1.2	1.6	1.4	1.4
Laboratory conductivity	μmhos/cm	2400	2290	2150	2180	2030	2170	2190	2150	2000	2150	2130	2170	2740	3080	3220	3100	2170	2040	1980	2210	2000	1600	1920	2040
Laboratory pH	s.u.	11.5	11.2	10	9.7	10	9.5	9	9.2	9.7	9.4	9.2	9.1	10	10.1	10.8	9.9	11.7	10	10	9.3	11.5	10.9	9.6	9.3
Nitrate/Nitrite	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Dissolved Solids	mg/L	1140	1190	1260	1240	1220	1260	1220	1240	1200	1250	1240	1250	1600	1760	1900	1860	870	1160	1110	1300	940	960	1080	1170
Major Ions																									
Calcium	mg/L	8	3	1	1	2	2	3	3	2	3	3	3	3	2	3	2	4	2	2	2	5	4	2	2
Magnesium	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Potassium	mg/L	39	31	23	16	34	22	15	13	23	21	17	14	32	23	36	22	44	21	21	15	48	27	11	10
Sodium	mg/L	427	405	470	476	460	447	468	454	463	522	467	449	686	722	688	645	302	473	405	452	315	369	390	480
Bicarbonate	mg/L	<5	<5	159	256	188	337	399	391	246	338	398	426	168	143	<5	208	<5	133	134	374	<5	<5	282	389
Carbonate	mg/L	171	200	172	121	171	87	54	61	124	82	62	49	195	199	312	166	128	137	150	72	160	195	93	74
Chloride	mg/L	376	362	395	402	449	392	437	438	473	535	425	438	699	818	539	640	139	523	371	422	182	326	345	385
Sulfate	mg/L	30	37	29	28	23	4	1	<1	11	4	2	<1	75	71	146	123	29	12	15	6	42	30	9	7
Metals																									
Aluminum, dissolved	mg/L	0.6	0.5	0.3	0.1	0.2	<0.1	<0.1	<0.1	0.2	0.2	<0.1	<0.1	<0.1	0.5	0.1	<0.1	0.4	<0.1	<0.1	<0.1	0.4	0.2	<0.1	<0.1
Arsenic, dissolved	mg/L	0.007	0.008	0.007	0.005	0.008	0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	0.014	0.009	0.008	0.007	0.007	0.007	0.008	<0.005	0.01	0.01	0.006	<0.005
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	0.4	0.5	0.7	0.7	0.6	0.7	0.8	0.9	0.7	0.8	0.8	0.9	0.8	0.9	0.8	1	0.3	0.5	0.6	0.8	0.4	0.5	0.7	0.8
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	<0.05	<0.05	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	0.06	0.1	<0.05	<0.05	<0.05	0.21	0.08	0.1	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron, total	mg/L	0.15	0.06	0.05	<0.05	2.92	0.72	0.33	0.15	0.73	0.87	0.17	0.09	1.02	1.81	10.2	2.22	0.39	0.11	0.29	<0.05	0.21	0.36	0.31	<0.05
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	<0.02	<0.02	<0.02	<0.02	0.05	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	0.15	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	0.06	0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	0.02	0.02	<0.02	0.06	0.03	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	0.012	0.017	0.013	0.008	0.014	0.012	0.012	0.01	0.014	0.014	0.009	0.013	0.017	0.023	0.016	0.014	0.008	0.009	0.006	0.01	0.008	<0.005	0.012	0.01
Silver, dissolved	mg/L			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003			<0.003	<0.003
Uranium, dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium, suspended	mg/L		<0.001	<0.001			0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001			<0.001	<0.001	
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.02	0.01	0.02	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.09	0.02	<0.01	0.04	0.04	<0.01	0.04	0.02
Radiological																									
Lead 210, dissolved	pCi/L		<1	<1			1.1	<1			1.16	<1			<1	<1			<1	<1			<1	<1	
Lead 210, suspended	pCi/L		<1	<1			<1	<1			1.25	<1			<1	1			<1	<1			<1	<1	
Polonium 210, dissolved	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1			<1	<1			<1	<1	
Polonium 210, suspended	pCi/L		<1	<1			<1	<1			<1	<1			<1	<1			<1	<1			<1	<1	
Ra-226, dissolved	pCi/L	0.28	0.22	<0.2	0.4	0.35	0.21	<0.2	0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2
Ra-226, suspended	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	0.5			<0.2	<0.2			<0.2	<0.2	
Ra-228, Dissolved	pCi/L	<1	<1	<1	<1	<1	<1	<1	1.56	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Radon-222	pCi/L	242				156								<25				<29				<28			
Th-230, dissolved	pCi/L		<0.2	<0.2			<0.2	<0.2			0.24	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	<0.2	
Th-230, suspended	pCi/L		<0.2	<0.2			<0.2	<0.2			<0.2	<0.2			<0.2	0.325			<0.2	<0.2			<0.2	<0.2	
Gross Alpha	pCi/L	4.7	3.2	<2	<2	13.7	2.1	<3.1	28.3	<2	2.3	3.53	4.5	3.5	4.4	20	10.5	<2	<2	<3.5	3.1	<2	<2	<3.5	<2
Gross Beta	pCi/L	24.1	18.8	12	11.8	32.3	17.2	8.24	41	16.2	13	8.33	9.2	19.4	10.5	28	16.3	32.6	13.1	10.1	6.6	34.3	19.7	<6.8	8.9
QA/QC																									
Anion Sum	meq/L	20.6	19.32	20.15	20.19	21.98	19.65	20.74	20.84	21.8	23.5	20.66	21.03	30.57	33.57	29.22	29.61	14.56	21.77	18.03	20.62	15.69	16.94	17.72	19.95
Cation Sum	meq/L	19.97	18.51	21.07	21.14	21	20.14	20.89	20.2	20.83	23.4	20.87	20.03	30.93	32.08	31.01	28.7	14.47	21.21	18.22	20.15	15.18	16.94	17.36	21.22
Total Anion/Cation Balance	%	1.54	2.14	2.25	2.3	2.28	1.22	0.36	1.55	2.26	0.21	0.49	2.43	0.57	2.27	2.96	1.54	0.29	1.29	0.52	1.17	1.64	0.01	1.03	3.09
Total Dissolved Solids (calc)	mg/L	1160	1090	1170	1170	1230	1120	1170	1160	1220	1330	1170	1160	1770	1900	1740	1700	820	1230	1030	1150	880	970	990	1150

Table 3.4-41. DM Zone Comparison with WDEQ Class of Use Standards

Well ID	Probable WDEQ Class of Use	Parameters Exceeding Class I Standards[1]	Parameters Exceeding Class II Standards[1]	Parameters Exceeding Class III Standards[1]
12-18DM	III	Ammonia, TDS, chloride	Chloride	
14-18DM	III-IV	Ammonia, TDS, chloride, boron, gross alpha	Chloride, boron, gross alpha	Gross alpha
21-19DM	III	Ammonia, TDS, chloride, boron	Chloride, boron	
34-7DM	III-IV	Ammonia, TDS, chloride, boron, manganese, gross alpha	Chloride, boron, selenium, gross alpha	Gross alpha
34-18DM	III	Ammonia, TDS, chloride, boron	Chloride, boron	
42-19DM	III	Ammonia, TDS, chloride, boron	Chloride, boron	

[1] pH and iron were not compared to class of use standards since these constituents are easily treatable

Table 3.4-42. DM Zone Comparison with EPA Standards

Well ID	Parameters Exceeding Primary MCLs	Parameters Exceeding Secondary MCLs[1]
12-18DM		TDS, chloride, aluminum
14-18DM	Gross alpha	TDS, chloride, aluminum
21-19DM		TDS, chloride, aluminum
34-7DM	Arsenic, gross alpha	TDS, chloride, aluminum, manganese
34-18DM		TDS, chloride, aluminum
42-19DM		TDS, chloride, aluminum

[1] EPA designates secondary standards as non-enforceable contaminants that may cause cosmetic or aesthetic effects in drinking water

Table 3.4-43. Plant Area Piezometer Monitoring Results

Parameter	Units	SA43-18-1			SA43-18-2			SA43-18-3			SA13-17-1		
		2Q10	3Q10	4Q10	2Q10	3Q10	4Q10	2Q10	3Q10	4Q10	2Q10	3Q10	4Q10
Field													
Field Conductivity	µmhos/cm	7490	7540	7580		8550	5630	867	814	754			
Field pH	s.u.	7.96	7.85	7.77		7.78	7.79	8.16	7.78	7.89			
Field turbidity	NTUs	881	457	604		883	>1000	>1000	52.6	210			
Depth to Water	ft	20.88	20.82	20.64	10.22	11.02	12.38	13.03	14.75	16.1	DRY	DRY	DRY
Temperature	Deg C	9.9	10.2	9.1		10	10	9	13.3	9.1			
ORP	millivolts			223			141	83		255			
Dissolved oxygen	mg/L			6.03			5.71			2.67			
Dissolved oxygen, pct	%			53			51.2			24.9			
General													
Alkalinity (as CaCO3)	mg/L	450	453	456		589	549	369	342	310			
Ammonia	mg/L	<0.1	0.2	0.4		0.2	<0.1	<0.1	<0.1	<0.1			
Fluoride	mg/L	0.3	0.3	0.1		0.6	0.3	0.7	0.9	0.6			
Laboratory conductivity	µmhos/cm	6840	7050	6810		7850	5080	761	708	632			
Laboratory pH	s.u.	7.9	8	8.2		8	8.3	8.4	8.1	8.4			
Nitrate/Nitrite	mg/L	2.2	2.3	2.1		10.5	4.5	0.4	0.4	0.5			
Total Dissolved Solids	mg/L	6600	6520	6400		7280	4190	510	430	420			
Major Ions													
Calcium	mg/L	337	339	327		325	155	21	18	20			
Magnesium	mg/L	162	181	173		264	110	13	12	12			
Potassium	mg/L	27	26	28		52	35	4	4	4			
Sodium	mg/L	1180	1330	1270		1500	908	152	133	115			
Bicarbonate	mg/L	549	553	556		719	670	435	417	370			
Carbonate	mg/L	<5	<5	<5		<5	<5	7	<5	<5			
Chloride	mg/L	53	60	53		270	134	1	<1	1			
Sulfate	mg/L	3270	4190	3960		3950	2100	65	53	45			
Metals													
Aluminum, dissolved	mg/L	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	<0.1	<0.1			
Arsenic, dissolved	mg/L	0.005	<0.005	<0.005		<0.005	0.006	<0.005	<0.005	<0.005			
Barium, dissolved	mg/L	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5			
Boron, dissolved	mg/L	0.2	0.3	<0.1		<0.1	<0.1	0.1	0.1	<0.1			
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002		<0.002	<0.002	<0.002	<0.002	<0.002			
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01			
Copper, dissolved	mg/L	<0.01	0.01	<0.01		0.02	<0.01	<0.01	<0.01	<0.01			
Iron, dissolved	mg/L	<0.05	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05	<0.05			
Iron, total	mg/L	19.7	4.52	24.3		19	39.8	24.6	0.8	4.67			
Lead, dissolved	mg/L	<0.02	<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02			
Manganese, total	mg/L	0.95	0.37	0.9		0.54	1.1	0.45	0.05	0.13			
Mercury	mg/L	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001			
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02			
Nickel, dissolved	mg/L	<0.01	0.02	0.01		0.02	0.01	<0.01	<0.01	<0.01			
Selenium, dissolved	mg/L	0.057	0.05	0.053		0.955	0.402	<0.005	<0.005	<0.005			
Silver, dissolved	mg/L		<0.003	<0.003		<0.003	<0.003		<0.003	<0.003			
Uranium, dissolved	mg/L	0.062	0.064	0.063		0.264	0.146	0.013	0.011	0.01			
Uranium, suspended	mg/L	0.003	<0.001			<0.001			<0.001				
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02			
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01			
Radiological													
Lead 210, dissolved	pCi/L	<1	<1			<1			<1				
Lead 210, suspended	pCi/L	1.98	4.1			2.33			3.81				
Polonium 210, dissolved	pCi/L	<1	<1			<1			<1				
Polonium 210, suspended	pCi/L	<1	2.09			<1			<1				
Ra-226, dissolved	pCi/L	0.53	0.3	0.7		0.45	0.5	<0.2	<0.2	<0.2			
Ra-226, suspended	pCi/L	3.45	<0.2			0.86			<0.2				
Ra-228, Dissolved	pCi/L	<1	<1	<1		<1	2.5	<1	<1	2.2			
Radon-222	pCi/L												
Th-230, dissolved	pCi/L	<0.2	<0.2			<0.2			<0.2				
Th-230, suspended	pCi/L	1.64	<0.2			<0.2			<0.2				
Gross Alpha	pCi/L	66	81.7	83.7		218	115	17	8.44	18			
Gross Beta	pCi/L	40	63.3	46.6		137	83.7	12.5	6.49	15.5			
QA/QC													
Anion Sum	meq/L	78.72	98.09	93.12		101.64	58.44	8.79	8.01	7.2			
Cation Sum	meq/L	82.07	90.21	86.65		104.54	57.16	8.89	7.76	7.07			
Total Anion/Cation Balance	%	2.08	4.18	3.59		1.4	1.1	0.55	1.56	0.88			
Total Dissolved Solids (calc)	mg/L	5300	6400	6090		6710	3770	480	430	380			

No sample collected at SA43-18-2 during 2Q10, well dry when drilled and allowed to purge and develop prior to sample collection in 3Q10.

Table 3.4-44. Sampled Water Supply Wells

Well ID	WSEO Permit	Total Depth (ft)	Use	Legal Location (Tns-Rng-Sec-¼¼)	3Q09	4Q09	1Q10	2Q10	3Q10	4Q10
19XX18	P67747W	536	IND_GW	53-67-18-SESW	**X**	**X**	**X**	**X**	**X**	**X**
22X-19	P50917W	750	IND_GW	53-67-19-SENW	1	1	**X**	**X**	**X**	**X**
CSWELL01	P132537W	330	DOM_GW; STK	53-67-20-NWNW	**X**	**X**	**X**	**X**	**X**	**X**
CSWELL03	P619W	120	STK	53-67-30-NENE	2	**X**	3	**X**	**X**	**X**
DWWELL01	Unknown	Unknown	DOM_GW	53-67-17-SWNW	**X**	**X**	**X**	**X**	**X**	**X**
HBWELL01	P7328P	207	STK	53-67-6-NENE	**X**	4	4	4	4	4
HBWELL03	P7324P	160	STK	53-67-5-SWSW	**X**	1	**X**	**X**	**X**	**X**
HBWELL04	P7326P	100	STK	53-67-8-NENW	**X**	1	**X**	**X**	**X**	2
HBWELL05	P7430P	150	DOM_GW; STK	53-67-8-SESW	**X**	1	**X**	**X**	**X**	**X**
HBWELL06	Unknown	Unknown	DOM_GW; STK	53-67-22-NWNW	1	1	**X**	4	4	4
P144030W	P144030W	401	DOM_GW; STK	53-68-23-SESW	1	1	1	1	**X**	4
P17177W	P17177W	180	STK	53-68-1-SENW	**X**	**X**	4	4	**X**	**X**
P21128P	P21129P	200	STK	53-68-24-SESW	1	1	1	**X**	**X**	**X**
P22582P	P22582P	150	STK	53-67-19-SWSW	1	**X**	2	2	2	**X**
P31770W	P31770W	600	DOM_GW	52-67-6-SENW	**X**	**X**	**X**	4	4	4
P42868W	P42868W	243	DOM_GW; STK	53-68-14-NWSE	**X**	1	5	1	1	1
P50113W	P50113W	40	STK	53-68-2-SWNE	**X**	**X**	4	4	**X**	**X**
P50883W	P50883W	150	STK		1	1	1	1	**X**	**X**
P61006W	P61006W	335	DOM_GW; STK	53-68-15-NWSW	**X**	4	4	4	4	4
P61007W	P61007W	304	STK	53-68-15-NWSW	**X**	4	4	4	4	4
P71108W	P71108W	220	STK	53-68-2-SENE	**X**	**X**	4	**X**	**X**	6
P78287W	P78287W	560	DOM_GW; STK; MIS	53-67-9-SESW	**X**	4	4	4	4	4
P84665W	P84665W	50	STK	53-68-2-NWNW	**X**	4	4	4	**X**	**X**
SBWELL01	Unknown	Unknown	STK	53-68-2-SWNE	**X**	**X**	4	**X**	**X**	**X**
SBWELL02	Unknown	Unknown	STK	53-68-1-NESE	2	2	2	**X**	**X**	**X**
TSWELL01	Unknown	Unknown	DOM_GW	53-68-8-SESE	1	**X**	4	4	4	4
TW01	P74302W	200	DOM_GW; STK	53-67-7-NESE	**X**	7	**X**	**X**	**X**	**X**
TW02	P103666W	160	DOM_GW; STK	53-67-8-SWSW	**X**	**X**	**X**	**X**	**X**	**X**
TWWELL03	P192896W	Unknown	STK	53-68-12-SESE	8	8	8	8	**X**	**X**

Notes:

X – Sample collected

1-7 – No sample collected due to:

1 – No landowner permission
2 – Well not functioning
3 – Well winterized – not operational
4 – Well outside GW sampling area (established in January 2010)
5 – Well dry or frozen
6 – Landowner request
7 – No access
8 – Well constructed August 2010

Table 3.4-45. Industrial Well Water Quality

Parameter	Units	19XX18	22X-19
Field			
Field conductivity	umhos/cm	2790-3120	1987-2720
Field pH	s.u.	8.5-8.8	8.9-9.0
Field turbidity	NTUs	0.3-2.1	0.2-2.9
Temperature	Deg C	8.7-14.2	10.4-13.1
Dissolved oxygen	mg/L	4.0-7.5	1.2-1.6
General			
Alkalinity (as CaCO3)	mg/L	521-659	462-472
Ammonia	mg/L	<0.1-0.2	0.3-0.5
Fluoride	mg/L	0.5-0.6	0.6-0.7
Laboratory conductivity	umhos/cm	2320-2410	1840-2080
Laboratory pH	s.u.	8.5-8.6	8.6-8.7
Nitrate/nitrite	mg/L	0.1-0.5	<0.1
Total dissolved solids	mg/L	1660-1790	1420-1520
Major Ions			
Calcium	mg/L	7-8	5-6
Magnesium	mg/L	2-3	2
Potassium	mg/L	4-5	4-5
Sodium	mg/L	499-655	444-507
Bicarbonate	mg/L	605-770	520-547
Carbonate	mg/L	15-27	13-26
Chloride	mg/L	6-8	10-13
Sulfate	mg/L	616-685	511-538
Metals			
Aluminum, dissolved	mg/L	<0.1	<0.1
Arsenic, dissolved	mg/L	<0.005	<0.005
Barium, dissolved	mg/L	<0.5	<0.5
Boron, dissolved	mg/L	0.4	0.4
Cadmium, dissolved	mg/L	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01
Iron, dissolved	mg/L	<0.05	<0.05-0.06
Iron, total	mg/L	<0.05-0.14	<0.05-0.07
Lead, dissolved	mg/L	<0.02	<0.02
Manganese, total	mg/L	<0.02	<0.02
Mercury, dissolved	mg/L	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005	<0.005
Silver, dissolved	mg/L	<0.003	<0.003
Uranium, dissolved	mg/L	0.074	0.02-0.022
Uranium, suspended	mg/L	<0.001	<0.001
Vanadium, dissolved	mg/L	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01
Radiological			
Lead 210, dissolved	pCi/L	2.41-6.13	<1
Lead 210, suspended	pCi/L	1.43-2.8	1.21-1.46
Polonium 210, dissolved	pCi/L	<1-6.4	<1
Polonium 210, suspended	pCi/L	3.91-5.9	<1-1.12
Ra-226, dissolved	pCi/L	37.3-47.23	3.05-3.38
Ra-226, suspended	pCi/L	0.28-0.31	<0.2
Ra-228, dissolved	pCi/L	<1-1.65	<1-1.4
Radon-222	pCi/L	18000	9100
Th-230, dissolved	pCi/L	<0.2	<0.2
Th-230, suspended	pCi/L	<0.2	<0.2
Gross Alpha	pCi/L	167.7-324	38.5-47.9
Gross Beta	pCi/L	39.7-81.4	7.3-12.3

Table 3.4-46. Stock Well Monitoring Results

Parameter	Units	CSWELL03	HBWELL01	HBWELL03	HBWELL04	P17177W	P21128P	P22582P	P50113W	P50883W	P61007W	P71108W	P84665W	SBWELL01	SBWELL02	TWWELL03
Field																
Field Conductivity	µmhos/cm	599-682	706	1542-1862	1477-1761	794-998	964-1051	1026-1141	1440-1757	658-699	1065	1652-1940	804-983	1088-1263	789-1043	1381-1437
Field pH	s.u.	7.89-8.28	7.52	7.45-7.87	7.2-7.45	7.34-7.66	8.47-8.6	8.9-9.11	7.43-7.85	7.78-8.02	8.63	7.47-7.62	7.42-7.84	8.73-9.09	7.7-8.15	8.91-9.07
Field turbidity	NTUs	4.61-84.5		7.83-21.1	2.15-6.23	0.37-1.34	3.52-130	1.05-1.99	0.18-0.98	1.35-19.48	1.43	0.25-1.86	0.88-25	0.37-3.08	0.94-1.75	0.51-0.9
Depth to Water	ft		41.3													
Temperature	Deg C	10.4-11.6	11	8.3-11	6.6-10.2	8.3-10.1	11.2-12.1	8.7-10.5	8-9.5	10.5-11	12.5	10.5-13	9.2-11	9.9-14.4	10.4-10.8	10.9-11.5
Dissolved oxygen	mg/L	1.64-2.89		1.03-2.3	0.92-1.38	2.75-4	2.66-3.34	1.68	1.86-2.79	4.37-5.58		0.94-1.94	3.14-3.5	0.92-1.71	0.82-2.36	1.81-7.5
Dissolved oxygen, pct	%	15-26.4		9.4-20.4	8.2-11.3	24.1-35.2	24.4-30.4	15	15.4-24.1	39.3-51.5		8-18	28.3-30.7	8.3-15.7	7.7-21.1	16.7-67.6
General																
Alkalinity (as CaCO3)	mg/L	318-336	343	460-531	351-444	320-415	414-438	440-491	511-553	296-340	537	541-580	406-412	531-535	387-488	596-603
Ammonia	mg/L	<0.1-0.3	<0.1	<0.1-0.3	<0.1	<0.1	<0.1-0.1	<0.1-0.6	<0.1-0.5	<0.1-0.1	<0.1	<0.1	<0.1	<0.1-0.2	<0.1-0.2	<0.1-0.2
Fluoride	mg/L	0.1-0.2	0.1	0.2	0.2	<0.1-0.1	0.1-0.2	0.6-0.9	0.2-0.3	0.2	0.2	0.2	0.1	<0.1-0.1	<0.1-0.2	1.3-1.5
Laboratory conductivity	µmhos/cm	543-654	732	1520-1800	1620-1740	822-923	956-973	972-1120	1500-1840	588-686	1170	1660-2190	922-952	1130-1170	735-1010	1440-1490
Laboratory pH	s.u.	8.1-8.4	8	8-8.2	7.8-8	7.8-8	8.4-8.5	8.6-8.7	8-8.1	8.1-8.2	8.8	7.9-8.1	8-8.1	8.6-8.7	8.1-8.3	8.7-8.8
Nitrate/Nitrite	mg/L	<0.1	1.6	<0.1	0.9-1.2	20-22.4	1.1-1.6	<0.1	23.9-44.9	0.1-0.2	<0.1	0.2-0.6	0.9-2.4	<0.1	<0.1-0.4	<0.1
Total Dissolved Solids	mg/L	370-430	440	1140-1370	1370-1420	530-610	620-640	610-730	1060-1320	370-430	720	1160-1610	590-650	740-770	480-650	970-1000
Oil and Grease	mg/L															
Total Petroleum Hydrocarbons	mg/L															
Major Ions																
Calcium	mg/L	28-38	63	79-106	195-203	100-117	13-20	6-12	94-120	33-44	3	65-76	74-81	1-2	19-39	2-3
Magnesium	mg/L	15-20	47	44-56	58-64	27-31	7-11	3-6	52-67	16-20	1	66-98	36-37	<1	11-26	1-2
Potassium	mg/L	9	14	14-20	7	5	15-20	4-5	6-7	6-7	3	9	5-6	2-3	12-16	4-7
Sodium	mg/L	74-97	26	178-275	117-141	38-39	185-207	234-277	162-208	81	293	230-381	75-83	268-313	98-205	360-374
Bicarbonate	mg/L	379-410	419	561-648	429-542	391-507	491-514	500-536	624-675	361-414	591	660-707	495-503	592-609	472-595	657-664
Carbonate	mg/L	<5	<5	<5	<5	<5	7-13	18-31	<5	<5	32	<5	<5	20-30	<5	35
Chloride	mg/L	3-4	6	8-15	12-17	17-21	2-3	2-4	36-63	3	<1	4-7	6-8	<1-1	<1-1	2
Sulfate	mg/L	28-32	53	402-540	583-654	40-46	91-96	85-112	172-259	39-44	83	377-679	98-107	94-102	37-78	195-201
Metals																
Aluminum, dissolved	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1-0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	0.006-0.007	<0.005	<0.005
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	<0.1	<0.1	0.1-0.2	<0.1	<0.1	<0.1	0.2-0.3	<0.1	<0.1	0.2	<0.1-0.1	<0.1	<0.1-0.1	0.1-0.2	0.5-0.6
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	0.16-0.83	0.21	0.55-4.14	<0.05	<0.05	<0.05-0.1	<0.05-0.07	<0.05	0.07-0.09	<0.05	<0.05	<0.05-0.07	<0.05	0.06-0.2	<0.05
Iron, total	mg/L	1.3-3.94	0.8	2.33-7.22	0.07-0.95	<0.05-0.11	0.13-16.5	0.11-0.22	<0.05	0.23-1.6	0.17	<0.05-0.07	0.07-3.75	<0.05	0.12-0.61	<0.05
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	0.08-0.34	<0.02	0.15-0.9	0.07-0.08	<0.02	<0.02-0.51	<0.02	0.07-0.44	0.02-0.05	<0.02	0.18-0.25	<0.02-0.05	<0.02	0.04-0.05	<0.02
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005-0.006	0.006	<0.005	<0.005	<0.005-0.005	0.103-0.165	<0.005	0.026-0.05	<0.005	<0.005	0.007-0.026	<0.005-0.009	<0.005	<0.005	<0.005
Silver, dissolved	mg/L	<0.003		<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003		<0.003	<0.003	<0.003	<0.003	<0.003
Uranium, dissolved	mg/L	<0.001-0.001	0.01	0.002-0.006	0.033-0.034	0.022-0.024	0.271-0.388	<0.001-0.003	0.173-0.212	0.025-0.028	0.001	0.064-0.113	0.056	<0.001-0.002	<0.001-0.005	<0.001
Uranium, suspended	mg/L	<0.001		<0.001	<0.001	<0.001	0.002-0.004		<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01-0.01	0.18	<0.01-0.25	0.03-0.05	<0.01	<0.01	<0.01	<0.01	0.04-0.07	<0.01	0.02-0.03	0.08	<0.01	<0.01	<0.01
Radiological																
Lead 210, dissolved	pCi/L	<1		<1	<1	<1	1.76-17.4		2.1	<1		<1	<1	<1-1.04	<1	<1
Lead 210, suspended	pCi/L	<1		<1-1.21	<1-1.8	<1	1.26-1.8		<1	<1		<1	<1	<1-1.5	<1-1.11	<1
Polonium 210, dissolved	pCi/L	<1		<1	<1	<1	<1		<1	<1		<1	<1	<1	<1	<1
Polonium 210, suspended	pCi/L	<1		<1	<1	<1	<1		<1	<1		<1	<1	<1	<1	<1
Ra-226, dissolved	pCi/L	0.3-0.4	0.27	0.77-1.03	0.28-0.52	<0.2-0.3	0.21-0.3	<0.2	0.2-0.6	<0.2-7.7	<0.2	<0.2-0.9	0.3-0.4	<0.2	<0.2-0.21	<0.2
Ra-226, suspended	pCi/L	<0.2		0.32-0.5	<0.2-0.59	<0.2	0.7-0.91		<0.2	<0.2		<0.2	<0.2	<0.2-0.7	<0.2-7	<0.2
Ra-228, Dissolved	pCi/L	<1	<1	<1-1.2	<1	<1	<1	<1-2.59	<1	<1-1.27	<1	<1-1.6	<1	<1	<1-1.22	<1
Radon-222	pCi/L				1600											
Th-230, dissolved	pCi/L	<0.2		<0.2	<0.2	<0.2	<0.58		<0.2	<0.2		<0.2	<0.2	<0.2	<0.2	<0.2
Th-230, suspended	pCi/L	<0.2		<0.2	<0.2	<0.2	0.209-0.49		<0.2	<0.2		<0.2	<0.2	<0.2	<0.2	<0.2
Gross Alpha	pCi/L	<2-5.53	5.8	7-10.1	12.1-23	12.1-19.5	178-239	2.7-2.8	78.6-100	15.4-16.9	2.3	37-59.2	26.7-37.3	<2-3.4	2.7-4.1	<3.1-6.7
Gross Beta	pCi/L	7.36-8.8	12.2	9.3-17.3	7.9-17.4	6.4-9.8	67.9-128	<3-4.1	37.3-40.7	6.4-10.1	<2	14.8-22.3	15.2-16.4	<3.7	7.6-12.3	<6.7-6.9
QA/QC																
Anion Sum	meq/L	7.05-7.47	8.24	17.83-21.51	19.75-22.92	9.26-9.89	10.36-10.8	10.72-12.25	17.03-20.39	6.82-7.8	12.47	18.97-25.99	10.4-10.86	12.64-12.8	8.56-11.41	16.12-16.39
Cation Sum	meq/L	6.78-7.33	8.46	17.32-20.83	19.72-21.56	9.03-10.12	10.19-11.34	11.34-12.69	16.27-20.7	6.64-7.5	13.08	19.46-28.63	10.08-10.74	11.81-13.76	8.62-11.07	16.01-16.65
Total Anion/Cation Balance	%	0.93-1.97	1.29	1.44-2.39	0.14-3.06	0.23-1.93	0.83-2.95	1.77-2.83	0.76-2.96	1.29-1.98	2.4	1.14-4.83	0.48-2.14	0.02-4.13	0.13-1.5	0.34-0.79
Total Dissolved Solids (calc)	mg/L	360-390	420	1030-1270	1190-1350	450-500	580-610	610-700	870-1060	360-400	710	1090-1600	540-570	690-730	450-620	570-950

Table 3.4-47. Stock Well Comparison with WDEQ Class of Use Standards

Well ID	Probable WDEQ Class of Use	Parameters Exceeding Class I Standards[1]	Parameters Exceeding Class II Standards[1]	Parameters Exceeding Class III Standards[1]
CSWELL03	III	Manganese	Manganese	
HBWELL01	I			
HBWELL03	III	TDS, sulfate, manganese	Sulfate, manganese	
HBWELL04	IV	TDS, sulfate, manganese, gross alpha	Sulfate, gross alpha	Gross alpha
P17177W	IV	TDS, gross alpha	Gross alpha	Gross alpha
P21128P	IV	TDS, manganese, selenium, gross alpha	Manganese, selenium, gross alpha	Selenium, gross alpha
P22582P	II	Ammonia, TDS		
P50113W	IV	TDS, sulfate, manganese, gross alpha	Sulfate, manganese, selenium, gross alpha	Gross alpha
P50883W	IV	Radium-226 and 228, gross alpha	Radium 226 and 228, gross alpha	Radium 226 and 228, gross alpha
P61007W	II	TDS		
P71108W	IV	TDS, sulfate, manganese, gross alpha	Sulfate, manganese, gross alpha	Gross alpha
P84665W	IV	TDS, gross alpha	Gross alpha	Gross alpha
SBWELL01	II	TDS		
SBWELL02	II	TDS		
TWWELL03	II	TDS	Sulfate	

[1] pH and iron were not used to assess the suitability of groundwater since these constituents are easily treatable

Table 3.4-48. Stock Well Comparison with EPA Standards

Well ID	Parameters Exceeding Primary Standards[1]	Parameters Exceeding Secondary Standards[1]
CSWELL01		Manganese
HBWELL01		
HBWELL03		TDS, sulfate, manganese
HBWELL04	Uranium, gross alpha	TDS, sulfate, manganese
P17177W	Gross alpha	TDS
P21128P	Selenium, uranium, gross alpha	TDS, aluminum, manganese
P22582P		TDS
P50113W	Uranium, gross alpha	TDS, sulfate, manganese
P50883W	Radium-226 and 228, gross alpha	
P61007W		TDS
P71108W	Uranium, gross alpha	TDS, sulfate, manganese
P84665W	Uranium, gross alpha	TDS
SBWELL01		TDS
SBWELL02		
TWWELL03		TDS

[1] Provided for comparison only, since these wells are not used as a drinking water supply

Table 3.4-49. Domestic Well Monitoring Results

Parameter	Units	CSWELL01	DWWELL01	HBWELL05	HBWELL06	P144030W	P31770W	P42868W	P61006W	P78287W	TSWELL01	TW01	TW02
Field													
Field Conductivity	µmhos/cm	1635-3310	2980-3430	1343-1575	1450	913	1910-3620	1167	918	737	1303	1616-2680	1889-2890
Field pH	s.u.	7.94-8.44	8.21-8.69	7.51-7.84	8.8	7.44	7.8-7.96	8.71	7.83	7.72	8.81	8.05-8.42	7.81-8.29
Field turbidity	NTUs	0-0.27	4.86-37.7	14.46-141	1.2	1.51	0.02-0.69	1.71	1.2	0.74	2540	0.19-1.35	0.56-2.05
Depth to Water	ft	148.8										27.7	20.4
Temperature	Deg C	7.8-17.3	8.4-14.8	8.5-12.6	8.9	14.8	8.2-12	10.8	12.9	16.1	10.4	7.5-13.2	5.5-13.6
Dissolved oxygen	mg/L	0.83-2.08	1.19-2.7	2.72-4.72		1.21						1.03-1.29	0.78-2.29
General													
Alkalinity (as CaCO3)	mg/L	633-792	586-647	499-543	768	443	499-504	547	490	116	587	668-836	613-654
Ammonia	mg/L	<0.1-0.1	0.4-1.2	<0.1	0.5	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	<0.1-0.2	0.2-0.3
Fluoride	mg/L	0.3-0.4	0.6-0.7	0.2-0.3	2.5	0.1	0.3	0.3	0.1	1.1	0.4	1.2	0.5-0.6
Laboratory conductivity	µmhos/cm	1550-2600	2210-2690	1370-1660	1410	846	2510-2550	1250	1030	841	1300	2000-2150	1840-2190
Laboratory pH	s.u.	8.3-8.4	8.4-8.5	8-8.2	8.5	8	8.2	8.7	8.3	8	8.7	8.4-8.5	8.3-8.5
Nitrate/Nitrite	mg/L	<0.1-0.9	<0.1	<0.1-0.5	<0.1	<0.1	0.6-1.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
Total Dissolved Solids	mg/L	1030-1920	1760-1880	1090-1160	960	520	1800-1920	810	660	580	910	1350-1440	1450-1550
Oil and Grease	mg/L				<5								
Total Petroleum Hydrocarbons	mg/L				<5								
Major Ions													
Calcium	mg/L	9-43	15-17	79-90	3	49	56-74	2	18	22	4	8-9	19-26
Magnesium	mg/L	6-33	6	33-38	2	25	23-37	1	9	5	2	4-5	8-12
Potassium	mg/L	8-14	11-13	7-8	3	16	11-14	3	8	6	4	6-8	11-13
Sodium	mg/L	393-574	558-665	229-258	397	113	514-593	321	244	148	353	438-509	466-544
Bicarbonate	mg/L	748-931	682-774	609-662	886	541	609-615	616	578	142	666	793-935	742-780
Carbonate	mg/L	5-18	8-18	<5	25	<5	<5	25	9	<5	24	8-42	<5-18
Chloride	mg/L	2-7	7-16	4-6	46	1	21-23	1	<1	6	1	4-8	8-15
Sulfate	mg/L	224-723	663-794	327-381	25	56	842-865	117	74	260	122	331-393	467-576
Metals													
Aluminum, dissolved	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.02	<0.005	<0.005	<0.005	<0.005	<0.005
Barium, dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron, dissolved	mg/L	0.3-0.4	0.5-0.6	0.2	0.5	<0.1	0.2-0.3	0.2	0.1	0.5	0.3	0.5-0.59	0.4-0.52
Cadmium, dissolved	mg/L	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chromium, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Iron, dissolved	mg/L	<0.05	0.21-1.96	0.17-1.55	<0.05	0.08	<0.05-0.9	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05-0.06
Iron, total	mg/L	<0.05	1.71-5.02	2.4-32.8	0.1	0.13	0.05-0.91	<0.05	0.16	0.14	0.22	<0.05-0.12	<0.05-0.22
Lead, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese, total	mg/L	<0.02-0.02	0.03-0.07	0.08-0.17	0.08	0.08	0.04-0.15	<0.02	<0.02	0.12	<0.02	<0.02	0.02-0.03
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel, dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium, dissolved	mg/L	<0.005-0.009	<0.005	<0.005-0.007	<0.005	<0.005	<0.005-0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Silver, dissolved	mg/L	<0.003	<0.003	<0.003		<0.003						<0.003	<0.003
Uranium, dissolved	mg/L	0.004-0.02	<0.001	0.01-0.015	<0.001	0.024	0.015-0.071	<0.001	0.002	<0.001	0.004	<0.001	<0.001
Uranium, suspended	mg/L	<0.001	<0.001	<0.001		<0.001						<0.001	<0.001
Vanadium, dissolved	mg/L	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc, dissolved	mg/L	<0.01	<0.01	<0.01-0.01	<0.01	<0.01	0.02-0.06	<0.01	<0.01	<0.01	<0.01	<0.01-0.02	0.01-0.03
Radiological													
Lead 210, dissolved	pCi/L	<1	<1	<1		<1						<1	<1
Lead 210, suspended	pCi/L	<1	1.21-1.78	<1-1.56		<1						<1	<1
Polonium 210, dissolved	pCi/L	<1	<1	<1		<1						<1	<1
Polonium 210, suspended	pCi/L	<1	8.91-9.2	<1		<1						<1	<1
Ra-226, dissolved	pCi/L	<0.2-0.86	<0.2-0.4	<0.2-0.2	0.27	0.8	0.32-0.43	<0.2	1.13	<0.2	0.46	<0.2-0.32	0.31-1.1
Ra-226, suspended	pCi/L	<0.2	<0.2	<0.2		<0.2						<0.2	<0.2
Ra-228, Dissolved	pCi/L	<1-1.66	<1-2.84	<1	<1	<1	<1	<1	<1	<1	1.17	<1	<1-1.54
Radon-222	pCi/L	1600					390						
Th-230, dissolved	pCi/L	<0.2	<0.2	<0.2		<0.2						<0.2	<0.2
Th-230, suspended	pCi/L	<0.2	<0.2	<0.2		<0.2						<0.2	<0.2
Gross Alpha	pCi/L	7.2-18.3	10.7-17.3	7.1-12.7	<2	23.9	7.8-36.8	<2	4.8	<2	10.8	<2-4.2	<2-4.61
Gross Beta	pCi/L	<2-13.2	5.1-11.8	6.4-10	3.6	23.8	12.9-17.1	<2	3.6	4.1	7.3	<2-8.55	<2-11.7
QA/QC													
Anion Sum	meq/L	17.4-30.39	25.79-28.57	17-18.61	17.32	10.07	28.2-28.71	13.43	11.34	7.97	14.32	21.5-23.9	22.59-25.36
Cation Sum	meq/L	18.28-29.96	25.79-30.51	17.03-18.73	17.63	9.84	27.32-31.63	14.24	12.44	8.11	15.75	20.03-23.14	22.76-25.55
Total Anion/Cation Balance	%	0.31-3.22	0.01-3.27	0.33-4.86	0.88	1.13	2.02-4.83	2.91	4.62	0.82	4.74	0.44-3.54	0.29-4.39
Total Dissolved Solids (calc)	mg/L	1020-1830	1610-1850	1020-1080	940	530	1780-1880	770	650	520	840	870-1370	1370-1560

Table 3.4-50. Domestic Well Comparison with WDEQ Class of Use Standards

Well ID	Probable WDEQ Class of Use	Parameters Exceeding Class I Standards[1]	Parameters Exceeding Class II Standards[1]	Parameters Exceeding Class III Standards[1]
CSWELL01	III-IV	TDS, sulfate, gross alpha	Sulfate, gross alpha	Gross alpha
DWWELL01	III-IV	Ammonia, TDS, sulfate, manganese, gross alpha	Sulfate, gross alpha	Gross alpha
HBWELL05	III	TDS, sulfate, manganese	Sulfate	
HBWELL06	II	TDS, manganese		
P144030W	II	TDS, manganese, gross alpha	Gross alpha	Gross alpha
P31770W	IV	TDS, sulfate, manganese, gross alpha	Sulfate, gross alpha	Gross alpha
P42868W	II	TDS		
P61006W	II	TDS		
P78287W	III	TDS, sulfate, manganese	Sulfate	
TSWELL01	II	TDS		
TW01	III	TDS, sulfate	Sulfate	
TW02	III	TDS, sulfate	Sulfate	

[1] pH and iron were not compared to class of use standards since these constituents are easily treatable

Table 3.4-51. Domestic Well Comparison with EPA Standards

Well ID	Parameters Exceeding Primary Standards	Parameters Exceeding Secondary Standards[1]
CSWELL01	Gross alpha	TDS, sulfate
DWWELL01	Gross alpha	TDS, sulfate, manganese
HBWELL05		TDS, sulfate, manganese
HBWELL06		Fluoride, TDS, manganese
P144030W	Gross alpha	TDS, manganese
P31770W	Uranium, gross alpha	TDS, sulfate, manganese
P42868W	Arsenic	TDS
P61006W		TDS
P78287W		TDS, sulfate, manganese
TSWELL01		TDS
TW01		TDS, sulfate
TW02		TDS, sulfate

[1] EPA designates secondary standards as non-enforceable contaminants that may cause cosmetic or aesthetic effects in drinking water

Table 3.4-52. Nubeth Wells

Well ID	Well Use	Sampling Time Period
3X (B-1)	Buffer	4/1978 – 10/1981
4X (B-3)	Buffer	4/1978 – 10/1981
5X (M-2)	Monitor	4/1978 – 4/1980
6X (M-4)	Monitor	4/1978 – 4/1980
7X (OSA-1)	Observation	4/1978 – 4/1980
11X (M-5)	Monitor	4/1978 – 4/1980
12X (M-1)	Monitor	4/1978 – 4/1980
19X	Recovery	4/1978 – 10/1981
20X (I-2)	Injection	4/1978 – 10/1981

Table 3.4-53. Nubeth Baseline Groundwater Quality

Well ID	Water Type	Gross Alpha (pCi/L)	Radium-226 (pCi/L)	Uranium (mg/L)
3X	Sodium sulfate	290	73	0.071
4X	Sodium sulfate	180	16	0.080
5X	Sodium sulfate	157	0.3	0.100
6X	Sodium sulfate	128	0.6	0.075
7X	Sodium sulfate	ND	0.5	0.008
11X	Sodium sulfate	112	1.4	0.079
12X	Sodium sulfate	72	2.3	0.073
19X	Sodium sulfate	310	97	0.300
20X	Sodium bicarbonate	7.7	0.6	0.006

Source: ND Resources, Inc. (1978)

Table 3.4-54. Nubeth Restoration Groundwater Quality

Well ID	Sample Date	Water Type	Gross Alpha (pCi/L)	Radium-226 (pCi/L)	Uranium (mg/L)
3X	10/4/81	Sodium sulfate	130	22	0.240
4X	10/4/81	Sodium sulfate	180	26	0.220
5X	4/24/80	Sodium sulfate	37	0.5	0.035
6X	4/24/80	Sodium sulfate	66	0.1	0.095
7X	4/24/80	Sodium bicarbonate	180	0.6	ND
11X	4/24/80	Sodium sulfate	116	1	0.082
12X	4/24/80	Sodium sulfate	111	1.6	0.076
19X	10/4/81	Sodium sulfate	300	31	0.480
20X	10/4/81	Sodium sulfate	85	20	0.068

Sources: ND Resources (1980), ND Resources (1982).

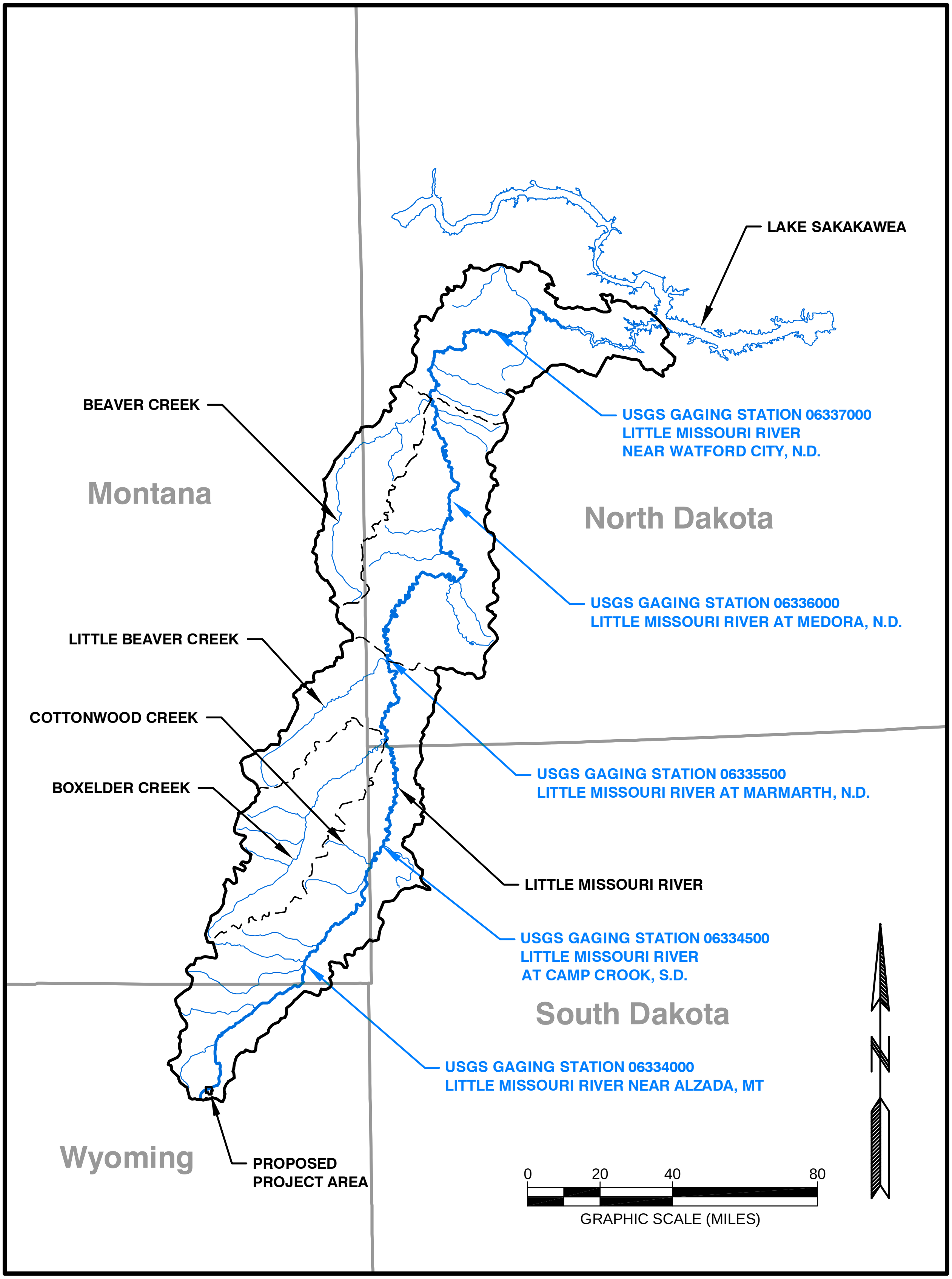
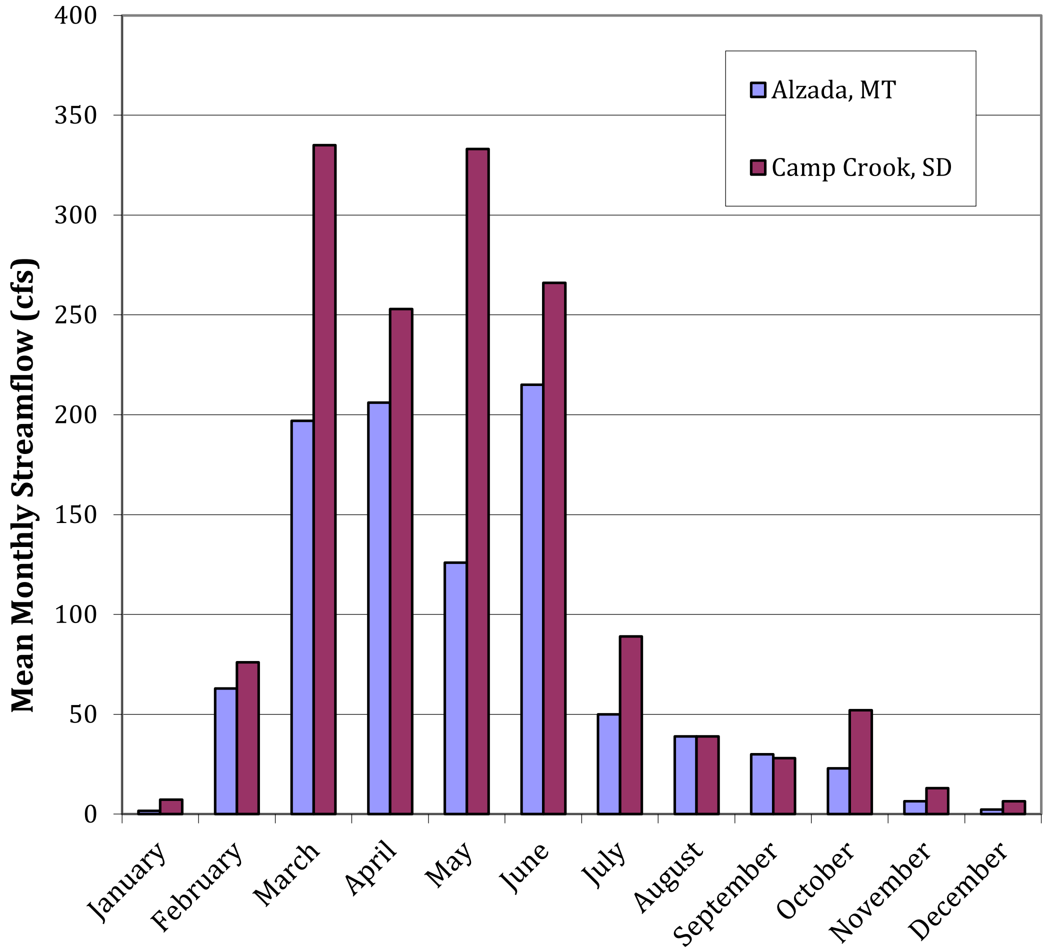
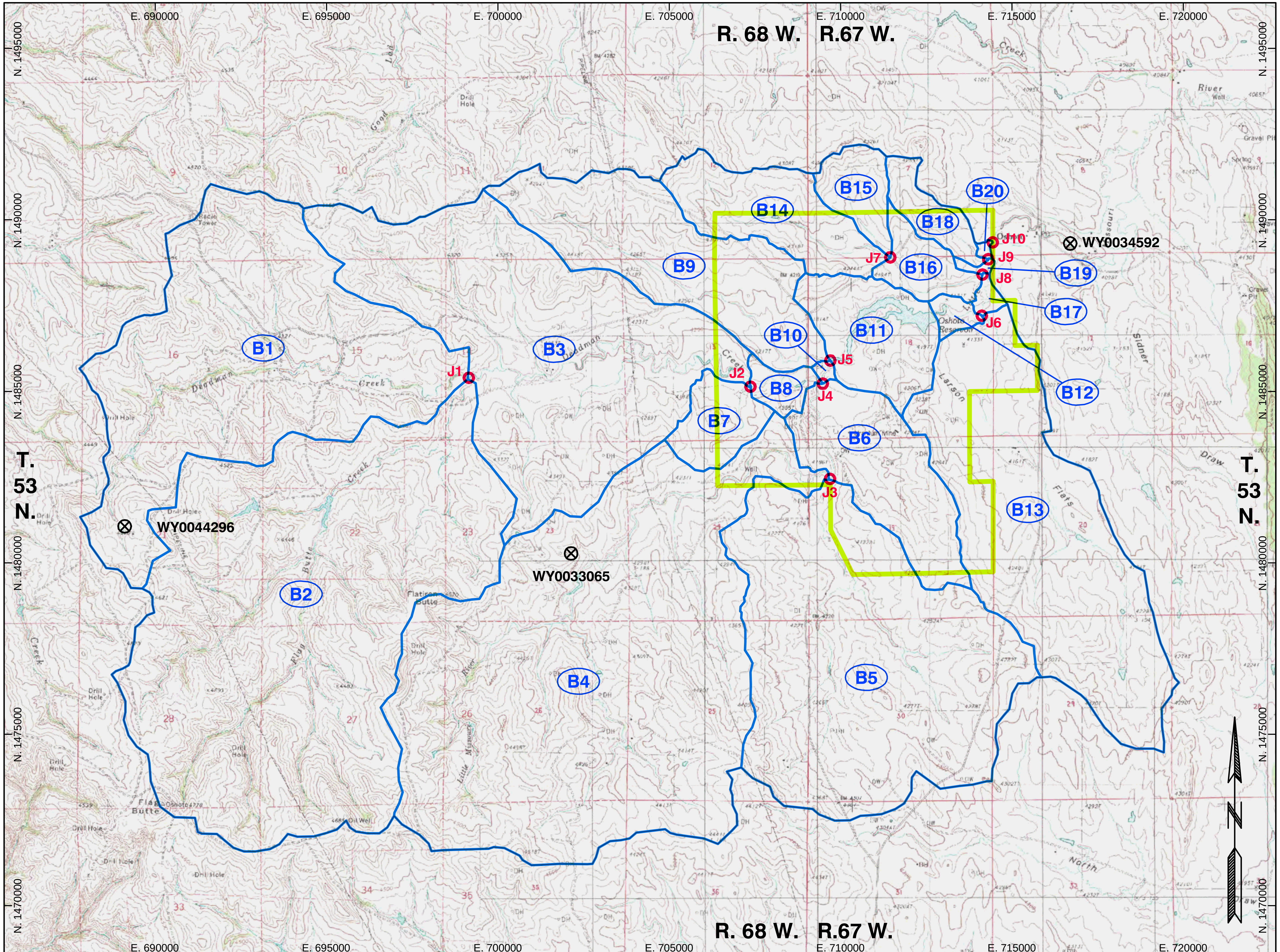


Figure 3.4-1. Little Missouri River Basin

Figure 3.4-2. Little Missouri River Mean Monthly Flow



Source: USGS 2010a



LEGEND

PROPOSED ROSS PERMIT BOUNDARY

DRAINAGE DIVIDE

WY0034592 ⊗ WYPDES DISCHARGE LOCATION AND PERMIT NUMBER

J1 ○ JUNCTION

B1 SUBWATERSHED ID

0 1500 3000 6000

GRAPHIC SCALE (FEET)

ROSS PROJECT AREA

Drawing Coordinates: WY83EF

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS

Date	Description

ENVIRONMENTAL REPORT
FIGURE 3.4-3

PROJECT DRAINAGE BASINS

Drawn By: MBM
Checked By: CEA
Date: 11/19/10

WWC ENGINEERING
www.wwcengineering.com

FILE: ROSS_ER_HYD_PROJ_DB

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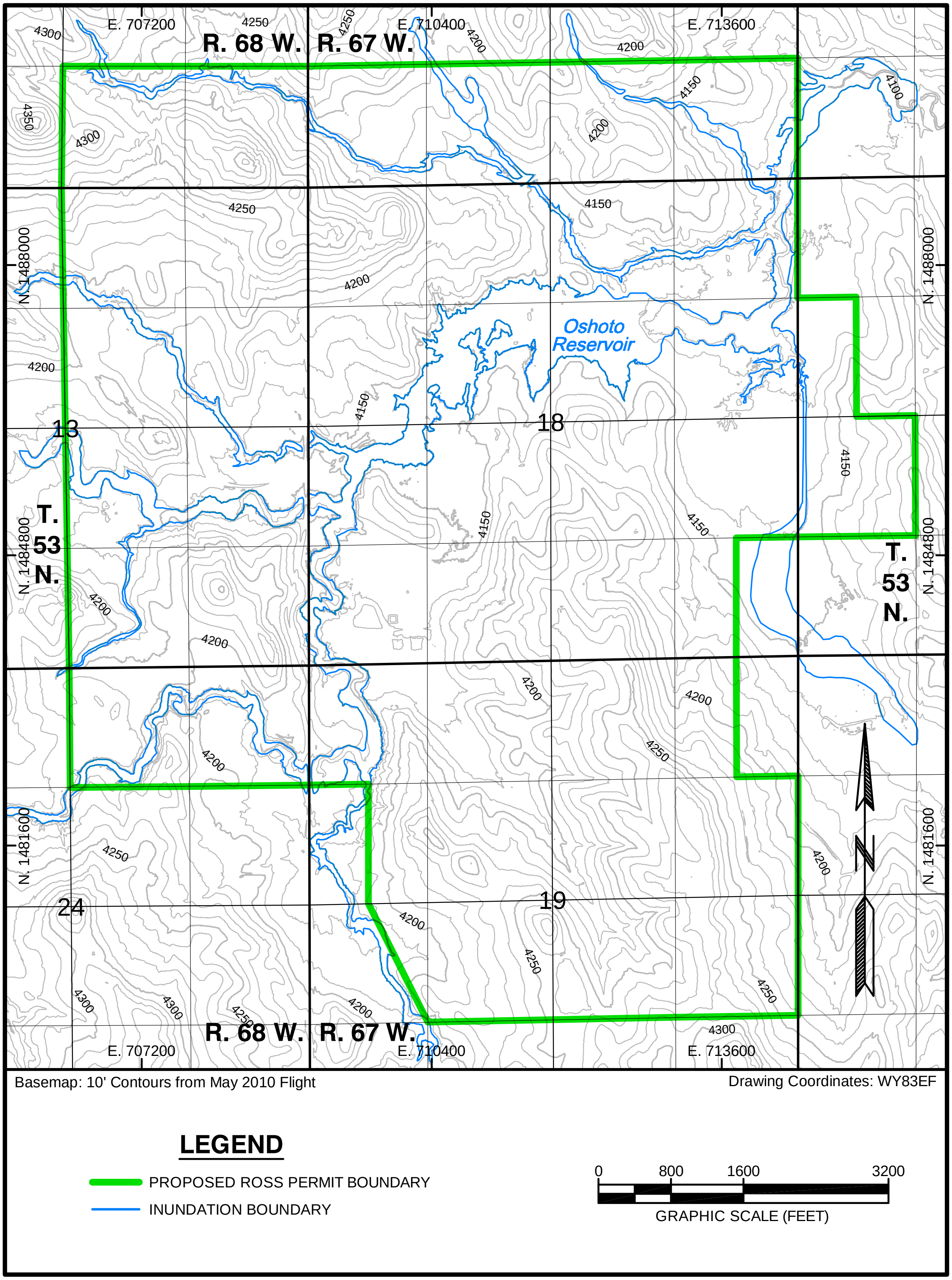
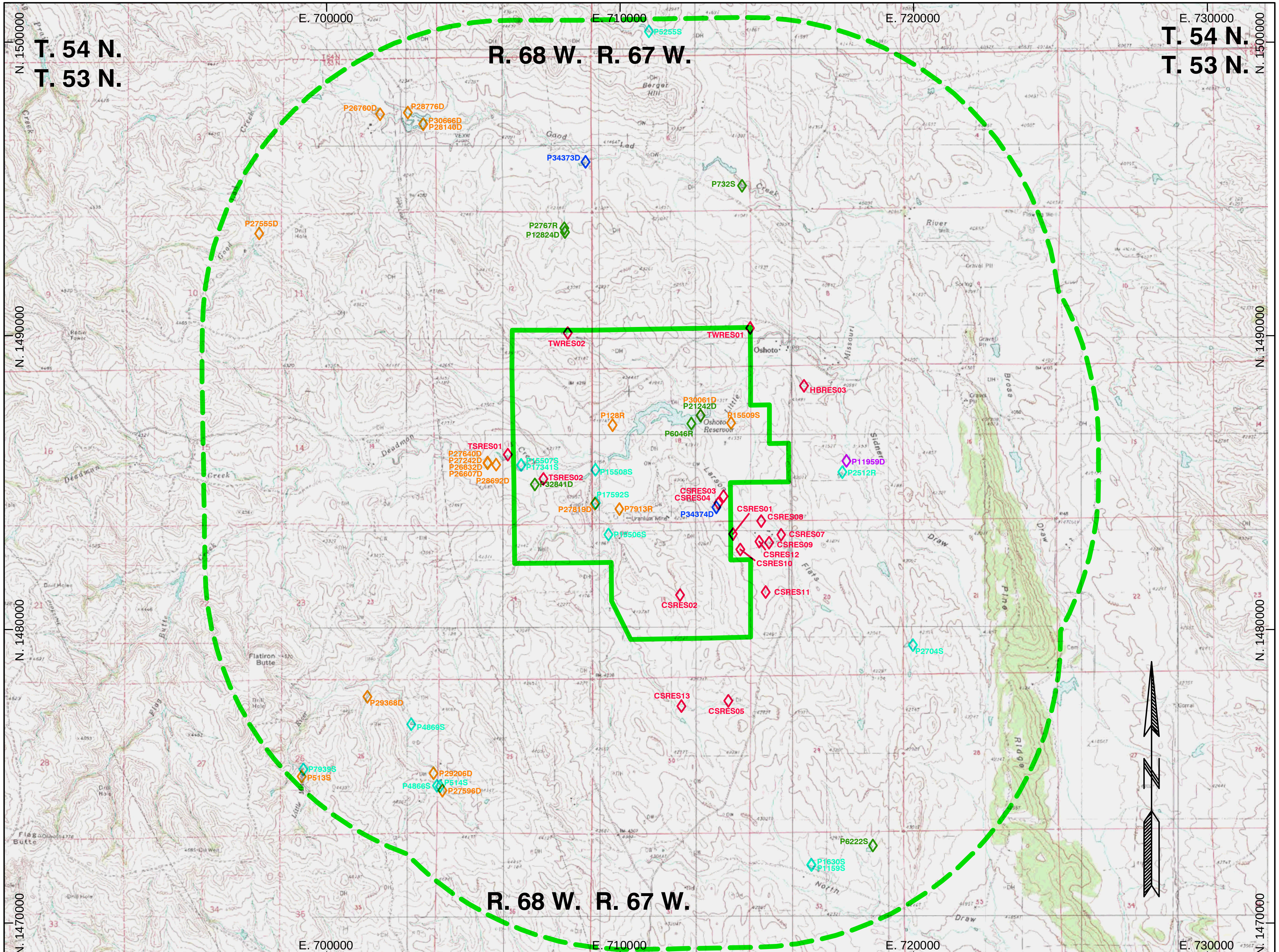


Figure 3.4-4. 100-year Flood Inundation Boundaries



ROSS PROJECT AREA

Drawing Coordinates: WY83EF

LEGEND

PROPOSED ROSS PERMIT BOUNDARY

2 MILE BUFFER FROM PROPOSED PERMIT BOUNDARY

WR NUMBER ◇ COMPLETE WATER RIGHT

WR NUMBER ◇ UNADJUDICATED WATER RIGHT

WR NUMBER ◇ CANCELLED WATER RIGHT

WR NUMBER ◇ FULLY ADJUDICATED WATER RIGHT

WR NUMBER ◇ NO STATUS LISTED IN WSEO DATABASE

WR NUMBER ◇ NOT LISTED IN WSEO DATABASE

Source: WSEO 2010

0 1750 3500 7000

GRAPHIC SCALE (FEET)

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS

Date	Description

ENVIRONMENTAL REPORT
FIGURE 3.4-5

SURFACE WATER RIGHTS

Drawn By: MBM
Checked By: JWF
Date: 12/6/10

WWC ENGINEERING
www.wwcengineering.com

FILE: ROSS_ER_HYD_SW_SEO

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ER_HYD_SW_SEO.dwg, ER_FIGURE_3.4-5, 12/18/2010 2:23:27 PM

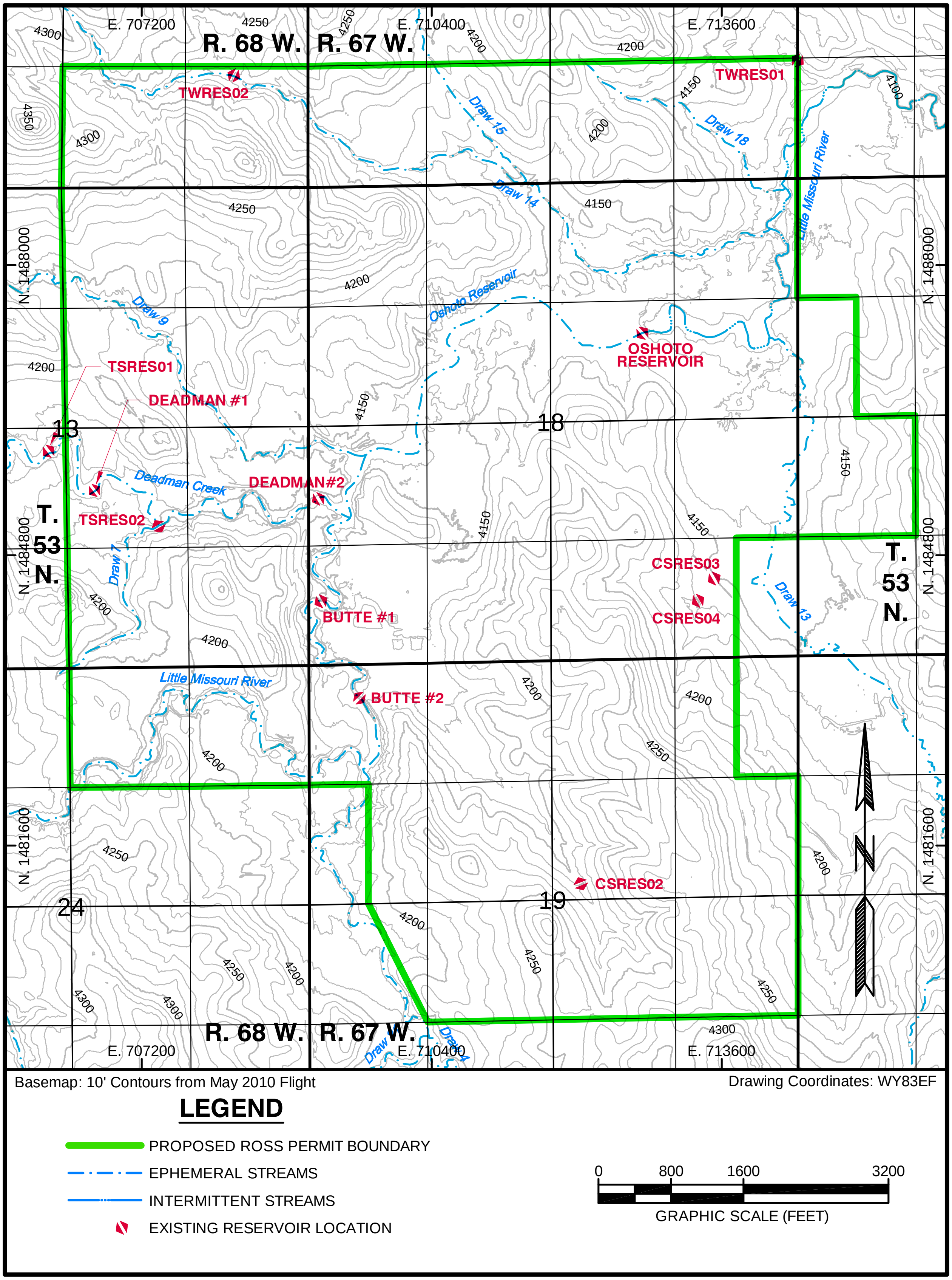


Figure 3.4-6. Surface Water Features

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ER_HYD_EX_RESERVOIRS.dwg, ER_FIGURE_3.4-6, 12/18/2010 2:25:19 PM

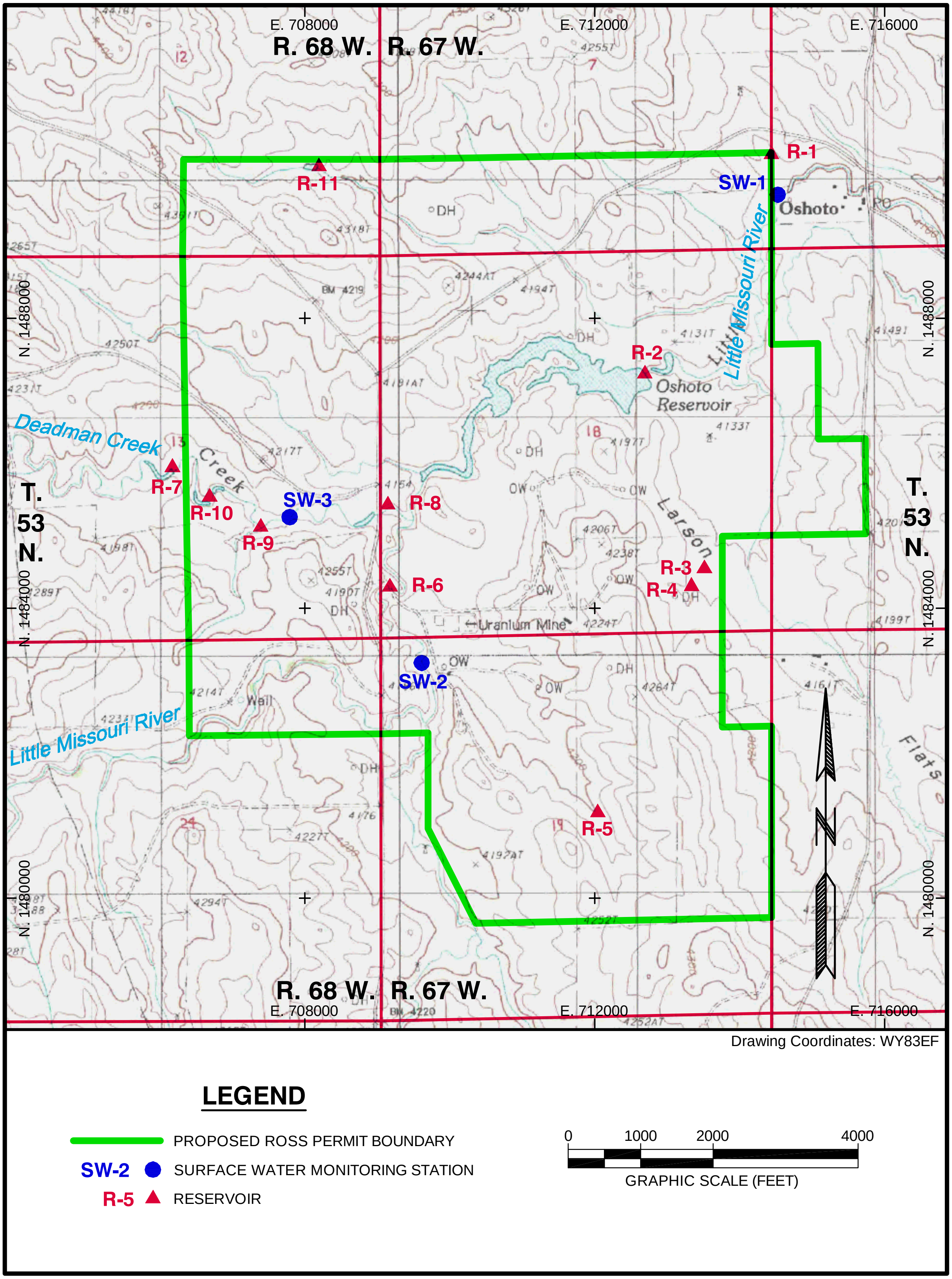
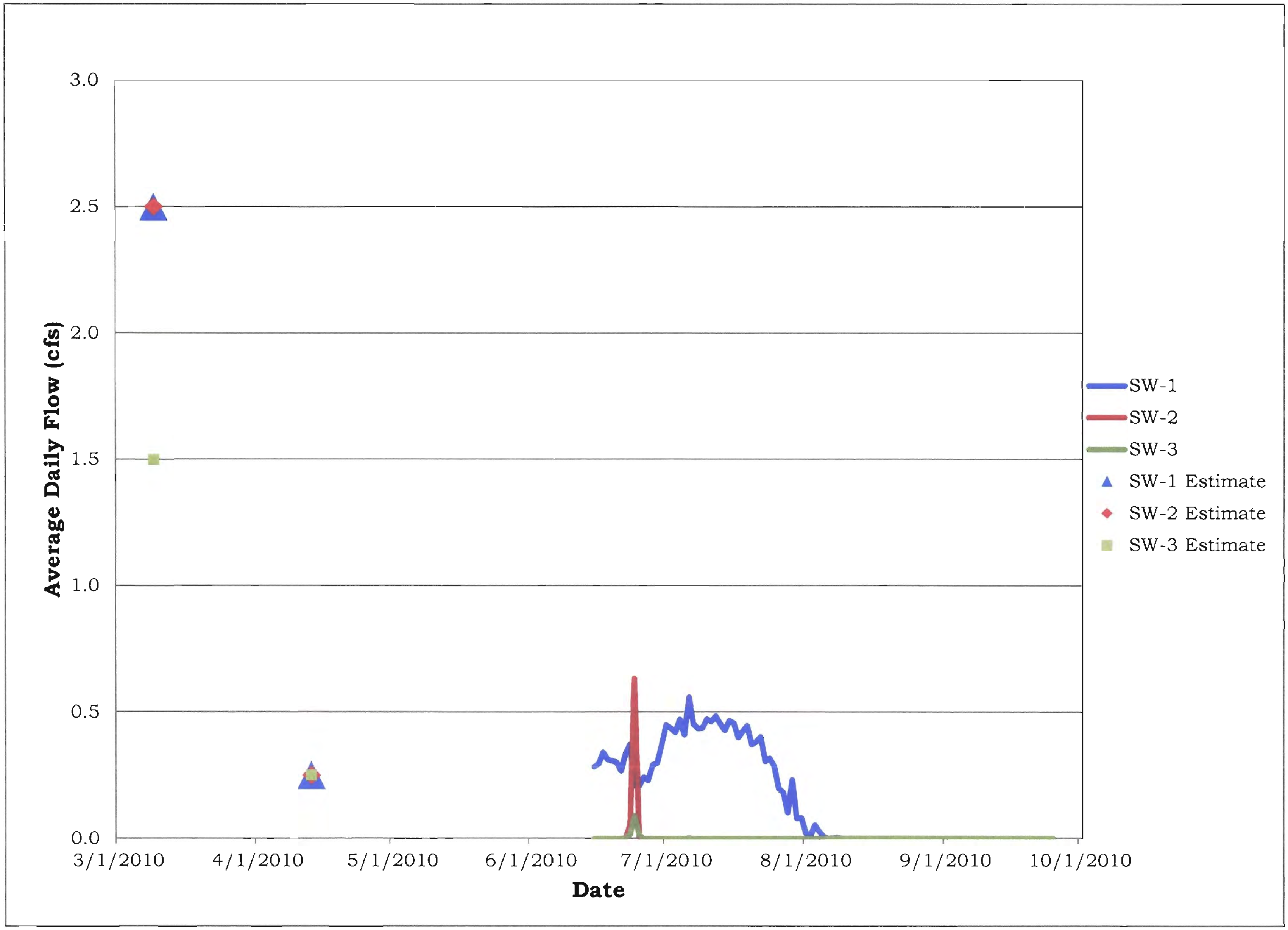


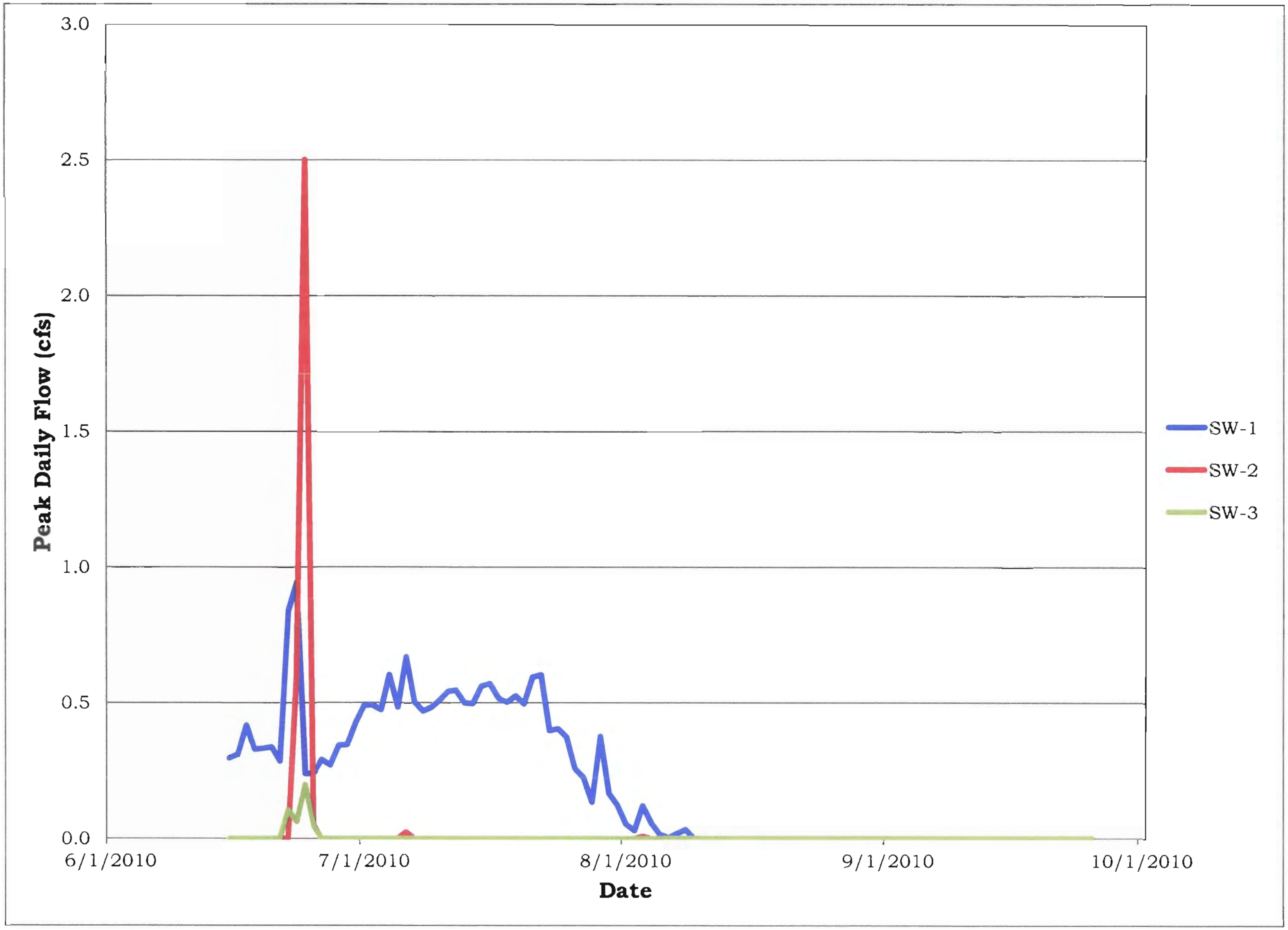
Figure 3.4-7. Surface Water Monitoring Network

Ross ISR Project

Figure 3.4-8. Surface Water Monitoring Station Average Daily Flow

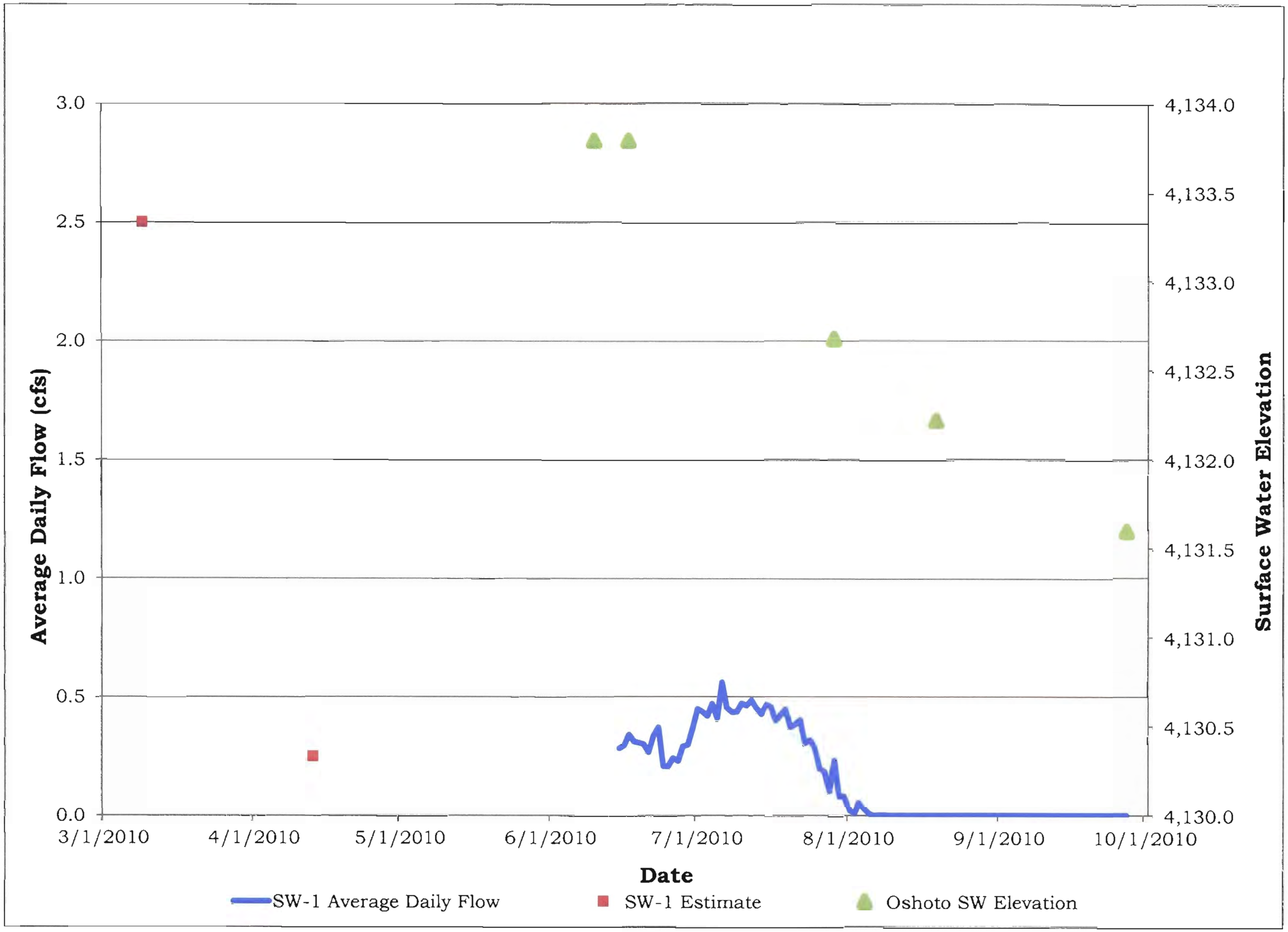
Note: No flow was recorded at the three sites after August 9, 2010 and no data recorded from September 25 to November 2, 2010.





Note: No flow was recorded at the three sites after August 9, 2010 and no data recorded from September 25 to November 2, 2010.

Figure 3.4-9. Surface Water Monitoring Station Peak Daily Flow



Note: No flow was recorded at the three sites after August 9, 2010 and no data recorded from September 25 to November 2, 2010.

Figure 3.4-10. Little Missouri River Flow Downstream of Oshoto Reservoir and Oshoto Reservoir Stage Elevation

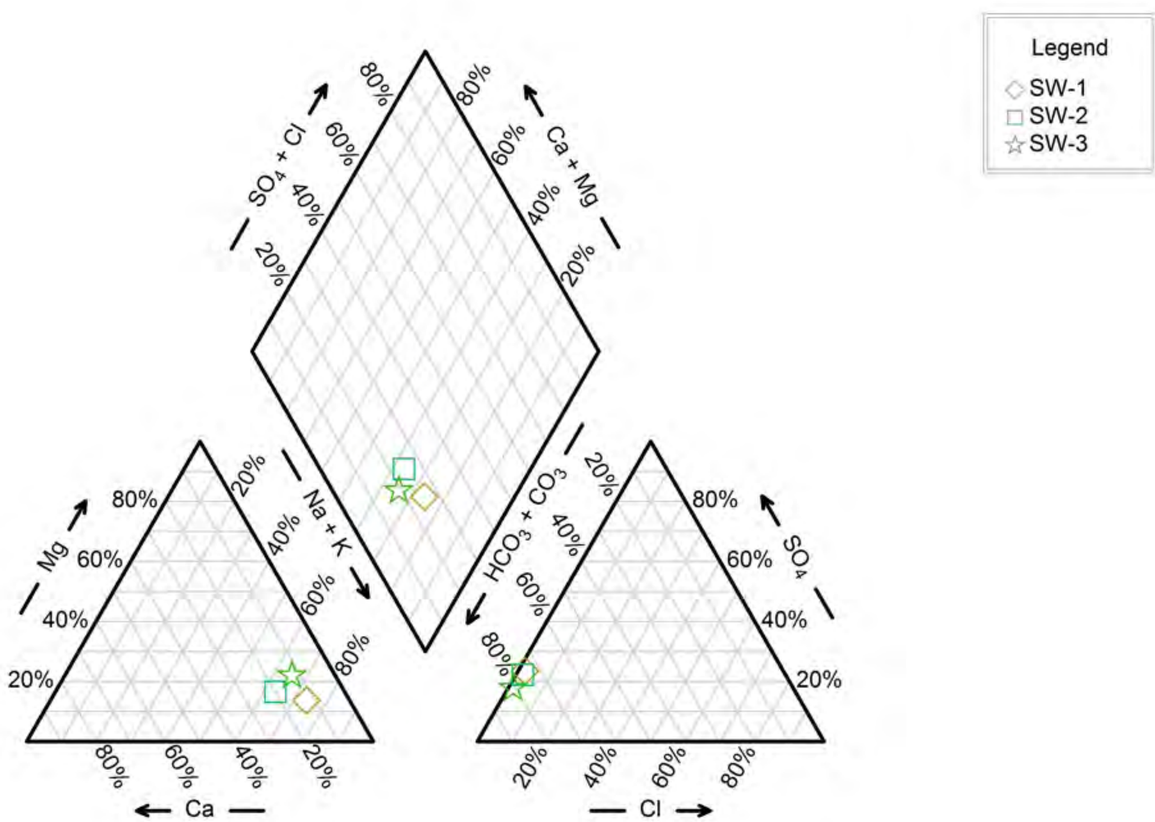


Figure 3.4-11. Surface Water Monitoring Station Piper Diagram
Note: data points represent average concentrations for each monitoring station.

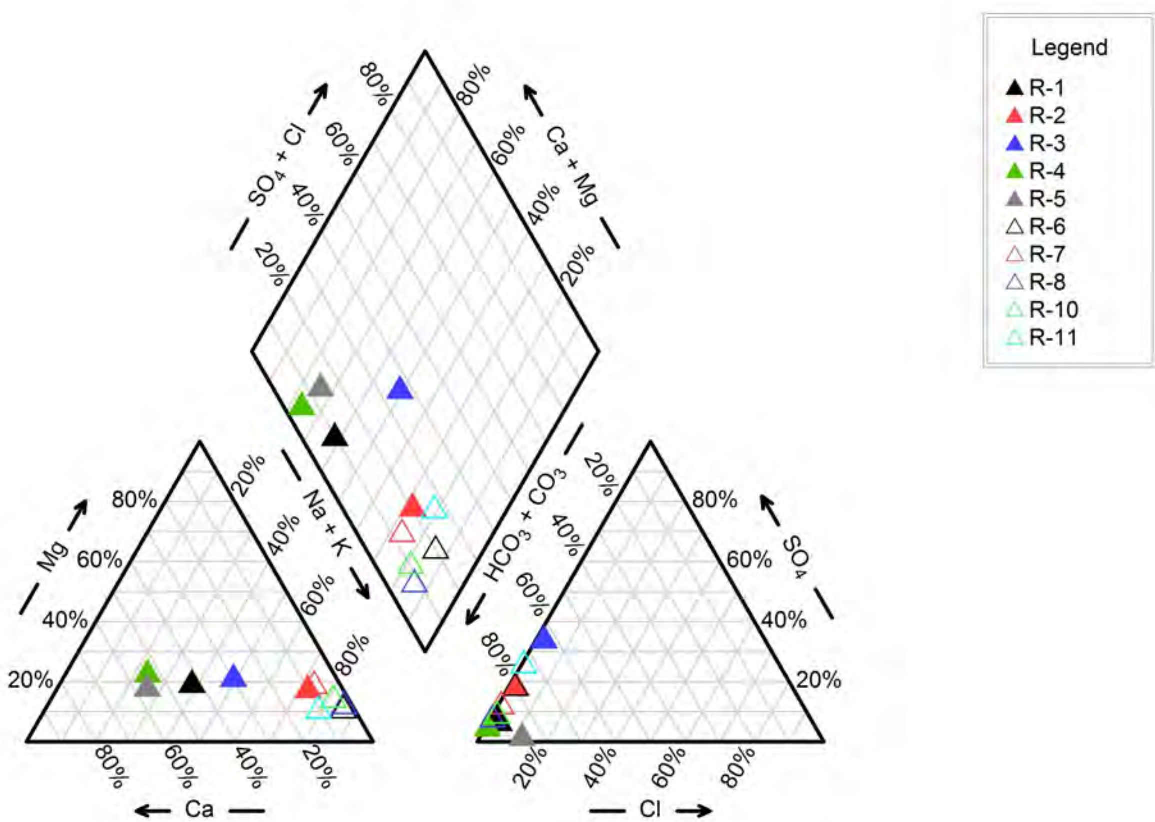
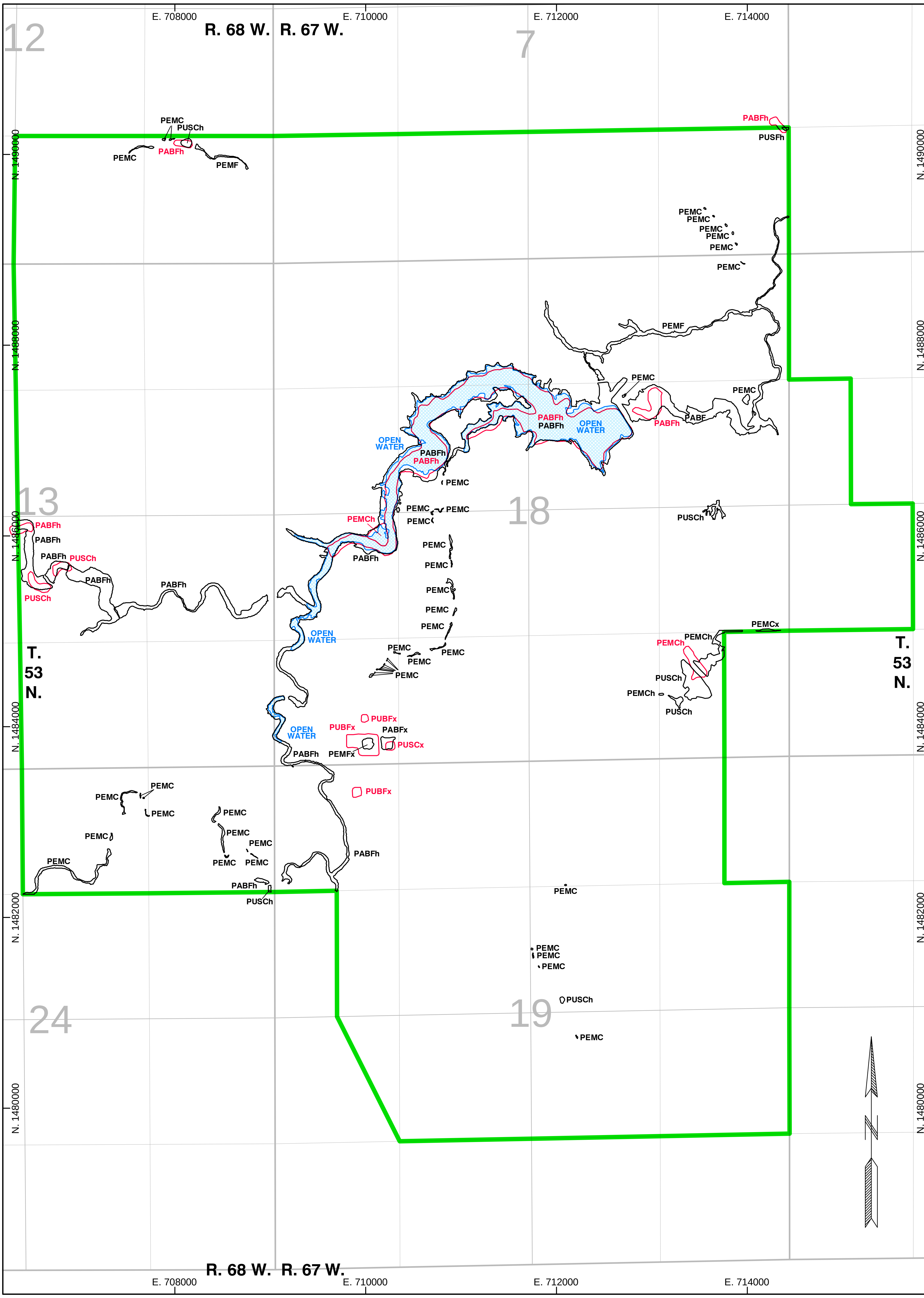


Figure 3.4-12. Reservoir Piper Diagram
Note: data points represent average concentrations for each reservoir.



Drawing Coordinates: WY83EF

WETLANDS MAP

NWI CLASSIFICATIONS (Cowardin et al. 1979)

PABFh Palustrine, Aquatic Bed, Semipermanently Flooded, Diked
PABFx Palustrine, Aquatic Bed, Semipermanently Flooded, Excavated
PEMC Palustrine, Emergent, Seasonally Flooded
PEMCh Palustrine, Emergent, Seasonally Flooded, Diked
PEMCx Palustrine, Emergent, Seasonally Flooded, Excavated
PEMF Palustrine, Emergent, Semipermanently Flooded
PEMFx Palustrine, Emergent, Semipermanently Flooded, Diked
PUBFx Palustrine, Unconsolidated Bottom, Semipermanently Flooded, Excavated
PUSCh Palustrine, Unconsolidated Shore, Seasonally Flooded, Diked
PUSCx Palustrine, Unconsolidated Shore, Seasonally Flooded, Excavated
PUSFh Palustrine, Unconsolidated Shore, Semipermanently Flooded, Diked

LEGEND

PROPOSED ROSS PERMIT BOUNDARY
PUSCx CLASSIFIED BY USFWS (NWI MAPPING)
PEMFx CLASSIFIED BY WWC
OPEN WATER

Source: NWI Mapping (USFWS 2010)
WWC Field Survey - 2010

0 500 1000 2000
GRAPHIC SCALE (FEET)

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS	
Date	Description

ENVIRONMENTAL REPORT
FIGURE 3.4-13

WETLANDS AND WATERS OF THE U.S.

Drawn By: MBM
Checked By: JDB
Date: 11/6/10
FILE: ROSS_ER_HYD_WETLANDS

WWC ENGINEERING
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K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ER_HYD_WETLANDS.dwg, ER_FIGURE_3.4-13, 12/18/2010 2:29:35 PM

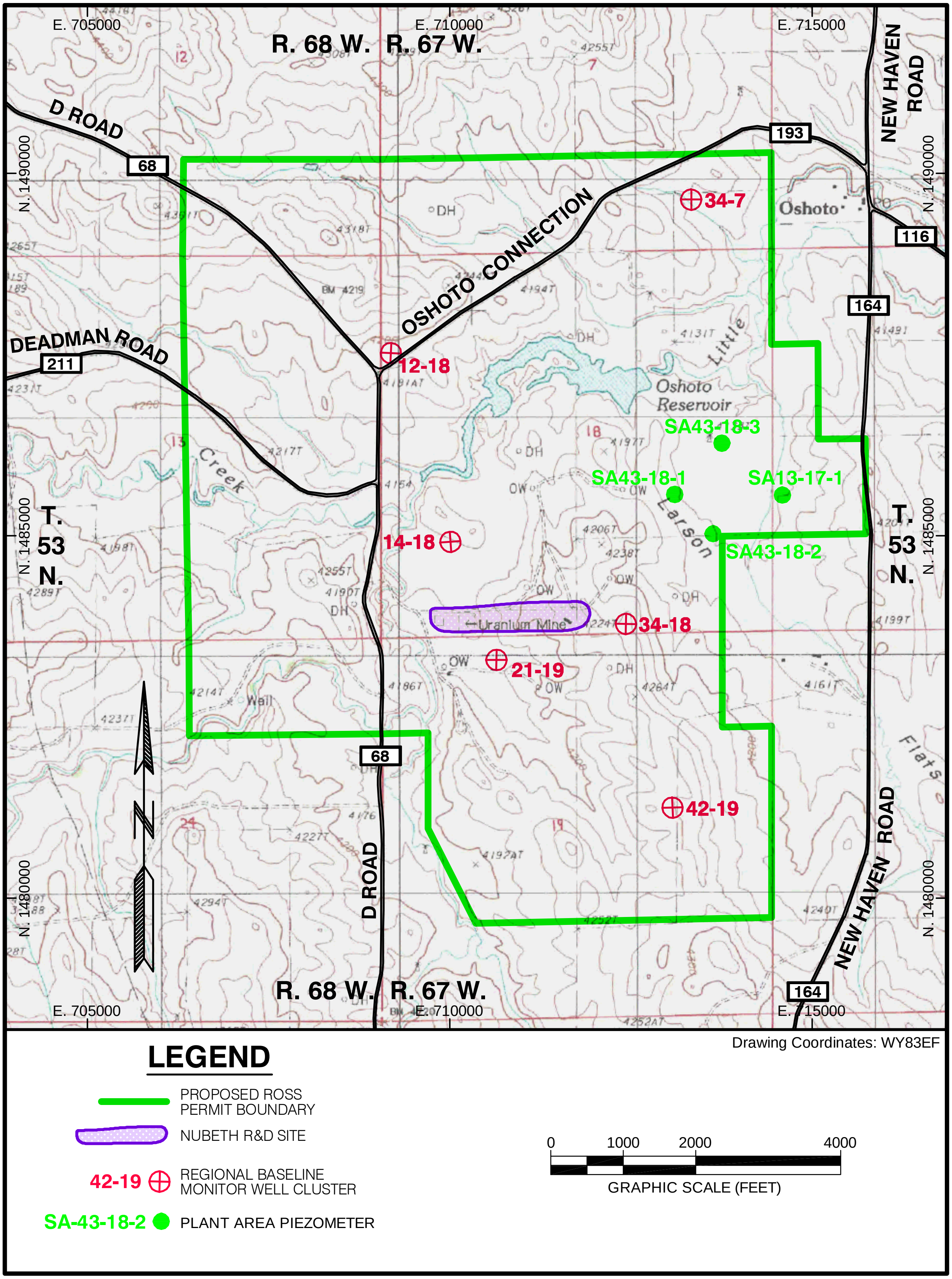
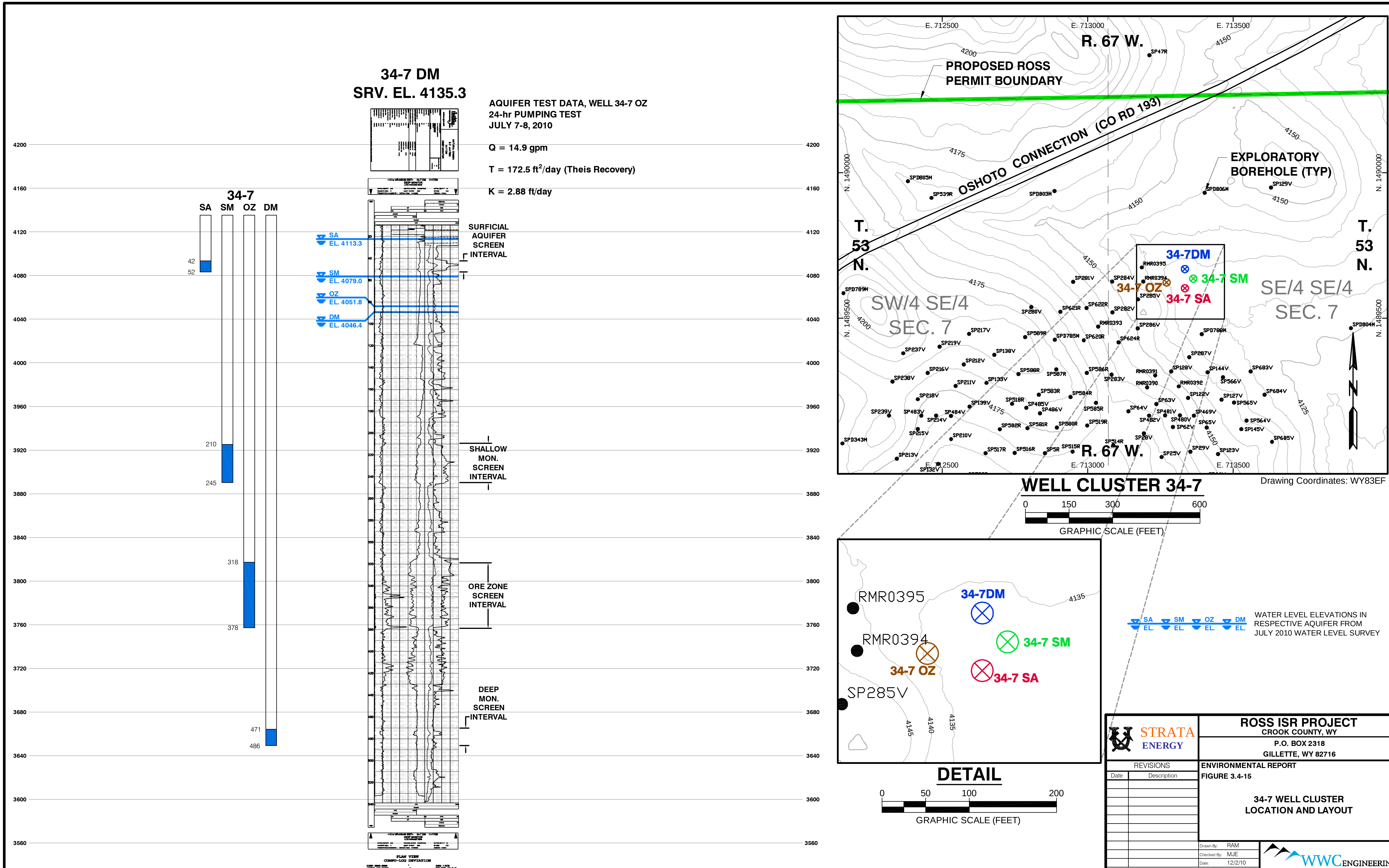
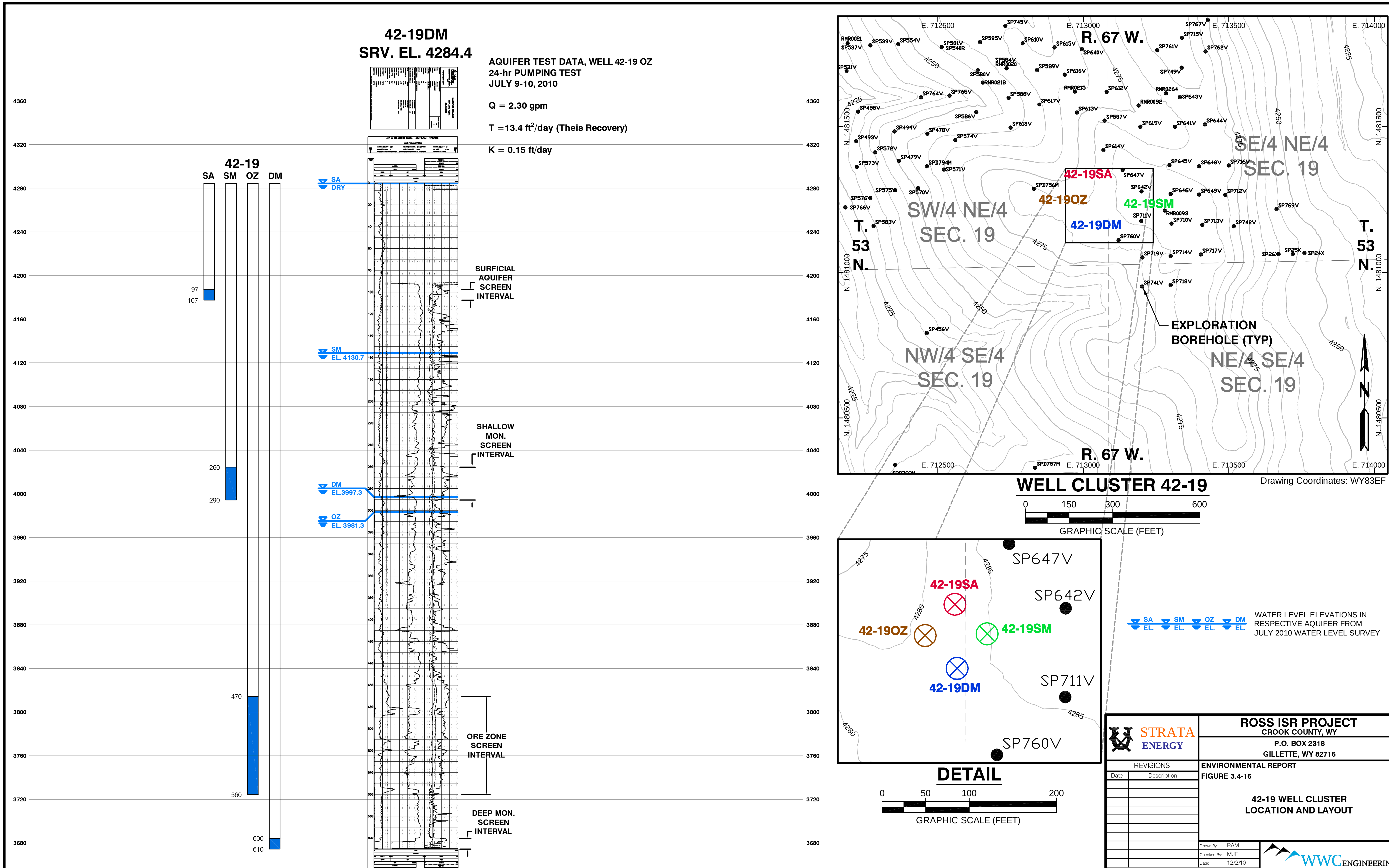
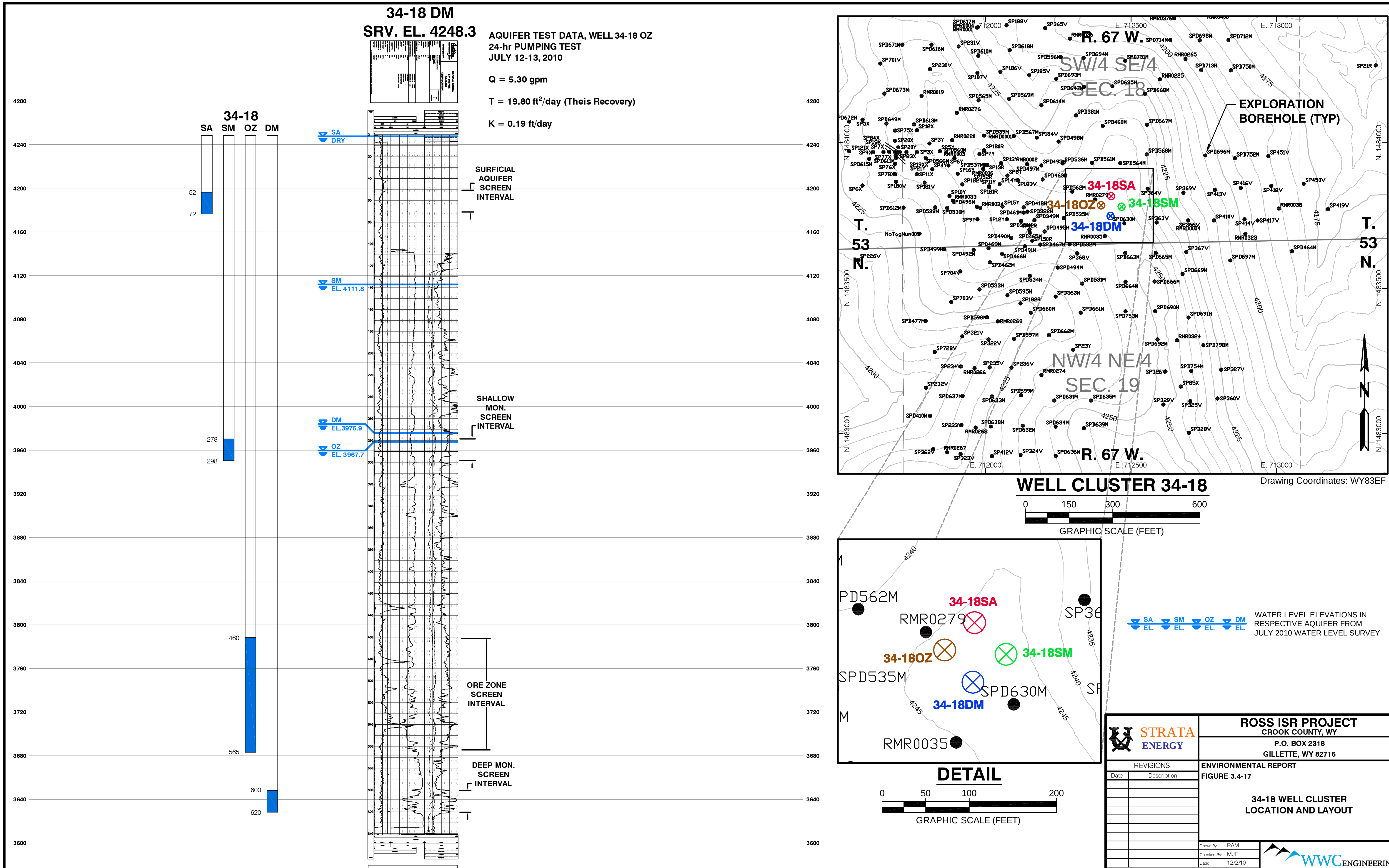


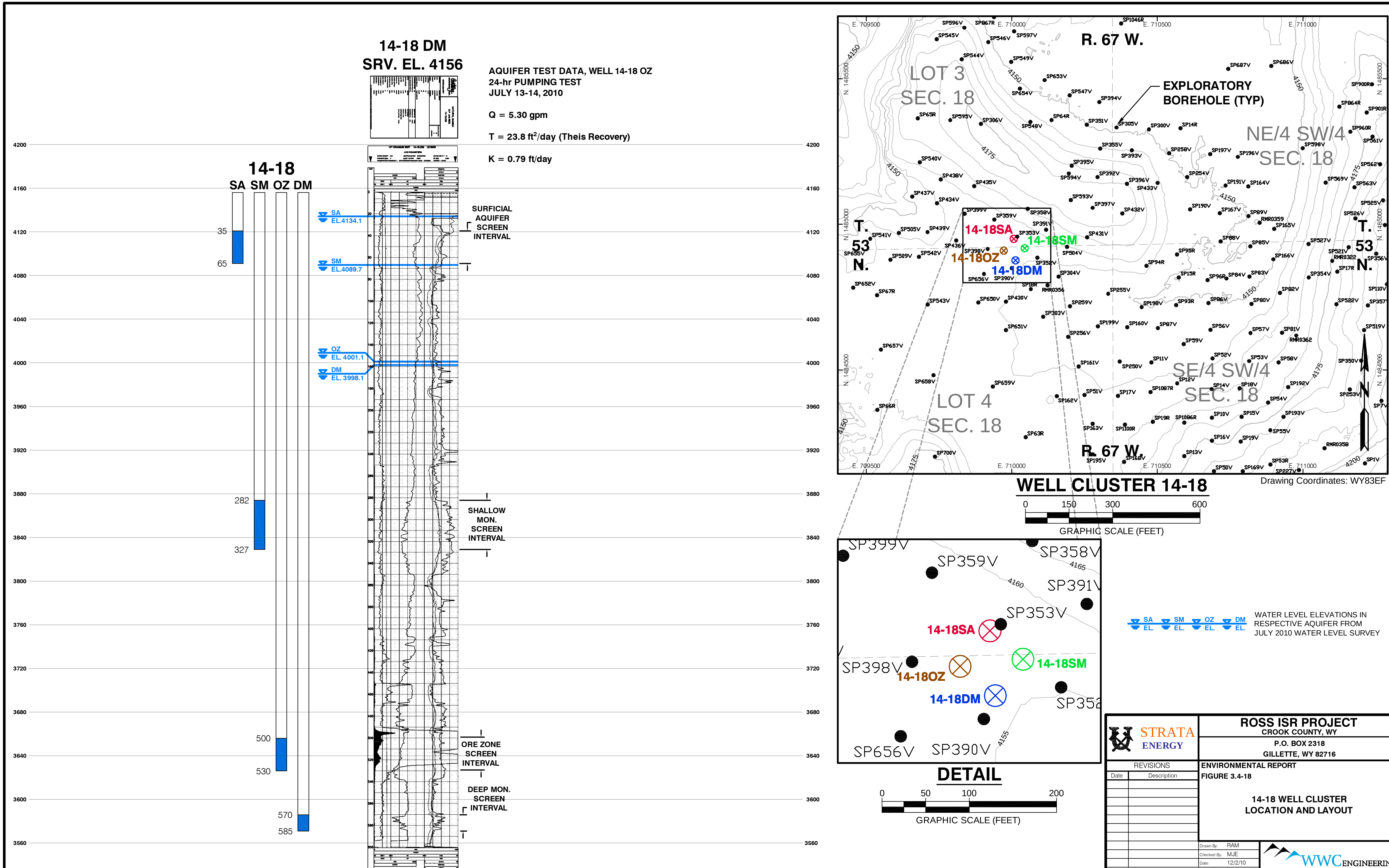
Figure 3.4-14. Regional Baseline Groundwater Monitoring Network


34-7 DM
SRV. EL. 4135.3
AQUIFER TEST DATA, WELL 34-7 OZ
24-hr PUMPING TEST
JULY 7-8, 2010
Q = 14.9 gpm
T = 172.5 ft²/day (Theis Recovery)
K = 2.88 ft/day
34-7
SA SM OZ DM
SA EL. 4113.3
SM EL. 4079.0
OZ EL. 4051.8
DM EL. 4046.4
SURFICIAL AQUIFER SCREEN INTERVAL
SHALLOW MON. SCREEN INTERVAL
ORE ZONE SCREEN INTERVAL
DEEP MON. SCREEN INTERVAL
42
52
210
245
318
378
471
486
4200
4160
4120
4080
4040
4000
3960
3920
3880
3840
3800
3760
3720
3680
3640
3600
3560
E. 712500
E. 713000
E. 713500
R. 67 W.
PROPOSED ROSS PERMIT BOUNDARY
OSHOTO CONNECTION (CO RD 193)
EXPLORATORY BOREHOLE (TYP)
T. 53 N.
N. 1490000
N. 1489500
SW/4 SE/4 SEC. 7
SE/4 SE/4 SEC. 7
34-7DM
34-7 SM
34-7 OZ
34-7 SA
WELL CLUSTER 34-7
0 150 300 600
GRAPHIC SCALE (FEET)
Drawing Coordinates: WY83EF
RMR0395
RMR0394
SP285V
DETAIL
0 50 100 200
GRAPHIC SCALE (FEET)
WATER LEVEL ELEVATIONS IN RESPECTIVE AQUIFER FROM JULY 2010 WATER LEVEL SURVEY
STRATA ENERGY
ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716
REVISIONS
Date Description
ENVIRONMENTAL REPORT
FIGURE 3.4-15
34-7 WELL CLUSTER LOCATION AND LAYOUT
Drawn By: RAM
Checked By: MJE
Date: 12/2/10
FILE: ROSS_ATR_OW_CL_34-7
WWC ENGINEERING

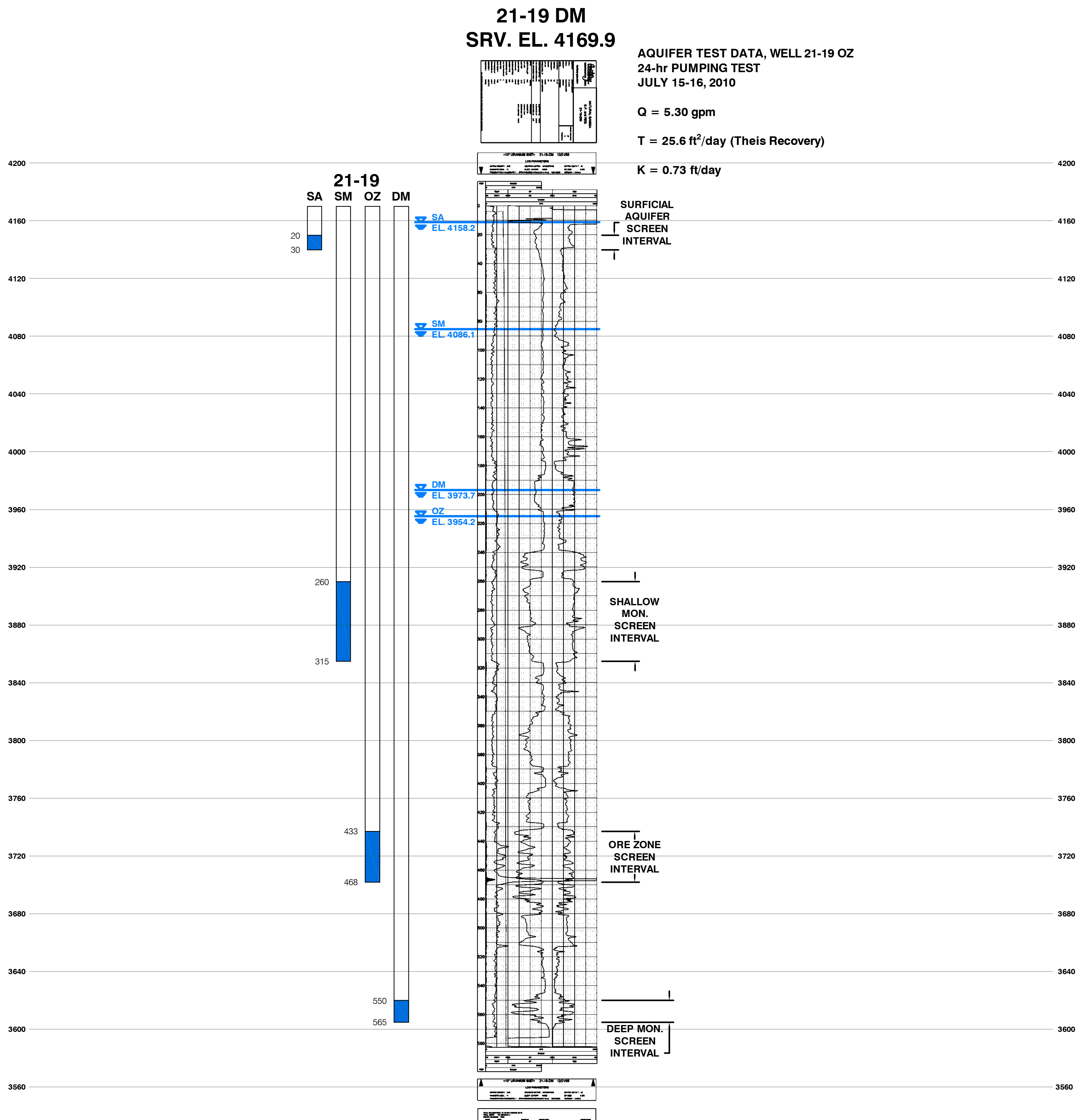


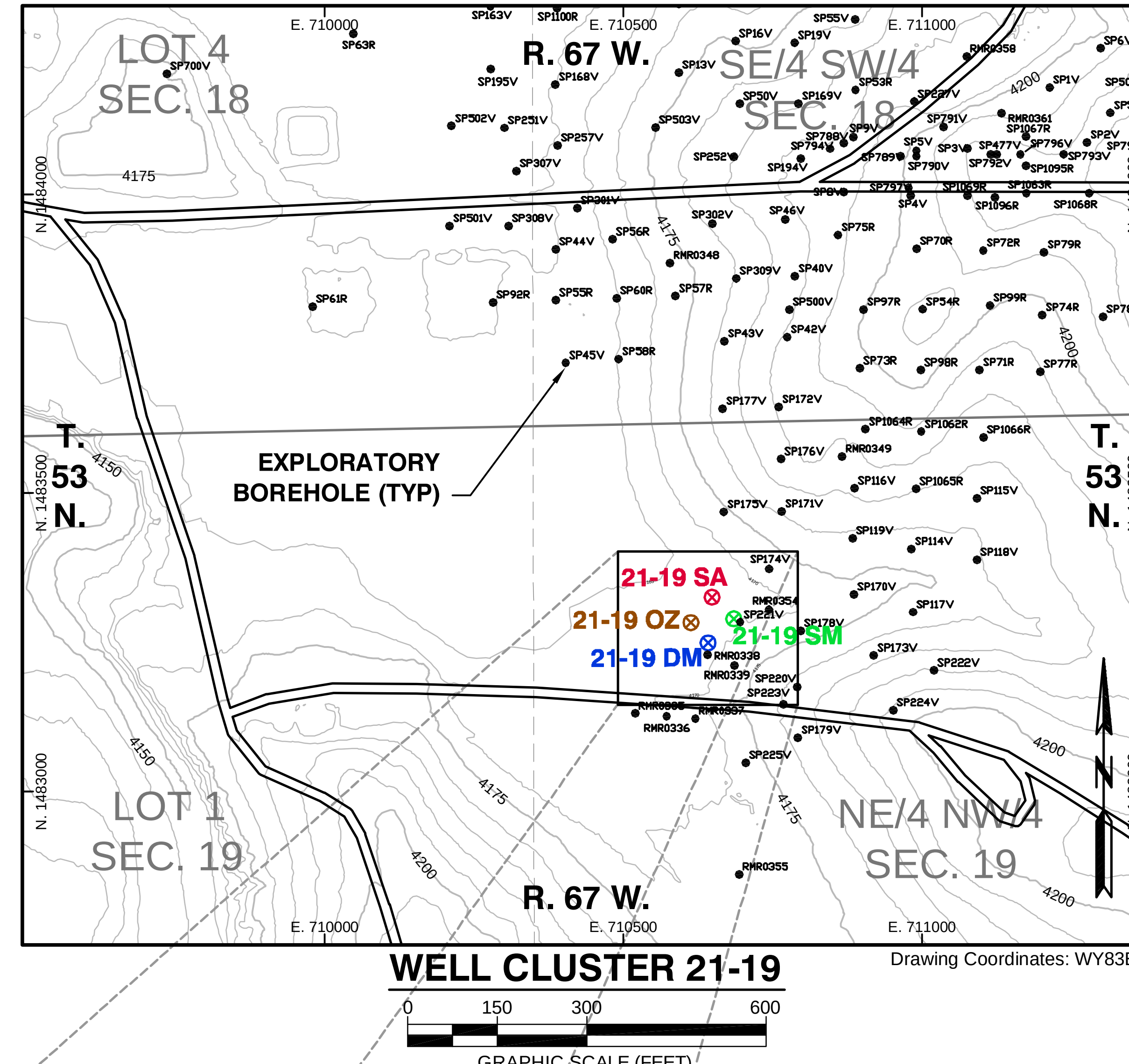
K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ATR_OW_CL_42-19.dwg, ER_FIGURE_3.4-16, 12/18/2010 2:33:45 PM

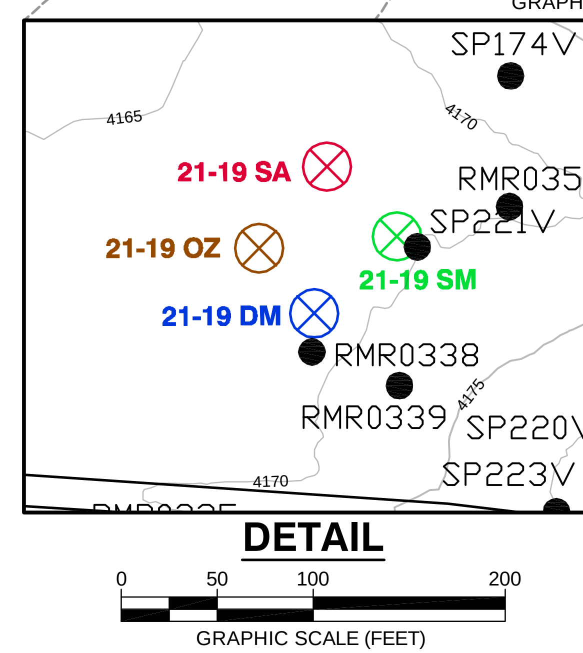

34-18 DM
SRV. EL. 4248.3
AQUIFER TEST DATA, WELL 34-18 OZ
24-hr PUMPING TEST
JULY 12-13, 2010
Q = 5.30 gpm
T = 19.80 ft²/day (Theis Recovery)
K = 0.19 ft/day
34-18
SA SM OZ DM
SA DRY
SM EL. 4111.8
DM EL.3975.9
OZ EL. 3967.7
SURFICIAL AQUIFER SCREEN INTERVAL
SHALLOW MON. SCREEN INTERVAL
ORE ZONE SCREEN INTERVAL
DEEP MON. SCREEN INTERVAL
R. 67 W.
SW/4 SE/4 SEC. 18
NW/4 NE/4 SEC. 19
T. 53 N.
EXPLORATION BOREHOLE (TYP)
34-18SA
34-18OZ
34-18SM
34-18DM
WELL CLUSTER 34-18
Drawing Coordinates: WY83EF
GRAPHIC SCALE (FEET)
DETAIL
WATER LEVEL ELEVATIONS IN RESPECTIVE AQUIFER FROM JULY 2010 WATER LEVEL SURVEY
STRATA ENERGY
ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716
REVISIONS
ENVIRONMENTAL REPORT
FIGURE 3.4-17
34-18 WELL CLUSTER LOCATION AND LAYOUT
Drawn By: RAM
Checked By: MJE
Date: 12/2/10
FILE: ROSS_ATR_OW_CL_34-18
WWC ENGINEERING



14-18 DM
SRV. EL. 4156
AQUIFER TEST DATA, WELL 14-18 OZ
24-hr PUMPING TEST
JULY 13-14, 2010
Q = 5.30 gpm
T = 23.8 ft²/day (Theis Recovery)
K = 0.79 ft/day
14-18
SA SM OZ DM
SA EL.4134.1
SM EL.4089.7
OZ EL. 4001.1
DM EL. 3998.1
35
65
282
327
500
530
570
585
SURFICIAL AQUIFER SCREEN INTERVAL
SHALLOW MON. SCREEN INTERVAL
ORE ZONE SCREEN INTERVAL
DEEP MON. SCREEN INTERVAL
4200
4160
4120
4080
4040
4000
3960
3920
3880
3840
3800
3760
3720
3680
3640
3600
3560
R. 67 W.
EXPLORATORY BOREHOLE (TYP)
LOT 3 SEC. 18
NE/4 SW/4 SEC. 18
LOT 4 SEC. 18
SE/4 SW/4 SEC. 18
T. 53 N.
14-18SA
14-18SM
14-18OZ
14-18DM
WELL CLUSTER 14-18
0 150 300 600
GRAPHIC SCALE (FEET)
Drawing Coordinates: WY83EF
SP399V
SP359V
SP358V
SP391V
SP353V
SP398V
SP352
SP656V
SP390V
DETAIL
0 50 100 200
GRAPHIC SCALE (FEET)
WATER LEVEL ELEVATIONS IN RESPECTIVE AQUIFER FROM JULY 2010 WATER LEVEL SURVEY
STRATA ENERGY
ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716
REVISIONS
Date Description
ENVIRONMENTAL REPORT
FIGURE 3.4-18
14-18 WELL CLUSTER LOCATION AND LAYOUT
Drawn By: RAM
Checked By: MJE
Date: 12/2/10
FILE: ROSS_ATR_OW_CL_14-18
WWC ENGINEERING







SA EL. SM EL. OZ EL. DM EL. — WATER LEVEL ELEVATIONS IN RESPECTIVE AQUIFER FROM JULY 2010 WATER LEVEL SURVEY

STRATA ENERGY

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CROOK COUNTY, WY
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REVISIONS	
Date	Description

ENVIRONMENTAL REPORT
FIGURE 3.4-19

21-19 WELL CLUSTER LOCATION AND LAYOUT

Drawn By: RAM
Checked By: MJE
Date: 12/2/10

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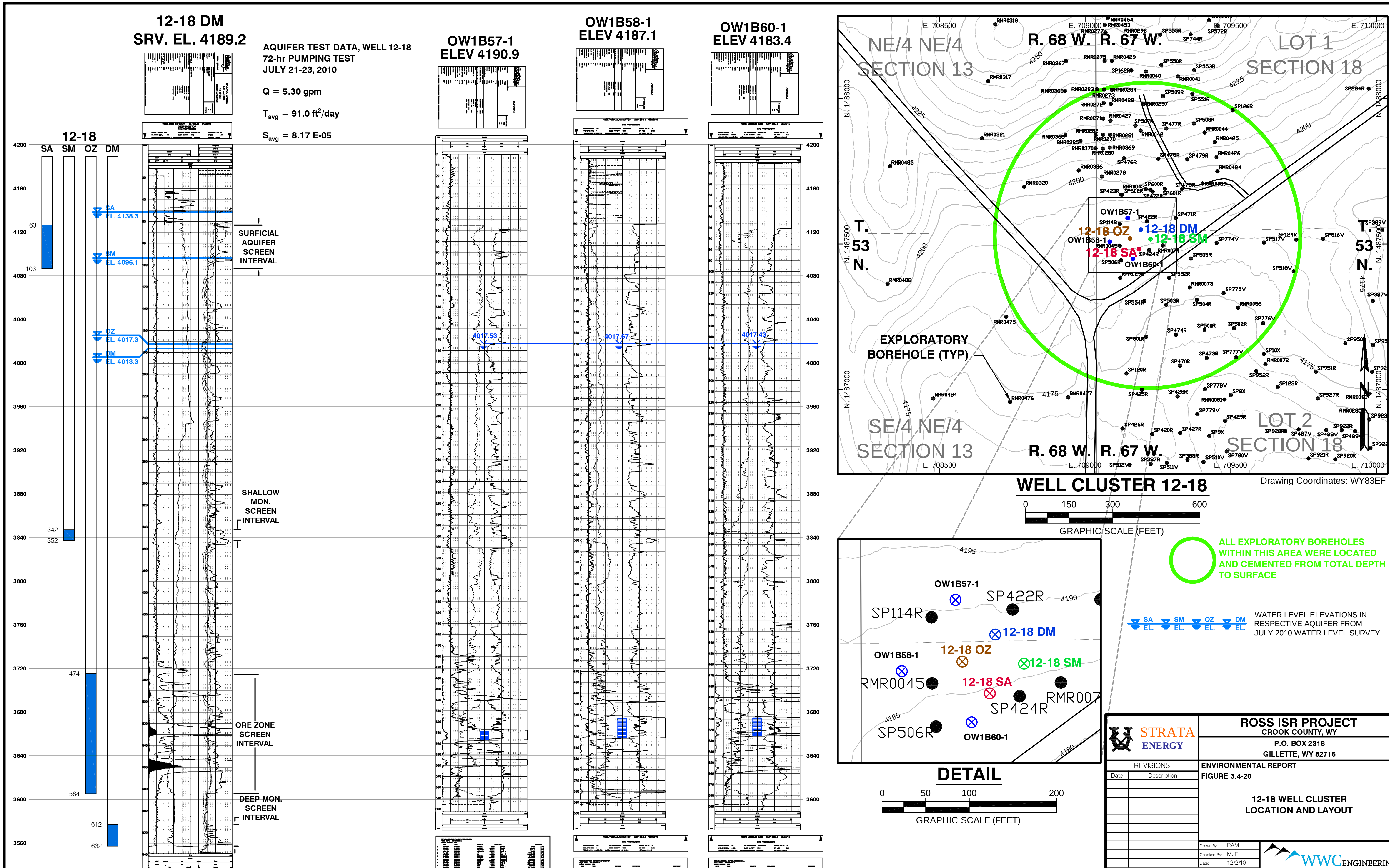
FILE: ROSS_ATR_OW_CL_21-19

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ATR_OW_CL_21-19.dwg, ER_FIGURE_3.4-19, 12/18/2010 2:38:01 PM



12-18 DM
SRV. EL. 4189.2
AQUIFER TEST DATA, WELL 12-18
72-hr PUMPING TEST
JULY 21-23, 2010
Q = 5.30 gpm
T avg = 91.0 ft²/day
S avg = 8.17 E-05
OW1B57-1
ELEV 4190.9
OW1B58-1
ELEV 4187.1
OW1B60-1
ELEV 4183.4
12-18
SA
SM
OZ
DM
SA EL. 4138.3
SM EL. 4096.1
OZ EL. 4017.3
DM EL. 4013.3
SURFICIAL AQUIFER SCREEN INTERVAL
SHALLOW MON. SCREEN INTERVAL
ORE ZONE SCREEN INTERVAL
DEEP MON. SCREEN INTERVAL
4017.53
4017.67
4017.43
NE/4 NE/4 SECTION 13
LOT 1 SECTION 18
SE/4 NE/4 SECTION 13
LOT 2 SECTION 18
R. 68 W. R. 67 W.
T. 53 N.
EXPLORATORY BOREHOLE (TYP)
12-18 OZ
12-18 DM
12-18 SM
12-18 SA
WELL CLUSTER 12-18
Drawing Coordinates: WY83EF
GRAPHIC SCALE (FEET)
ALL EXPLORATORY BOREHOLES WITHIN THIS AREA WERE LOCATED AND CEMENTED FROM TOTAL DEPTH TO SURFACE
WATER LEVEL ELEVATIONS IN RESPECTIVE AQUIFER FROM JULY 2010 WATER LEVEL SURVEY
DETAIL
STRATA ENERGY
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ENVIRONMENTAL REPORT
FIGURE 3.4-20
12-18 WELL CLUSTER LOCATION AND LAYOUT
REVISIONS
Drawn By: RAM
Checked By: MJE
Date: 12/2/10
WWC ENGINEERING

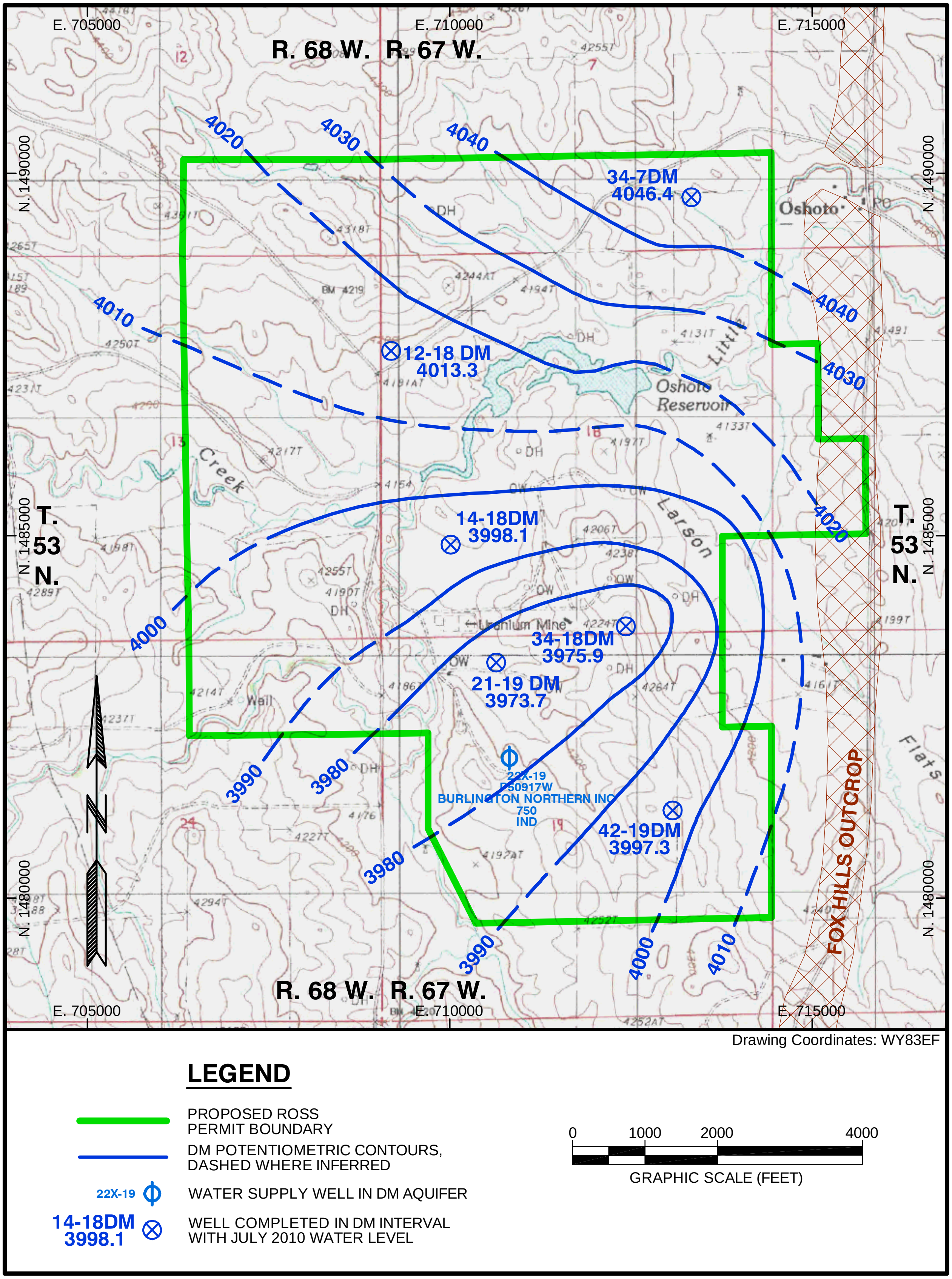


Figure 3.4-21. DM Potentiometric Contours

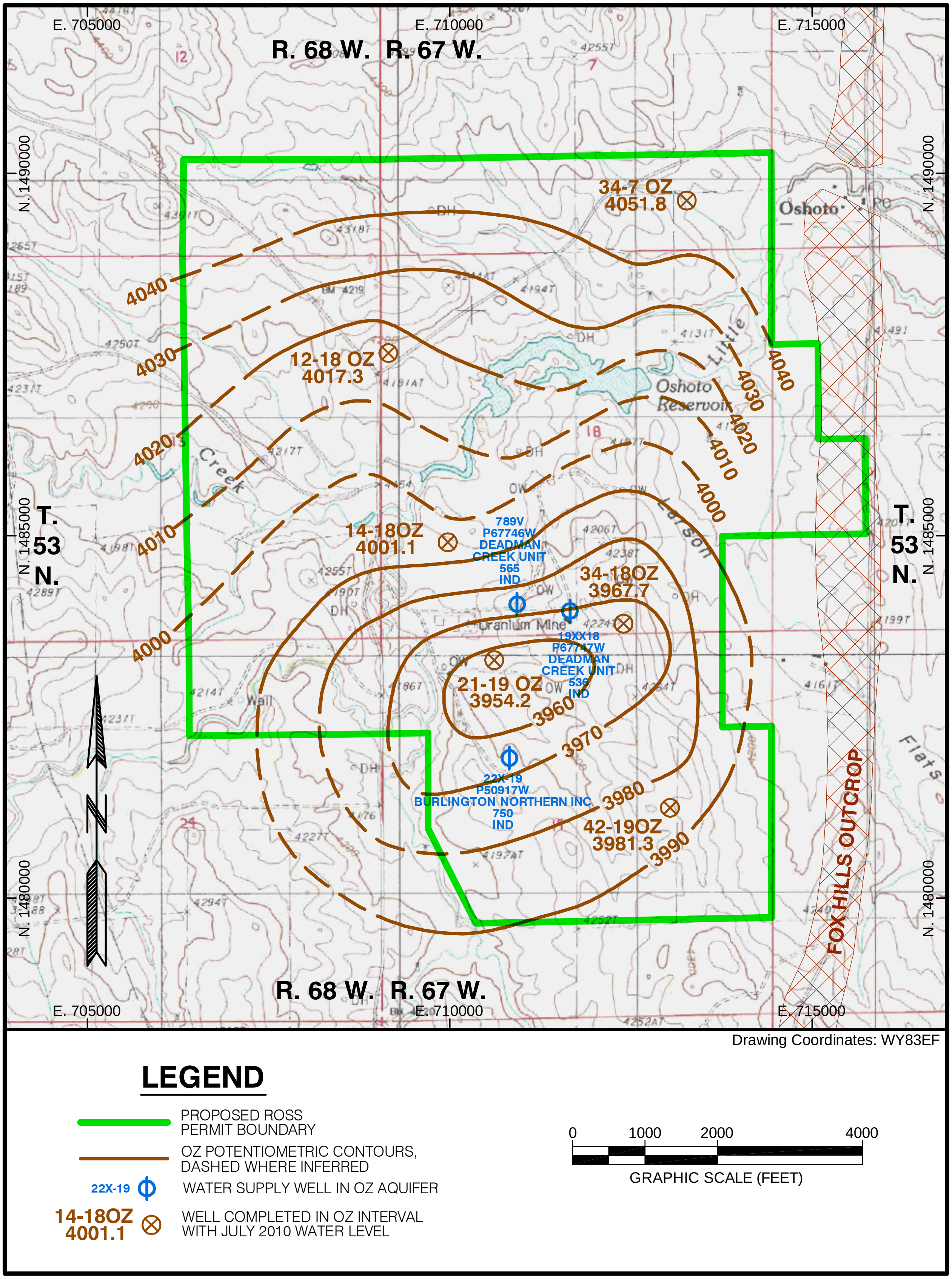
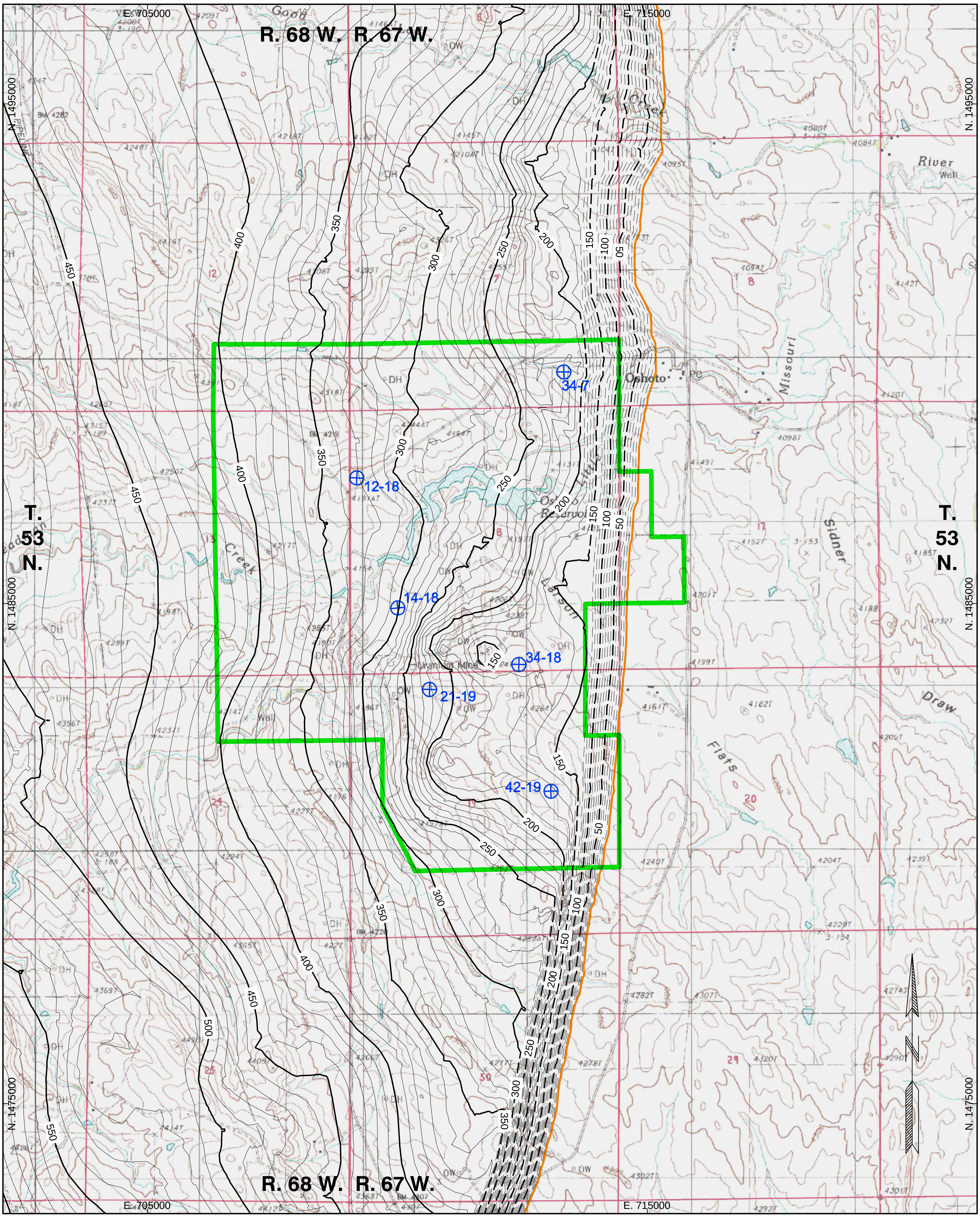


Figure 3.4-22. OZ Potentiometric Contours

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ER_HYD_POT_OZ.dwg, ER_FIGURE_3.4-22, 12/18/2010 2:44:39 PM



LEGEND

PROPOSED ROSS PERMIT BOUNDARY

ISOPACH LINE (10' CONTOUR INTERVAL) OF POTENTIOMETRIC HEAD ABOVE ORE ZONE INTERVAL. CONTOUR LINES ARE DASHED WHERE POTENTIOMETRY AND STATIGRAPHIC STRUCTURE WERE PROJECTED ALONG THE BLACK HILLS MONOCLINE FLEXURE.

EDGE OF AQUIFER

21-19 REGIONAL BASELINE MONITOR WELL CLUSTER

NOTE:

TOP OF ORE ZONE SURFACE DERIVED FROM GEMCOM GEMS© SOFTWARE CUSTOMIZED FOR STRATA ENERGY, INC. AND DEVELOPED IN SUPPORT OF SITE SPECIFIC GROUNDWATER MODEL. 2010 POTENTIOMETRIC SURFACE GENERATED FROM GW VISTAS© GROUNDWATER MODEL USING MODFLOW. THIS FIGURE REPRESENTS THE DIFFERENCE BETWEEN THOSE TWO SURFACES.

0 1000 2000 4000

GRAPHIC SCALE (FEET)

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS

Date	Description

ENVIRONMENTAL REPORT
FIGURE 3.4-23

ISOPACH OF AVAILABLE POTENTIOMETRIC HEAD IN 2010 ABOVE THE ORE ZONE AQUIFER

Drawn By: RAM
Checked By: BJS
Date: 11/21/10

FILE: ROSS_GEO_OZ_CONHEAD_ISO.DWG

WWC ENGINEERING
www.wwcengineering.com

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ER_GEO_OZ_CONHEAD_ISO.dwg, ER_FIGURE_3.4-23, 12/18/2010 2:46:55 PM

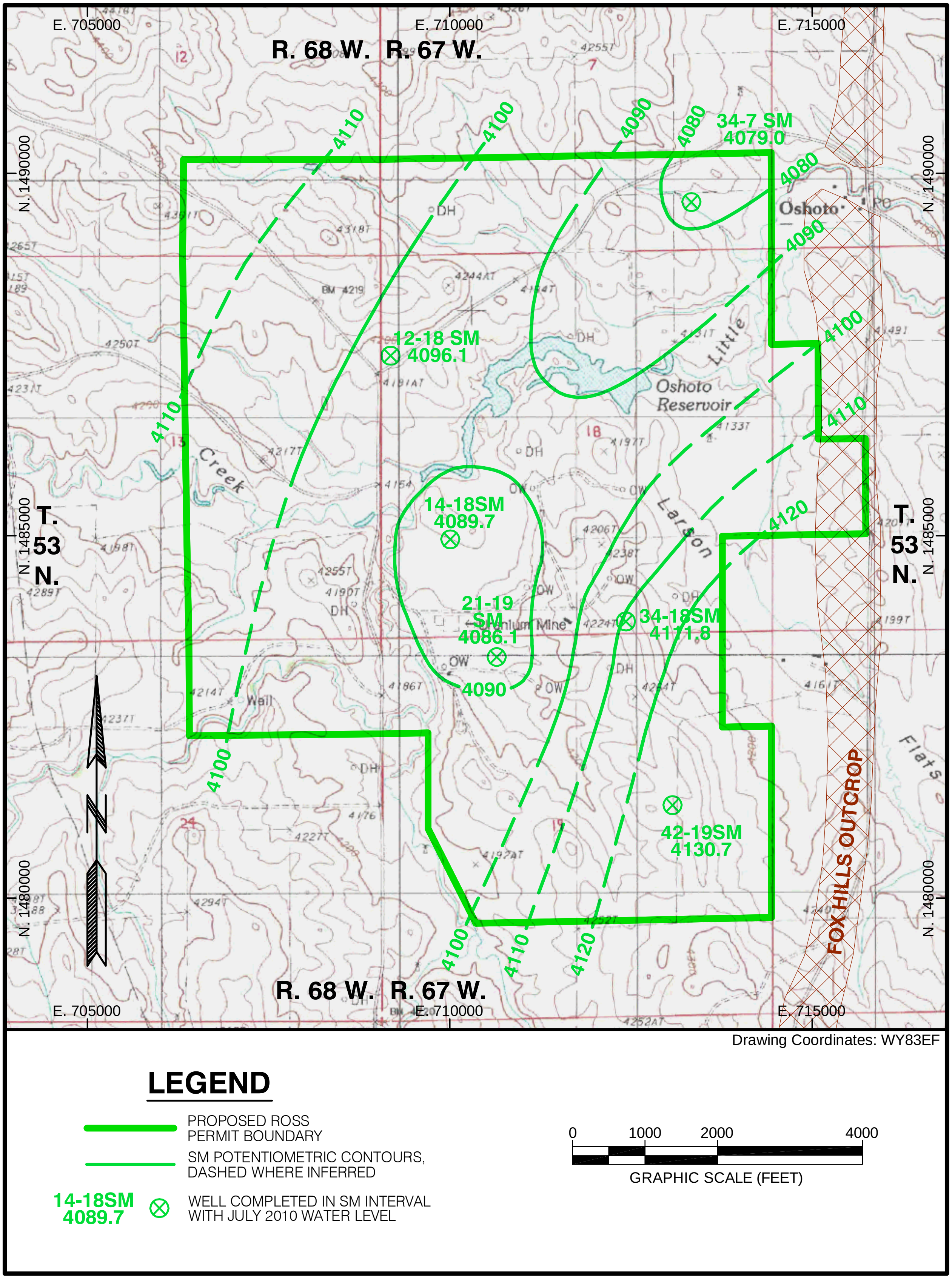


Figure 3.4-24. SM Potentiometric Contours

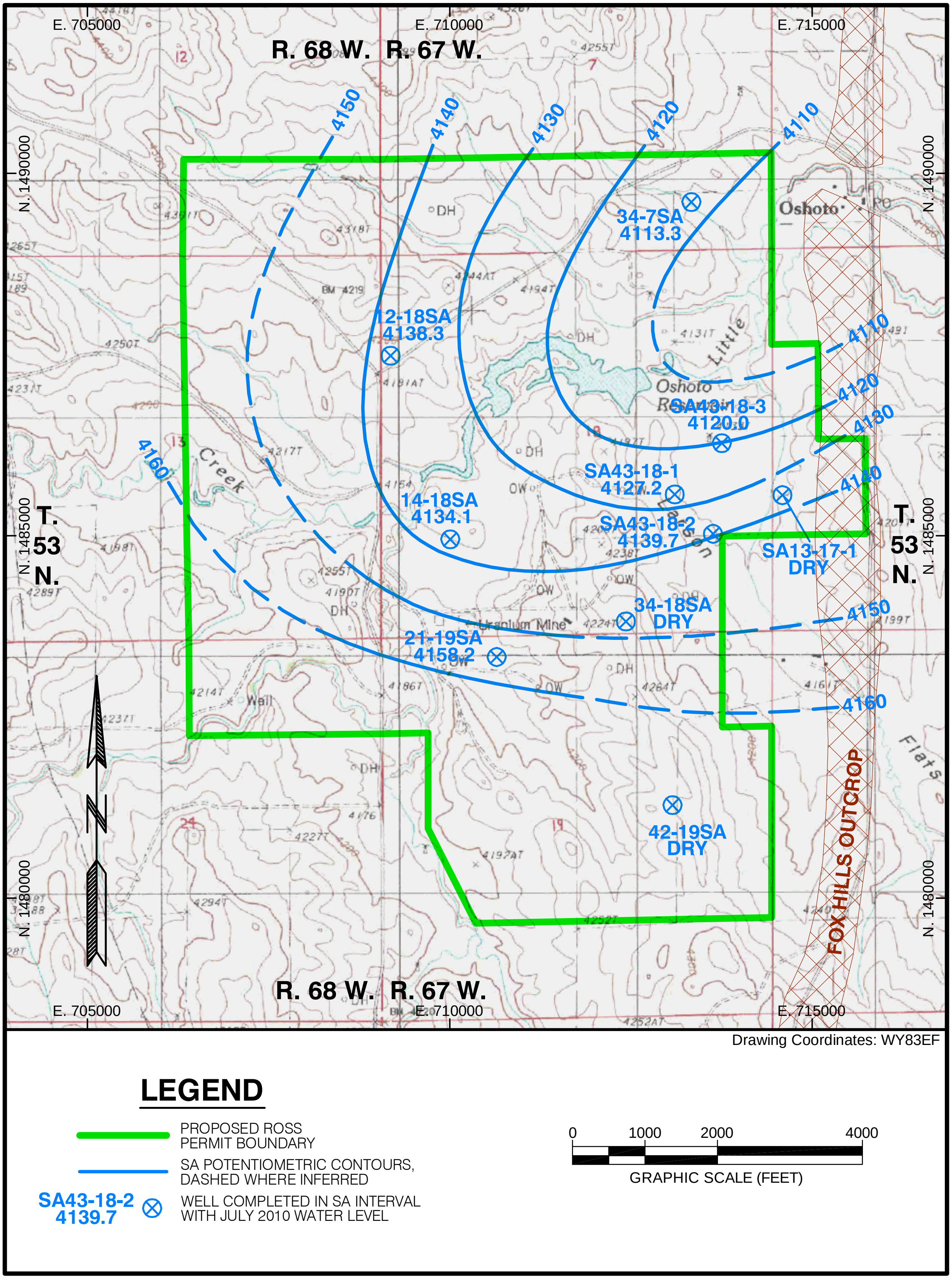
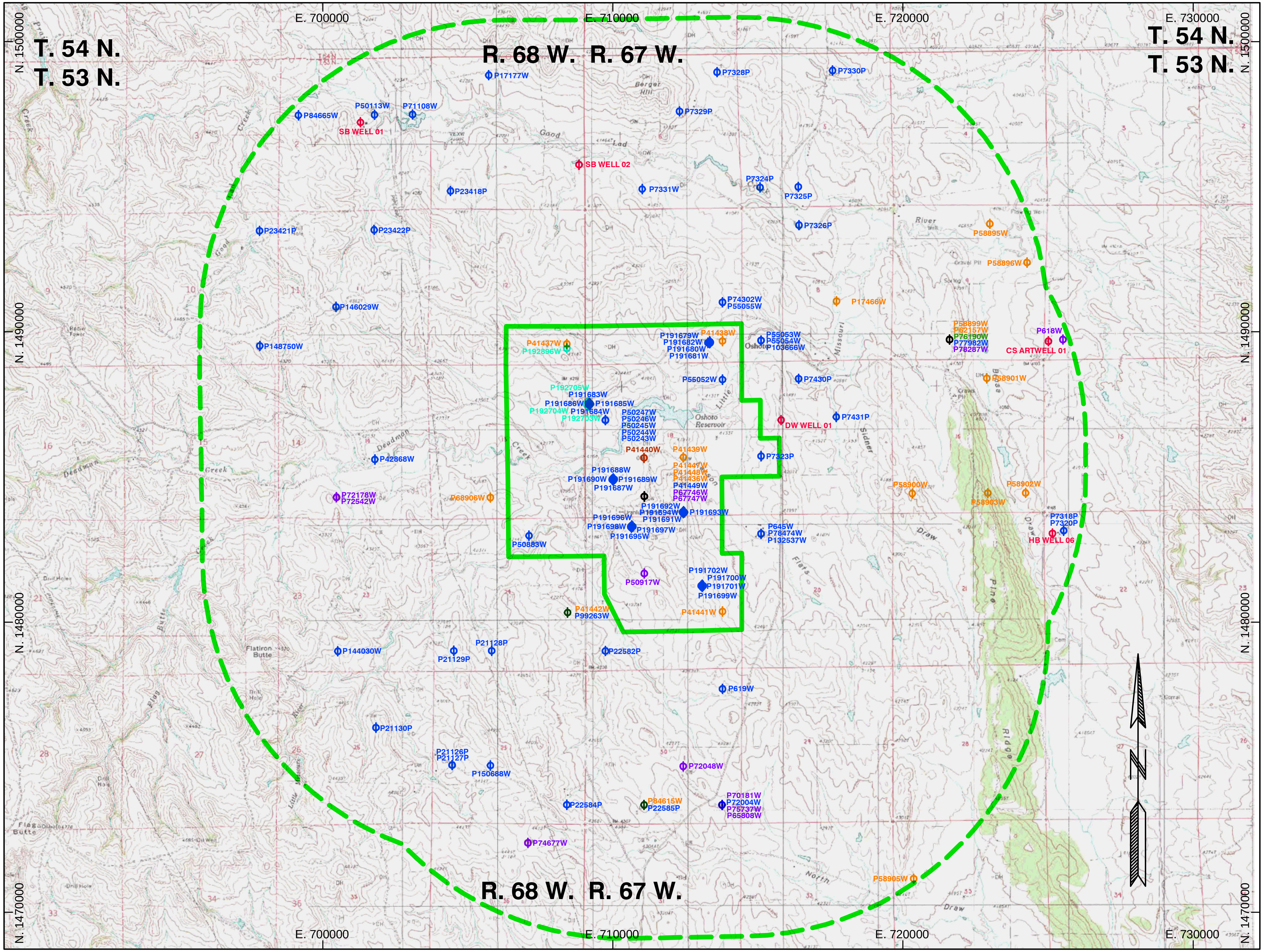


Figure 3.4-25. SA Potentiometric Contours



ROSS PROJECT AREA

Drawing Coordinates: WY83EF

LEGEND

- PROPOSED ROSS PERMIT BOUNDARY
- 2 MILE BUFFER FROM PROPOSED PERMIT BOUNDARY
- WR NUMBER — COMPLETE WATER WELL
- WR NUMBER — INCOMPLETE WATER WELL
- WR NUMBER — CANCELLED WATER WELL
- WR NUMBER — FULLY ADJUDICATED WATER WELL
- WR NUMBER — ABANDONED WATER WELL
- WR NUMBER — NO STATUS LISTED IN WSEO DATABASE
- WR NUMBER — NOT LISTED IN WSEO DATABASE

Source: WSEO 2010

0 1750 3500 7000

GRAPHIC SCALE (FEET)

STRATA ENERGY

ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716

REVISIONS

Date	Description

ENVIRONMENTAL REPORT
FIGURE 3.4-26

GROUNDWATER RIGHTS AND UNREGISTERED WELLS WITHIN TWO MILES OF THE PROPOSED PROJECT AREA

Drawn By: MBM
Checked By: JWF
Date: 12/6/10

WWC ENGINEERING
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FILE: ROSS_ER_HYD_GW_SEO

K:\Peninsula_Minerals\09142\DWGS_WY83E\ROSS_ER_HYD_GW_SEO.dwg, ER_FIGURE_3.4-26, 12/18/2010 2:52:52 PM

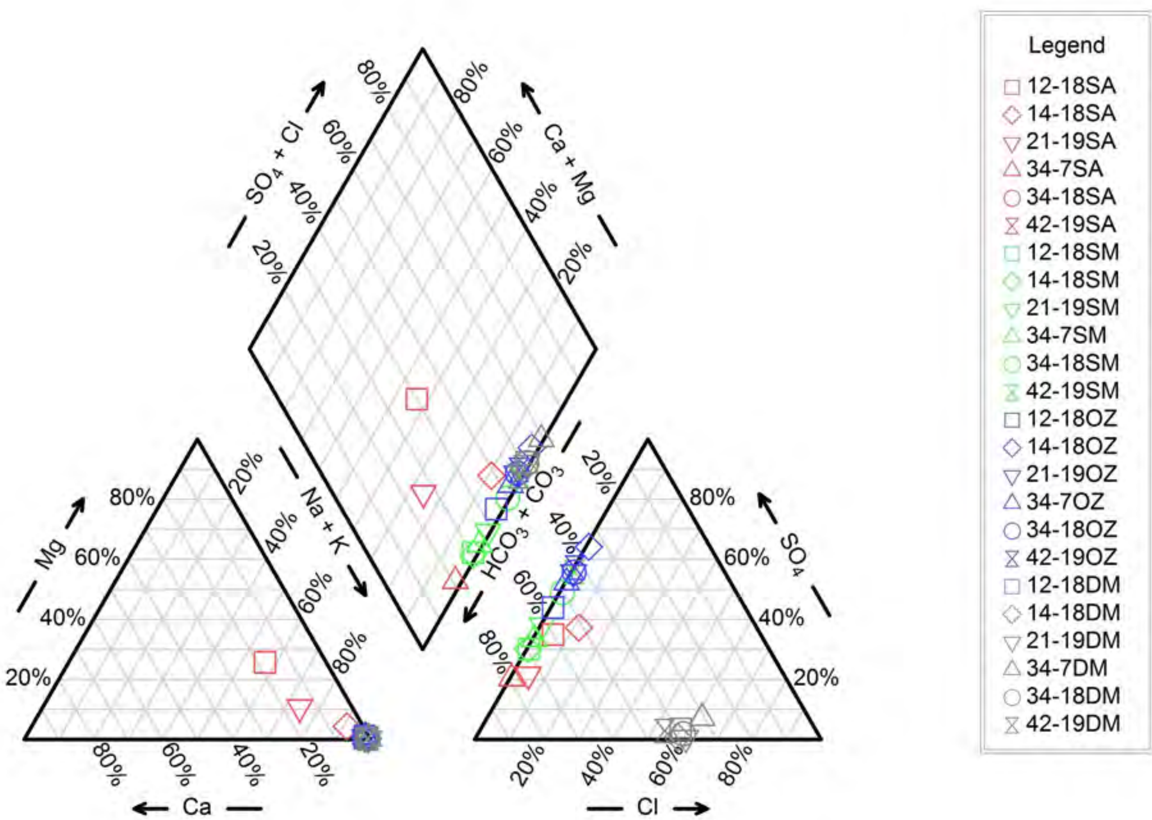


Figure 3.4-27. Regional Baseline Monitoring Network Piper Diagram
Note: data points represent average concentrations for each well.

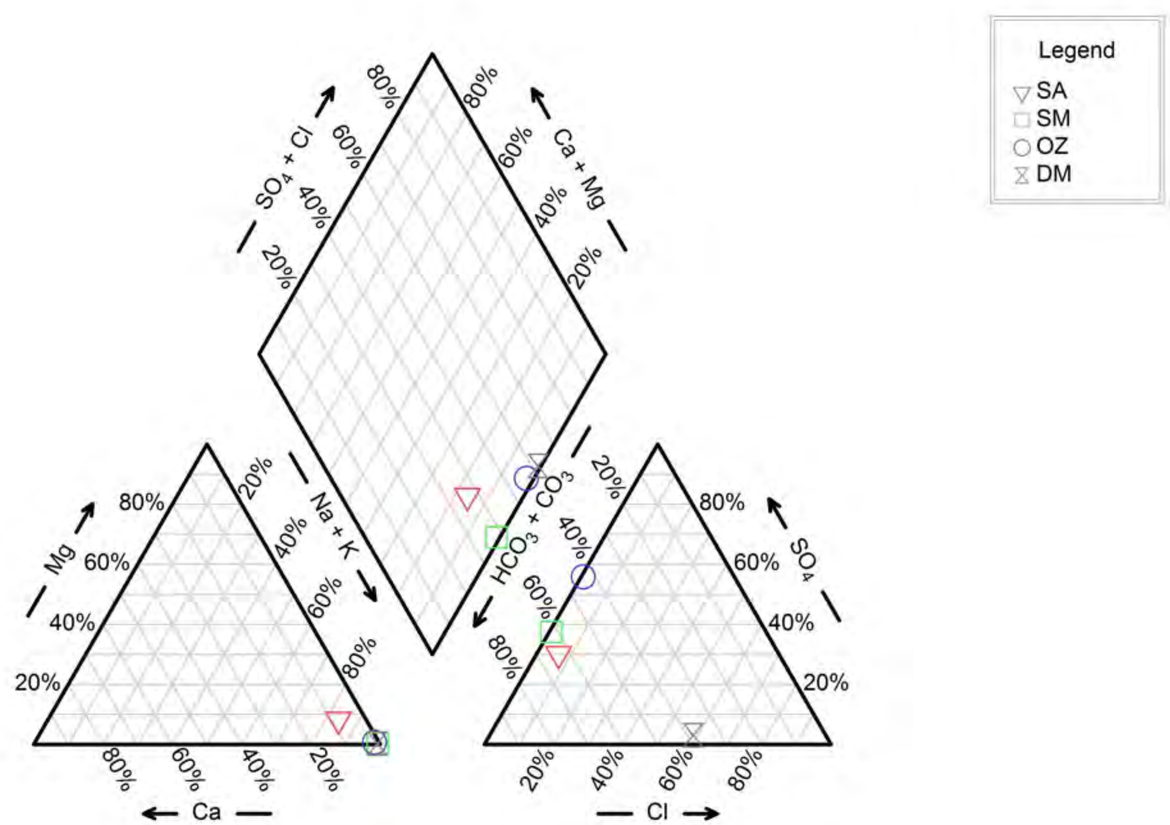


Figure 3.4-28. Regional Baseline Monitoring Network Piper Diagram by Zone
Note: data points represent average concentrations for each zone.

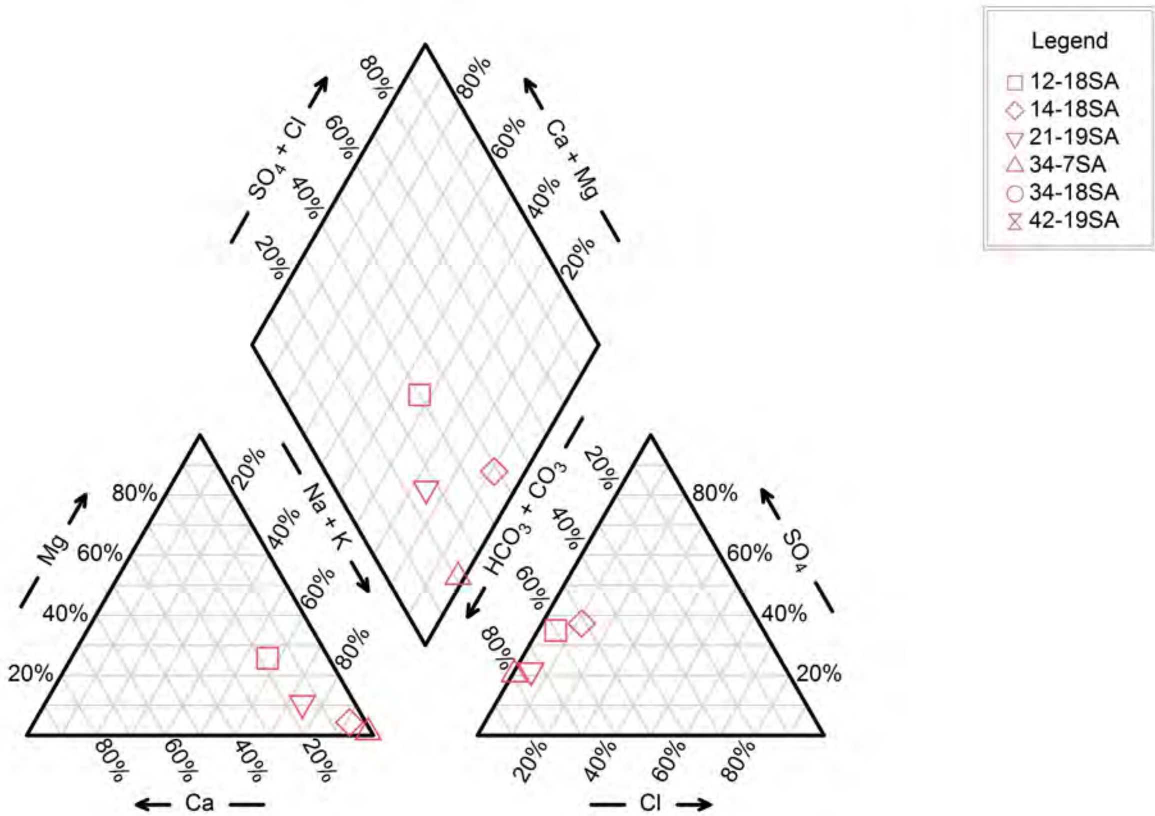


Figure 3.4-29. SA Zone Piper Diagram
Note: data points represent average concentrations for each well.

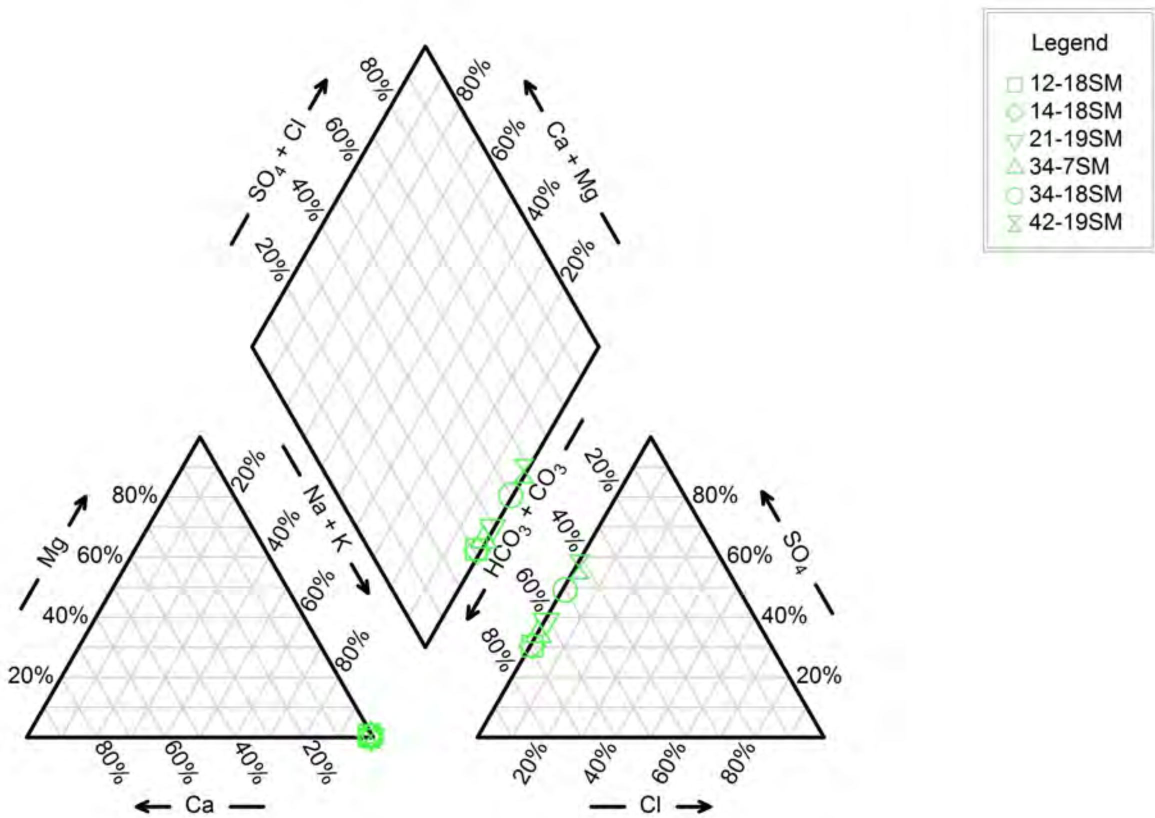


Figure 3.4-30. SM Zone Piper Diagram
Note: data points represent average concentrations for each well.

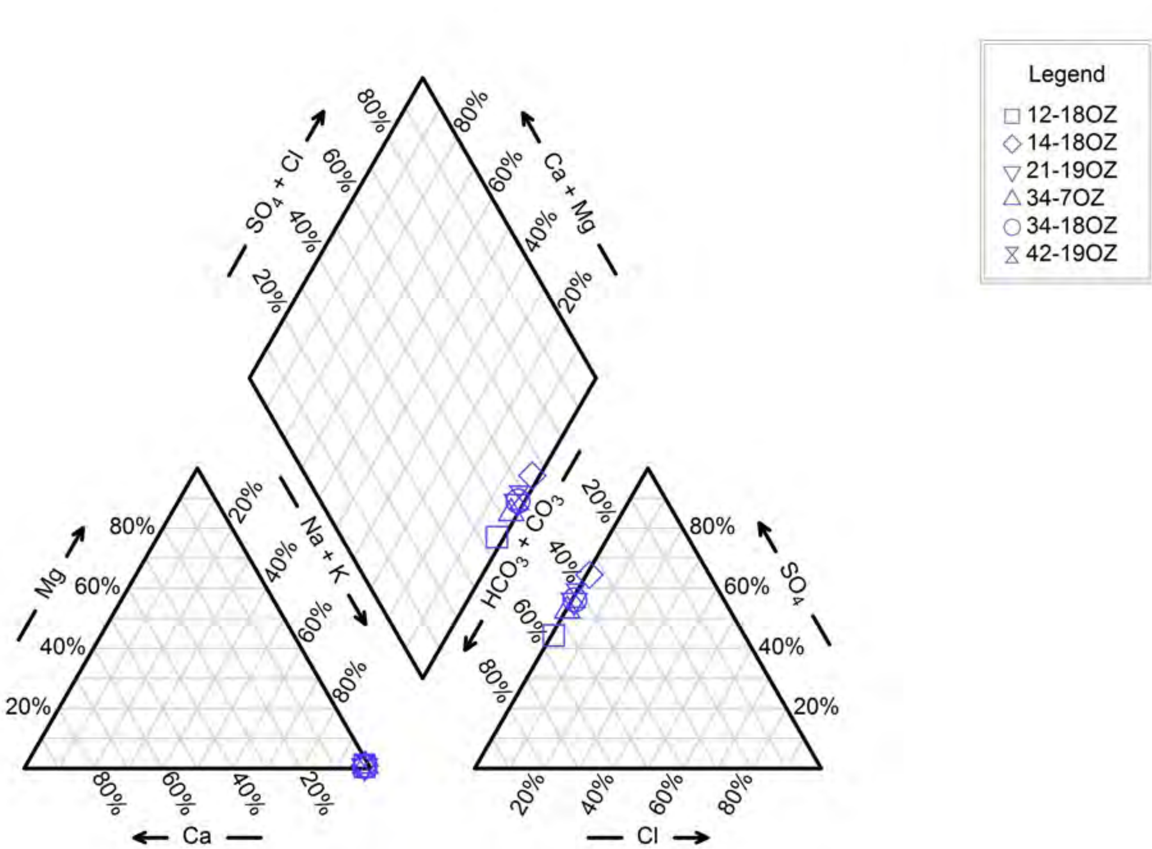


Figure 3.4-31. OZ Zone Piper Diagram
Note: data points represent average concentrations for each well.

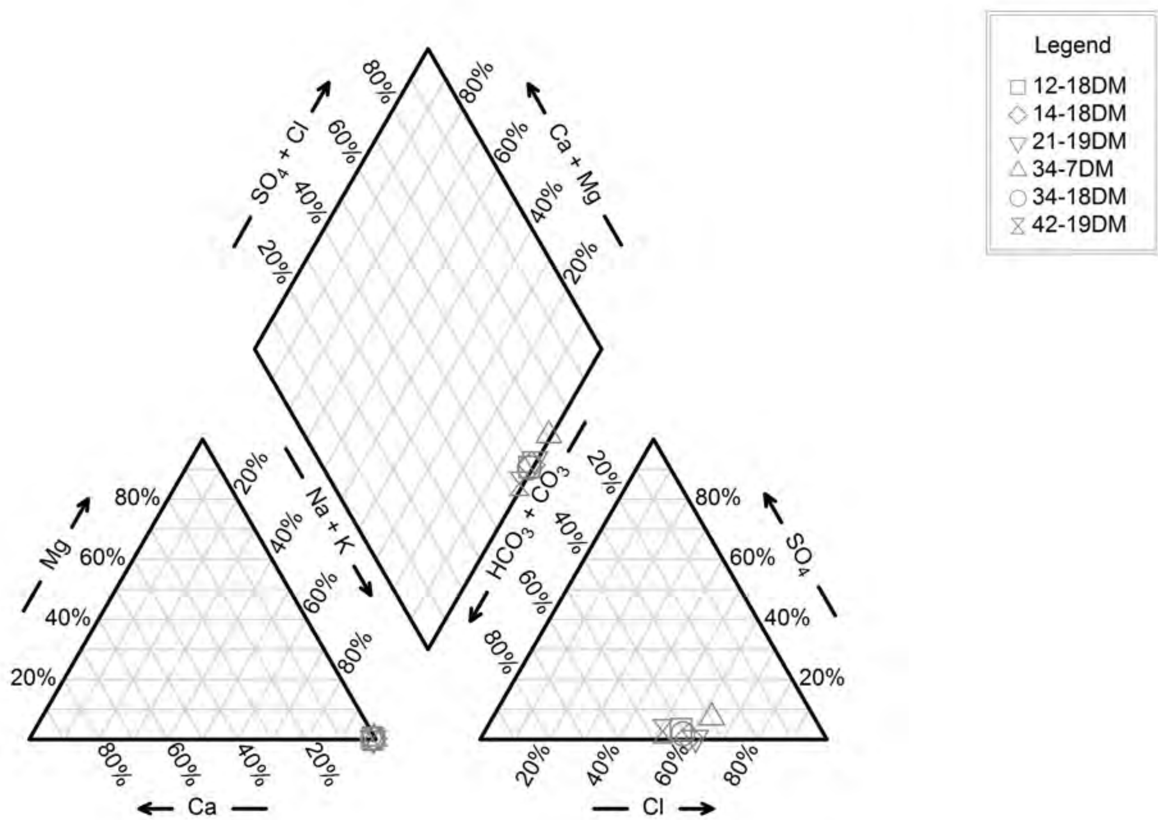


Figure 3.4-32. DM Zone Piper Diagram
Note: data points represent average concentrations for each well.

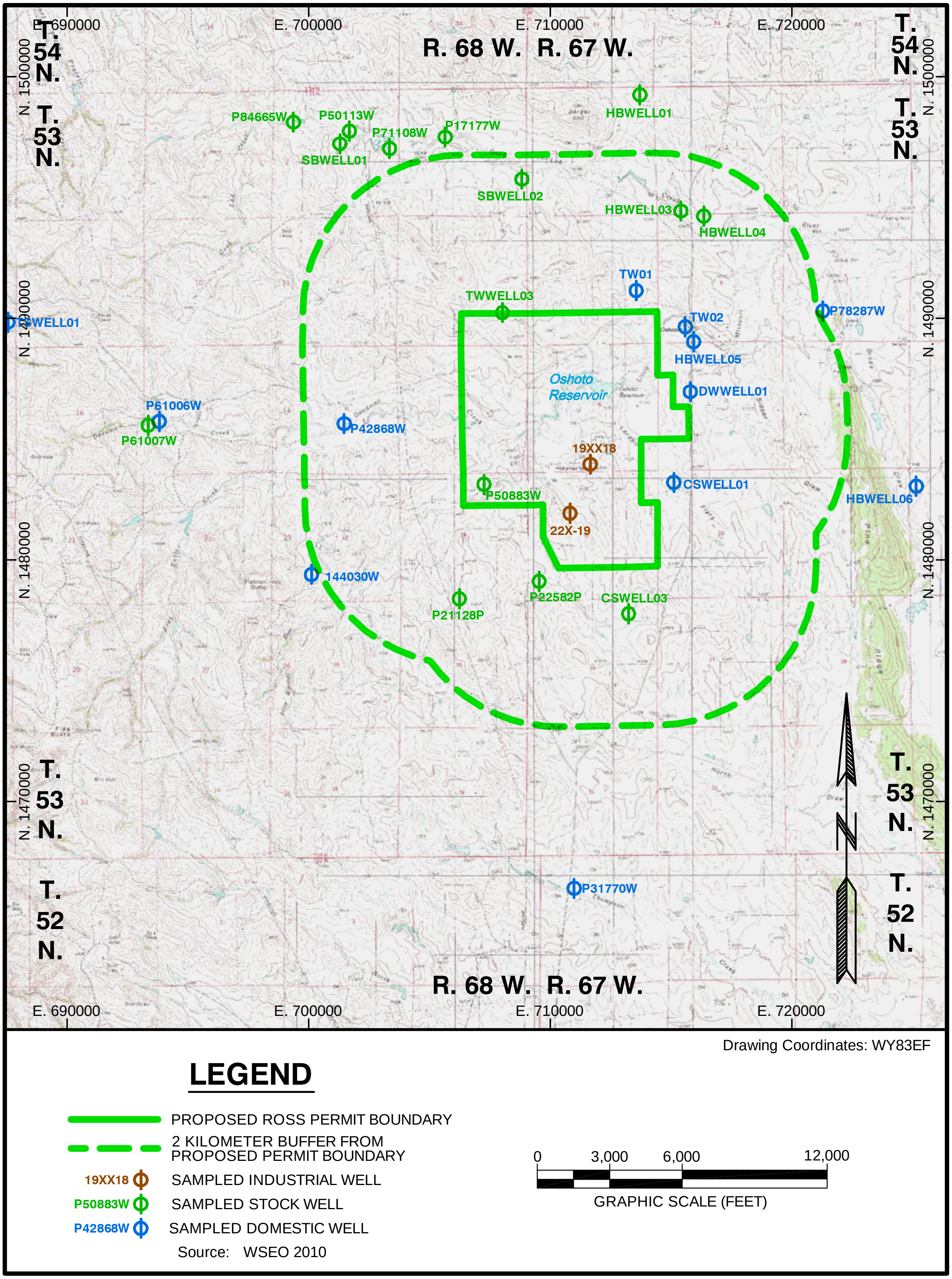


Figure 3.4-33. Sampled Water Supply Wells

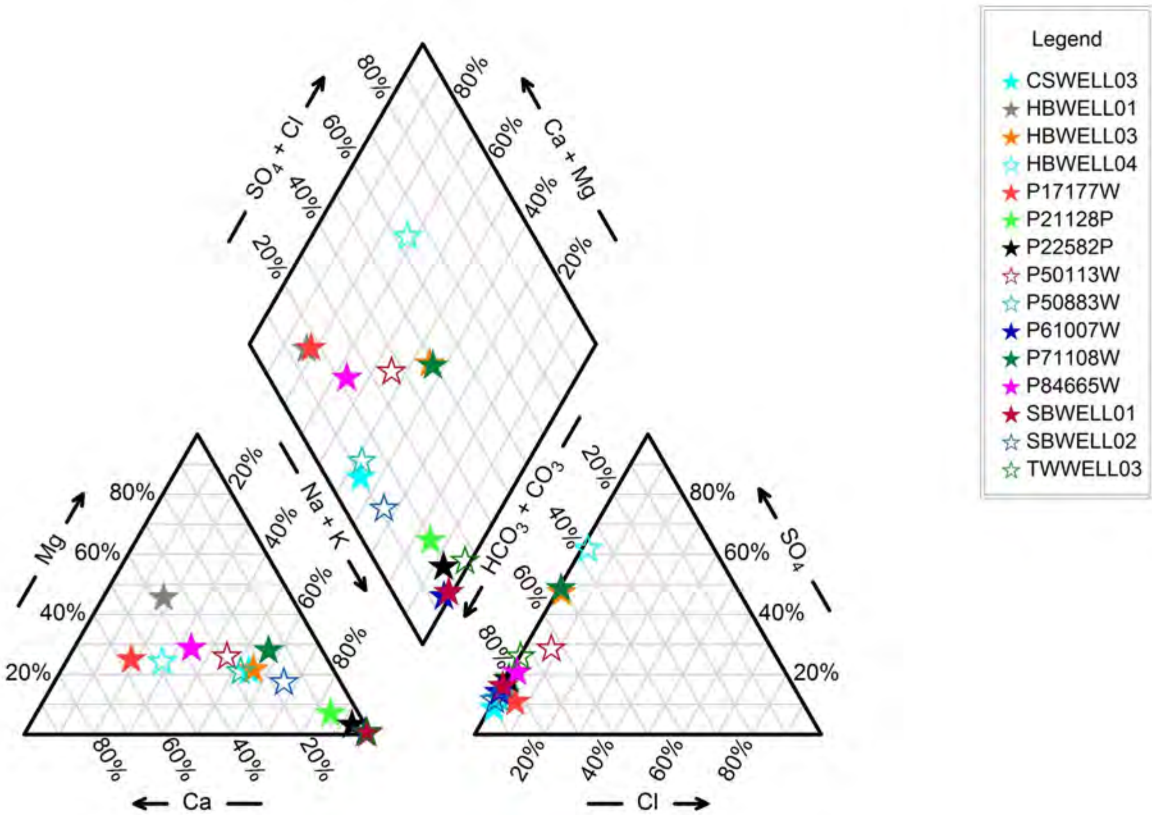


Figure 3.4-34. Stock Well Piper Diagram
Note: data points represent average concentrations for each well.

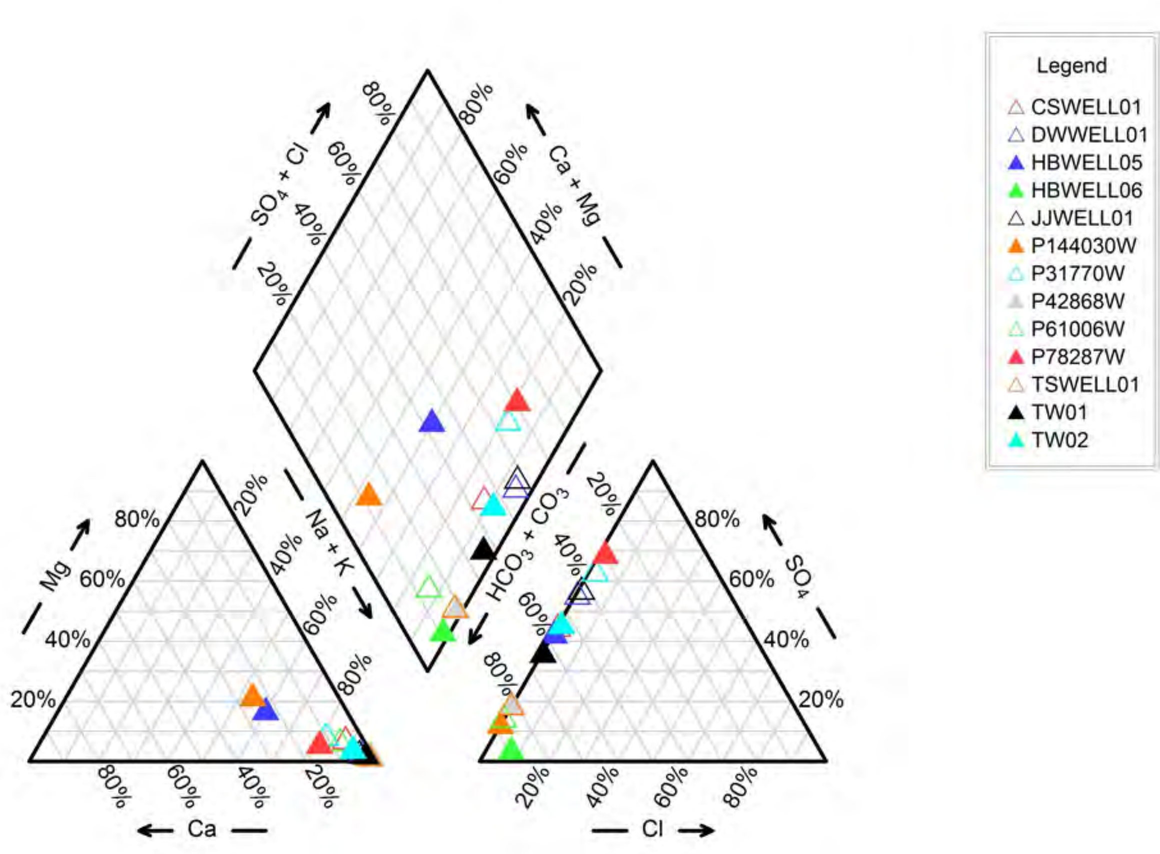


Figure 3.4-35. Domestic Well Piper Diagram
Note: data points represent average concentrations for each well.

3.5 Ecological Resources

3.5.1 Introduction

This section describes the existing ecological resources within the Ross ISR Project and documents the fact that the search for threatened and endangered (T&E) species that may potentially be present did not result in the finding of any T&E species. Background information on ecological resources within the proposed project area was drawn from several sources, including the WGFD and USFWS records, the Wyoming Natural Diversity Database, consultations with BLM, personal contacts with WGFD and USFWS biologists, and consultation with landowners and nearby residents.

Terrestrial ecological baseline field surveys included vegetation, wetlands, and wildlife. The methodology and results are discussed below, by resource. Vegetation and wildlife surveys were conducted by Intermountain Resources of Laramie, Wyoming during fall 2009 and throughout 2010. Wetland surveys were conducted by WWC Engineering during summer 2010.

3.5.2 Regional Setting

According to EPA, there are seven ecoregions delineated in Wyoming. The ecoregion concept, designed to serve as a spatial framework for environmental resource management, denotes areas within which ecosystems (and the type, quality, and quantity of environmental resources) are generally similar (EPA 2010a). The proposed project area is located in the Northwestern Great Plains Level III ecoregion. The Northwestern Great Plains ecoregion encompasses the Missouri Plateau section of the Great Plains. It is a semiarid rolling plain of shale and sandstone punctuated by occasional buttes. Native grasslands, largely replaced on level ground by spring wheat and alfalfa, persist in rangeland areas on broken topography. Agriculture is restricted by the erratic precipitation and limited opportunities for irrigation (EPA 2010a). The Northwestern Great Plains Level III ecoregion has been subdivided into two Level IV ecoregions near proposed project area. The proposed project area occurs within the Powder River Basin Level IV ecoregion, which is characterized by rolling prairies and dissected river breaks. Just east of the proposed project area is the Semiarid Pierre Shale Plains Level IV ecoregion, which is characterized by heavy, mesic soils derived from underlying shale (USGS 2004) Ecoregions are depicted on Figure 3.5-1.

The proposed project area is characterized by rolling, upland grasslands influenced by previous disturbance from county roads, oil and gas development, and reservoirs. The elevation within the proposed project area ranges from 4,114 feet to 4,312 feet and averages 4,190 feet above mean sea level.

3.5.3 Climate

As described in Section 3.6.1, the climate in the proposed project area is typical of a semiarid, high plains environment with relatively large seasonal and diurnal variations in temperature and seasonal variation in precipitation. In general, the project region has an annual average precipitation of 10 to 15 inches. Spring showers and thunderstorms produce over half of the precipitation. May is typically the wettest month and January and August the driest. Snowfall averages about 50 to 60 inches per year, but major snowstorms (more than 5 in/day) typically occur less than three times per year. Summers are relatively short and warm, while winters are longer and cold. The annual average temperature is about 46°F to 47°F. July typically has the highest average temperature (74°F) and December and January the lowest (26°F to 27°F). Temperature extremes typically range from around -21°F to 104°F. The frost-free period typically extends from mid May to mid September, or about 100 to 120 days.

3.5.4 Terrestrial Ecology

3.5.4.1 Vegetation

As described in Section 3.5.2, the proposed project area occurs within the Powder River Basin Level IV ecoregion. The ISR GEIS (pg. 3.3-24) describes typical vegetation within the Powder River Basin ecoregion. The vegetation generally consists of mixed-grass prairie dominated by blue grama, western wheatgrass, junegrass, Sandberg bluegrass, needle-and-thread grass, rabbitbrush, fringed sage, and other forbs, shrubs and grasses. The vegetation survey results presented in Section 3.5.4.1.2 below and Addenda 3.5-A through 3.5-D demonstrate that the vegetation within the proposed project area is consistent with the general vegetation described in the ISR GEIS for this ecoregion.

3.5.4.1.1 Survey Methodology

General

All sampling procedures and methodologies are consistent with standard industry practices and were approved by WDEQ/LQD in a June 1, 2010 letter, a copy of which is provided along with the sampling plan in Addendum 3.5-E. Vegetation surveys were conducted by Intermountain Resources of Laramie, Wyoming starting in late 2009 (mapping) and continuing through September 2010 (surveys of identified plant communities). Refer to Addendum 3.5-E for the submitted methodology and to Addenda 3.5-A through 3.5-D for the complete Intermountain Resources vegetation survey report. The vegetation survey area included the proposed project boundary and a buffer distance of 805 meters (0.5 mile). As approved by WDEQ/LQD, crop lands were not sampled as they were actively being used for crop production (Addendum 3.5-E).

Mapping

Plant communities were preliminarily identified within the proposed project area using high quality 2009 National Agriculture Imagery Program (NAIP) aerial photography (USDA-FSA 2009) and were later verified by field surveys.

Transect Origin Selection

Transects were randomly located in the field within each sampled vegetation community, using two sets of computer generated random numbers; one set corresponded to the x-axis of a grid and the other corresponded to the y-axis. Grids were oriented north/south and east/west to avoid bias. Sample site grid intervals were no more than 65 meters (213 feet) on the ground. The grid intersections represented the prospective sample points and were located in the field using aerial photographs and topographic maps.

Percent Cover Data

Cover sampling was done for each vegetation community type within the sample area unless it was a crop or hayland community type. Cover data were collected using 50-meter (164-foot) line transects with a meter-long pin dropped at 1-meter intervals for 50 points per transect. The tape used for the cover transect was pulled tight over the vegetation. The sampling device was a

1-meter (39.4 inches) long, 3.175-mm (⅛ inch) diameter straight rod sharpened to a point dropped vertically at each meter mark along the 50-meter tape. The pin was dropped vertically with the point of the pin beginning at each meter mark. Gravity ensured the pin dropped straight down. Data were recorded by plant species and ground cover class (e.g., lichens, litter, rock, bare ground). The minimum number of samples collected (sample adequacy) corresponded to WDEQ/LQD Guideline No. 2 (WDEQ/LQD 1997). This is demonstrated in Table 3.5-2. Production and shrub density data were not required, as approved by WDEQ/LQD.

Total Vegetation and Ground Cover

Absolute vegetation cover data were determined by plant species and by life-form. Ground cover data were also determined for each category. Computerized field data included species, life-form, and ground cover class for each transect sampled.

Trees

Trees were present within the proposed project area and were inventoried. The species, numbers, locations, and sizes (diameter at breast height and height) were determined.

Species Composition

The study area was surveyed monthly during the growing season (April through September 2010) to develop a representative plant species list. The species list was compiled by species (common/scientific names) and life-form, with a notation of the vegetation types in which each species was present.

3.5.4.1.2 Vegetation Survey Results

The complete Intermountain Resources vegetation survey report (including a complete species list) is included in Addenda 3.5-A through 3.5-D. The following is a summary of the survey results.

Table 3.5-1 presents the vegetation mapping results. The following vegetation and other units were mapped in the proposed project area: upland grassland, sagebrush shrubland, pastureland, hayland, reservoir/stockpond, wetland, disturbed land, cropland, and wooded draw. Figure 3.5-2 depicts the vegetation and other unit mapping for the proposed project area.

3.5.4.1.2.1 Upland Grassland

The Upland Grassland plant community type occurs on approximately 917.55 acres or 53.3% of the proposed project area. The perennial grass life form dominated this type in terms of cover. The most dominant individual species recorded was needleandthread (*Stipa comata*) followed by western wheatgrass (*Agropyron smithii*), bulbous bluegrass (*Poa bulbosa*), Kentucky bluegrass (*Poa pratensis*), buffalograss (*Buchloe dactyloides*) and prairie junegrass (*Koeleria macrantha*). The Upland Grassland type is found throughout the proposed project area on relatively flat to steep slopes with generally shallow sandy to sandy loam and loamy soils.

3.5.4.1.2.2 Sagebrush Shrubland

The Sagebrush Shrubland vegetation type occupies approximately 377.05 acres or 21.9% of the proposed project area. This type is dominated by the perennial grass and shrub life forms. The most common individual species recorded on this type was Kentucky bluegrass followed by bulbous bluegrass, western wheatgrass, big sagebrush (*Artemisia tridentata*), buffalograss and silver sagebrush (*Artemisia cana*). This vegetation type is found throughout the study area and occurs on relatively flat to gentle slopes within a variety of soil types from shallow to moderately deep, primarily loams.

3.5.4.1.2.3 Pastureland

The Pastureland vegetation type (approximately 125.94 acres or about 7.3% of the proposed project area) was mapped primarily in the western portion of the study area. This type was dominated by perennial grass species. The most dominant plant species recorded was intermediate wheatgrass (*Agropyron intermedium*). Other common plant species recorded on this type were smooth brome (*Bromus inermis*), crested wheatgrass (*Agropyron cristatum*), bulbous bluegrass and western wheatgrass. This vegetation type is found on relatively flat to gently sloping areas with moderately deep, sandy loam to loamy soils. The Pasturelands within the proposed project area are primarily grazed by cattle but may also be hayed.

3.5.4.1.2.4 Hayland

This map unit is dominated by the perennial grass life form. The most dominant species observed were smooth brome and crested wheatgrass.

Another common plant species observed was alfalfa (*Medicago sativa*). This plant community type is found on relatively flat to gently sloping areas with moderately deep, sandy loam to loamy soils. This vegetation type occupies about 121.15 acres or 7.0% of the proposed project area. The Haylands are generally harvested every year in July and may be grazed following harvest.

3.5.4.1.2.5 Reservoir/Stockpond

The Reservoir/Stockpond map unit (approximately 33.85 acres or about 2.0% of the proposed project area) was made up primarily of the Oshoto Reservoir. Several smaller stockponds exist within the proposed project area but may not hold water throughout the entire summer. The Oshoto Reservoir holds water year around and is supplied by Deadman Creek, the Little Missouri River, and, likely, springs. Vegetation along the shorelines of reservoirs and stockponds consists of cattail (*Typha latifolia*), bulrush (*Scirpus sp.*), sedges (*Carex sp.*), rushes (*Juncus sp.*) and spikerush (*Eleocharis sp.*).

3.5.4.1.2.6 Wetland

This map unit occupies approximately 31.15 acres or about 1.8% of the proposed project area. Note that the potential wetland areas identified in Section 3.4.2 (see Table 3.4-18) include both the Wetland and Reservoir/Stockpond vegetation map units. The Wetland vegetation map unit transects the northern and central portion of the permit area and is primarily associated with Deadman Creek, Little Missouri River and its tributaries and the Oshoto Reservoir. Topography is relatively flat with shallow to deep soils underlain by sand or gravel which allows for natural subirrigation. Mapping was based on aerial photography and surveying completed by Intermountain Resources. A complete description of wetland attributes is provided in Section 3.4.2 of this ER.

3.5.4.1.2.7 Disturbed Lands

Disturbed lands consist of existing roads and oil and gas development where vegetation is generally absent. Annuals such as Kochia (*Kochia scoparia*), Russian thistle (*Salsola kali*) and goosefoot (*Chenopodium sp.*) may be present on some disturbed areas. Smooth brome, bulbous bluegrass and crested wheatgrass may be present along some roadsides and in borrow ditches. This map unit occupies approximately 56.99 acres or about 3.3% of the proposed project area.

3.5.4.1.2.8 Cropland

This map unit was seeded to wheat (*Triticum aestivum*) in 2010 but has also been used for the production of oats (*Avena sativa*) and barley (*Hordeum vulgare*) in the past. This map unit is found on relatively flat to gently sloping areas with moderately deep, sandy loam to loamy soils. This map unit occupies about 48.71 acres or 2.8% of the proposed project area.

3.5.4.1.2.9 Wooded Draw

The Wooded Draw vegetation type occupies approximately 8.92 acres or about 0.5% of the proposed project area. Dominant woody species are plains cottonwood (*Populus deltoides*), boxelder maple (*Acer negundo*), peachleaf willow (*Salix amygdaloides*), snowberry (*Symphoricarpos occidentalis*), big sagebrush and silver sagebrush. Common understory species are Kentucky bluegrass, smooth brome, Japanese chess (*Bromus japonicus*) and stinging nettle (*Urtica dioica*). The Wooded Draw type is only found in a few small stands within ephemeral drainages and will not generally be disturbed by ISR uranium recovery activities. Soils are generally loamy and moderately deep to deep.

3.5.4.1.3 Vegetation Survey Discussion

Cover Data

Cover data were collected on the proposed project area from June 21 through June 24, 2010 on the Upland Grassland, Sagebrush Shrubland, and Pastureland plant community/habitat types. Cover sampling was not required on the other map units, as agreed upon with the WDEQ/LQD (Addendum 3.5-E). Twenty-one cover samples were collected on the Upland Grassland type, while 20 samples were collected each on the Sagebrush Shrubland and the Pastureland. Table 3.5-2 provides the results of the cover sampling for the three plant community types inventoried in 2010.

Statistical Evaluations

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. Sample adequacy (determining the minimum number of sample locations needed to ensure statistical validity) was met based on WDEQ/LQD Guideline No. 2 for all parameters, as shown in Table 3.5-2.

Species Diversity

Table 3.5-3 shows the diversity of plant species encountered in cover sampling for each vegetation type sampled on the proposed project area in 2010. The Sagebrush Shrubland vegetation type exhibited the highest total number of individual plant species recorded in cover transects during the 2010 survey followed by the Upland Grassland and Pastureland vegetation types. The Upland Grassland type exhibited the highest number of species with greater than 2% relative cover followed by the Sagebrush Shrubland and Pastureland.

3.5.4.1.4 Threatened, Endangered and Species of Concern

According to the USFWS' Federal Threatened, Proposed, and Candidate Species that Occur in or may be Affected by Projects in Crook County, Wyoming, there were no T&E plant species encountered within the proposed project area during the 2010 surveys (USFWS 2010b). Typical habitat for the Ute ladies'-tresses orchid (*Spiranthes diluvialis*) was encountered in the wetlands within the proposed project area. These wetlands were found primarily along Deadman Creek, the Little Missouri River and along the Oshoto Reservoir. These wetland habitats were surveyed on August 11, 12 and 13, 2010 but no orchids were observed. Typical habitat for the blowout penstemon (*Penstemon haydenii*) is not found in the proposed project area.

No rare or sensitive plant species of concern as listed by state agencies, federal agencies or the Wyoming Natural Diversity Database were found in the study area.

3.5.4.1.5 Noxious Weeds

Several species of designated and prohibited noxious weeds listed by the Wyoming Weed and Pest Control Act were identified in the proposed project area. These species included field bindweed (*Convolvulus arvensis*), perennial sow thistle (*Sonchus arvensis*), Quackgrass (*Agropyron repens*), Canada thistle (*Cirsium arvense*), hounds tongue (*Cynoglossum officinale*), leafy spurge (*Euphorbia esula*), common burdock (*Arctium minus*), Scotch thistle (*Onopordum acanthium*), Russian olive (*Eleagnus angustifolia*) and skeletonleaf bursage (*Ambrosia tomentosa*). These species may be abundant in small localities, especially around the Oshoto Reservoir and along the Little Missouri River and Deadman Creek, but were not common throughout the area.

Selenium indicator species identified in the proposed project area in 2010 included two-grooved milkvetch (*Astragalus bisulcatus*), woody aster (*Xylorhiza glabriuscula*) and Stemmy goldenweed (*Haplopappus multicaulis*). These selenium indicator species were not abundant in the proposed project area. Little larkspur (*Delphinium bicolor*), locoweed (*Oxytropis sericea* and *Oxytropis lambertii*) and meadow deathcamas (*Zigadenus venenosus*) were poisonous plants commonly observed on the area in limited amounts. Cheatgrass, although not a state listed noxious weed, was abundant on some sites within the proposed project area.

3.5.4.1.6 Trees

A survey of the trees within the proposed project area shows that four species of trees were present and included boxelder maple, plains cottonwood, peachleaf willow and Russian olive. The boxelder maple was the most common tree species recorded in the proposed project area followed by the plains cottonwood, peachleaf willow and Russian olive. The average height calculated for the boxelder maple for the entire survey area was 19.2 feet and exhibited an average diameter at breast height (DBH) of 11.2 inches. The plains cottonwood averaged a height of 47.5 feet and an average DBH of 29.0 inches for the entire survey area. The average height calculated for the peachleaf willow for the entire survey area was 27.4 feet and exhibited an average DBH of 15.3 inches. The Russian olive averaged a height of 5.2 feet and an average DBH of 3.0 inches for the entire survey area.

3.5.4.2 Wildlife

3.5.4.2.1 General Setting

Wildlife and aquatics sampling were conducted by Intermountain Resources of Laramie, Wyoming. Background information on terrestrial vertebrate wildlife species and aquatic vertebrates in the vicinity of the proposed project area was obtained from several sources, including records from WGFD, BLM, USFWS, and the ISR GEIS. Previous site-specific data for the proposed project area and surrounding perimeter were obtained from those same sources and the Nubeth Joint Venture Environmental Report Supportive Information (ND Resources 1977), with current data collected during regular site visits and targeted surveys conducted from November 2009 through October 2010 to meet agency requirements of one year of baseline data.

All sampling procedures and methodologies were consistent with standard industry practices and were approved by WGFD, BLM, and USFWS. Agency correspondence is provided in Addendum 3.5-I. Survey protocols and timing were developed collaboratively with WGFD, BLM, and USFWS to meet species specific requirements. The proposed site boundary and 1.6-kilometer (1 mile) buffer area survey covered bald eagle (*Haliaeetus leucocephalus*) winter roosts, all nesting raptors, T&E species, BLM sensitive species, and other migratory birds of conservation concern, as defined by USFWS. The sage-grouse survey area included a 3.2-kilometer (2 mile) buffer. Surveys were conducted within the proposed project area for swift fox (*Vulpes velox*), breeding birds, and northern leopard frogs (*Rana pipiens*). Aquatic (fish and benthic invertebrates) sampling was not conducted within the proposed project area due to the lack of suitable waters that would support viable fisheries, the lack of perennial streams, and the fact there will be minimal to no disturbance of aquatic habitats from this project. In a February 12, 2010 letter from the WGFD to Intermountain Resources (Addendum 3.5-I), the WGFD concluded the following:

> "We agree with your conclusion that the Little Missouri River is ephemeral and does not pick up significant flows until downstream of the confluence with the North Fork of Little Missouri [approximately 30 miles downstream]. Therefore, we do not recommend that surveys of benthic invertebrates or fish of the Little Missouri River be completed."

The proposed project area contains the Oshoto Reservoir. This reservoir is relatively small and shallow and has not been documented to support a sport fishery; however, fish were caught from the reservoir as part of the radiological baseline sampling program as described below. In addition to these targeted efforts, incidental observations of all vertebrate wildlife species seen within the wildlife survey area were recorded during each site visit over the course of the year-long baseline survey period. A list of wildlife species observed within and near the proposed project area is provided in Addendum 3.5-G. Big game, most predatory mammals, lagomorph, small mammal, and black-footed ferret (*Mustela nigripes*) surveys were not required for this project due the availability of existing information from the WGFD and the block clearance for ferrets issued by the USFWS in the survey area.

All required wildlife surveys were conducted by qualified biologists using standard field equipment and appropriate field guides. Most observations were recorded from vantage points during pedestrian or vehicular surveys to avoid

disturbing wildlife. Raptor nests and other features or observation points of special interest were mapped in the field.

3.5.4.2.2 Big Game

No crucial big game habitats or migration corridors are recognized by the WGFD in the proposed project area or surrounding 1.6 kilometers (1 mile) perimeter. 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.

Pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), and white-tailed deer (*0. virginianus*), are the big game species that were observed on the proposed project area in 2009 and 2010. American elk (*Cervus elaphus*) were recorded by WGFD as occurring in the area. Pronghorn and mule deer were common but not abundant within the proposed project area. The pronghorn is a browse species and sagebrush-obligate, using shrubs for both forage and cover (Fitzgerald et al. 1994). Pronghorn herds were most often observed in sagebrush shrubland and upland grassland habitats and mule deer frequented the sagebrush shrubland habitat. Both species utilized haylands and cultivated fields in the area. White-tailed deer were not abundant but were observed in the riparian habitats and on the cultivated fields within and near the proposed project area.

Pronghorn use has been classified by WGFD as yearlong and mule deer use within the area is winter/yearlong. White-tailed deer and elk use has been classified by WGFD as out of their normal range.

The study area is located within the WGFD North Black Hills pronghorn herd unit, the Powder River and Black Hills mule deer herd units, and the Thunder Basin and Black Hills white-tailed deer herd units. The proposed project area is not within a specific elk herd unit but is included in Hunt Area 129.

3.5.4.2.3 Other Mammals

A variety of small and medium-sized mammalian species have the potential to occur in the proposed project area. These potential species include a variety of predators and furbearers such as the coyote (*Canis latrans*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), bobcat (*Lynx rufus*), badger (*Taxidea taxus*), beaver (*Castor canadensis*), and muskrat (*Ondatra zibethicus*). As

determined through consultations with USFWS, BLM, and WGFD, no small mammal, lagomorph (hares and rabbits), black-footed ferret (*Mustela nigripes*), or bat surveys were conducted within the proposed project area. Correspondence with these agencies is provided in Addendum 3.5-I.

Numerous prey species, including rodents (e.g., mice, rats, voles, gophers, ground squirrels, chipmunks, prairie dogs, etc.), jackrabbits (*Lepus* spp.), and cottontails (*Sylvilagus* spp.) can also be found in the project survey area. These species are cyclically common and widespread throughout the region, and are important food sources for raptors and other predators. Each of these prey species was either directly observed during the field surveys or was known to exist through burrow formation or scat. Jackrabbit and cottontail sightings were common.

While black-tailed prairie dogs (*Cynomys ludovicianus*) are listed as occurring in the general area of the proposed project, no black-tailed prairie dog colonies (important as habitat for black-footed ferrets) were located within 1.6 kilometers (1 mile) of the study area. Other mammal species such as the striped skunk (*Mephitis mephitis*), porcupine (*Erethizon dorsatum*), and various weasels (*Mustela* spp.) inhabit sagebrush grassland and riparian communities and these species were recorded within the proposed project area during wildlife surveys. No bat species were observed during the baseline monitoring.

There are no records of prior use of the proposed project area by swift fox (*Vulpes velox*) but, at the request of WGFD, surveys for swift fox were conducted within the proposed project area. No swift fox were observed during the 2009 or 2010 surveys.

Two mammal species (the black-tailed prairie dog and prairie vole (*Microtus 0ochrogaster*)) of concern were observed within the proposed project area (Addendum 3.5-G). Both were Wyoming Species of Concern but neither was on the BLM list of Sensitive Species.

3.5.4.2.4 Raptors

Raptor species observed during the 2009-2010 baseline wildlife surveys included the bald eagle (*Haliaeetus leucocephalus*), red-tailed hawk (*Buteo jamaicensis*), golden eagle (*Aquila chrysaetos*), ferruginous hawk (*Buteo regalis*), Swainson's hawk (*Buteo swainsoni*), northern harrier (*Circus cyaneus*), American kestrel (*Falco sparverius*), Cooper's hawk (*Accipiter cooperii*), Sharp-shinned Hawk (*Accipiter striatus*), rough-legged hawk (*Buteo lagopus*), great

horned owl (*Bubo virginianus*), and short-eared owl (*Asio flammeus*). Turkey vultures (*Cathartes aura*) and prairie falcons (*Falco mexicanus*) have also been recorded in the area, but not during the 2009-2010 baseline surveys.

Raptors were observed hunting, perching on nest trees, power poles, and topographic features, nest tending, incubating, and exhibiting nest defense. Biologists watched for active raptor nests and breeding behavior (territory defense, courtship flights, prey deliveries, etc.) during all site visits within the breeding season. Additional nest searches were conducted concurrently with other surveys completed during the non-breeding season. Nests were monitored from a distance using binoculars and a spotting scope early in the nesting season to avoid impacting active nests. All active nests were monitored throughout the breeding season to determine their success and production level. Nine nests were located within the 1.6 kilometer survey area in 2010 (Figure 3.5-3). One intact (i.e., material present) raptor nest was documented within the proposed project area during the 2010 baseline survey period. Seven additional intact nests and one nest no longer intact were recorded in the 1.6 kilometers (1 mile) survey perimeter. The 2010 status and productivity for the nine nests are listed in Table 3.5-4. The red-tailed hawk was the only raptor species that successfully nested within the 1.6 kilometer study area perimeter.

Six raptor species of concern (bald eagle, Swainson's hawk, ferruginous hawk, golden eagle, prairie falcon, and short-eared owl) were observed within the proposed project area (Addendum 3.5-G). All six were USWFS Birds of Conservation Concern, four were Wyoming Species of Concern (bald eagle, Swainson's hawk, ferruginous hawk, and short-eared owl), and one was a BLM Sensitive Species (ferruginous hawk).

3.5.4.2.5 Upland Game Birds

The wild turkey (*Meleagris gallopavo*), greater sage-grouse (*Centrocercus urophasianus*), sharp-tailed grouse (*Tympanuchus phasianellus*), and mourning dove (*Zenaida macroura*) were the upland game bird species observed in the project survey area during baseline inventories conducted in 2010. Five searches for sage-grouse leks and sharp-tailed grouse dancing grounds were completed between March 31 and April 29, 2010. Biologists searched for displaying grouse by driving the 3.2 kilometer (2 mile) buffer area.

According to WGFD records, no sharp-tailed grouse dancing grounds have been documented within 3.2 kilometers of the proposed project area (WGFD 2009). No sharp-tailed grouse dancing grounds were located within the 3.2-kilometer buffer during the 2010 surveys.

Based on 2010 WGFD records, one sage-grouse lek had been documented approximately 1.6 kilometers (1 mile) from the proposed project area (Figure 3.5-3). As of 2010, this lek has a WGFD *occupied* management status (active during at least one strutting season within the prior ten years) and an *inactive* annual status (no birds observed in 2010) (WGFD 2010c). The nearest active sage-grouse lek was the Cap'n Bob Lek, which is approximately 3.5 kilometers (2.2 miles) southeast of the proposed project area (Figure 3.5-3). Potential habitat for sage-grouse is present (Upland Grassland, Sagebrush Shrubland, Pastureland, Hayland, and Reservoir/Stockpond).

The greater sage-grouse is a species of great concern throughout the west and is considered a "landscape species" due to its use of wide expanses of sagebrush as primary habitat during each phase of its life cycle. USFWS currently classifies the greater sage-grouse as a candidate T&E species under the Endangered Species Act (ESA). Candidate species are plants and animals that the USFWS has sufficient information on their biological status and threats to propose them as endangered or threatened, but development of a proposed listing regulation is precluded by other higher priority listing activities. Candidate species receive no statutory protection under the ESA (USFWS 2010b). In August 2010, Wyoming Governor Dave Freudenthal issued a revised executive order (2010-4) updating Wyoming's sage-grouse Core Population Area strategy, to help avoid listing the bird under the ESA (State of Wyoming 2010). The core areas represent habitats where special restrictions apply to several activities, including energy development, agriculture and recreation. The new executive order included modified boundaries describing the core areas, including corridors for potential electrical transmission lines. There are no sage-grouse core areas or connectivity areas within or near the proposed project area (WGFD 2010c). Figure 3.5-4 indicates the regional sage-grouse core/connectivity areas in relationship to the proposed Ross ISR Project.

3.5.4.2.6 Other Birds

At the request of the WGFD, breeding bird surveys were conducted within the proposed project area. Transects were placed in four habitat types (Upland Grassland, Sagebrush Shrubland, Pastureland/Hayland, and Wetland/Reservoir). Transects were sampled on May 28 and June 10, 2010. Twenty-seven species were recorded during the 2010 breeding bird surveys. The Wetland/Reservoir transect produced the greatest species diversity, with 19 species observed. The Upland Grassland transect had the fewest species (six).

Fourteen non-raptor or nongame species on the USFWS Bird Species of Conservation Concern list could potentially occur within the proposed project area. Of the 14 bird species, eight have been observed within or near the area (Addendum 3.5-G). Ten non-raptor or nongame bird species on the BLM Sensitive Species list could potentially occur within the proposed project area. Of the 10 bird species, four have been observed within or near the area (Addendum 3.5-G). Thirty-two non-raptor or nongame bird species on the Wyoming Species of Concern list could potentially occur within the proposed project area. Of the 32 bird species, 15 have been observed within or near the area (Addendum 3.5-G).

3.5.4.2.7 Waterfowl, Shorebirds

As described previously, natural aquatic habitats in the proposed project area occur mainly in association with the Oshoto Reservoir and the Little Missouri River, with several scattered stock reservoirs also present. A wetland transect was included as part of the breeding bird surveys and biologists also recorded all waterfowl/shorebirds observed during the year-long survey period. Seventeen waterfowl species and eight shorebird species were observed during the baseline inventories (Addendum 3.5-G). The horned grebe (*Podilymbus podiceps*) and upland sandpiper (*Bartramia longicauda*) are the only USFWS Bird Species of Conservation Concern observed within or near the proposed project area (Addendum 3.5-G).

3.5.4.2.8 Reptiles, Amphibians and Fish

At the request of the WGFD, amphibian call surveys were conducted at six locations within and near the proposed project area. Reptile surveys were conducted within the proposed project area in conjunction with the amphibian

surveys. A listing of potentially occurring reptile and amphibian species and observations from the 2009-2010 surveys or from other sources are documented in Addendum 3.5-G.

The aquatic resources present within the proposed project area and surrounding perimeter have been thoroughly described in previous sections. Water is a limiting factor throughout the proposed project area and surrounding lands, with only one stream with intermittent flow passing through the proposed project area. The Oshoto Reservoir is a major water feature within the proposed project area. All other natural flow is categorized as intermittent or ephemeral. The lack of deepwater habitat and perennial water sources limits the presence of fish, and decreases the potential for other aquatic species to exist.

As indicated in Addendum 3.5-F, three aquatic or semi-aquatic amphibian species and two aquatic reptiles were recorded during the 2010 survey: the tiger salamander (*Ambystoma tigrinum*), boreal chorus frog (*Pseudacris triseriata*), northern leopard frog, common snapping turtle (*Chelydra serpentine*), and western painted turtle (*Chrysemys picta*). All five species were heard and/or seen in the Oshoto Reservoir, Little Missouri River, or near stock reservoirs. All five species are common to the proposed project area, and the region as a whole. No egg masses were definitively identified during the egg mass surveys completed in early June 2010. The reason may have been that recent high winds could have broken up the masses and dispersed the eggs. During walking surveys along shorelines and riparian areas in August 2010 the leopard frog appeared to be quite common (over 500 individual adults counted) while the chorus frog was uncommon.

The eastern short-horned lizard (*Phrynosoma douglassi brevirostre*) and northern sagebrush lizard (*Sceloporus graciosus graciosus*) were often observed sunning themselves on rocks and on sandy soil in the summer months during all except the early morning hours. These sightings were widespread throughout the survey area, with observations increasing as the summer progressed and the days got hotter. Other reptiles observed in the area included the bullsnake (*Pituophis cantenifer*), wandering garter snake (*Thamnophis elegans vagrans*), and the prairie rattlesnake (*Crotalus viridis viridis*).

The northern leopard frog was the only BLM reptile, amphibian, or fish sensitive species actually observed in the area. Three amphibian and five reptile Wyoming Species of Concern were observed within or near the proposed project area (Addendum 3.5-G).

Fish sampling from the Oshoto Reservoir occurred one time in September 2010 under a WGFD Chapter 33 collection permit as part of the radiological baseline monitoring program. The dominant fish population includes black bullheads and green sunfish, but white suckers were also caught. An analysis of the collection results revealed a fish population where individuals are stunted in size for their age due to high reproductive rates and limited predation, leading to over-population and stunted growth. A summary of the number, length, and weight of each fish caught from the Oshoto Reservoir is provided in Table 2.9-19 in the TR.

3.5.4.3 Threatened, Endangered, or Candidate Species

3.5.4.3.1 Federally Listed Species

As of July 2010 the USFWS has listed two individual wildlife species and one individual plant species for Crook County, Wyoming (USFWS 2010b). The wildlife species listed are the sage-grouse (Candidate) and mountain plover (Proposed). The plant species listed is the threatened Ute Ladies'-tresses (*Spiranthes diluvialis*). T&E species surveys were conducted during November and December 2009 and January through September 2010. One former T&E (bald eagle) and one candidate (sage-grouse) wildlife species were observed during those surveys. The sage-grouse is listed as a Candidate Species and is discussed in the Upland Game Bird section, above. The mountain plover is a species proposed for listing as a threatened species under the ESA. This bird was not recorded during wildlife surveys completed on this area, and the proposed project area does not contain optimal habitat for this species.

Typical habitat for the Ute ladies'-tresses orchid was encountered in the wetlands within the proposed project area. These wetlands were found primarily along Deadman Creek, the Little Missouri River and along the Oshoto Reservoir. These wetland habitats were surveyed on August 11, 12, and 13, 2010 but no orchids were observed.

Although not on the USFWS Federal Threatened, Proposed, and Candidate Species for Crook County, the blowout penstemon (*Penstemon*

haydenii) is in the Campbell County list so the potential to encounter the plant in the proposed project area was evaluated. According to the USFWS, the plant is restricted to two habitat types: steep, northwest facing slopes of active sand dunes with less than 5% vegetative cover; and on north facing sandy slopes, on the lee side of active blowouts with 25-40% vegetative cover (USFWS 2010b). Typical habitat for the blowout penstemon was not found in the proposed project area.

No federally listed T&E vertebrate species were documented in the proposed project area during the year-long survey period. The black-footed ferret was the only federal T&E vertebrate species that could potentially occur in the proposed project area. The USFWS issued a block-clearance for ferrets throughout much of the state of Wyoming in recent years, including the proposed project area in Crook County. As described previously, no black-tailed prairie dog colonies are located in the proposed project area.

3.5.4.3.2 State Listed Species

The State of Wyoming maintains lists of wildlife Species of Special Concern (WGFD 2004 and WGFD 2010d). Two mammal, 19 avian, two amphibian, and five reptile species on the Wyoming Species of Special Concern lists were observed within or near the proposed project area (Addendum 3.5-G). Thirteen of the 29 Species of Special Concern observed within or near the proposed project area were listed wholly or in part due to absence of data. As additional management information becomes available, species may be removed from these lists or other species may be added (WGFD 2004).

Table 3.5-1. Vegetation or Map Unit Survey Results, 2010

	Project Area	
Vegetation or Map Unit Type[1]	Acres	%
Upland Grassland	917.55	53.3
Sagebrush Shrubland	377.05	21.9
Pastureland	125.94	7.3
Hayland	121.15	7.0
Reservoir/Stockpond[2]	33.85	2.0
Wetland[2]	31.15	1.8
Disturbed Land	56.99	3.3
Cropland	48.71	2.8
Wooded Draw	8.92	0.5
Total	**1,721.31**	**100.0**

[1] See Figure 3.5-2

[2] See Table 3.4-18; potential wetland areas identified in Table 3.4-18 include both Wetland and Reservoir/Stockpond vegetation map unit in this table.

Source: Intermountain Resources 2010 Ross Project Vegetation Survey (Addenda 3.5-A through 3.5-D)

Table 3.5-2. Statistical Evaluations for the Vegetation Cover Data, 2010

Plant Community Type	Parameters			
	Absolute Cover (%)	Relative Cover (%)	# of Samples[1]	# to Meet Sample Adequacy[2]
Upland Grassland				
Total Perennial Cover	65.0	94.2	21	2
Total Vegetation Cover	69.0	100.0	21	5
Total Ground Cover	89.2	--	21	2
Sagebrush Shrubland				
Total Perennial Cover	65.0	93.0	20	3
Total Vegetation Cover	69.9	100.0	20	9
Total Ground Cover	88.0	--	20	5
Pastureland				
Total Perennial Cover	63.9	99.8	20	1
Total Vegetation Cover	64.0	100.0	20	4
Total Ground Cover	90.2	--	20	2

[1] Refer to Figure 3.5-2 for sample locations
[2] WDEQ/LQD Guideline 2, Section IV
Source: Intermountain Resources 2010 Ross Project Vegetation Survey (Addenda 3.5-A through 3.5-D)

Table 3.5-3. Number of Plant Species Recorded in Cover Data for Each Vegetation Type Sampled on the Proposed Project Area, 2010

	Plant Community Type					
	Upland Grassland		**Sagebrush Shrubland**		**Pastureland**	
	Total	**> 2% Relative Cover**	**Total**	**> 2% Relative Cover**	**Total**	**> 2% Relative Cover**
PERENNIALS						
Grass	16	10	16	7	9	7
Grasslike	2	2	2	-	-	-
Forb	27	1	28	1	6	1
Subshrub	4	-	4	-	1	-
Full Shrub	1	-	5	2	1	-
Succulent	1	-	1	-	-	-
Subtotal	51	13	56	10	17	8
ANNUALS						
Grass	2	1	2	1	-	-
Forb	3	-	7	-	1	-
Subtotal	5	1	9	1	1	0
TOTAL	**56**	**14**	**65**	**11**	**18**	**8**

Source: Intermountain Resources 2010 Ross Project Vegetation Survey (Addenda 3.5-A through 3.5-D)

Table 3.5-4. Raptor Production Summary for Nests Located within One Mile of the Proposed Project Area, 2010

Species / Nest No.	Nest Substrate/ Condition	2010 Status[1]
Ferruginous Hawk		
FH-1a	Hilltop/Good (Alternate)	I
FH-1b	Hilltop/Poor (Alternate)	I
FH-1c	Power pole/D-N	A,0,0
FH-2a	Hilltop/Good	I
FH-2b	Hilltop/Poor (Alternate)	I
FH-2c	Hilltop/Good (Alternate)	I
TOTAL	5 intact nests	1,0,0
Red-tailed Hawk		
RTH-1	Cottonwood/Good	A,0,0
RTH-2	Cottonwood/Good	A,2,2
TOTAL	2 intact nests	2,2,2
Swainson's Hawk		
SH-1 (Within Proposed Permit Boundary)	Boxelder Maple/Good	I
TOTAL	1 intact nest	0,0,0
Total Nesting Success	**8 total intact nests**	**3,2,2**

Source: Intermountain Resources 2010 Ross Project Wildlife Inventory (Addenda 3.5-F through 3.5-I).

[1] Nest Status, # hatched, # fledged
A = Active
D-N = Destroyed Natural Causes
I = Inactive

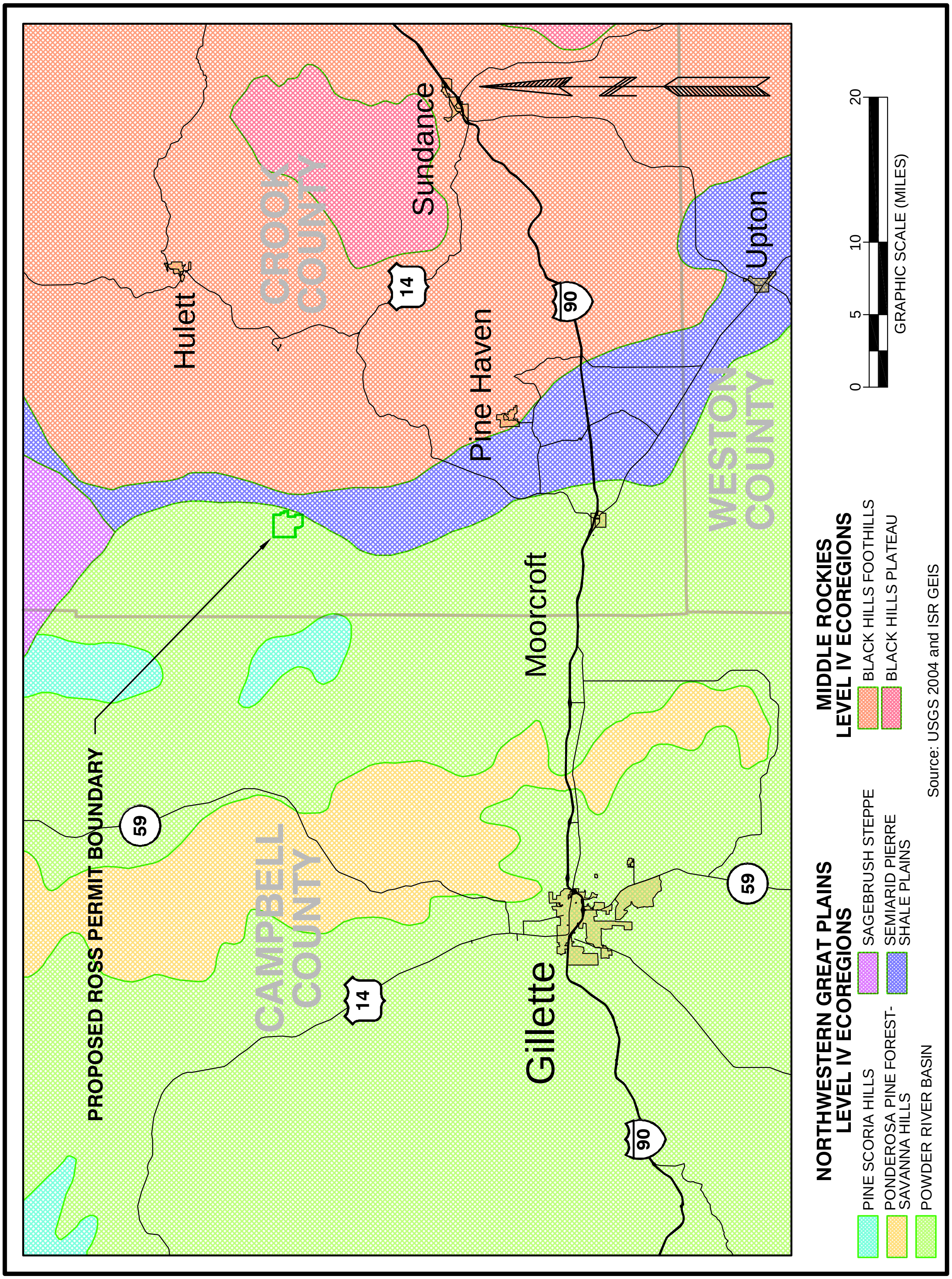
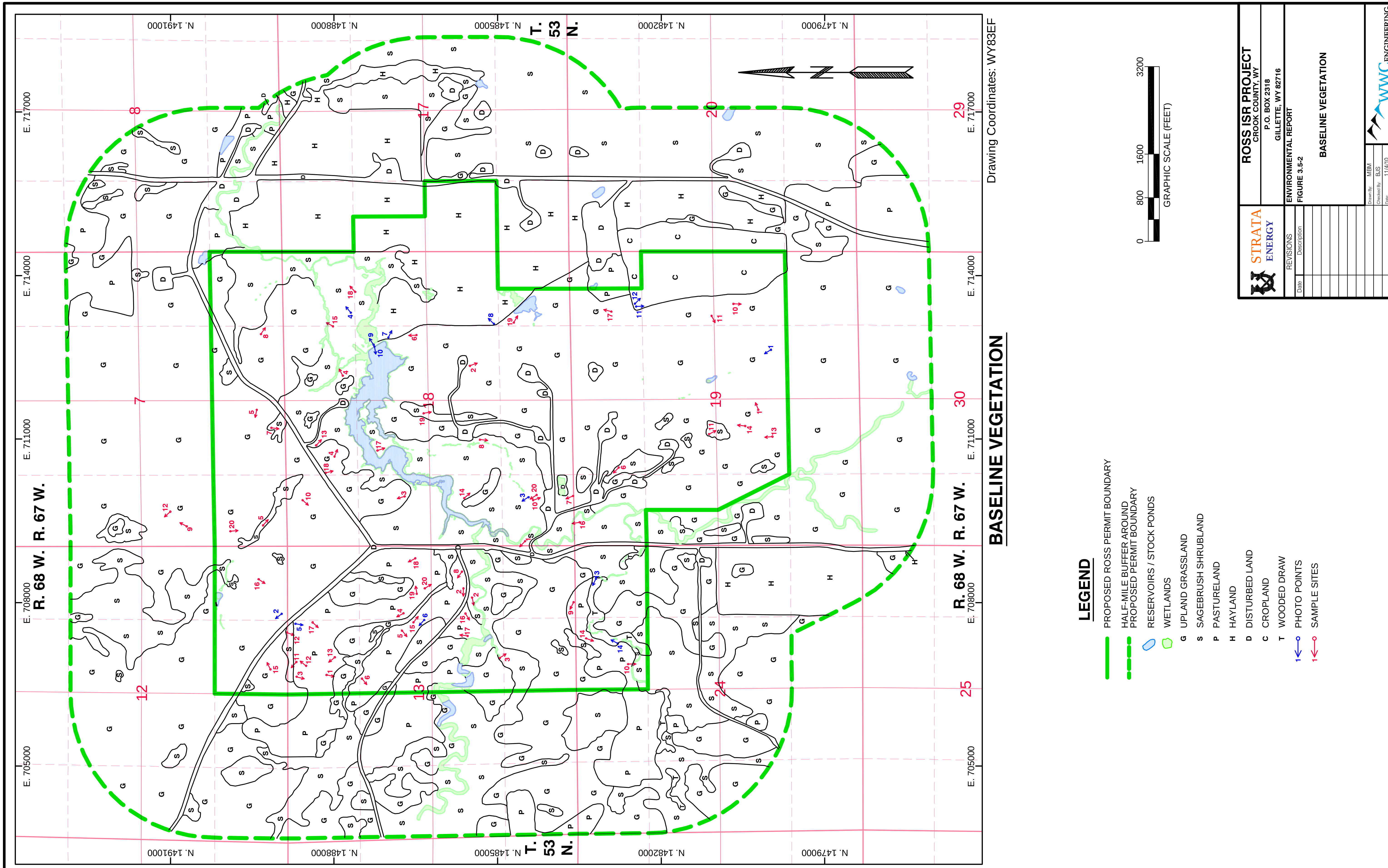


Figure 3.5-1. Ecoregions


BASELINE VEGETATION
Drawing Coordinates: WY83EF
LEGEND
PROPOSED ROSS PERMIT BOUNDARY
HALF-MILE BUFFER AROUND PROPOSED PERMIT BOUNDARY
RESERVOIRS / STOCK PONDS
WETLANDS
G UPLAND GRASSLAND
S SAGEBRUSH SHRUBLAND
P PASTURELAND
H HAYLAND
D DISTURBED LAND
C CROPLAND
T WOODED DRAW
PHOTO POINTS
SAMPLE SITES
GRAPHIC SCALE (FEET)
0 800 1600 3200
T. 53 N.
R. 68 W.
R. 67 W.
ROSS ISR PROJECT
CROOK COUNTY, WY
P.O. BOX 2318
GILLETTE, WY 82716
ENVIRONMENTAL REPORT
FIGURE 3.5-2
BASELINE VEGETATION
STRATA ENERGY
WWC ENGINEERING
REVISIONS
FILE: ROSS_ER_ECOL_VEG

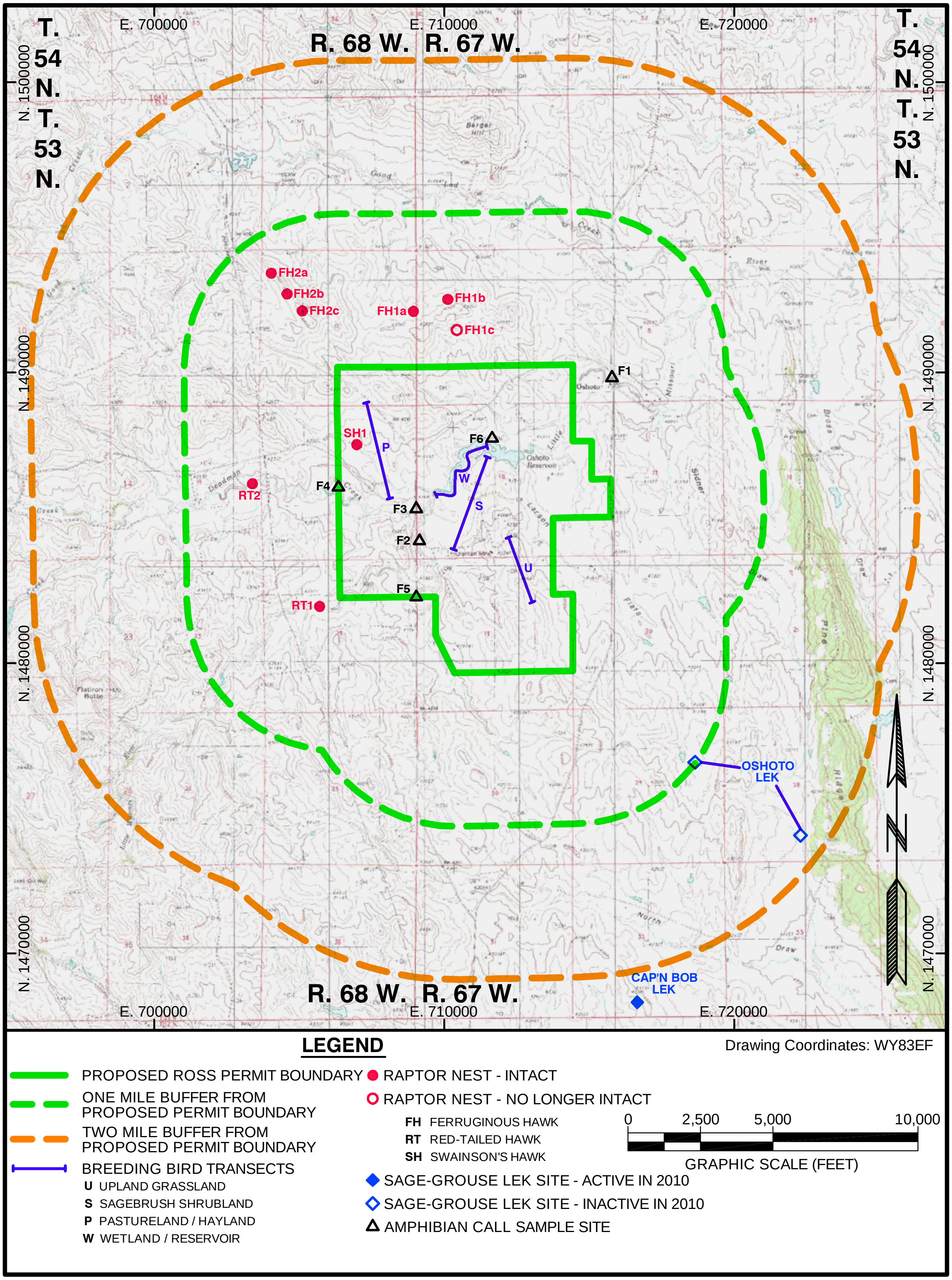


Figure 3.5-3. Wildlife Survey Results

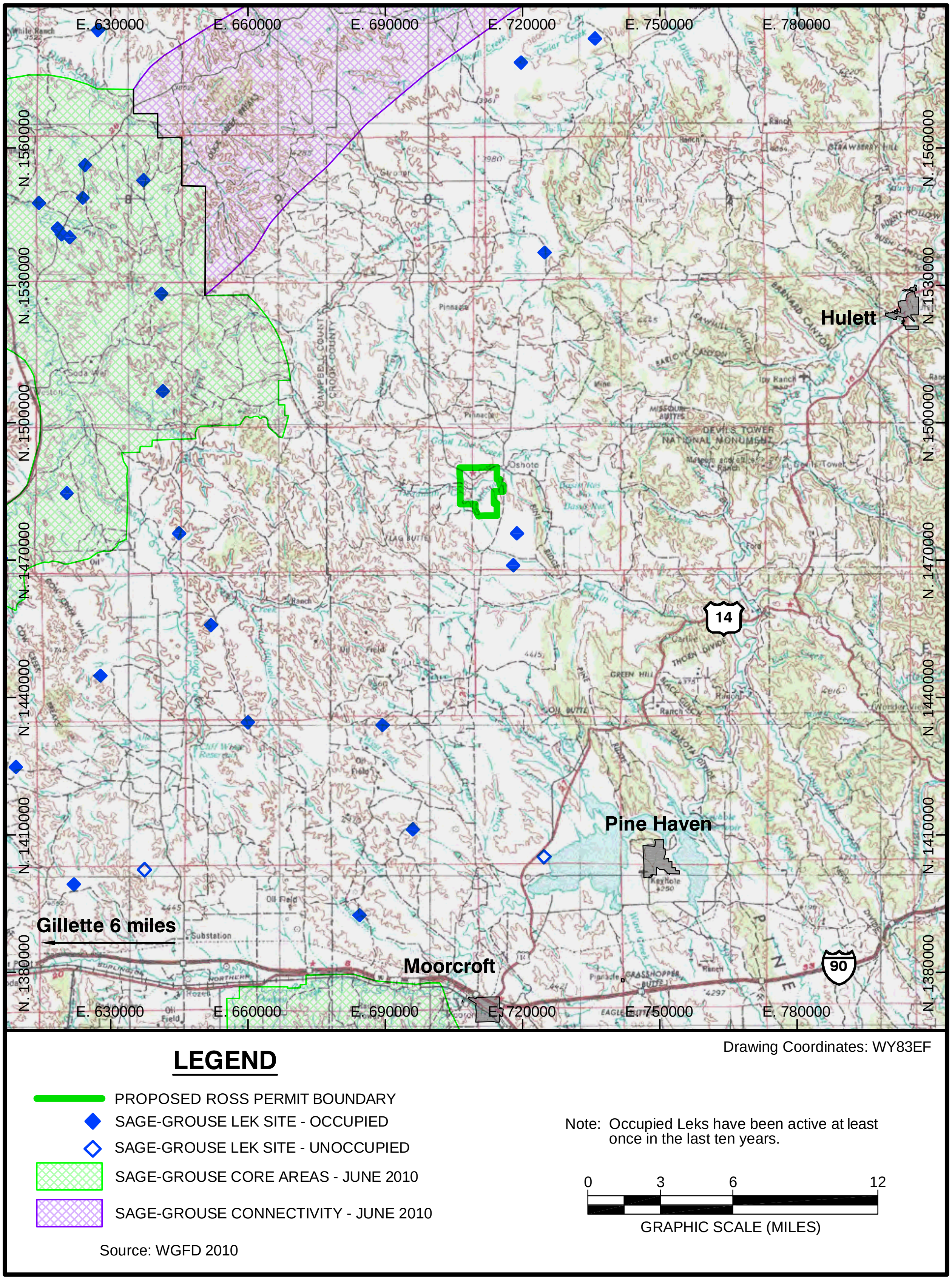


Figure 3.5-4. Sage-Grouse Leks and Core Areas