UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

In the Matter of CROW BUTTE RESOURCES, INC. (Marsland Expansion Area)	Docket No. 40-8943-MLA-2 ASLBP No. 13-926-01-MLA-BD01

Hearing Exhibit

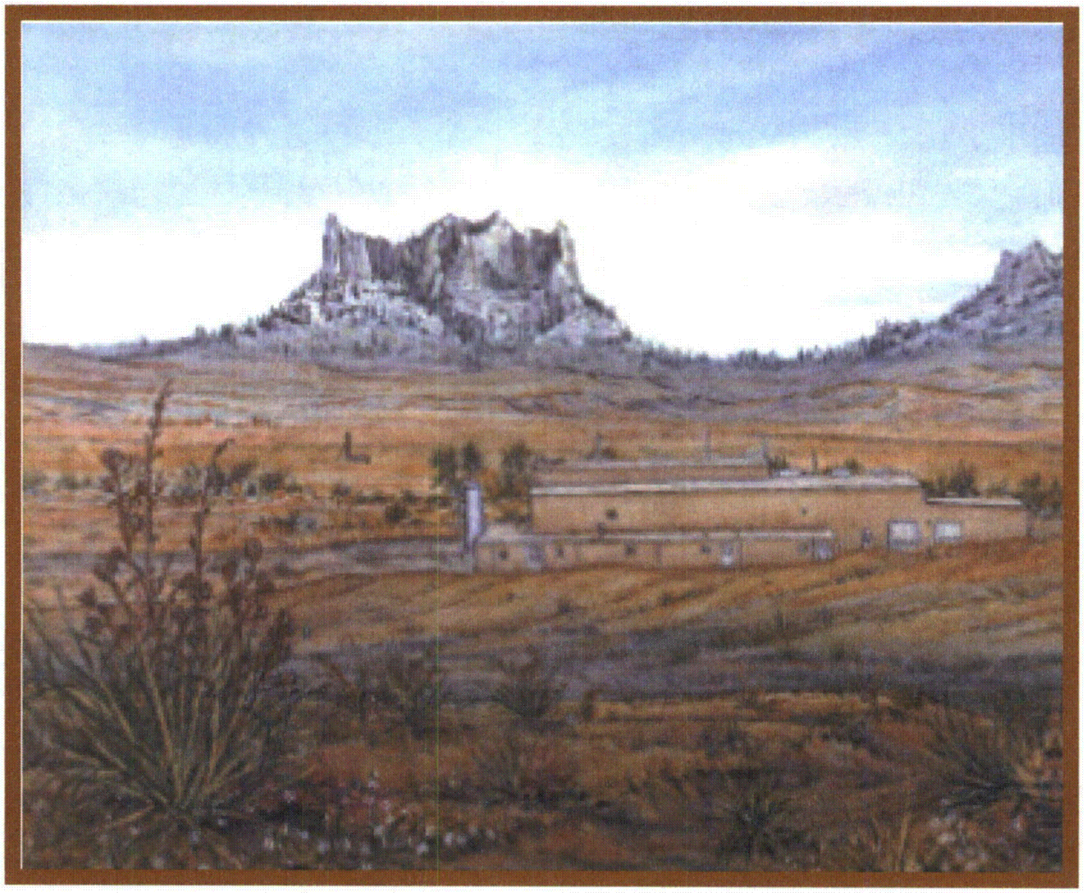
Exhibit Number: CBR005

Exhibit Title: Environmental Report (Consolidated)

Application for Amendment of USNRC Source Materials License SUA-1534 Marsland Expansion Area Crawford, Nebraska

Volume I

Environmental Report



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May 2012

CROW BUTTE RESOURCES, INC.

Nuclear Regulatory Commission

Environmental Report

Volume I

Marsland Expansion Area

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Acronyms and Abbreviations

µCi/kg	microCuries per kilogram
$\mu g/m^3$	micrograms per cubic meter
µmhos/cm	micromhos per centimeter
ACL	Alternate Concentration Limit
AEA	Atomic Energy Act
AERMOD	AMS/EPA Regulatory Model
ALARA	as low as reasonably achievable
AMS	American Meteorological Society
amsl	above mean sea level
AOR	Area of Review
API	American Petroleum Institute
ASOS	Automated Surface Observation Station
ASTM	ASTM International
ATV	all-terrain vehicle
AWWARF	American Water Works Association Research Foundation
BBS	breeding bird survey
bgs	below ground surface
BLM	Bureau of Land Management
BMP	best management practice
BNSF	Burlington Northern Santa Fe
BPT	best practicable technology
$CaCO^3$	calcium carbonate
CAD/GIS	computer aided drafting/geographic information system
CBR	Crow Butte Resources, Inc.
CESQG	conditionally exempt small-quantity generator
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm/sec	centimeters per second
cm^2	square centimeters
CO	carbon monoxide
CO_2	carbon dioxide
COOP	Cooperative Observer Program
CPF	central processing facility
CPM	counts per minute
DAC	derived air concentration
dBA	A-weighted decibel
DDW	deep disposal well
DEM	Digital Elevation Model
DFIRM	Digital Flood Insurance Rate Map
DLG	Digital Line Graph
DOT	U.S. Department of Transportation
dpm	disintegrations per minute
DPS	Distinct Population Segment
DQO	data quality objective
DUSA	Dension Mines (USA)

EA	Environmental Assessment
Eh	oxidation-reduction potential
ELI	Energy Laboratories, Inc.
EPA	U.S. Environmental Protection Agency
ER	Environmental Report
ESA	Ecological Study Area
ESRI	Earth Sciences and Research Institute
ET	evapotranspiration
FEMA	Federal Emergency Management Agency
FESA	Federal Endangered Species Act
ft/day	feet per day
ft^2/day	square feet per day
GAM(NAT)	natural gamma
GEIS	Generic Environmental Impact Statement
GM	Geiger-Mueller
GNIS	Geographical Names Information System
gpd	gallons per day
gpm	gallons per minute
GPS	global positioning system
GR	gamma ray
H_2O_2	hydrogen peroxide
H_2S	hydrogen sulfide
HDPE	high-density polyethylene
HMR	Hazardous Materials Regulations
HSMS	Health and Safety Management System
HUC	hydrologic unit code
HUC12	12-digit hydrologic unit code
ICRP	International Commission on Radiological Protection
ISL	in-situ leach
ISR	in-situ recovery
IX	ion exchange
JFD	Joint Frequency Distribution
km^2	square kilometers
LAN	local area network
lbs	pounds
LLD	lower limit of detection
LSA	Low Specific Activity
LULC	land use and land cover data
Ma	million years
MBTA	Migratory Bird Treaty Act
MCL	Maximum Contaminant Level
md	millidarcies
MDC	Minimum Detectable Concentration
MEA	Marsland Expansion Area
meq	milliequivalents
meq/L	milliequivalents per liter
mg/cm^2	milligrams per square centimeter

mg/L	milligrams per liter
Mgal/da	million gallons per day
mi^2	square miles
MM	Modified Mercalli
mph	miles per hour
mR/hr	milli-Roentgens per hour
mRem/yr	millirems per year
MU	mine unit
Na_2S	sodium sulfide
NAAQS	National Ambient Air Quality Standards
$NaCO_3$	sodium carbonate
NAD 1927	North American Datum of 1927
$NaHCO_3$	sodium bicarbonate
NAIP	National Agriculture Imagery Program
NaOH	sodium hydroxide
NCDC	National Climate Data Center
NDA	Nebraska Department of Agriculture
NDED	Nebraska Department of Economic Development
NDEQ	Nebraska Department of Environmental Quality
NDHHS	Nebraska Department of Health and Human Services
NDNR	Nebraska Department of Natural Resources
NED	National Elevation Dataset
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NGPC	Nebraska Game and Parks Commission
NGS	National Geodetic Survey
NGWA	National Groundwater Association
NHD	National Hydrology Dataset
NHPA	National Historic Preservation Act
NLCD	National Land Cover Data
NMSS	Nuclear Material Safety and Safeguards
NNHP	Nebraska Natural Heritage Program
NNLP	Nebraska Natural Legacy Project
NOAA	National Oceanic and Atmospheric Administration
NOGCC	Nebraska Oil and Gas Conservation Commission
NOI	Notice of Intent
NOx	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRCS	Natural Resource Conservation Service
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NSHS	Nebraska State Historical Society
NTEA	North Trend Expansion Area
NTU	nephelometric turbidity units
NVLAP	National Voluntary Laboratory Accreditation Program
NWI	National Wetlands Inventory

NWS	National Weather Service
O_2	gaseous oxygen
OHSAS	Occupational Health and Safety Management System
OSHA	Occupational Safety and Health Administration
OSLD	optically stimulated luminescence dosimeter
PFYC	Potential Fossil Yield Classification
$PM_{2.5}$	particulate matter with a diameter less than 2.5 microns
PM_{10}	particulate matter with a diameter less than 10 microns
pCi/L	picoCuries per liter
PPE	personal protective equipment
ppm	parts per million
PPMP	preoperational/preconstruction monitoring program
PSD	prevention of significant deterioration
psi	pounds per square inch
PVC	polyvinyl chloride
QA	quality assurance
QAM	Quality Assurance Manual
QC	quality control
RCRA	Resource Conservation and Recovery Act
RES	Single Point Resistance
RFFA	reasonably foreseeable future actions
RG	Regulatory Guide
RL	reporting limit
RMP	Risk Management Program
RO	reverse osmosis
ROI	radius of influence
RSA	Resource Study Area
RSO	Radiation Safety Officer
RUSLE	Revised Universal Soil Loss Equation
S.U.	standard units
SCDA	Sequential Control and Data Acquisition
SCS	Soil Conservation Service
SDR-17	Standard Dimension Ratio 17
SEIS	Supplemental Environmental Impact Statement
SER	Safety Evaluation Report
SERP	Safety and Environmental Review Panel
SH	State Highway
SHEQMS	Safety, Health, and Environment Quality Management System
SHPO	State Historic Preservation Office
SO_2	sulfur dioxide
SOP	standard operating procedure
SP	spontaneous potential
SPCC	Spill Prevention, Control, and Countermeasure
SS	stainless steel
SSURGO	Soil Survey Geographic Database
SSPT	statistic spontaneous potential
SWMA	State Wildlife Management Area

SWPPP	Storm Water Pollution Prevention Plan
TCEA	Three Crow Expansion Area
TDS	total dissolved solids
TEDE	total effective dose equivalent
TLD	thermoluminescent dosimeter
TMDL	total maximum daily load
TSP	total suspended particulates
TSS	total suspended solids
UCL	upper control limit
UDC	uranyl dicarbonate
UIC	underground injection control
UMTRCA	Uranium Mill Tailings Radiation Control Act
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
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
USLE	Universal Soil Loss Equation
UTC	uranyl tricarbonate
VCD	voltage current direct
VOC	volatile organic compound
VRM	visual resource management
VTPD	vehicle trips per day
WFC	Wyoming Fuel Company
WRCC	Western Regional Climate Center
XRD	x-ray diffraction
yd^3	cubic yards
ZOEI	Zone of Endangering Influence

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1 INTRODUCTION OF THE ENVIRONMENTAL REPORT

1.1 Introduction

Crow Butte Resources, Inc. (CBR) submits this Environmental Report (ER) in support of a license amendment application to the United States Nuclear Regulatory Commission (NRC) for amendment of Radioactive Source Materials License SUA-1534. The amendment request concerns the proposed development of additional uranium in-situ recovery (ISR) mining resources located in Dawes County and Sioux County, Nebraska. The area proposed for use as a satellite facility to the main CBR Central Processing Facility (CPF) is referred to as the Marsland Expansion Area (MEA).

By letter dated November 27, 2007, CBR applied for a renewal of Source Materials License No. SUA-1534 for the CPF. This renewal will allow for the continued operation of the current CPF. The NRC issued a draft license by letter dated May 23, 2011. Following comments by CBR, the NRC issued a second draft of the CBR renewal license on August 11, 2011. As part of the licensing process, the NRC issued a Safety Evaluation Report (SER) for the license renewal dated December 2012 (NRC 2012). The SER documents the safety portion of the NRC staff's review of the license renewal application, as amended, and includes an analysis to determine CBR's compliance with these and other applicable 10 Code of Federal Regulations (CFR) Part 40 requirements, and applicable requirements set forth in 10 CFR Part 40, Appendix A (NRC 2012). The SER also evaluates CBR's compliance with applicable requirements in 10 CFR Part 20, "Standards for Protection against Radiation." An Environmental Assessment (EA) is also being prepared in parallel with the SER to address environmental impacts of the proposed action, which complies with the NRC's implementation regulations for the National Environmental Policy Act (NEPA; NRC 2012). While negotiations continue, the current license remains in effect.

This ER provides the supplemental information necessary to determine the environmental impacts of amending License No. SUA-1534 to allow uranium recovery in the MEA. The amendment application is submitted in accordance with the licensing requirements contained in 10 CFR Part 40 and provides the NRC staff with the necessary information to support the preparation of a Supplemental Environmental Impact Statement (SEIS) as required in 10 CFR Part 51.

The proposed MEA is located within the southern portion of Dawes County, which is within the Nebraska-South Dakota-Wyoming Uranium Milling Region identified in the NRC Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities (GEIS). The GEIS provides the NRC with a starting point for new ISR facilities, as well as for applications to amend or renew existing ISR licenses. The NRC will use the site-specific information provided in the CBR ER to determine whether the proposed activities and site characteristics are consistent with those evaluated in the GEIS. The NRC will then determine relevant sections, findings, and conclusions in the GEIS that can be incorporated by reference into an SEIS. When such conditions are met, the NRC will prepare an SEIS for the CBR amendment, fulfilling agency responsibilities under the NEPA.

This ER has been prepared using suggested guidelines and a standard format from NRC. The ER is presented primarily in the format provided in RG-1748, Environmental Review Guidance for Licensing Actions Associated with Nuclear Material Safety and Safeguards (NMSS) Programs

(August 2003). The pertinent guidance in RG-1748 was used to ensure that complete information is provided to NRC for review. In addition, NRC document RG-1569, Standard Review Plan for In Situ Leach Uranium Extraction License Applications (June 2003) was consulted to ensure that all necessary information is provided that will allow NRC Staff to complete their review of this amendment application.

1.1.1 Crow Butte Uranium Project Background

The original CBR was developed by Wyoming Fuel Company (WFC), which constructed an R&D Facility in 1986. The project was subsequently acquired (Ferret 1987) and operated by Ferret Exploration Company of Nebraska until May 1994, when the name was changed to CBR. This change was only a name change and not an ownership change. CBR is the owner and operator of the CPF.

The land (fee and leases) at the CPF is held by Crow Butte Land Company, which is a Nebraska corporation. All of the officers and directors of Crow Butte Land Company are U.S. citizens. Crow Butte Land Company is owned by CBR, which is the licensed operator of the facility. CBR, which does business as Cameco Resources, is also a Nebraska corporation. All of its officers are U.S. citizens, as are two thirds of its directors. CBR is owned by Cameco US Holdings, Inc., which is a U.S. corporation registered in Nevada. For Cameco US Holdings, three quarters of the officers are U.S. citizens, as are two thirds of the directors. Cameco US Holdings is held by Cameco Corporation, a Canadian corporation publicly traded on both the Toronto and New York Stock Exchanges.

The R&D Facility was located in N ½ SE ¼ of section 19, Township (T) 31 North (N), Range (R) 51 West (W). Operations at this facility were initiated in July 1986, and mining took place in two wellfields (WF-1 and WF-2). Mining in WF-2 was completed in 1987, and restoration of that wellfield has been completed. WF-1 was incorporated into Mine Unit (MU) 1 of the current operations.

The CPF is located in Section 19, T31N, R51W, Dawes County, Nebraska (**Figure 1.1-1**). The current license area occupies approximately 2,861 acres, and the surface area affected over the estimated life of the project is approximately 2,000 acres.

CBR has successfully operated the current processing area since commercial operations began in 1991. Production of uranium has been maintained at design quantities throughout that period with no adverse environmental impacts. Groundwater restoration for MU 1 has been completed and approved by the NRC and Nebraska Department of Environmental Quality (NDEQ), with NRC issuing the final approval on February 12, 2003. The operating history and timelines for the current production area are discussed in more detail in Section 1.1.3.

1.1.2 Site Location and Description

The proposed MEA project site is located within sections 26, 35, 36 of T30N, R51W; sections 1, 2, 11, 2, 13 of T29N R51W and sections 7, 18, 19, 20, 29, 30 of T29N, R50W (**Figure 1.1-2**). The project area occupies 4,622.3 acres. The Marsland satellite facility is located approximately 11.1 miles (17.9 km) south-southeast of the CPF (centerpoint of MEA satellite building to centerpoint of CPF processing building) and approximately 4.6 miles (7.4 km) northeast of the

community of Marsland (centerpoint of MEA satellite building to centerpoint of Town of Marsland). **Figure 1.1-3** shows the locations of the current license area and the proposed MEA.

All mineral resources leased within the MEA are privately owned, with the exception of the SW ¼ section of section 36 of T30N, R51W. This quarter section is designated as State Trust Land and is a small part of the nearly 1,300,000 acres of land now held in trust for Nebraska's K-12 public schools (NBELF 2013). The surface and mineral rights are leased by Cameco from the State of Nebraska. There are no federal surfaces or minerals in the MEA license boundary. **Figure 1.1-4** shows land ownership in the proposed MEA.

1.1.3 Operating Plans, Design Throughput, and Processing

The CPF is licensed for a flowrate of 9,000 gallons per minute (gpm), excluding restoration flow, under License No. SUA-1534. Total annual production is limited to 2,000,000 pounds of yellowcake, per license condition 10.2 of License SUA-1534.

Uranium extracted from the Marsland wellfield will be processed at a satellite facility located within the MEA. The MEA will operate at an overall average production flowrate of 6,000 gpm (excluding 1,500 gpm for restoration). The anticipated bleed rate is assumed to be 0.5 to 2.0 percent of the total mining flow. The MEA will operate with an expected annual production rate of approximately 600,000 pounds (lbs) of U_3O_8. Indicated ore reserves as U_3O_8 for the MEA are 6,161,679 lbs, with an additional inferred estimate of 3,389,518 lbs. Total reserves for the MEA are currently estimated at 9,551,197 lbs. The uranium extracted from the MEA will be loaded onto ion exchange (IX) resin in the MEA satellite facility, which will then be transported by tanker truck to the main plant for elution, precipitation, drying, and packaging. Barren resin will be returned to the MEA satellite facility by tanker truck. The MEA operations are discussed in more detail in Section 1.3.2

The proposed MEA occupies approximately 4,622.3 acres. Over the life of the project, an estimated ~~1,753~~1,754 acres may be impacted.

Proposed Operating Timelines

1.1.3.1 Current Production Area

Sufficient reserves in the current license area have been estimated to allow mining operations to continue until the end of 2015. Completion of groundwater restoration in the current license area is scheduled for 2033, with site restoration to be completed by 2038. Projected production and restoration timelines for the CPF are shown on **Figure 1.1-5**. The current status of the 11 MUs are shown in **Table 1.1-1**. In 2010, the total annual production rate for the CPF was 751,632 lbs of U_3O_8, and in 2009 it was 734,047 lbs of U_3O_8. Additional MU plans are developed approximately 1 year prior to the planned commencement of new mining operations. For the current production area, production is ongoing in MUs 7, 8, 9, 10, and 11. MU 1 has been restored, and restoration is occurring in MUs 2, 3, 4, 5, and 6. The layout of the current and planned MUs in the current CPF license area is shown on **Figure 1.1-1**.

1.1.3.2 Marsland Expansion Area

The proposed MEA project site map and timeline are shown on **Figures 1.1-2** and **1.1-6,** respectively. There is a potential for 11 MUs, with construction for MU 1 to commence in 2014.

Production for the project (all MUs) will start in 2015 and terminate in 2033. Restoration in designated MUs will commence in the year 2020 and will be completed in 2039. Site reclamation will be completed in 2040.

The MEA will be subdivided into an appropriate number of MUs (**Figure 1.1-7**). Each MU will contain wellhouses where injection and recovery solutions from the satellite plant building are distributed to the individual wells. The injection and production manifold piping from the MEA satellite facility to the wellhouses will be either polyvinyl chloride (PVC) or high-density polyethylene (HDPE) with butt-welded joints or equivalent. Pressure switches will be installed to each injection manifold in the wellhouse to alert the plant and wellfield operators of increasing manifold pressures. Pressure gauges, pressure shutdown switches, and pressure transducers will be used to monitor and control trunkline pressures. Oxidizer will be added to the injection stream, and all injection lines off of the injection manifold will be equipped with totalizing flowmeters, which will be monitored in the satellite Control Room. The MEA wellfields will be designed consistent with the existing CPF wellfields. More detailed information about the site operations is discussed in Section 1.3.2.

1.1.3.3 Three Crow Expansion Area Timeline

On July 12, 2010, CBR submitted a Class III underground injection control (UIC) Application and Aquifer Exemption Petition to the NDEQ for the proposed Three Crow Expansion Area (TCEA), which will be used as a satellite facility supporting the CPF. On Aug. 3, 2010, CBR submitted a request to the NRC for an amendment to Source Materials License SUA-1534 for the development of the TCEA (Young 2010; ML102230170). By email dated April 14, 2011 (Leftwich 2011; ML11160020), Cameco requested that the NRC suspend review of the TCEA application so that the option of a pipeline to carry mine fluids directly to the main plant could be evaluated. By letter dated October 11, 2012 (Leftwich 2012; ML12299A211), Cameco advised the NRC that the pipeline option would not be pursued. CBR requested that NRC restart the application process for TCEA, with the project to be operated as a satellite facility to the main CBR operation located near Crawford, Nebraska. The major change in the originally proposed TCEA satellite facility is that surge/evaporation ponds are deemed to no longer be required to support project and associated deep disposal well (DDW) operations.

TCEA construction is planned for completion in 2016, with production from 2016 to 2032, restoration from 2023 to 2038, and completion of final site reclamation in 2039.

1.1.3.4 North Trend Expansion Area Timeline

The proposed North Trend Expansion Area (NTEA) will consist of a support satellite facility for the CPF. CBR has received approval from the NDEQ for a Class III UIC permit (NDEQ 2011a) and an aquifer exemption (NDEQ 2011b) that will allow for construction and operation of the satellite facility for ISR mining of the proposed NTEA. A radioactive source material license amendment (CBR 2007) for the NTEA is pending before the NRC for the proposed NTEA. Current plans are for this project to be constructed in 2023, with production from 2024 to 2032, and groundwater restoration activities ongoing from 2029 through 2039. Final site reclamation would be completed in 2041.

The locations of the CPF, TCEA, and, NTEA are shown on **Figure 1.1-3**.

1.2 Purpose and Need for the Proposed Action

NRC Source Materials License SUA-1534 authorizes CBR to conduct mining operations in the current license area. Based on current plans, mining timelines, and reserve estimates, CBR could continue production at the present annual levels of approximately 700,000 pounds of U_3O_8 until the end of 2014, when reserves would begin to significantly deplete. CBR estimates that by 2014, production in the current license area would decrease to the point where commercial operations would no longer be economical and would be discontinued. Groundwater restoration, surface reclamation, and decommissioning would become the primary activities.

CBR has developed commercially viable uranium resources in the area near the current license area. Development and recovery of these resources using satellite facilities will allow CBR to extend the operation of the existing CPF in the current license area. The use of satellite facilities in these areas will minimize the cost and environmental impact from construction activities.

The timely approval of uranium recovery activities in the MEA and NTEA will allow CBR to maintain uranium production at currently licensed quantities and provide a smooth transition of mining activities from the CPF license area to the satellite facility. CBR has developed a talented, qualified workforce mostly of local residents. If the MEA and NTEA are not developed, CBR estimates that some of these personnel (e.g., well drilling, well and wellfield construction) will no longer be required and workforce reduction will begin as early as 2013.

Failure to develop these additional resources would leave a large resource unavailable for energy production supplies. Although CBR is continuing to develop estimates of the reserves at MEA, the current indicated ore reserves as U_3O_8 for the MEA are 6,161,679 lbs, with an additional inferred estimate of 3,389,518 lbs. Total reserves for the MEA are currently estimated at 9,551,197 lbs. The MEA will operate with an expected annual production rate of approximately 600,000 lbs U_3O_8.

In 2012, total domestic U.S. uranium concentrate production was approximately 4,100,000 lbs of U_3O_8, of which more than 800,000 lbs (or approximately 20 percent) was produced at the CPF (EIA 2013a). During the same year, U.S. civilian nuclear power reactors purchased 58,000,000 lbs U_3O_8e (equivalent) from U.S. and foreign suppliers, with approximately 17 percent supplied by domestic producers (EIA 2013b). Foreign-origin uranium accounted for the remaining 83 percent of deliveries. The CPF (including the MEA, TCEA, and NTEA) represents an important source of new domestic uranium supplies essential to providing a continuing source of fuel to power generation facilities.

In addition to leaving a large deposit of valuable mineral resources untapped, a denial of this amendment request would result in the loss of a large investment in time and money made by CBR for the rights to and development of these valuable deposits.

Denial of the amendment request would have an adverse economic effect on the individuals that have surface leases with CBR and own the mineral rights in the MEA.

1.3 The Proposed Action

1.3.1 Site Location and Layout

The location of the current license area of the CPF is in sections 11, 12, 13, 24 of T31N, R52W and sections 18, 19, 20, 29, 30 of T31 N, R51W, Dawes County, Nebraska. The proposed MEA is located in sections 26, 35, 36 of T30N, R51W; sections 1, 2, 11, 12, 13 of T29N, R51W; and sections 7, 18, 19, 20, 29, 30 of T29N, R50W. The maps used in this and other sections of this amendment application are Vector 7.5-minute quad maps. These are computer-aided drafting/geographic information system (CAD/GIS) drawings where each road, stream, and contour line is an individual entity. The layers in these maps were derived from the U.S. Census Bureau's TIGER/Line data, U.S. Geological Survey (USGS) Digital Line Graph (DLG) Data, USGS Digital Elevation Model (DEM) data, Bureau of Land Management (BLM) Section Line data, National Geodetic Survey (NGS) Benchmark data, and USGS Geographical Names Information System (GNIS) data. This base map was then used for each of the figures prepared for this document with the addition of the pertinent information for that figure.

The longitudes and latitudes for the site boundary vertices and satellite facility are summarized in **Table 1.3-1**. The datum on topographic maps presented in the application is North American Datum of 1983 (NAD 1983), and the geographic coordinate reference system (map projection) is:

NAD_1983_StatePlane_Nebraska_North_FIPS_2600 (US_Foot).

Figure 1.1-2 shows the general area surrounding the MEA project area, including the proposed MEA, Area of Review (AOR), and Zone of Endangering Influence (ZOEI).

Figure 1.1-1 shows the general project site layout and Restricted Areas for the current license area including the CPF building area, the Reverse Osmosis (RO) facility, the current MU boundaries, ~~the~~two DDWs, and the R&D and commercial evaporation ponds.

Figure 1.1-7 shows the proposed locations of the satellite facility, MUs, access roads, license boundary perimeter fencing, and six DDWs. within the MEA. The latitude and longitude for the license boundary and center of the satellite facility are provided in **Table 1.3-1**. The easting/northing and longitude/latitude for the proposed DDWs are provided in **Table 1.3-7.** The exact locations will be determined prior to construction.

Figure 1.1-3 shows the project location in relation to the CPF and the proposed MEA, NTEA, and TCEA projects. This figure shows topographical features, drainage and surface water features, nearby population centers, and political boundaries as well as principal highways, railroads, transmission lines, and waterways.

1.3.2 Description of Proposed Facility

Production of uranium by ISR mining techniques involves a mining step and a uranium recovery step. Mining is accomplished by installing a series of injection wells through which the leach solution is pumped into the ore body. Corresponding production wells and pumps promote flow through the ore body and allow for the collection of uranium-rich leach solution. Uranium is removed from the leach solution by IX, and then from the IX resin by elution. The leach solution can then be reused for mining. The elution liquid containing the uranium (the "pregnant" eluent)

is then processed by precipitation, dewatering, and drying to produce a transportable form of uranium called yellowcake.

The MEA is being developed by CBR in conjunction with the CPF licensed under NRC Source Material License SUA-1534. The MEA will be developed by constructing independent wellfields and mining support facilities while employing existing processing equipment for uranium recovery. Transfer of recovered leach solutions from the area is prohibitive because of the distance over which a relatively large stream would have to be pumped. Therefore, a satellite facility will be constructed in the MEA to provide chemical makeup of leach solutions, recovery of uranium by IX, and restoration capabilities. The IX processes at the satellite facility recover the uranium from the leach solution in a form (loaded IX resin) that is relatively safe and simple to transport by tanker truck to the CPF, which will serve as the CPF for elution and further processing of recovered uranium. Regenerated resin is then transported back to the satellite facility for reuse in the IX circuit.

1.3.2.1 Solution Mining Process and Equipment

Ore body

In the CPF license area, uranium is recovered by ISR from the basal sandstone of the Chadron Formation at a depth that varies from 400 feet to 900 feet. The overall ore body width of the mineralized area varies from 1,000 feet to 5,000 feet. The ore body ranges in grade from less than 0.05 to more than 0.5 percent U_3O_8, with an average grade estimated at 0.27 percent U_3O_8. The layout of the ore body as determined to date is shown in **Figure 1.3-1**.

In the MEA, uranium will also be recovered via ISR from the basal sandstone of the Chadron Formation. The depth of the ore body in the MEA ranges from 800 to 1,250 feet below ground surface (bgs), and the width varies from approximately 1,000 feet to 4,000 feet. The ore body ranges in grade from 0.11 percent to 0.33 percent U_3O_8, with an average grade estimated at 0.22 percent U_3O_8. The ore-grade uranium deposits underlying the MEA are depicted on **Figure 1.3-1**.

Typical stratigraphic intervals to be mined by the ISR mining method are shown in the geologic cross-sections contained in Section 3.3. For ISR wellfields, the production zone is the geological sandstone unit where the leaching solutions are injected and recovered (i.e., basal sandstone of the Chadron Formation).

1.3.2.2 Well Construction and Integrity Testing

Three well construction methods and appropriate casing materials are used for the construction and installation of production and injection wells.

Well Materials of Construction

The well casing material will be PVC 5-inch Standard Dimension Ratio-17 (SDR-17). However, should a larger pump size be required, larger-diameter casing may be employed. The PVC casing joints are 20 feet long, and the bottom joint can be made either 10 or 20 feet long, depending on the casing depth. With SDR-17 PVC casing, each joint has a watertight O-ring seal and is held together with a high-strength nylon spline.

There are two types of well screen that will be used for development of the MEA: PVC and stainless steel (SS). Both types of screens have been used historically for the existing Crow Butte production, injection, and monitor wells. SS screens are more durable than PVC screens, are rated for greater depths than PVC screens, are easier to install, and can achieve better flow. The SS screens are significantly more expensive than the PVC screens. Currently, CBR primarily uses SS screens, but would maintain the option to use PVC screens as necessary at the satellite facility based on site conditions and purpose of the borehole. For example, PVC well screens are currently used in both shallow observation monitor wells and commercial production monitor wells. This practice will continue to be an option for the MEA. PVC screens are used for these types of wells primarily because they typically have much longer screen intervals than other types of wells. This results in employee safety issues due to the handling of the heavy SS screens. In addition, flowrate using PVC screens is less of a concern for these types of wells.

The PVC well screen consists of a perforated 3-inch PVC pipe. PVC rods run longitudinally along the sides of the pipe. Keystone-shaped PVC wire is helically wrapped around the outsides of the pipe and ribs and solvent-welded to the pipe. Spacing between consecutive wraps of the wire varies depending upon the screen ordered. Slot sizes from 0.010 to 0.020 inch have been used successfully at CBR. In most cases, a slot size of 0.020 inch is sufficient to prevent sand from entering the screens.

The SS well screen consists of longitudinal ribs of SS with an SS "V" shaped wire wrapped helically around the interior ribbing. The wire is welded to the circular rib array for support. As with PVC screens, slot sizes of 0.010 to 0.020 inch have been used historically at CBR.

Well Construction Methods

Pilot holes for monitor, production, and injection wells will be drilled through the target completion interval with a small rotary drilling unit using native mud and a small amount of commercial drilling fluid additive for viscosity control. The hole will be logged, reamed, casing set, and cemented to isolate the completion interval from all other aquifers. Three well construction methods are described. Any of these methods is appropriate for monitor wells and have been approved by the NDEQ under the current Crow Butte Class III UIC Permit and recently issued Class III UIC Permit for the NTEA satellite facility. All wells will be constructed in accordance with the provisions of this section.

Of the three methods, CBR routinely uses Method 1, shown on **Figure 1.3-2**. Method 2, shown on **Figure 1.3-3,** may be used by the CBR geologic staff when there is a need to study the geology of an area and to determine the best placement of the screens without having to attach screens to the casing string. Method 3, shown on **Figure 1.3-4,** is not routinely used, but is maintained as an option so that the method (including minor modifications) can be used if warranted for specific geological formations. All of these methods are appropriate for constructing monitor wells and have been approved by the NDEQ under the UIC Permit.

- Method 1

For this method, the well is drilled to depth in the Pierre Shale and then logged. Based upon the e-log, geological staff will select a casing depth, and will then begin to review the local area wells for the best location (depth) to install the screened interval. The well is cased through the mining zone and cemented in place. Cement flows down the inside of the casing,

exits out the bottom, and flows back up the annulus to the surface. Cement may be pushed out of the bottom of the casing by using a rubber cement plug pushed to the bottom, or may be displaced using fresh water. If the cement is displaced with water, a rig will need to drill the excess cement out of the casing prior to under-reaming and setting screens. If the cement is displaced using a cement plug, then nothing further is required prior to under-reaming. The under-reaming process begins with a rig tripping (inserting in borehole) a specialized drill bit into the depths to be screened. Blades on the bit open outward to cut away and remove the casing and cement grout from the area to be screened. When the interval to be screened has been cut away, the drill rig removes the drill pipe, and the hole is logged to make certain that the cut is accurate. If the cut-check depths are determined to be satisfactory, the rig is used to place the screen assembly at the selected depth and then develop the well.

Method 1 is the primary method used for all injection and production wells. A slight variation of this method is used for monitor wells. Monitor wells are cased to the top of the mining zone and cemented using water displacement. After allowing the cement to set up (harden), the excess cement is drilled out of the casing and the well is logged to determine where to place the well screens.

Method 1 is similar to Method 2, except that a plug and weep holes are not used.

- Method No. 2

Method 2 uses a screen telescoped down inside the cemented casing. A hole is drilled and geophysically logged to locate the desired screen interval. The hole is then reamed if necessary only to the top of the desired screen interval. Next, a string of casing with a plug at the lower end and weep holes just above the plug is set into the hole. Cement is then pumped down the casing and out the weep holes. It returns to the surface through the annulus. After the cement has cured, the residual cement in the casing and plug are drilled out, with the drilling continuing through the desired zone. The screen with a K-packer and/or shale traps is then telescoped through the casing and set in the desired interval. The packer and/or shale traps hold the screen in the desired position while acting as a fluid seal. Well development is again accomplished by airlifting or pumping. Minor variations from these procedures may be used as conditions require.

Method 2 is an improvement over Method 3 due to drilling only to the top of the mining zone. At that point, the well is cased and cemented. Because the drill hole does not penetrate through the mining zone, no cement basket must be used. A cement plug and weep holes are used to place the cement.

- Method No. 3

This method involves setting an integral casing/screen string. The method consists of drilling a hole to the Pierre Shale; geophysically logging the hole to define the desired screen interval; and reaming the hole, if necessary, to the desired depth and diameter. Next, a string of casing with the desired length of screen attached to the lower end is placed into the hole. A cement basket is attached to the blank casing just above the screen to prevent plugging of the screen interval during cementing. The cement is pumped down the inside of the casing to a plug set just below the cement basket. The cement passes out through weepholes in the casing and is directed by the cement basket back to the surface through the annulus between the casing and

the drill hole. After the cement has sufficiently cured, the residual cement and plug are drilled out and the well is developed by airlifting or pumping.

For all three well completion methods, casing centralizers, located at a maximum spacing of 100 feet, are run on the casing to ensure that it is centered in the drill hole and that an effective cement seal is provided. The purpose of the cement is to stabilize and strengthen the casing and plug the annulus of the hole to prevent vertical migration of solutions. The volume of cement used in each well is determined by estimating the volume required to fill the annulus and ensure that cement returns to the surface. In almost all cement jobs, returns to the surface are observed. In rare cases, however, the drilling may result in a larger annulus volume than anticipated, and cement may not return all the way to the surface. In these cases, the upper portion of the annulus will be cemented from the surface to backfill as much of the well annulus as possible and stabilize the wellhead. This procedure is performed by placing a tremie hose from the surface as far down into the annulus as possible. Cement is pumped into the annulus until return to the surface is observed.

Screening

The exact size of the screen slot is determined by analyzing the formation samples brought to the surface during the drilling process, and is selected at the discretion of the CBR geology staff. The location and amount of drill screen to be set in a well is based upon the geologic and economic factors. Well screens are placed at a selected depth using the drilling rig. The screens are secured in place using a rubber K-packer and blank assembly attached to the top of the screens. The K-packer suspends the screens in the open portion of the well until well development creates a natural gravel pack surrounding the screen.

For injection and production wells, the screen interval is determined by the geology staff based on the location of sands and ore grade material. The zones to be mined are correlated and selected by reviewing geophysical logs, which also confirms that the screened intervals between wells are hydrologically connected. Typically, an interval of approximately 18 feet is screened; however, individual intervals may range from 6 feet to 35 feet in length.

For monitor wells, a slightly different process is followed for placement of the screens. When the monitor well is drilled, the total thickness of the production zone is calculated. The number of screens to be placed in the well must cover the production zone, and the screen-to-blank ratio must exceed 50 percent. Care should be taken to ensure that those zones impacted by nearby wells are covered by screens, and not left blank. A well completion report is documented for each well and submitted to the NDEQ. These data are kept available on site for review. All wells are constructed by a licensed/certified water well contractor, as defined by the Nebraska Health and Human Services System, Water Well Standards and Licensing Act, Article 46.

1.3.2.3 Cement/Grout Specifications

All cement will be ASTM International (ASTM) Type I, II or American Petroleum Institute (API) Class B or G and will meet the following criteria:

- The cement will have a density of no less than 11.5 lbs/gal.
- A bentonite grout shall be mixed as close as possible to a concentration of 1.5 lb. bentonite per gallon of water (1 quart polymer per 100 gallons of water may be premixed

to prevent the clays from hydrating prematurely) and shall have a density of 9.2 lbs./gal or higher.

1.3.2.4 Process Description

Uranium solution mining is a process that takes place underground, or in-situ, by injecting lixiviant (leach) solutions into the ore body and then recovering these solutions when they are rich in uranium. The chemistry of solution mining involves an oxidation step to convert the uranium in the solid state to a form that is easily dissolved by the leach solution. Hydrogen peroxide (H_2O_2) or gaseous oxygen (O_2) is typically used as the oxidant because both revert to naturally occurring substances. Carbonate species are also added to the lixiviant solution in the injection stream to promote the dissolution of uranium as a uranyl carbonate complex.

The reactions representing these steps at a neutral or slightly alkaline pH are:

Oxidation:	$UO_{2\ (solid)} + H_2O_{2\ (in\ solution)}$	$\longrightarrow$	$UO_{3\ (at\ solid\ surface)} + H_2O$
	$UO_{2\ (solid)} + \frac{1}{2}\ O_{2\ (in\ solution)}$	$\longrightarrow$	$UO_{3\ (at\ solid\ surface)}$
Dissolution:	$UO_3 + 2\ HCO_3^{-1}$	$\longrightarrow$	$UO_2(CO_3)_2^{-2} + H_2O$
	$UO_3 + CO_3^{-2} + 2HCO_3^{-1}$	$\longrightarrow$	$UO_2(CO_3)_3^{-4} + H_2O$

The principal uranyl carbonate ions formed as shown above are uranyl dicarbonate, $UO_2(CO_3)_2^{--2}$, (UDC), and uranyl tricarbonate $UO_2(CO_3)_3^{-4}$ (UTC). The relative abundance of each is a function of pH and total carbonate strength.

Solutions resulting from the leaching of uranium underground will be recovered through the production wells and piped to the satellite facility for extraction. The uranium recovery process employs the following steps:

1. Loading of uranium complexes onto an IX resin
2. Reconstitution of the leach solution by addition of carbon dioxide (CO_2) and/or sodium bicarbonate ($NaHCO_3$) and an oxidizer
3. Elution of uranium complexes from the resin
4. Precipitation of uranium

The first two steps will be performed at the satellite facility. Steps 3 and 4 will be performed at the CPF. The process flow sheet for the above steps is shown on **Figure 1.3-5**. The left side of **Figure 1.3-5** depicts the uranium extraction process completed at the satellite facility. The right side of the figure shows the uranium recovery steps that will be performed at the CPF. Once the IX resin at the satellite facility is loaded to capacity with uranium complexes, the resin will be transferred to the CPF for uranium recovery.

Uranium Extraction

The recovery of uranium from the leach solution in the satellite facility will take place in the IX columns. The uranium-bearing leach solution enters the pressurized downflow IX column and passes through the resin bed. The uranium complexes in solution are loaded onto the IX resin in the column. This loading process is represented by the following chemical reaction:

$$2\ R\ HCO_3 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2HCO_3^{-1}$$

$$2\ RCl + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2Cl^-$$

$$R_2SO_4 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + SO_4^{-2}$$

As shown in the reaction, loading of the uranium complex results in simultaneous displacement of chloride, bicarbonate, or sulfate ions.

The now barren leach solution passes from the IX columns to be reinjected into the formation. The solution is refortified with sodium and carbonate chemicals, as required, and pumped to the wellfield for reinjection into the formation. The expected lixiviant concentration and composition are shown in **Table 1.3-2.**

Resin Transport and Elution

Once the majority of the IX sites on the resin in an IX column are filled with uranium, the column will be taken out of service. The resin loaded with uranium will be transported by tanker truck to the CPF for elution and final processing. Once the resin has been stripped of the uranium by elution, it will be returned to the satellite facility for reuse in the IX circuit.

At the CPF, the loaded resin will be stripped of uranium by an elution process based on the following chemical reaction:

$$R_2UO_2(CO_3)_2 + 2Cl^- + CO_3^{-2} \longrightarrow 2\ RCl + UO_2(CO_3)_2^{-2}$$

After the uranium has been stripped, the resin is rinsed with a solution containing $NaHCO_3$. This rinse removes the high chloride eluent physically entrained in the resin and partially converts the resin to bicarbonate form. In this way, chloride ion buildup in the leach solution can be controlled.

Precipitation

When a sufficient volume of pregnant eluent is held in storage, it is acidified to destroy the uranyl carbonate complex ion. The solution is agitated to assist in removal of the resulting CO_2. The decarbonization can be represented as follows:

$$UO_2(CO_3)_3^{-4} + 6H^+ \longrightarrow UO_2^{++} + 3\ CO_2 + 3H_2O$$

Sodium hydroxide (NaOH) is then added to raise the pH to a level conducive for precipitating pure crystals.

H_2O_2 is then added to the solution to precipitate the uranium according to the following reaction:

$$UO_2^{++} + H_2O_2 + 2H_2O \longrightarrow UO_4 \bullet 2H_2O + 2H^+$$

The precipitated uranyl peroxide slurry is pH adjusted, allowed to settle, and the clear solution decanted. The decant solution is recirculated back to the barren makeup tank, sent to fresh salt brine makeup, or sent to waste. The thickened uranyl peroxide is further dewatered and washed. The solids discharge is either sent to the vacuum dryer for drying before shipping or is sent to storage for shipment as slurry to a licensed recovery or converting facility.

Wellfield and Process Wastes

All well development water will be captured in water trucks specifically labeled and dedicated for such purpose, and equipped with signage indicating that these trucks may only discharge their contents to the MEA wastewater system. The management of these wastewaters is discussed in Section 3.12.2.1..

The operation of the satellite facility will produce a production bleed stream continuously withdrawn from the recovered lixiviant stream at a rate that is expected to be 0.5 to 2.0 percent of the total volume of recovered lixiviant. The production bleed stream is taken following the recovery of uranium by IX and has the same chemical characteristics as the lixiviant. The production bleed waste stream will be managed by a DDW well injection, which will be constructed at the satellite facility.

The other source of wastewater resulting from uranium mining activities in the MEA is the eluent bleed stream at the CPF. This is an existing source of wastewater at the CPF currently produced at a rate of approximately 5 to 10 gpm. It is likely that the eluent bleed stream will increase by a maximum of 10 percent due to processing of IX resin from the satellite facility. The eluent bleed waste stream will be managed by reuse in the processing facility or disposal by DDW injection at the CPF.

All byproduct material produced as a result of the operation of the satellite facility will be disposed of at a licensed facility approved for disposal of 11e.(2) byproduct material, similar to provisions made for the byproduct material currently produced. All solid waste will be disposed of in an approved landfill in accordance with current practice. There will be no onsite disposal of these materials.

Based on the proposed project development schedule and the water balance of the MEA project, liquid waste disposal methods will be phased for the MEA operations. Initially, two DDWs will be used as the primary disposal option, and as flows increase over the years due the addition of new MUs and restoration activities, additional disposal options will be added. Liquid waste disposal operations and alternatives are discussed in more detail in Sections 2.3.1.3 (waste management), 3.12.2.1 (liquid waste disposal options), and 3.12.2.2 (project water balance).

1.3.2.5 Logging Procedures and Other Tests

Appropriate geophysical logs and other tests are conducted during the drilling and construction of new Class III wells. These are determined based on the intended function, depth, construction, and other characteristics of the well; availability of similar data in the area of the drilling site; and the need for additional information that may arise from time to time as the construction of the well progresses.

Logging Equipment

CBR currently owns three operational logging units. All were built by Century Geophysical Corporation in Tulsa, Oklahoma. These units are capable of logging drill holes to a depth of approximately 2,000 feet.

These trucks are capable of using a wide variety of tools. All of these tools (or probes, as used by CBR) measure Single Point Resistance (RES), static spontaneous potential (SSP), Natural

Gamma (GAM[NAT]), and Deviation. Some of the probes used by CBR are also capable of measuring temperature, 16-inch normal resistance, and 64-inch normal resistance (**Table 1.3-3**). Deviation with these units is measured using a slant angle and azimuth technique. Standardized procedures are used by trained personnel to carry out the logging tasks.

Groundwater Measurements

Groundwater sampling and water level measurements are two tests typically conducted for new wells. Results of the groundwater sampling and analysis are used to evaluate water quality baseline values for future restoration to groundwater standards, and water level measurements provide for a more detailed understanding of the hydraulic gradient within the MEA. Groundwater monitoring for new wells is discussed below.

Well Development

Following well construction (and before baseline water quality samples are taken for restoration and monitoring wells), the wells must be developed to restore the natural hydraulic conductivity and geochemical equilibrium of the aquifer. All wells are initially developed immediately after construction using airlifting or other accepted development techniques. This process is necessary to allow representative samples of groundwater to be collected. Well development removes water and drilling fluids from the casing, formation, and borehole walls along the screened interval. The primary goal for well development is to allow formation water to enter the well screen.

Initially, well development is performed by airlifting and cleanup with a drill rig. The well is developed until the water produced is clear. This can be determined visually or with a turbidimeter. During the final stages of initial development, water samples will be collected in a transparent or translucent container and visually examined for turbidity (i.e., cloudiness and visual suspended solids). Development continues until clear, sediment-free formation water is produced.

When the water begins to clear, the development flow will be temporarily stopped and/or the flowrate will be varied. Sampling and examination for turbidity will continue. When varying the development rate no longer causes the sample to become turbid, the initial development will be deemed complete.

Before obtaining baseline samples from monitor or restoration wells, the well must be further developed to ensure that representative formation water is available for sampling. Final development is performed by pumping the well or swabbing for an adequate period to ensure that stable formation water is present. pH and conductivity are monitored during this process to ensure that development activities have been effective. The field parameters must be stable at representative formation values before baseline sampling will begin.

Following well installation, all well development water will be captured in water trucks specifically labeled and dedicated for such purpose, and equipped with signage indicating that these trucks may only discharge their contents for injection into ~~the~~an onsite DDW (see additional discussions in Section 3.12.2.1). Alternatively, these fluids may be transported to the CPF evaporation ponds, but only if there are fluid separation equipment issues at the MEA satellite facility. Additional wellfield and process waste are discussed below. Section 4.2.1.1 discusses handling and disposal of well drilling fluids and well development water.

Well Integrity Testing

All wells (i.e., injection, production, and monitor) are field tested under pressure-packer tests to demonstrate the mechanical integrity of the well casing. Every well will be tested after well construction before it can be placed into service; after any workover with a drill rig or servicing with equipment or procedures that could damage the well casing; at least once every 5 years; and whenever there is any question of casing integrity. To ensure the accuracy of the integrity tests, periodic comparisons are made between the field pressure gauges and a calibrated test gauge. The mechanical integrity test procedure has been approved by the NDEQ and is currently contained in the Safety, Health, Environment and Quality Management System (SHEQMS) Volume III, Operating Manual. These same procedures will be used at the MEA.

The following general mechanical integrity test procedure is employed:

- The well is tested after well development and prior to the well being placed into service. The test consists of placement of two packers within the casing. The bottom packer is set just above the well screen and the upper packer is set at the wellhead. The packers are inflated with nitrogen, and the casing is pressurized with water to 125 percent of the maximum operating pressure (i.e., 125 pounds per square inch [psi]).
- The well is then "closed in" and the pressure is monitored for a minimum of 20 minutes.
- If more than 10 percent of the pressure is lost during this period, the well has failed the integrity test. When possible, a well that fails the integrity testing will be repaired and the testing repeated. If the casing leakage cannot be repaired or corrected, the well is plugged and reclaimed as described in Section 6.

CBR submits all integrity testing records to the NDEQ for review after the initial construction of an MU or wellfield. Test results are also maintained on site for regulatory review.

1.3.2.6 Wellfield Design and Operation

The proposed MEA MU timeline and MU map are shown on **Figures 1.1-6** and **1.1-7**, respectively. The preliminary map and mine timeline are based on current knowledge of the area. As the MEA is developed, the mine timeline and an MU map will be further developed. The MEA will be subdivided into an appropriate number of MUs. Each MU will contain wellhouses where injection and recovery solutions from the satellite facility building are distributed to the individual wells. The injection and production manifold piping from the satellite process facility to the wellhouses will be either PVC or HDPE with butt-welded joints or equivalent. Injection pressure will be monitored in the wellhouse manifolds. Oxidizer will be added to the injection stream, and all injection lines off of the injection manifold will be equipped with totalizing flowmeters, which will be monitored in the satellite Control Room. The MEA wellfield will be designed consistent with the existing CBR wellfields.

The wellfield injection/production pattern employed is based on a hexagonal seven-spot pattern, modified as needed to fit the characteristics of the ore body. The standard production cell for the seven-spot pattern contains six injection wells surrounding a centrally located recovery well.

The cell dimensions vary depending on the formation and the characteristics of the ore body. The injection wells placed in a normal pattern are expected to be between 65 and 150 feet apart. A typical wellfield layout is shown on **Figure 1.3-6**. The wellfield is a repeated seven-spot design,

with the spacing between production wells ranging from 65 to 150 feet. Other wellfield designs include alternating single line drives.

All wells are completed so they can be used as either injection or recovery wells, so that wellfield flow patterns can be changed as needed to improve uranium recovery and restore the groundwater in the most efficient manner. During operations, leaching solution enters the formations through the injection wells and flows to the recovery wells. Within the monitor well ring, prior to stability monitoring, more water is produced than injected to create an overall hydraulic cone of depression in the production zone. Under this pressure gradient, the natural groundwater movement from the surrounding area is toward the wellfield, providing additional control of the leaching solution movement. The difference between the amount of water produced and injected is the wellfield "bleed". The minimum over-production or bleed rates will be a nominal 0.5 percent of the total wellfield production rate, and the maximum bleed rate typically approaches 2.0 percent. Bleed is adjusted as necessary to ensure that the perimeter ore zone monitor wells are influenced by the cone of depression until stability monitoring described in Section 5.4.1.5 begins.

Monitor wells will be placed in the basal sandstone of the Chadron Formation and overlying Brule Formation and Arikaree Group aquifers. All monitor wells will be completed by one of the three methods discussed above and developed prior to leach solution injection. The development process for monitor wells includes establishing baseline water quality before the initiation of mining operations. As the MEA is developed, the MU map showing the locations of monitor wells will be developed further.

Injection of solutions for mining will be at a rate of 6,000 gpm with a 0.5 to 2.0 percent production bleed stream. Production solutions returning from the wells to the production manifold will be monitored with a totalizing flowmeter. All pipelines and trunklines will be pressure checked for leaks and buried prior to production operations.

A water balance for the proposed satellite facility is shown on **Figure 1.3-7** and **Appendix T**. The liquid waste generated at the satellite facility will be primarily the production bleed which, at a maximum, is estimated at 1.2 percent of the production flow. At 6,000 gpm process flow, the maximum volume of liquid waste in the year 2024 would be approximately 31 gpm. CBR proposes to handle the liquid waste using DDW injections. Detailed discussions of the MEA water balance calculation and evaluation are discussed in Section 3.12.2.2.

Regional information, previous CBR license and permit submittals, and historical operational practices indicate that the minimum pressure that could initiate hydraulic fracture is 0.63 psi per foot of well depth. This value has historically and successfully been applied to CBR operations. Calculations for MEA result in a value of 0.53 psi. As such, the injection pressure for the MEA will be limited to less than 0.53 psi per foot of well depth. Injection pressures also will be limited to the pressure at which the well was integrity tested.

As discussed in Section 3.4.3.2, a regional pumping test has been conducted to assess the hydraulic characteristics of the basal sandstone of the Chadron Formation and overlying confining units. Pumping tests will also be performed for each MU not covered by the regional pump test to demonstrate hydraulic containment above the production zone, demonstrate

communication among the production zone mining and exterior monitor wells, and to further evaluate the hydrologic properties of the basal sandstone of the Chadron Formation.

~~A full and detailed analysis of the potential impacts of the mining operations at the MEA on surrounding water users will be provided in an Industrial Groundwater Use Permit application. A similar permit application was submitted by Ferret Exploration of Nebraska (predecessor to CBR) in 1991.~~ The Industrial Groundwater Use Permit application for the exitisting pla~~application~~tn states that water levels in the City of Crawford (approximately 3 miles [4.8 km] northwest of the mining area) could potentially be impacted by approximately 20 feet by consumptive withdrawal of water from the basal sandstone of the Chadron Formation during mining and restoration operations (based on a 20-year operational period). In contrast, t~~T~~he nearest town to the MEA site is the community of Marsland, which is located approximately 4.6 miles (7.4 km) southwest of the MEA (centerpoint of Town of Marsland to centerpoint of MEA satellite building). There is no public water supply for the community of Marsland, with residences scattered throughout the MEA AOR being supplied with domestic water from private wells. Private well use is discussed in more detail in Section 3.4.1, and impacts to water levels are discussed in Section 4.14.3.6.

Although similar impacts to water levels in the basal sandstone of the Chadron Formation are expected at the MEA, ~~No~~ impacts to other users of groundwater are~~is~~ not expected because there is no documented existing use of the basal sandstone of the Chadron Formation in the proposed MEA or associated AOR.

Because the basal sandstone of the Chadron Formation (production zone) is a deep confined aquifer, no surface water impacts are expected. Based on available information, all water supply wells within the MEA and AOR are completed in the relatively shallow Arikaree and/or Brule Formation, with no domestic or agricultural use of groundwater from the basal sandstone of the Chadron Formation.

Further, the geologic and hydrologic data presented in Sections 3.3 and 3.4, respectively, demonstrate that (1) uranium mineralization is limited to the basal sandstone of the Chadron Formation, and (2) the basal sandstone of the Chadron Formation is isolated from underlying and overlying sands. Hence, the mining operations are expected to impact water quality only in the basal sandstone of the Chadron Formation, and restoration operations will be conducted in the basal sandstone of the Chadron Formation following completion of mining.

Based on a bleed of 0.5 to 2.0 percent, the potential impact from consumptive use of groundwater is expected to be minimal. A bleed of 0.5 to 1.5 percent has been successfully applied in the current licensed area. In this regard, the vast majority (on the order of 98 percent) of groundwater used in the mining process will be treated and re-injected (**Figure 1.3-7**). Potential impacts on groundwater quality due to consumptive use outside the license area are expected to be negligible.

The data were evaluated using a Theis semi-steady state analytical solution, which includes the following assumptions:

- The aquifer is confined and has apparent infinite extent.
- The aquifer is homogeneous and isotropic, and of uniform effective thickness over the area influenced by pumping.

- The piezometric surface is horizontal prior to pumping.
- The well is pumped at a constant rate.
- Water removed from storage is discharged instantaneously with a decline in head.
- The pumping well is fully penetrating.
- Well diameter is small, so well storage is negligible.

Based on a drawdown

response observed at the most distant observation well locations (Monitor 2 and Monitor 8), the ROI during the pumping test was estimated to be in excess of approximately 8,800 feet. More than 0.8 foot of drawdown was achieved during testing in all observation wells completed in the basal sandstone of the Chadron Formation, with a maximum drawdown of 23.40 feet observed in CPW-2010-1A (pumping well) during the test. Furthermore, during pumping and recovery periods, no discernible drawdown or recovery responses attributed to the test were observed in overlying Brule Formation observation wells, which supports the conclusion that adequate confinement exists between the overlying Brule Formation and the basal sandstone of the Chadron Formation. The results of the pumping test are provided in more detail in Section 3.4.3.2.

As discussed in Section 6 of this document, an extensive water sampling program will be conducted prior to, during, and following mining operations at the satellite facility to identify any potential impacts to water resources in the area.

The groundwater monitoring program is designed to establish baseline water quality prior to mining, detect excursions of lixiviant either horizontally or vertically outside of the production zone, and determine when the production zone aquifer has been adequately restored following mining. The program will include sampling of monitoring wells and private wells within and surrounding the license area to establish pre-mining baseline water quality. Water quality sampling will continue throughout the operational phase of mining for detection of excursions. Water quality will also be sampled during restoration, including stabilization monitoring at the end of restoration activities, to determine when baseline or otherwise acceptable water quality has been achieved.

During operation, the primary purpose of the wellfield monitoring program will be to detect and correct conditions that could lead to an excursion of lixiviant or detect such an excursion, should one occur. The techniques employed to achieve this objective include monitoring of production and injection rates and volumes, wellhead pressure, water levels, and water quality.

Monitoring of production (extraction) and injection rates and volumes will enable an accurate assessment of water balance for the wellfields. A bleed system will be employed that will result in less leach solution being injected than the total volume of fluids (leach solution and native groundwater) being extracted. A bleed of 0.5 to 2.0 percent will be maintained during production. Maintenance of the bleed will cause an inflow of groundwater into the production area and prevent loss of leach solution.

Injection pressures are monitored in the wellhouse at the manifold with an audible and visible alarm monitored 24 hours per day, 7 days per week in the control room. The alarms are set to

prevent pressure in excess of 100 psi at the wellhouse manifold, below the 125 psi integrity test pressure. Due to line losses, pressures at the wellheads remain below that which is monitored at wellhouse manifold.

Each new production well (extraction and injection) will be pressure-tested to confirm the integrity of the casing prior to being used for mining operations. Wells that fail pressure testing will be repaired or abandoned and replaced as necessary.

Water levels will be routinely measured in the production zone and overlying aquifer. Sudden changes in water levels within the production zone may indicate that the wellfield flow system is out of balance. Flow rates would be adjusted to correct this situation. Increases in water levels in the overlying aquifer may indicate fluid migration from the production zone. Adjustments to well flowrates or complete shutdown of individual wells may be required to correct this situation. Increases in water levels in the overlying aquifer may also indicate casing failure in a production, injection, or monitor well. Isolation and shutdown of individual wells can identify wells causing the water level increases.

To ensure that the leach solutions are contained within the designated area of the aquifer being mined, the production zone and overlying aquifer monitor wells will be sampled once every 2 weeks as discussed in Section 6.2.2.

1.3.2.7 Central Processing Facility, Satellite Facility, and Chemical Storage Facilities – Equipment Used and Material Processed

The uranium recovery process described in the preceding section will be accomplished in two steps. The uranium will be recovered from the leach solution by IX at the satellite facility. The subsequent processing of the loaded IX resin to remove the uranium (elution), the precipitation of uranium, and the dewatering and packaging of solid uranium (yellowcake) will be performed at the existing CPF. The CPF has been expanded in response to the increase in the IX resin handling, elution, precipitation, thickening, and drying circuits to handle additional production from the proposed NTEA and TCEA. Depending on the mining timelines for the existing CPF wellfields and the MEA, it is possible that the belt filter and dryer capacity of the CPF may need to be increased.

Marsland Satellite Facility Equipment

Only the equipment proposed for the satellite facility is described in this section. The equipment and processes in the CPF are covered under the existing NRC Source Materials License Number SUA-1534. A general arrangement of equipment for the satellite facility is shown on **Figure 1.1-8**. The satellite facility equipment will be housed in a building approximately 130 feet long by 100 feet wide. The satellite facility equipment includes the following systems:

- IX
- Filtration
- Resin transfer
- Chemical addition

The satellite facility will be located within a 1.8-acre area in section 30, T31N, R52W. ~~The DDW will be located nearby.~~ **Figure 1.1-7** shows the plan view of these facilities.

The satellite facility will house the IX columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, wastewater tanks, and an employee lunch room/ break area. Bulk soda ash, CO_2, and O_2 in compressed form and/or H_2O_2 will be stored adjacent to the satellite facility or in the wellfield. $NaHCO_3$ and/or gaseous CO_2 are added to the lixiviant as the fluid leaves the satellite facility for the wellfields. O_2 is added to the injection line for each injection well at the wellhouses.

The IX system consists of eight fixed-bed IX columns. The IX columns will be operated as three sets of two columns in series with two columns available for restoration. The IX system is designed to process recovered leach solution at a rate of 6,000 gpm. Once a set of columns is loaded with uranium, the resin is transported by truck to the CPF. The downflow columns are pressurized, sealed systems so there is no overflow of water, O_2 stays in solution, and radon emissions are contained. Radon releases from the pressurized downflow columns only when the individual columns are disconnected from the circuit and opened to remove the resin for elution. One disadvantage of the downflow column is that there must be good pressure control. Exposure pathways associated with downflow columns to be used at MEA are discussed in Section 4.12.2.1.

After the IX process, the barren leach solution recovered from the wellfield is replenished with an oxidant and leaching chemicals (i.e., $NaHCO_3$ and/or CO_2). The injection filtration system consists of optional backwashable filters, with an option of installing polishing filters downstream. The lixiviant injection pumps are centrifugal type.

Areas in the proposed satellite facility where fumes or gases could be generated are discussed in Section 4.12.2. The potential sources are minimal in the satellite facility because the mining solutions contained in the process equipment are maintained under a positive pressure. Building ventilation in the process equipment area will be accomplished by the use of an exhaust system that draws in fresh air and sweeps the satellite facility air to the atmosphere.

Chemical Storage Facilities

Chemical storage facilities at the satellite facility will include both hazardous and non-hazardous material storage areas. Bulk hazardous materials, which have the potential to impact radiological safety, will be stored outside and segregated from areas where licensed materials are processed and stored. Other non-hazardous bulk process chemicals (e.g., $NaCO_3$) that do not have the potential to impact radiological safety may be stored within the satellite facilities.

Process Related Chemicals

Process-related chemicals stored in bulk at the satellite facility will include carbon dioxide (CO_2), oxygen (O_2), and/or hydrogen peroxide (H_2O_2). Sodium sulfide may also be stored for use as a reductant during groundwater restoration.

- CO_2

CO_2 is stored adjacent to the satellite facility, where it will be added to the lixiviant prior to leaving the satellite facility.

- O_2

O_2 is also typically stored at the satellite facility, or within wellfield areas (where it is centrally located) for addition to the injection stream in each wellhouse. Because O_2 readily supports combustion, fire and explosion are the principal hazards that must be controlled. The O_2 storage facility will be located a safe distance from the satellite facility and other chemical storage areas for isolation. The storage facility will be designed to meet industry standards in the National Fire Protection Act (NFPA-50; NFPA 1996).

O_2 service pipelines and components must be clean of oil and grease because O_2 will cause these substances to burn with explosive violence if ignited. All components intended for use with the O_2 distribution system will be properly cleaned following recommended methods in CGA G-4.1 (CGA 2000). The design and installation of O_2 distribution systems is based on CGA G-4.4 (CGA 1993).

- Sodium Sulfide

Hazardous materials typically used during groundwater restoration activities include the addition of a chemical reductant (i.e., sodium sulfide [Na_2S] or hydrogen sulfide [H_2S] gas). To minimize potential impacts to radiological safety, these materials are stored outside of process areas. Na_2S is currently used as the chemical reductant during groundwater restoration at the CPF. The material consists of a dry flaked product and is typically purchased on pallets of 55-pound bags or in super sacks of 1,000 pounds. The bulk inventory is stored outside process areas in a cool, dry, clean environment to prevent contact with any acid, oxidizer, or other material that may react with the product. H_2S gas has never been used at the CPF. In the event that CBR determines that use of H_2S as a chemical reductant is necessary, proper safety precautions will be taken to minimize potential impacts to radiological and chemical safety.

As part of the SHEQMS, a risk assessment was completed to identify potential hazards and risks associated with chemical storage facilities (and other processes) and to mitigate those risks to acceptable levels. The risk assessment process identified hydrochloric acid as the most hazardous chemical with the greatest potential for impacts to chemical and radiological safety. The hydrochloric acid storage and distribution system is located only at the existing CPF and will not be used at the satellite facility.

None of the hazardous chemicals used at the CPF are regulated under the U.S. Environmental Protection Agency (EPA) Risk Management Program (RMP) regulations. The RMP regulations require certain actions by covered facilities to prevent accidental releases of hazardous chemicals and minimize potential impacts to the public and environment. These actions include measures such as accidental release modeling, documentation of safety information, hazard reviews, operating procedures, safety training, and emergency response preparedness.

1.3.2.8 Non-Process Related Chemicals

Non-process related chemicals that will be stored at the satellite facility include petroleum (gasoline, diesel) and propane. Due to the flammable and/or combustible properties of these materials, all bulk quantities will be stored outside of process areas at the satellite facility. All gasoline and diesel storage tanks are located aboveground and within secondary containment structures to meet regulatory requirements.

1.3.2.9 Satellite Facility Instrumentation and Control

The wellhouses will be located remotely from the satellite facility building. A distribution system will be used to control the flow to and from each well in the wellfield. Wellfield instrumentation will measure total production and injection flow and indicate the pressure being applied to the injection trunklines. Wellhouses will be equipped with wet alarms to monitor the presence of liquids in the wellhouse sumps. The system is monitored 24 hours per day, 7 days per week by control room operators. The operators rely on visual and audible alarms from a variety of systems to control mine operations. Power failures, pressure exceedances, and flow disruption are some of the conditions for which alarm systems will be monitored.

Instrumentation will monitor the total flow into the satellite facility, the total injection flow leaving the facility, and the total waste flow leaving the facility. Instrumentation on the facility injection manifold will record an alarm in the event of any pressure loss that might indicate a leak or rupture in the injection system. The instruments used for flow measurement will include, but are not limited to, turbine meters, ultrasonic meters, variable area meters, electromagnetic flow meters, differential pressure meters, positive displacement meters, piezoelectric, and vortex flow meters.

The injection pumps are equipped with pressure-reducing valves so that they are incapable of producing pressures high enough to exceed design pressure of the injection lines or the maximum pressure demonstrated in each injection well. Pressure gauges, pressure shutdown switches, and pressure transducers will be used to monitor and control the trunkline pressures. During power failures, overpressurizing of wells is not possible, as all pump systems are shut down.

The basic control system at the satellite facility and associated wellfields will be built around a Sequential Control and Data Acquisition (SCDA) network. At the heart of this network is a series of programmable logic controllers. This system allows for extensive monitoring and control of all waste flows, wellfield flows, and facility recovery operations.

The SCDA system will be interconnected throughout the facility via a Local Area Network (LAN) to computer display screens. The software used to display facility processes and collect data incorporates a series of menus which allows the facility operators to monitor and control a variety of systems and parameters. Critical processes, pressures, and wellfield flows will have alarmed set-points that alert operators when any are out of tolerance.

In addition, each wellhouse will contain its own processor, which will allow it to operate independent of the main computer. Pressure switches will be fitted to each injection manifold in the wellhouse to alert the facility and wellfield operators of increasing manifold pressures. All critical equipment will be equipped with uninterruptible 30-minute power supply systems to be used in the event of a power failure.

Through this system, not only will the facility operators be able to monitor and control every aspect of the operation in real time, but management will be able to review historical data to develop trend analysis for production operations. This will not only ensure an efficient operation, but will allow CBR personnel to anticipate problem areas and to remain in compliance with appropriate regulatory requirements.

In the process areas, tank levels are measured in chemical storage tanks as well as process tanks.

Detailed information on the instrumentation and controls will be developed as part of the final design activities prior to construction. This information will be made available to the NRC for review prior to any construction activities.

Handheld radiation detection instruments and portable samplers will be used to monitor radiological conditions at the satellite facility. Specifications for this equipment are included in the SHEQMS Volume IV, Health Physics Manual.

1.3.2.10 Gaseous and Airborne Particulate Control

This section describes the gaseous effluent control systems that will be installed in the MEA.

Tank and Process Vessel Ventilation Systems

A separate ventilation system will be installed for all indoor non-sealed process tanks and vessels where radon-222 or process fumes would be expected. The system will consist of an air duct or piping system connected to the top of each of the process tanks that could potentially produce radon-222 (i.e., resin transfer tank and wastewater tanks). Redundant exhaust fans will direct collected gases to discharge piping that will exhaust fumes to the outside atmosphere. The fans will be designed such that the system will be capable of limiting employee exposures with the failure of any single fan. Discharge stacks will be located away from building ventilation intakes to prevent introducing exhausted radon into the facility as recommended in Regulatory Guide (RG) 8.31. Airflow through any openings in the vessels will be from the process area into the vessel and the ventilation system, controlling any releases that occur inside the vessel. Separate ventilation systems may be used as needed for the functional areas within the satellite facility process building.

A tank ventilation system of this type is used in the CPF process area. Operational radiological in-plant monitoring for radon concentrations has proven this system to be effective for minimizing employee exposure.

Work Area Ventilation System

The ventilation system at the proposed MEA facilities would be similar to that used at the CPF. Exhaust fans would exhaust air within the building outside to the top of the building, drawing in fresh air. The discharge stacks will be located away from the building ventilation intakes and positioned on the leeward side of the satellite building (based on predominant wind direction) to prevent introducing exhausted emissions into the facility. These exhaust fans would be located at different levels to ensure that areas where radon could accumulate are ventilated sufficiently. The exhaust fans will create a negative flow, ensuring that air will not enter the process areas from vessels and systems within the satellite building. There will be redundant fans of the same size and capacity, which will operate only when the primary fans are inoperative due to maintenance or repair.

Storage tanks with the potential for radon emissions would also be vented to the outside of the building. Separate and independent local ventilation systems may be used temporarily as needed for non-routine activities such as maintenance. Radon daughter monitoring at the proposed satellite facility would be used to verify that radon daughters are maintained below the 25 percent

derived air concentration (DAC) action level. Ongoing operations would ensure that the ventilation system operates satisfactorily and as designed through the use of standard operating procedures (SOPs).

Minor radon emissions may occur in a wellfield from wellheads and wellhouses. Vents will not be installed on wellhead enclosures, but SOPs will be followed when accessing a wellhead enclosure in order to ensure minimal exposures to personnel. Wellhouse buildings will be ventilated with either roof- or wall-mounted fans. When the buildings are accessed, the doors will be opened, allowing for additional ventilation of the building prior to entry by personnel. Radon emissions associated with wellfield operations will quickly disperse into the atmosphere.

Other emissions to the air are limited to exhaust and dust from limited vehicular traffic. No significant amounts of process chemicals will be used at the satellite facility. There are no significant combustion-related emissions from the process facility, as commercial electrical power is available at the site. The primary types of non-radiological pollutants that could occur during operations at the MEA site are discussed in Section 4.6.2. The satellite facility operational building would not house combustion devices, except for the propane heaters used for heating the building as needed.

Occupational and public exposures to radon emitted from the MUs and from the satellite processing facility were analyzed using the MILDOS-AREA computer model to ensure that the discharged amount would be within regulatory dose limits. The results of this modeling are presented in Section 4.12.2.3 through 4.12.2.6.

1.3.2.11 Liquid Waste

Sources of Liquid Waste

ISR mining produces several sources of liquid waste. The potential wastewater sources at the satellite facility will be similar to those currently generated and managed at the CPF. These sources include the following:

Water Generated during Well Development

This water is recovered groundwater and has not been exposed to any mining process or chemicals; however, the water may contain elevated concentrations of naturally occurring radioactive material if the development water is collected from the mineralized zone. Well development water will be captured in water trucks specifically labeled for such purpose and equipped with signage indicating that these trucks may only discharge their contents to the MEA wastewater disposal system.

Well development water will typically be transported to the MEA satellite building and transferred to the well workover fluid tank for eventual disposal in the DDWs. Use of this tank, as well as a backup option, are described in Section 3.12.2.1.

Liquid Process Waste

The operation of the satellite facility results in one primary source of liquid waste, a production bleed. This bleed will be routed to a wastewater tank in the satellite building and then pumped from the tank to ~~the~~an onsite DDW.

Waste Petroleum Products and Chemicals

Small quantities of waste petroleum products and chemicals typical of ISR facilities will be generated and will include items such as waste oil and out-of-date or partially used reagents/chemicals. All such wastes that are non-hazardous will be temporarily stored in appropriate sealed containers above ground prior to disposal by a contracted waste disposal entity. Additional discussions of the management of these products and chemicals are presented in Section 3.12.2.1.

Aquifer Restoration Waste

Following mining operations at MEA, restoration of the affected aquifer commences, which results in the production of wastewater. The current groundwater restoration plan consists of four activities:

1. Groundwater transfer
2. Groundwater sweep
3. Groundwater treatment
4. Wellfield circulation

Only the groundwater sweep and groundwater treatment activities will generate wastewater. During groundwater sweep, water is extracted from the mining zone without injection, causing an influx of baseline quality water to sweep the affected mining area. The extracted water must be sent to the wastewater disposal system during this activity.

Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected mining area. An RO unit will be used to reduce the total dissolved solids (TDS) in the groundwater. The RO unit produces clean water (permeate) and brine. The permeate is either injected into the formation or disposed of in the waste disposal system. The brine is sent to the wastewater disposal system.

Stormwater Runoff

Stormwater may be contaminated by contact with industrial materials. Stormwater management is controlled under permits issued by the NDEQ. CBR is subject to stormwater National Pollutant Discharge Elimination System (NPDES) permitting requirements for industrial facilities and construction activities. The NDEQ NPDES regulatory program contained in Title 119 requires that procedural and engineering controls be implemented so that runoff will not pose a potential source of pollution. The design and engineering controls for the proposed MEA facilities will be such that any potentially contaminated stormwater runoff or snowmelt (e.g., any tankage diking, or curbing outside the satellite building) will be collected and disposed of in ~~the~~an onsite DDW. Engineering and procedural controls contained in a Stormwater Pollution Prevention Plan (SWPPP), in combination with the design of the project facilities, will ensure that stormwater runoff is not a potential source of pollution.

Domestic Sewage

Domestic sewage from the satellite facility restroom/toilets and lavatories and the sink in the lunchroom/break area will be disposed of in an approved septic system that meets the requirements of the State of Nebraska. These systems are in common use throughout the United

States, and the effect of the system on the environment is known to be minimal when the systems are designed, maintained, and operated properly. CBR currently maintains a Class V UIC Permit issued by the NDEQ for operation of the septic system at the CPF. A similar permit will be required for the Marsland satellite facility. Because the groundwater on the MEA site is not found at shallow depths, and the site is remote with a relatively small work force, impacts are expected to be minimal.

Chemical toilets may be temporarily located at the MUs and other drilling areas. These toilets will be maintained by a licensed contractor. No impacts associated with the use of chemical toilets are anticipated during site activities.

CBR will employee an estimated 10 to 12 employees at the proposed MEA satellite facility. Assuming 13 gallons per day (gpd) for each employee (based on estimate for industrial employees by EPA), a total of approximately 130 to 160 gpd of sanitary waste would be generated (EPA 2002). An assumed additional 50 gpd of miscellaneous sanitary wastewater (e.g., from restroom/toilets, lavatories, and the sink in the lunchroom/break area) would result in approximately 180 to 210 gpd of sanitary wastewater being discharged to the septic system.

The number of temporary construction employees for the proposed satellite facility is estimated at 10 to 15 personnel. An assumed average of five to 10 full-time employees during construction would result in a total of 15 to 25 employees onsite for some periods. This would result in approximately 200 to 325 gpd of sanitary waste generation. During initial construction, portable sanitary units will be provided and serviced by a third-party contractor.

The septic system will be designed, constructed, operated, and permitted per applicable NDEQ Title 124 regulations.

Laboratory Waste

There will be no laboratory located in the MEA satellite building.

Liquid Waste Disposal

CBR has operated a DDW at the CPF for more than 10 years with excellent results and no serious compliance issues. A second DDW was added in 2011. CBR expects that the liquid waste stream at the MEA site will be chemically and radiologically similar to the waste disposed of in the current DDW.

CBR plans to install DDWs at the MEA site as the primary liquid waste disposal method. CBR has found that permanent deep disposal is preferable to evaporation in evaporation ponds. All compatible liquid wastes at the MEA site will be disposed of in the planned DDWs.

Detailed discussions of liquid waste management and disposal are provided in Sections 2.3.1.3, 3.12.2.1 and 3.12.2.2.

1.3.2.12 Solid Waste

Solid waste generated at the MEA site is expected to include spent resin, resin fines, empty reagent containers, miscellaneous pipe and fittings, and domestic trash. The solid waste will be

segregated based on whether it is clean or has the potential for contamination with 11(e).2 byproduct materials.

Non-contaminated Solid Waste

Non-contaminated solid waste is waste which is not contaminated with 11(e).2 byproduct material or which can be decontaminated and re-classified as non-contaminated waste. This type of waste may include trash, piping, valves, instrumentation, equipment, and any other items that are not contaminated or that may be successfully decontaminated. Release of contaminated equipment and materials is discussed in further detail in Section 5 of the Technical Report. Non-contaminated solid waste will be collected on the site in designated areas and disposed of in the nearest permitted sanitary landfill.

11(e).2 Byproduct Material

Solid 11(e).2 byproduct waste consists of solid waste contaminated with 11e.(2) byproduct material that cannot be decontaminated.

11(e).2 byproduct material generated at ISR facilities consists of filters, personal protective equipment (PPE), spent resin, piping, and other materials. These materials will be stored on site until a full shipment can be shipped to a licensed waste disposal site or licensed mill tailings facility. CBR currently maintains an agreement for waste disposal at a properly licensed facility as a license condition for SUA-1534. CBR is required to notify NRC in writing within 7 days if the disposal agreement expires or is terminated and to submit a new agreement for NRC approval within 90 days of the expiration or termination.

If decontamination is possible, surveys for residual surface contamination will be made prior to releasing the material. Decontaminated materials have activity levels lower than those specified in NRC guidance. An area will be maintained inside the restricted area boundary for storage of contaminated materials prior to their disposal.

Septic System Solid Waste

Domestic liquid wastes from the restroom toilets, lavatories, and a sink in the lunchroom/break area will be disposed of in an approved septic system that meets the requirements of the State of Nebraska. The satellite building will not have a laboratory. Solid materials collected in septic systems must be disposed of by companies or individuals licensed by the State of Nebraska. NDEQ regulations for control of these systems are contained in Title 124.

Hazardous Waste

The potential exists for any industrial facility to generate hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). In the State of Nebraska, hazardous waste is governed by the regulations contained in Title 128. Based on waste determinations conducted by CBR, as required in Title 128, CBR is a Conditionally Exempt Small Quantity Generator (CESQG). To date, CBR only generates universal hazardous wastes such as spent waste oil and batteries. CBR estimates that the proposed satellite facility would produce approximately 800 liters of waste oil per year. Waste oil is disposed of by a licensed waste oil recycler. CBR has management procedures in place in the SHEQMS Program Volume VI, Environmental Manual, to control and manage these types of wastes.

Additional discussions of solid wastes are presented in Sections 3.12.3 and 4.2.2.

1.3.2.13 Flooding and Erosion Potential

The potential for flooding or erosion that could impact the proposed in-situ MEA mining processing facilities and MUs has been assessed through two separate studies. The assessment is discussed in Section 4.3.1.1. The complete report of the hydrologic and erosion study, including tables and figures, is provided in **Appendix K-1** (ARCADIS 2012). The complete report of the hydrologic and flood study, including tables and figures, is provided in **Appendix K-2** (ARCADIS 2013). The studies addressed guidance in RG-1569 for an NRC licensee to assess the potential effects of erosion or surface water flooding on a proposed uranium in-situ facility. The ultimate objective of the studies was to determine whether the potential for erosion or flooding may require special design features or mitigation measures to be implemented.

The studies focused on catchment and watershed delineation, hydrologic characteristics, determination of areas most prone to flooding and erosion due to rainfall runoff, and determination of flood flow characteristics. The analysis presented in **Appendix K-1** identifies proposed wells and facilities in areas of moderate to high risk for erosion that may require mitigation measures. The analysis presented in **Appendix K-2** provides estimates of storm-related discharge rates and velocities within the MEA. Seven primary tasks comprise the comprehensive hydrologic and erosion analysis:

- Data collection and analysis: evaluating rainfall, digital elevation data, soil, and land use data
- Watershed delineation: dividing the project area basin into watersheds for detailed hydrologic analysis
- Hydrologic and erosion analysis: determining the flood routing characteristics of watersheds and generate the erosion risk map using hydrologic, land use, and soil data
- Erosion risk assessment: identifying MEA wells and other site facilities in locations of high erosion potential that may require erosion mitigation
- Flood discharge assessment: determining estimated storm-specific discharge rates within MEA watersheds
- Flood velocity assessment: determining estimated storm-specific flood velocities within MEA watersheds

Data Collection

Similar data collection processes were followed for the studies presented in **Appendix K-1** and **Appendix K-2**. The data necessary to complete the studies included digital terrain data or a DEM, existing floodplain maps, land use and land cover data (LULC), National Hydrography Dataset (USGS NHD) published stream network data, soil data, and rainfall data.

The terrain data were downloaded from the USGS National Elevation Dataset (NED) at a resolution of 30 meters. DEM data were used throughout the model domain to describe watershed topography and streams within the hydrologic model. The project area is in the watershed HUC12 101500020607 (Belmont Cemetery-Niobrara River Basin).

Floodplain maps in the form of Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Maps (DFIRM) were downloaded from the FEMA Map Service Center (FEMA 2011). Land use data for the study area were the National Land Cover Data (NLCD) 2006, which were downloaded from the USGS seamless online Data Warehouse.

Supplementary data used to prepare and recondition the DEM include the USGS NHD published stream network, NHD Flowline (Simley and Carswell 2009) and the NRCS published 12-digit hydrologic unit code (HUC12) watershed delineation (NRCS 2009).

Soil data were downloaded from the NRCS geospatial data gateway, Soil Survey Geographic Database (SSURGO). Regional soil characteristics, most importantly the infiltration rate, were represented by the Soil Conservation Service (SCS) Curve Number Method. Meteorological data, including precipitation, evaporation, and runoff values, were collected from the National Ocean and Atmospheric Administration (NOAA), the National Weather Service (NWS), and the National Climate Data Center (NCDC).

Analysis Procedures

A detailed description of procedures used for watershed delineation and basin characteristics, hydrologic and soil erosion analysis, and modeling is presented in **Appendix K-1.** Procedures for analysis of flood potential are presented in **Appendix K-2**.

A GIS-based erosion model (Revised Universal Soil Loss Equation [RUSLE]).was used to investigate potential erosion in the project area. The model provides a fine spatial resolution of the model results. The RUSLE model is relatively simple and is one of the most practical methods to estimate soil erosion potential and the effects of different management practices. It was selected due to its wide acceptance, including for construction site management at the federal level in NPDES Phase II permitting (Wachal and Banks 2007, EPA 2000).

The RUSLE is the modified version of U.S. Department of Agriculture's Universal Soil Loss Equation (USLE), which has been used to measure soil loss from agriculture lands with relatively uniform slopes. The RUSLE modified certain factors in USLE to more accurately account for more complex terrain. The output of the RUSLE model is an annual rate of erosion and sedimentation in tons per acre per year, as opposed to erosion resulting from specific storm events. A detailed description of RUSLE is presented in **Appendix K-1.**

For the flood analysis, software developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center was used to delineate watershed boundaries and approximate rainfall-runoff volumes. Detailed descriptions of models and modeling procedures used are presented in **Appendix K-2**. HEC-GeoRAS software was used to construct a hydraulic model to calculate flow velocity through the study area. Peak runoff calculated from the HEC-GeoHMS modeling was applied as the peak flow in the HEC-GeoRAS modeling.

Erosion Risk and Flood Analysis

MUs and other MEA facility locations were compared to the RUSLE map to evaluate erosion risk potential for each location. The proposed wellfield, the satellite building, and the areas adjacent to the satellite building were all evaluated for potential placement of the access road and DDWs. **Table 1.3-4** lists the risk of erosion for each wellfield, as well as the associated six DDWs. Maps

displaying the average annual erosion potential as estimated by the RUSLE model in relation to the MUs and satellite facility location are provided in **Appendix K-1**.

MU A and MU 1 carry low or very low erosion risk throughout, while MU C, MU D, MU E, and MU F carry very low erosion risk throughout. MU 5 has multiple locations of moderate erosion risk. MU 2, MU 3, MU 4, and MU B have locations of moderate and high erosion risk. Although MU 2, MU 3, MU 4, and MU B have areas of high erosion risk, only 2 to 7 percent of the area within the units is at a moderate to high risk. Placement of well locations around areas of moderate and high potential erosion should be feasible in these units, particularly in MU 3, where only 2 percent of the land is at an increased risk of erosion. In comparison, 11 percent of MU 5 carries a moderate risk of erosion. Though the overall risk of MU 5 is lower than in other units, it may be more difficult to place wells without additional mitigation measures due to the widespread risk of erosion in the unit.

If wells cannot be placed outside of areas within the wellfields deemed to have moderate to high risks, mitigation measures (e.g., berms) can be implemented to minimize the potential for flooding and erosion. The mitigation measures can be defined during final engineering and prior to any construction. Model results indicate that the risk of erosion is low or very low at the satellite facility, satellite facility access road, and the nearby DDW-M1. Therefore, the probable need for erosion mitigation in this area is low.

As part of the concentrated flow analysis, drainage lines (i.e., channels, gulleys, or areas of concentrated flow) and DFIRM floodplain extents were compared to MU locations. Although drainage lines are the primary contributor to increased erosion risk as part of the RUSLE analysis, the model was unable to accurately define erosion rates in these areas of concentrated flow during flood events. Thus, published FEMA DFIRM 100-year floodplain extents were compared to MUs in the area. MU locations within the 100-year floodplain should be considered at risk to flooding, as well as erosion caused by flood events. Further analysis, mitigation measures, or modification of well locations should be considered for those wells near concentrated flow routes or in the 100-year floodplain during the final engineering phase and prior to well installation and construction activities.

Figures 22 through **27** of **Appendix K-1** display the drainage lines and floodplain extents relative to the MU and satellite facility locations. Drainage line 21 (NRCS HUC number 149152245) runs generally north-to-south and crosses MUs 2, 3, 4, and 5. Well locations in these MUs will be positioned outside of the floodplain or will include flood protection measures in the final engineering plans. Drainage line 24 (NRCS HUC number 149157281) crosses the proposed access road to the satellite facility. However, the proposed access road and satellite facility are not within the 100-year floodplain. The access road will be constructed with consideration to the location of the drainage and potential for concentrated runoff and erosion to occur. Drainage line 21 is predicted to accumulate notably more surface runoff than other drainages and therefore has a higher potential for flooding and erosion. Further analysis, mitigation measures, or modification of well locations will be considered for those wells near concentrated flow routes during the final engineering phase and prior to well installation and construction activities.

Flood Risk Analysis

The hydrologic and flood study presented in **Appendix K-2** divides the MEA into two study areas based on drainage characteristics: Hydrologic Project South and Hydrologic Project East.

Hydrologic Project South contains the majority of sub-basins and drainages where project facilities and activities would occur (e.g., wellfields, ~~and~~ satellite facility, and DDWs). Drainage lines 21 and 24 described above in Erosion and Risk Analysis above are both located within Hydrologic Project South. Peak discharge rates and flood velocities were calculated for storms with return intervals of 10, 25, 50, and 100 years and are provided in **Appendix K-2**. Model results for the 100-year storm event are described below.

Peak discharge rates for the main drainages where they exit the MEA license boundary are summarized in **Tables 1.3-5 and 1.3-6**. The peak discharge for Hydrologic Project South during a 100-year storm is estimated to be 1,455 cubic feet per second (cfs), whereas the peak discharge for Hydrologic Project East during the same storm is estimated to be 2,659 cfs. These discharge values are almost double the rates expected for storms with a 10-year recurrence interval.

In order to determine the potential risk of project facilities and infrastructure due to flooding, the velocity of flood waters within MEA drainages during a 100-year storm were calculated using the HEC-RAS model. For the western tributary within Hydrologic Project South (drainage line 24 of **Appendix K-2**), the maximum flow velocity is estimated to be 5.8 ft/s. For the main stem drainage within Hydrologic Project South (drainage line 21 of **Appendix K-2**), the maximum flow velocity is estimated to be 6.3 ft/s upstream of the confluence with the western tributary and 6.5 ft/s downstream of the confluence. The maximum flow velocity for the main stem drainage within Hydrologic Project East is estimated to be 8.9 ft/s.

Although not within FEMA-designated flood zones, portions of the MEA may be subject to concentrated water flow during storm runoff and may also be at risk of damage. FEMA-designated flood zones supersede any estimated flood widths presented in **Appendix K-2**. For locations within or adjacent to the drainages assessed in this study, but beyond the FEMA flood zones, model results can be used as described below to estimate areas potentially affected under these circumstances, in addition to peak discharge rates and flood velocity. For example, the location where the access road to the proposed satellite facility crosses drainage line 24 (**Appendix K-2**) is outside of a FEMA-designated flood zone. However, model results indicate that runoff velocity within that drainage during a 100-year storm is estimated to be between 2.8 and 3.3 ft/s. Model results also indicate that the total width of flowing water at the access road crossing during a 100-year storm would be between approximately 140 and 220 feet.

Flood Risk Planning

CBR will use the results of the two hydrologic and erosion studies in support of current and future planning and additional project design and layout. Once more detailed engineering commences, the results of these studies will be used to assess the potential for erosion and flooding that may require implementation of special design features or mitigation measures (e.g., berms around areas of MUs, strategically located drainage channels, culverts on roadways). Additional hydrologic and erosion analysis may be required during specific phases of site grading and engineering design to supplement the current studies. For example, specific phases requiring additional analysis may include the final design of MUs (locations of buildings, wells, and piping), DDWs, or the satellite facility building and associated structures.

1.3.2.14 Surface Water Management and Erosion Control

In general, CBR will carry out tasks including the following in regard to surface water management and erosion control.

CBR will use ditches, diversions, culverts, and other best management practices (BMPs) to control surface water flow within the license boundary.

An erosion and sediment control plan will be developed and implemented during construction, operation, and reclamation activities in order to reduce soil losses within the license area and to protect surface and subsurface assets.

Using the results of erosion and flood analyses, CBR will construct facilities outside of these flood-prone boundaries in order to avoid potential impacts to facilities from flooding and potential impacts to major ephemeral drainages, and the Niobrara River in the event of any potential spills or leaks. When possible, CBR will locate surface structures/wells outside of the 100-year flood zone boundaries. Any facilities that will have to be built within the 100-year flood zone boundaries will be protected from flood damage by the use of control measures such as diversion/collection ditches, channels, storm drains, slope drains, and/or berms.

Pipelines will be buried below the frost line, and pipeline valve stations will be located outside of the 100-year flood zone in order to avoid damage due to potential surface flooding.

Efforts will be made to avoid placement of production, injection wells, ~~and~~ monitor wells, and DDWs in potential flood-prone areas (using results of erosion and flood risk analyses), but if it is necessary to place such wells in these areas, surface water control measures (e.g., diversion or erosion control structures) will be used. Wellheads in these areas can be built so that the casing extends above grade and is mounted in a concrete pad. In addition, an aboveground protective housing can be used to protect the well casing in the event of flooding. CBR currently uses an anchored metal or plastic protective housing (similar to a 55-gallon drum with the ends cut out), which affords protection in the event of flooding. As applicable, well heads will be sealed in order to withstand brief periods of submergence.

CBR will carry out all construction tasks in compliance with applicable NPDES stormwater general permit requirements.

Sections 4.4.1 and 4.4.2 describe mitigation measures to protect surface water from potential spills and leaks. Section 4.4.3 describes mitigation measures to protect groundwater from potential spills and leaks.

1.3.2.15 Erosion Control During Construction and Decommissioning

The greatest potential for erosion and sedimentation will be during the construction and decommissioning phases of the MEA project. Land management and farming techniques will be used by CBR in order to minimize the erosion of disturbed, reclaimed, and native areas. Mitigation measures are discussed in Section 5.1. CBR will typically prepare and seed ground areas that are disturbed as soon as possible in order to minimize the potential for erosion. As discussed above, erosion controls will be used in order to reduce overland flow velocity, reduce runoff volume, and minimize the transport of sediment into drainages. Examples include, runoff

control diversion structures, storm drains, slope drains, channels, mulch, cover crops, rip-rap, sediment fences, and other controls. Construction of the MUs will be sequenced so that only part of the site is affected at one time. This sequencing coordinates the timing of land-disturbing activities and the installation of erosion and sediment control measures (EPA 2013). This will assist with the erosion and sediment control because it helps to ensure that BMPs are installed where necessary and when appropriate (EPA 2013).

The need to control sediment will be most critical during wellfield construction and immediately after redistributing topsoil. Sediment control features that may be required include silt fences, sediment basins, sediment traps, vegetation buffers, and other features. CBR will use existing roads when possible and limit the various access road widths, which will minimize the surface disturbance to soil and vegetation. Traffic will be limited to established roadways to the extent possible.

Erosion and sediment controls will be developed prior to commencement of construction, at a time when site disturbance activities are clearly defined.

1.4 Security

CBR security measures for the current operation are specified in the Security Plan and Security Threat chapter in Volume VIII, Emergency Manual. CBR is committed to:

- Providing employees with a safe, healthful, and secure working environment
- Maintaining control and security of NRC licensed material
- Ensuring the safe and secure handling and transporting of hazardous materials
- Managing records and documents that may contain sensitive and confidential information

The NRC requires licensees to maintain control over licensed material (i.e., natural uranium [source material] and byproduct material defined in 10 CFR §40.4). 10 CFR 20, Subpart I, Storage and Control of Licensed Material, requires the following:

§20.1801 Security of Stored Material

The licensee shall secure from unauthorized removal or access licensed materials that are stored in controlled or unrestricted areas.

§20.1802 Control of Material Not in Storage

The licensee shall control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and that is not in storage.

Stored licensed material at the CPF would include uranium packaged for shipment from the facility or byproduct materials awaiting disposal. Examples of material not in storage would include yellowcake slurry or loaded IX resin removed from the restricted area for transfer to other areas.

At the MEA, licensed stored material would typically include loaded IX resin and byproduct waste awaiting disposal. Lixiviant would be found in production piping in the wellfield and wellhouses, production trunkline to the satellite facility, and within piping located in the satellite

building. Loaded IX resin would be placed in a transport truck and temporarily stored in the vehicle until the truck is filled and ready for delivery to the CPF.

1.4.1 Marsland Satellite Facility Security

Entrance to the MEA will be via Squaw Mound Road west of the facility. The entrance to the site will be posted indicating that permission is required prior to entry. A gate on the access route will be locked when not in use. The satellite facility site within the license area will be properly posted in accordance with 10 CFR § 20.1902 (e). The primary and alternate access routes to the satellite facility are shown in **Figure 1.4.-1** and discussed in Section 4.2.

Security at the MEA site will be consistent with policies and procedures used at the CBR current operating site. The security systems used at the current site and proposed for the MEA site are sufficient to prevent unauthorized entry into a) controlled areas and b) restricted areas. As defined in 10 CFR 20.1003, a "controlled area" refers to an area outside a restricted area but within the site boundary, to which the licensee can limit access for any reason. A "restricted area" refers to any area to which access is controlled for the protection of individuals from exposure to radiation and radioactive materials. Appropriate signage will be placed on all fencing advising of access restrictions.

CBR's security program has acceptable passive controls (such as perimeter fencing for wellfields) and active controls (such as daily inspections and locks on facility buildings). These security measures have been demonstrated to prevent unauthorized entry in controlled areas in accordance with 10 CFR Part 20, Subpart I.

Restricted area at the satellite facility refers to *"…an area where access to is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials"* (10 CFR 20.1003). Proposed restricted areas for the satellite facility are shown on **Figure 1.1-8**. Each radiation area will be posted with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIATION AREA" (10 CFR 20.1902). Radiological warnings are posted based upon actual or likely conditions. Actual conditions are determined through area monitoring. Likely conditions are identified based on professional judgment or experience regarding the probability of a radiological condition. When evaluating the likelihood of specific conditions, normal and unique situations that can reasonably be expected to occur will be considered.

All visitors, contractors, or inspectors entering the satellite facility site will be required to register at the facility office and will not be permitted inside the facility or wellfield areas without proper authorization. All visitors needing safety equipment, such as hardhats and safety glasses, will be issued the items by company personnel. Inexperienced visitors will be escorted within the controlled area of the facility unless they are frequent visitors who have been instructed regarding the potential hazards in various site areas. All appropriate and necessary safety or radiological training will be provided and documented by the Radiation Safety Officer (RSO) or designee. Training requirements associated with visitors and contractors are discussed in Section 5.5 of the MEA Technical Report.

The satellite facility will routinely operate 24 hours per day and 7 days per week so that CBR employees will normally be on site except for occasional shutdowns. The satellite facility structure will be equipped with locks to prevent unauthorized access. All facility personnel are

instructed to immediately report any unauthorized persons to their supervisors. The supervisor will contact the reported unauthorized person and make sure that they have been authorized for entry. If the person is unauthorized, they will be escorted to the main entrance for departure.

Access by unauthorized personnel to the stored and non-stored licensed materials (pregnant lixiviant solution, loaded IX resin, and byproduct material awaiting disposal) would be controlled by perimeter access gates with locks and site personnel. This would include piping, process vessels, tankage, and any truck vehicle containing loaded IX resin and parked within or near the satellite facility building.

Wellhouses where pregnant lixiviant solutions would be present in the production piping would be kept locked. Only authorized personnel would have keys to the wellhouses. The production trunk line conveying pregnant lixiviant from the wellhouses to the satellite building would be located within perimeter fencing that only authorized personnel would be allowed to enter. Gates associated with perimeter fencing enclosing any operating wellfield would be kept locked when operators and workers are not present (e.g., remote from the satellite facility). Security may be increased by installing continuous video surveillance of outside areas.

CBR maintains and enforces requirements of the SHEQMS, Volume IV Health Physics Manual, which specify access controls and security issues applicable to visitors, contractors, and employees; radiological posting; and radiological survey and monitoring requirements associated with activities at the site.

Even without consideration of reduced exposures due to the security measures discussed above, the highest estimated total effective dose equivalent (TEDE), as determined using methods described in Sections 3.11.2.2 and 4.12.2.3 through 4.12.2.6, for a downwind receptor near the MEA is 93 millirems per year (mRem/yr). This is based on an occupancy factor of 100 percent or 8,760 hours per year. If the routine visitor were on site for 10 hours per month, the visitor would receive an annual dose of 3 mRem/yr. It is unlikely that even frequent visitors to the MEA could receive annual doses near the 100 mRem public dose limit.

1.4.2 **Transportation Security**

CBR routinely receives, stores, uses, and ships hazardous materials as defined by the U.S. Department of Transportation (DOT). In addition to the packaging and shipping requirements contained in the DOT Hazardous Materials Regulations (HMR), 49 CFR 172, Subpart I, Security Plans, requires that persons that offer for transportation or transport certain hazardous materials develop a Security Plan. Shipments may qualify for this DOT requirement under the following categories:

> §172.800(b) (4) A shipment of a quantity of hazardous materials in a bulk package having a capacity equal to or greater than 13,248 L (3,500 gallons) for liquids or gases or more than 13.24 cubic meters (468 cubic feet) for solids;
>
> §172.800(b) (5) A shipment in other than a bulk packaging of 2,268 kg (5,000 pounds) gross weight or more of one class of hazardous material for which placarding of a vehicle, rail car, or freight container is required for that class under the provisions of subpart F of this part;
>
> §172.800(b) (7) A quantity of hazardous material that requires placarding under the provisions of subpart F of this part.

DOT requires that Security Plans assess the possible transportation security risks and evaluate appropriate measures to address those risks. All hazardous materials shippers and transporters subject to these standards must provide personnel security by screening applicable job applicants, prevent unauthorized access to the hazardous materials or vehicles being prepared for shipment and provide for en route security. Companies must also train appropriate personnel in the elements of the Security Plan.

Transport of licensed/hazardous material by CBR employees will generally be restricted to moving IX resin from a satellite facility to the CPF or transferring contaminated equipment between company facilities. This transport generally occurs over short distances through remote areas. Therefore, the potential for a security threat during transport in a CBR vehicle is minimal. The goal of the driver, cargo, and equipment security measures is to ensure the safety of the driver and the security and integrity of the cargo from the point of origin to the final destination by:

- Clearly communicating general point-to-point security procedures and guidelines to all drivers and non-driving personnel
- Providing the means and methods of protecting the drivers, vehicles, and customer cargo while on the road
- Establishing consistent security guidelines and procedures that shall be observed by all personnel

For the security of all tractors and trailers, the following will be adhered to:

- If material is stored in the vehicle, access must be secured at all openings with locks and/or tamper indicators.
- Off-site tractors will always be secured when left unattended with windows closed, doors locked, the engine shut off, and no keys or spare keys in or on the vehicle.
- The vehicle is to be kept visible by an employee at all times when left outside a restricted area.

The security guidelines and procedures apply to all transport assignments. All drivers and non-driving personnel are expected to know and adhere to these guidelines and procedures when performing any load-related activity.

1.4.3 **Contamination Control Program**

CBR will perform surveys for surface contamination in operating and clean areas of the satellite facility in accordance with the guidelines contained in RG 8.30. Surveys for total alpha contamination in clean areas will be conducted weekly. In designated clean areas, such as lunchrooms, offices, change rooms, and respirator cabinets, the target level of contamination is nothing detectable above background. If the total alpha survey indicates contamination that exceeds 250 disintegrations per minute (dpm)/100 square centimeters (cm^2) (25 percent of the removable limit) a smear survey must be performed to assess the level of removable alpha activity. If smear test results indicate removable contamination greater than 250 dpm/100 cm^2, the area will be promptly cleaned and resurveyed.

All personnel leaving a restricted area will be required to perform and document alpha contamination monitoring. In addition, personnel who could come in contact with potentially contaminated solutions outside a restricted area such as in the wellfields will be required to monitor themselves prior to leaving the area. All personnel receive training in surveys for skin and personal contamination. All contamination on skin and clothing is considered removable, so the limit of 1,000 dpm/100 cm^2 is applied to personnel monitoring. Personnel will also be allowed to conduct contamination monitoring of small, hand-carried items for use in wellfield and controlled areas as long as all surfaces can be reached with the instrument probe and the item does not originate in yellowcake areas. All other items are surveyed as described below.

The RSO, the radiation safety staff, or properly trained employees perform surveys of all items removed from the restricted areas with the exception of small, hand-carried items described above. Due to the distance separating the satellite facility and the CPF, where the RSO and radiation staff are based, it would be more efficient to have properly trained full-time personnel at the MEA site available to perform surveys for releasing items from the restricted area. Such a person would be the Lead Operator or a facility/wellfield operator trained by the RSO or radiation staff in the use of applicable radiation survey instruments and procedures. These staff members would have received training as operators and the required radiation safety training. They would also be subject to additional hands-on training as to the survey instruments and procedures. The release limits are set by the Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct or Source Materials (NRC 1987).

Surveys are performed with the following equipment:

1. Total surface activity will be measured with an appropriate alpha survey meter. A Ludlum Model 2241 scaler or a Ludlum Model 177 Ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe, or equivalent, will be used for the surveys.
2. Portable Geiger-Mueller (GM) survey meter with a beta/gamma probe with an end window thickness of not more than 7 milligrams per square centimeter (mg/cm^2), a Ludlum Model 3 survey meter with a Ludlum 44-38 probe or equivalent.
3. Swipes for removable contamination surveys as required.

Survey equipment is calibrated annually or at the manufacturer's recommended frequency, whichever is more frequent. Surface contamination instruments are checked daily when in use. Alpha survey meters for personnel surveys are response checked before each use, with other checks performed weekly.

As recommended in RG 8.30, CBR conducts quarterly unannounced spot checks of personnel to verify the effectiveness of the surveys for personnel contamination. A spot check of the employees assigned to the satellite facility will be conducted, concentrating on facility operators and maintenance personnel. The purpose of the surveys is to ensure that employees are adequately surveying and decontaminating themselves prior to exiting the restricted areas.

The contamination control program for the satellite facility will be implemented in accordance with the SHEQMS Volume IV, Health Physics Manual.

As noted earlier, Cameco is evaluating the implications of short-lived beta-emitting isotopes to contamination control, for both personal contamination and for free release of objects at the CPF, and will incorporate the results of that evaluation, as appropriate, into the Radiation Protection Program for both the CPF and the MEA.

1.5 Applicable Regulatory Requirements, Permits, and Required Consultations

1.5.1 Environmental Approvals for the Current Licensed Area

As discussed previously, this is an amendment application for Radioactive Source Materials License SUA-1534, originally submitted in September of 1987 and renewed in 1998. A license renewal application for continued operation of the CPF was submitted to the NRC on November 27, 2007. NRC approval is pending. A license amendment for the addition of the proposed NTEA satellite facility was submitted to the NRC on May 30, 2007. NRC approval is pending.

All other required permits for the existing CPF have been obtained and maintained as required by applicable regulatory requirements. The NDEQ has approved a Class III UIC permit and the NDEQ/EPA has approved the Petition for Aquifer Exemption for the proposed NTEA. A summary of the relevant permits and authorizations for the CPF license area is given in **Table 1.5-1**. Permits and authorizations anticipated for the satellite facility are shown in **Table 1.5-2**.

1.5.1.1 Environmental Approvals and Permits

The MEA will be subject to permitting requirements similar to the CPF. **Table 1.5-2** contains a summary list of the type of permit or authorization, the granting authority, and the status.

1.5.1.2 Licensing and Permitting Consultations

During the preparation of this License Amendment application and the NDEQ Class III UIC Application for MEA, the following agency officials were contacted:

U.S. Nuclear Regulatory Commission

Mr. Ronald Burrows, Project Manager
Decommissioning and Uranium Recovery Licensing Directorate
Davison of Waste Management and Environmental Protection
Office of Federal and State Materials and Environmental Management Programs
Mailstop T8-5
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Nebraska Department of Environmental Quality

Ms. Jenny Coughlin
Nebraska Department of Environmental Quality
Suite 400, The Atrium
1200 North N Street
P.O. Box 98922
Lincoln, NE 68509-8922

1.5.2 Environmental Consultations

During the preparation of this license amendment application, several agencies were consulted for information required for various sections of the application:

1.5.2.1 Land Use (Section 3.1)

Elaine Connelly
Nebraska Maps & More
School of Natural Resources
101 Hardin Hall
3310 Holdrege Street
Lincoln, NE 68583-0961

Echo Clark
Tax Assessor
Dawes County
451 Main St.
Chadron, NE 69337
308-432-0103

1.5.2.2 Surface Water (Section 3.4.2)

Assistance was requested in providing available surface water flow and water quality data for the Niobrara River in the proposed project area:

Tom Hayden
Supervisor
Water Field Office Operations
Nebraska Department of Natural Resources
Bridgeport Field Office

Guy H. Lindeman, P.E.
Nebraska Department of Natural Resources
301 Centennial Mall So.
PO Box 94676
Lincoln, NE. 68509

Dave Ihrie
Planning Section, Water Division
Nebraska Department of Environmental Quality
1200 "N" Street, Suite 400
Lincoln, NE 68509-8922
402-471-0283

Bill Peck
U.S. Reclamation Bureau
Field Office
1706 West 3rd St.
McCook, NE 69001

1.5.2.3 Ecological Resources (Section 3.5)

Preparation of the ecology discussion (Section 2.8) required consultations with the following individuals and agencies:

Greg Schenbeck
Wildlife Manager
Pine Ridge Field Office
Nebraska Game and Parks Commission
Chadron, NE

1.5.2.4 Historic, Scenic and Cultural Resources (Section 3.8)

Preparation of the historic, scenic, and cultural resources discussion required consultations with the following individuals and agencies:

Teresa Fatemi
Nebraska State Historical Society
State Historic Preservation Office
1420 P Street
Lincoln, NE 68508

Trisha Nelson
Archaeological Collections Manager
Nebraska State Historic Society
P.O. Box 82554
Lincoln, NE 68501

1.5.2.5 Population Distribution (Section 3.10)

Preparation of the population distribution discussion (Section 3.10) required consultations with the following individuals and agencies:

T. Vogl, School Clerk, Crawford Public Schools

1.5.2.6 Groundwater Quality Restoration, Surface Reclamation, and Facility Decommissioning (Section 3.4.3 and 6.0)

Ms. Jenny Coughlin
Nebraska Department of Environmental Quality
Suite 400, The Atrium
1200 North N Street
P.O. Box 98922
Lincoln, NE 68509-8922

Table 1.1-1 Current Crow Butte Production Area Mine Unit Status

Table 1.1-1 Current Crow Butte Production Area Mine Unit Status

Mine Unit	Production Initiated	Current Status
Mine Unit 1	April 1991	Groundwater Restored
Mine Unit 2	March 1992	Groundwater Restoration
Mine Unit 3	January 1993	Groundwater Restoration
Mine Unit 4	March 1994	Groundwater Restoration
Mine Unit 5	January 1996	Groundwater Restoration
Mine Unit 6	March 1998	Groundwater Restoration
Mine Unit 7	July 1999	Production
Mine Unit 8	July 2002	Production
Mine Unit 9	October 2003	Production
Mine Unit 10	August 2007	Production
Mine Unit 11	November 2010	Production

Table 1.3-1 Latitude and Longitude and Coordinates for Marsland Permit Boundary and Satellite Facility

Table 1.3-1 Latitude and Longitude and Coordinates for Marsland License Boundary and Satellite Facility

Layer	Geographic Projection: NAD 83 (Degrees)		Geographic Projection: NAD 27 (Degree)		NAD1983 StatePlane Nebraska North FIPS 2600(US Foot)		NAD1927 StatePlane Nebraska North FIPS 2601(US Foot)	
	Latitude	Longitude	Latitude	Longitude	Northing	Easting	Northing	Easting
A	42.4959	-103.2345	42.4959	-103.2340	986214	768453	440230	1128008
A	42.4957	-103.2345	42.4957	-103.2340	986145	768451	440161	1128006
A	42.4957	-103.2296	42.4957	-103.2291	986095	769765	440111	1129321
A	42.4884	-103.2299	42.4884	-103.2294	983444	769586	437459	1129139
A	42.4885	-103.2250	42.4885	-103.2245	983427	770914	437441	1130468
A	42.4809	-103.2248	42.4810	-103.2243	980670	770852	434685	1130405
A	42.4810	-103.2296	42.4810	-103.2291	980731	769563	434746	1129115
A	42.4739	-103.2297	42.4739	-103.2293	978161	769430	432176	1128981
A	42.4740	-103.2149	42.4741	-103.2144	978059	773427	432071	1132978
A	42.4666	-103.2151	42.4666	-103.2146	975348	773274	429360	1132823
A	42.4599	-103.2149	42.4599	-103.2144	972907	773242	426919	1132790
A	42.4591	-103.2173	42.4591	-103.2168	972635	772574	426647	1132122
A	42.4591	-103.2245	42.4591	-103.2241	972703	770633	426716	1130180
A	42.4591	-103.2295	42.4591	-103.2290	972750	769297	426765	1128845
A	42.4665	-103.2295	42.4666	-103.2290	975471	769397	429485	1128946
A	42.4665	-103.2344	42.4666	-103.2339	975519	768070	429534	1127619
A	42.4741	-103.2345	42.4741	-103.2341	978271	768138	432286	1127689
A	42.4740	-103.2443	42.4741	-103.2438	978352	765502	432369	1125052
A	42.4810	-103.2443	42.4811	-103.2438	980907	765597	434925	1125149
A	42.4811	-103.2496	42.4811	-103.2492	980966	764164	434985	1123716
A	42.4887	-103.2494	42.4887	-103.2489	983740	764329	437759	1123882
A	42.4886	-103.2544	42.4887	-103.2539	983778	762998	437797	1122551
A	42.4956	-103.2542	42.4956	-103.2537	986289	763143	440309	1122697
A	42.4954	-103.2647	42.4954	-103.2642	986336	760312	440357	1119866
A	42.5065	-103.2644	42.5065	-103.2639	990378	760549	444400	1120105
A	42.5064	-103.2692	42.5065	-103.2687	990402	759254	444424	1118811
A	42.5097	-103.2690	42.5098	-103.2686	991603	759327	445626	1118884
A	42.5097	-103.2739	42.5097	-103.2734	991631	758025	445654	1117582
A	42.5099	-103.2739	42.5100	-103.2734	991725	758032	445749	1117589
A	42.5172	-103.2738	42.5172	-103.2733	994360	758153	448384	1117712
A	42.5171	-103.2835	42.5171	-103.2831	994421	755527	448446	1115085
A	42.5244	-103.2835	42.5244	-103.2830	997082	755635	451107	1115195
A	42.5463	-103.2834	42.5463	-103.2829	1005052	755961	459078	1115525
A	42.5465	-103.2639	42.5465	-103.2634	1004932	761230	458955	1120795
A	42.5465	-103.2637	42.5465	-103.2632	1004932	761272	458955	1120838
A	42.5389	-103.2637	42.5389	-103.2633	1002164	761161	456187	1120724
A	42.5312	-103.2638	42.5312	-103.2633	999351	761048	453374	1120610
A	42.5314	-103.2545	42.5314	-103.2540	999330	763551	453351	1123113
A	42.5248	-103.2544	42.5249	-103.2539	996960	763475	450981	1123036
A	42.5246	-103.2544	42.5246	-103.2539	996874	763473	450895	1123033
A	42.5243	-103.2544	42.5244	-103.2539	996770	763469	450790	1123030
A	42.5244	-103.2492	42.5244	-103.2487	996740	764875	450760	1124436
A	42.5100	-103.2492	42.5100	-103.2487	991491	764681	445510	1124239
A	42.5100	-103.2440	42.5101	-103.2436	991461	766067	445480	1125625
A	42.5100	-103.2392	42.5101	-103.2387	991410	767368	445428	1126926
A	42.5031	-103.2393	42.5031	-103.2388	988886	767250	442903	1126807
A	42.5031	-103.2344	42.5031	-103.2340	988839	768558	442855	1128115
A	42.4959	-103.2345	42.4959	-103.2340	986214	768453	440230	1128008
B	42.5013	-103.2555	42.5013	-103.2550	988395	762875	442416	1122430

Notes:

A = Marsland Permit Boundary

B = Center of Satellite Facility

Revised December 2013

Table 1.3-2 Typical Lixiviant Concentrations

Table 1.3-2 Typical Lixiviant Concentrations

SPECIES	RANGE (in mg/l)	
	Low	High
Na	≤ 400	6,000
Ca	≤ 20	500
Mg	≤ 3	100
K	≤ 15	300
CO_3	≤ 0.5	2,500
HCO_3	≤ 400	5,000
Cl	≤ 200	5,000
SO_4	≤ 400	5,000
U_3O_8	≤ 0.01	500
V_2O_5	≤ 0.01	100
TDS	≤ 1650	12,000
pH	≤ 6.5	10.5

NOTE: The above values represent the concentration ranges that could be found in barren lixiviant or pregnant lixiviant and would include the concentration normally found in "injection fluid".

Table 1.3-3 Background Information for Logging Probes used at the Marsland Expansion Area

Table 1.3-3 Background Information for Logging Probes Used at the Marsland Expansion Area

Logging Tool	Tool Specifications
9060	Natural gamma, Spontaneous Potential, Single Point Resistance
9055	Vertical Deviation, Natural Gamma, Neutron Detector, Neutron Porosity, Spontaneous Potential, Single Point Resistance
9144	Natural Gamma, 64 in. Normal Resistivity, 16 in. Resistivity, Fluid Resistivity, Lateral Resistivity 48 in., Spontaneous Potential, Single Point Resistance, Temperature and Delta Temperature, Slant Angle and Aximuth.
9057	Natural Gamma, 64 in. Normal Resistivity, 16 in. Normal Resistivity, Neutron-Neutron, Lateral Resistivity 48 in., Spontaneous Potential, Single Point Resistance, Temperature and Delta Temperature, Slant Angle and Azimuth

Table 1.3-4 Summary of Risk of Erosion for Proposed MEA Mine Units

Table 1.3-4 Summary of Risk of Erosion for Proposed MEA Mine Units

Mining Unit	MU Maximum Soil Loss (ton/acre/year)	MU Maximum Erosion Risk	Percent MU Area of Moderate to High Erosion Risk	Drainage Lines Crossing MU
MU-A[a]	3.3	Low	N/A	N/A
MU-1[a]	3.4	Low	N/A	N/A
MU-2[b]	18.7	High	5	21
MU-3[c]	22.2	High	2	21
MU-4[d]	24.5	High	7	21
MU-5[e]	13.5	Moderate	11	21
MU-B[f]	20.0	High	6	N/A
MU-C	2.7	Very Low	N/A	N/A
MU-D	0.9	Very Low	N/A	30
MU-E	1.1	Very Low	N/A	N/A
MU-F	0.7	Very Low	N/A	N/A

[a] DDW-M6 associated with MU-A and MU-1.

[b] DDW-M5 associated with MU-2.

[c] DDW-M3 associated with MU-3.

[d] DDW-M1 associated with MU-4.

[e] DDW-M2 associated with MU5.

[f] DDW-M4 associated with MU-B.

Note: MU and DDW locations are shown in Figure 1.1-7.

Revised April 2014

Table 1.3-5 The Peak Flow for Hydrologic Project South

Table 1.3-5 The Peak Flow for Hydrologic Project South

Return Periods		100-year		50-year		25-year		10-year	
Hydrologic Element	Drainage Area (Km^2)	Peak Discharge (M^3/S)	Peak Discharge (Ft^3/S)	Peak Discharge (M^3/S)	Peak Discharge (Ft^3/S)	Peak Discharge (M^3/S)	Peak Discharge (Ft^3/S)	Peak Discharge (M^3/S)	Peak Discharge (Ft^3/S)
W310	0.65	2.5	88	2.1	74	1.7	60	1.2	42
W300	0.45	2.9	102	2.5	88	2.1	74	1.6	57
W290	0.36	2.5	88	2.1	74	1.7	60	1.2	42
W280	0.49	2.1	74	1.8	64	1.4	49	1.1	39
W270	1.50	4.9	173	4.1	145	3.4	120	2.5	88
W260	1.20	4.5	159	3.8	134	3.1	109	2.2	78
W250	0.87	4.0	141	3.4	120	2.8	99	2.0	71
W240	1.94	8.3	293	7.0	247	5.7	201	4.2	148
W230	0.78	5.8	205	5.0	177	4.2	148	3.2	113
W220	0.66	6.4	226	5.5	194	4.6	162	3.5	124
W210	4.18	10.9	385	9.1	321	7.5	265	5.7	201
W200	0.74	6.2	219	5.3	187	4.4	155	3.3	117
W190	1.39	8.9	314	7.6	268	6.4	226	4.8	170
W180	0.48	4.8	170	4.1	145	3.4	120	2.5	88
W170	2.12	12.0	424	10.2	360	8.5	300	6.4	226
Outlet S	17.82	41.7	1473	34.8	1229	28.8	1017	22.1	780
R40	2.60	12.6	445	10.7	378	9.0	318	6.8	240
R80	1.44	8.9	314	7.6	268	6.4	226	4.9	173
R90	4.73	17.3	611	14.6	516	12.2	431	9.3	328
R110	12.29	38.1	1345	31.9	1127	26.6	939	20.3	717
R120	14.36	38.9	1374	32.5	1148	27.0	953	20.6	727
R140	16.35	41.6	1469	34.8	1229	28.7	1014	22.0	777
R160	17.16	41.2	1455	34.4	1215	28.5	1006	21.9	773

Km^2 – square kilometer M^3/S – cubic meter per second Ft^3/S – cubic feet per second

Table 1.3-6 The Peak Flow for Hydrologic Project East

Table 1.3-6 The Peak Flow for Hydrologic Project East

Return Periods		100-year		50-year		25-year		10-year	
Hydrologic Element	Drainage Area (Km^2)	Peak Discharge (M^3/S)	Peak Discharge (Ft^3/S)	Peak Discharge (M^3/S)	Peak Discharge (Ft^3/S)	Peak Discharge (M^3/S)	Peak Discharge (Ft^3/S)	Peak Discharge (M^3/S)	Peak Discharge (Ft^3/S)
W127490	3.01	7.4	261	6.1	215	5.0	177	3.8	134
W127480	0.03	0.2	7	0.2	7	0.1	4	0.1	4
W127470	0.99	4.7	166	4.0	141	3.3	117	2.5	88
W127460	0.06	0.3	11	0.2	7	0.2	7	0.1	4
W127450	1.40	10.4	367	8.9	314	7.5	265	5.7	201
W127440	0.70	3.7	131	3.1	109	2.6	92	1.9	67
W127430	1.23	6.4	226	5.4	191	4.6	162	3.4	120
W127420	0.70	5.7	201	4.8	170	4.0	141	3.0	106
W127410	0.28	2.3	81	1.9	67	1.6	57	1.1	39
W127400	1.50	5.7	201	4.8	170	4.0	141	3.1	109
W127390	1.52	10.0	353	8.6	304	7.2	254	5.5	194
W127380	1.19	8.6	304	7.3	258	6.2	219	4.6	162
W127370	1.38	9.2	325	7.9	279	6.7	237	5.0	177
W127360	1.87	11.1	392	9.4	332	7.9	279	5.9	208
W127350	3.24	17.7	625	15.0	530	12.6	445	9.4	332
W127340	0.79	5.8	205	4.9	173	4.1	145	3.0	106
W127330	1.79	10.1	357	8.6	304	7.2	254	5.4	191
W127320	0.45	3.3	117	2.8	99	2.3	81	1.7	60
W127310	0.59	4.1	145	3.5	124	2.9	102	2.2	78
W127300	2.13	11.2	396	9.5	335	7.9	279	5.9	208
W127290	1.17	9.6	339	8.1	286	6.8	240	5.1	180
W127280	2.21	11.5	406	9.7	343	8.1	286	6.1	215
W127270	2.18	13.1	463	11.1	392	9.3	328	7.0	247
Outlet E	30.42	75.3	2659	63.2	2232	52.7	1861	40.9	1444
R127080	4.34	20.2	713	17.1	604	14.3	505	10.8	381
R127100	3.35	18.1	639	15.4	544	12.9	456	9.7	343
R127110	6.58	28.4	1003	24.0	848	20.1	710	15.2	537
R127120	11.31	45.0	1589	38.0	1342	31.7	1119	24.2	855
R127140	16.42	59.9	2115	50.4	1780	42.1	1487	32.3	1141
R127160	18.99	66.1	2334	55.6	1963	46.5	1642	35.8	1264
R127180	20.79	69.4	2451	58.5	2066	48.8	1723	37.7	1331

Table 1.3-6 The Peak Flow for Hydrologic Project East

Return Periods		100-year		50-year		25-year		10-year	
Hydrologic Element	**Drainage Area (Km^2)**	**Peak Discharge (M^3/S)**	**Peak Discharge (Ft^3/S)**	**Peak Discharge (M^3/S)**	**Peak Discharge (Ft^3/S)**	**Peak Discharge (M^3/S)**	**Peak Discharge (Ft^3/S)**	**Peak Discharge (M^3/S)**	**Peak Discharge (Ft^3/S)**
R127200	22.99	72.6	2564	61.1	2158	51.0	1801	39.4	1391
R127220	24.92	75.4	2663	63.5	2242	52.9	1868	41.0	1448
R127240	25.97	76.9	2716	64.8	2288	54.0	1907	41.8	1476
R127260	27.41	71.3	2518	59.9	2115	50.0	1766	38.8	1370

Km^2 – square kilometer M^3/S – cubic meter per second Ft^3/S – cubic feet per second

Table 1.3-7 Marsland Deep Disposal Well Locations and Radius of Influence Estimates

Table 1.3-7 Marsland Deep Disposal Well Locations and Radius of Influence Estimates

Well ID	Easting (ft) [a]	Northing (ft) [a]	Longitude [b]	Latitude [b]
DDW-M1	1122855	442699	-103 15' 14.107"	42 30' 7.640"
DDW-M2	1125071	440487	-103 14' 43.417"	42 29' 46.632"
DDW-M3	1121709	445318	-103 15' 30.739"	42 30' 33.053"
DDW-M4	1126255	437786	-103 14' 26.254"	42 29' 20.423"
DDW-M5	1120001	447497	-103 15' 54.639"	42 30' 53.923"
DDW-M6	1119617	450473	-103 16' 1.293"	42 31' 23.149"

[a] Nebraska State Plane, NAD 1927, Nebraska North FIPS 2601
[b] NAD 83

Assumptions:

Years of Operation	17
Formation Thickness	200
Formation Porosity	0.25

Average Flow Rate (gpm)	Radius of Emplaced Fluid (ft)
400	1745
300	1510
250	1380
200	1235
150	1070
100	873
50	617
25	437

Source: Cameco 2014

April 2014

Table 1.5-1 Environmental Approvals for Crow Butte Project

Table 1.5-1 Environmental Approvals for Crow Butte Project

Issuing Agency	Permit Description
U.S. Nuclear Regulatory Commission Washington, DC 20555	Source Materials License SUA-1534 Issued: December 29, 1989 Renewed: February 28, 1998 Source Materials License SUA – 1534 Amendment to Increase Flow Issued: November 30, 2007 Source Material License SUA – 1534 License Renewal request by CBR Submitted: November 27, 2007 NRC Approval: Pending Source Material License SUA – 1534 Amendment for New Satellite Facility: North Trend Expansion Area Submitted: May 30, 2007 NRC Approval: Pending
U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, NW Washington, DC 20460	Aquifer Exemption Approval Effective: June 22, 1990
Nebraska Department of Environmental Quality PO Box 98922 Lincoln, NE 68509-8922	Underground Injection Control Class III Authorization NE0122611 Approved: April 24, 1990 Amended to increase flow on August 16, 2007
	Aquifer Exemption Approval Effective: March 23, 1984
	Aquifer Exemption North Trend Expansion Area Submitted: August 15, 2007 Approved: April 18, 2011
	Underground Injection Control Class III Permit Application North Trend Expansion Area Submitted: August 15, 2008 (re-submittal) Approval: August 11, 2011
	Underground Injection Control Class I Authorization NE0206369 Approved: September 9, 1994 Replaced: July 2, 2004
	Underground Injection Control Class I Authorization NE0210825 Additional Class I well Approved: November 24, 2010
	National Pollutant Discharge Elimination System Permit NE0130613 Approved: September 27, 2011
	Mineral Exploration Permit NE0209317 Approved: June 3, 2003 Replaced: August 19, 2009 with NE0210824
	Mineral Exploration Permit NE0210679 Approved: July 16, 2007

Table 1.5-1 Environmental Approvals for Crow Butte Project

Issuing Agency	Permit Description
Nebraska Department of Environmental Quality PO Box 98922 Lincoln, NE 68509-8922	Mineral Exploration Permit NE0210678 Approved: July 16, 2007
	Mineral Exploration Permit NE0210680 Approved: July 18, 2007
	Mineral Exploration Permit NE0210824 Approved: August 19, 2009
	Underground Injection Control Class V Authorization NE0207388 Approved: November 6, 2000
	Evaporation Pond Design Approved: July 21, 1988
	Construction Stormwater NPDES General Permit NER 100000 Authorization #NER105203 Approved: December 19, 2006
Nebraska Department of Natural Resources 301 Centennial Mall South Lincoln, NE 68509-4676	Industrial Ground Water Permit Approved: August 7, 1991
Nebraska Department of Health and Human Services Regulation and Licensure PO Box 95007 Lincoln, NE 68509-5007	Class IV Public Water Supply Permit NE3121024 Approved: April 12, 2002

Table 1.5-2 Environmental Approvals for Proposed Marsland Expansion Area

Table 1.5-2 Environmental Approvals for Proposed Marsland Expansion Area

Issuing Agency	Description	Status
U.S. Nuclear Regulatory Commission Washington, DC 20555	Amendment to Source Materials License SUA-1534 (10 CFR 40)	The document containing this table has been submitted as a License Amendment for the Marsland Expansion Area
U.S. Environmental Protection Agency 1200 Pennsylvania Ave, NW Washington, DC 20460	Aquifer exemption application forwarded to EPA following NDEQ action	Aquifer exemption application forwarded to EPA by NDEQ following NDEQ action
Nebraska Department of Environmental Quality PO Box 98922 Lincoln, NE 68509-8922	Underground Injection Control Class III Permit (NDEQ Title 122)	Class III UIC Permit application submitted to NDEQ in July 2012 (approval pending)
	Aquifer Exemption (NDEQ Title 122)	Aquifer exemption application submitted to NDEQ in July 2012 (approval pending)
	Underground Injection Control Class I (NDEQ Title 122)	Class I UIC Permit application submitted to NDEQ in April 2013
	Industrial Stormwater NPDES Permit (NDEQ Title 119)	An Industrial Stormwater NPDES may not be required for a satellite facility depending on processes included and the final facility design. If required, an application will be submitted as per NDEQ requirements.
	Construction Stormwater NPDES Permit (NDEQ Title 119)	Construction Stormwater NPDES authorizations are applied for and issued annually under a general permit based on projected construction activities. The Notice of Intent will be filed at least 30 days before construction activities begin in accordance with NDEQ requirements.
	Mineral Exploration Permit (NDEQ Title 135)	Mineral Exploration Permit NE0209317 Approved: June 3, 2003 Replaced: July 16, 2007
	Underground Injection Control Class V (NDEQ Title 122)	The Class V UIC Permit will be applied for following installation of an approved site septic system during facility construction.
Nebraska Department of Natural Resources 301 Centennial Mall South Lincoln, NE 68509-4676	Industrial Ground Water Permit (NDNR Title 456)	The Industrial Groundwater Permit application will be prepared for submittal to NDNR; will be submitted following approval of Class III UIC permit.

Figure 1.1-1 Current License Area Project Layout

Document Path: C:\Users\jchen\Documents_PROJECTS\K_CBR_Projects\CO001396_ThreeCrow\2_GIS\ArcMaps\0004_ER\ER Fig_1_1-1 Current Project Layout.mxd

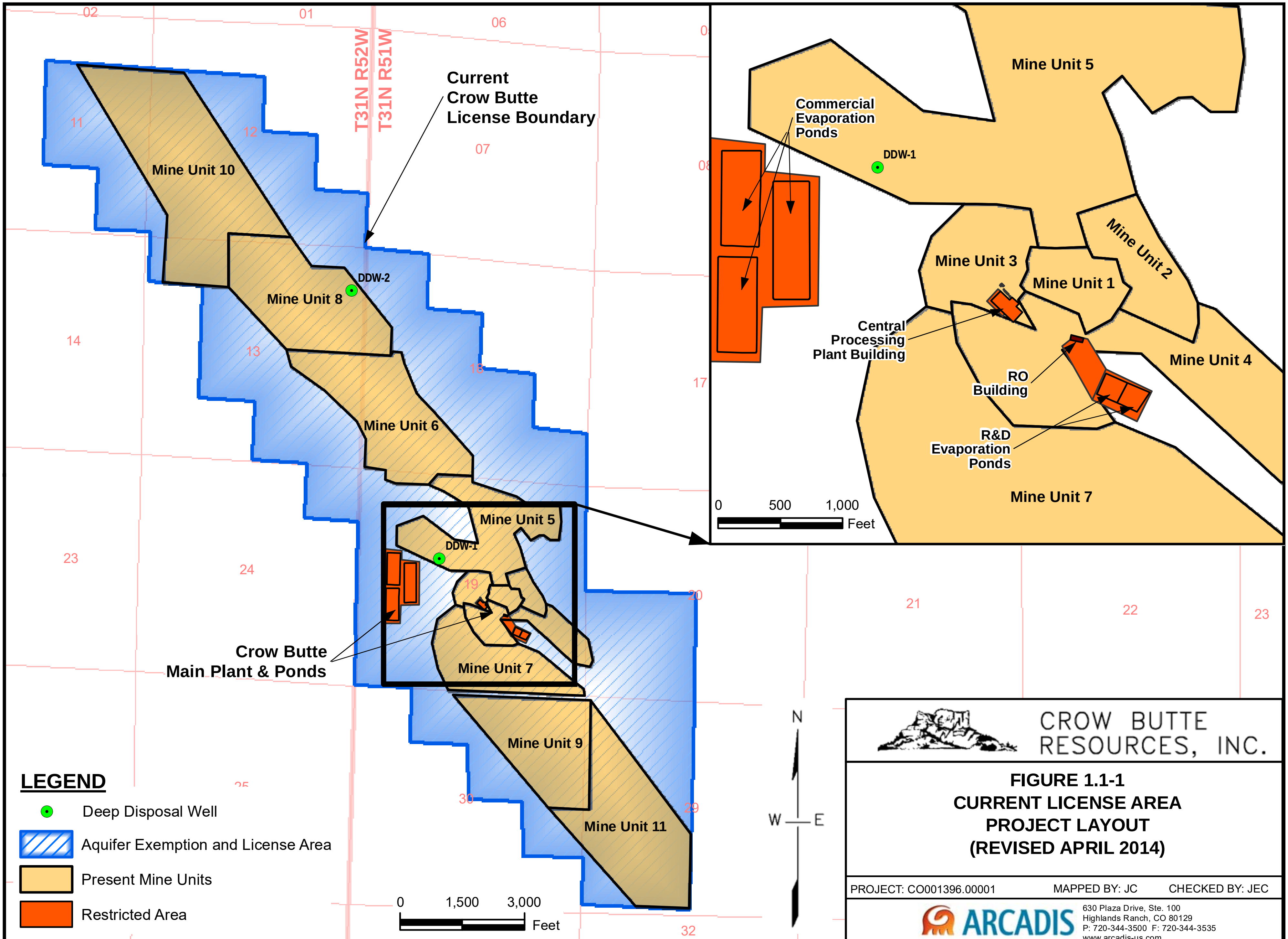
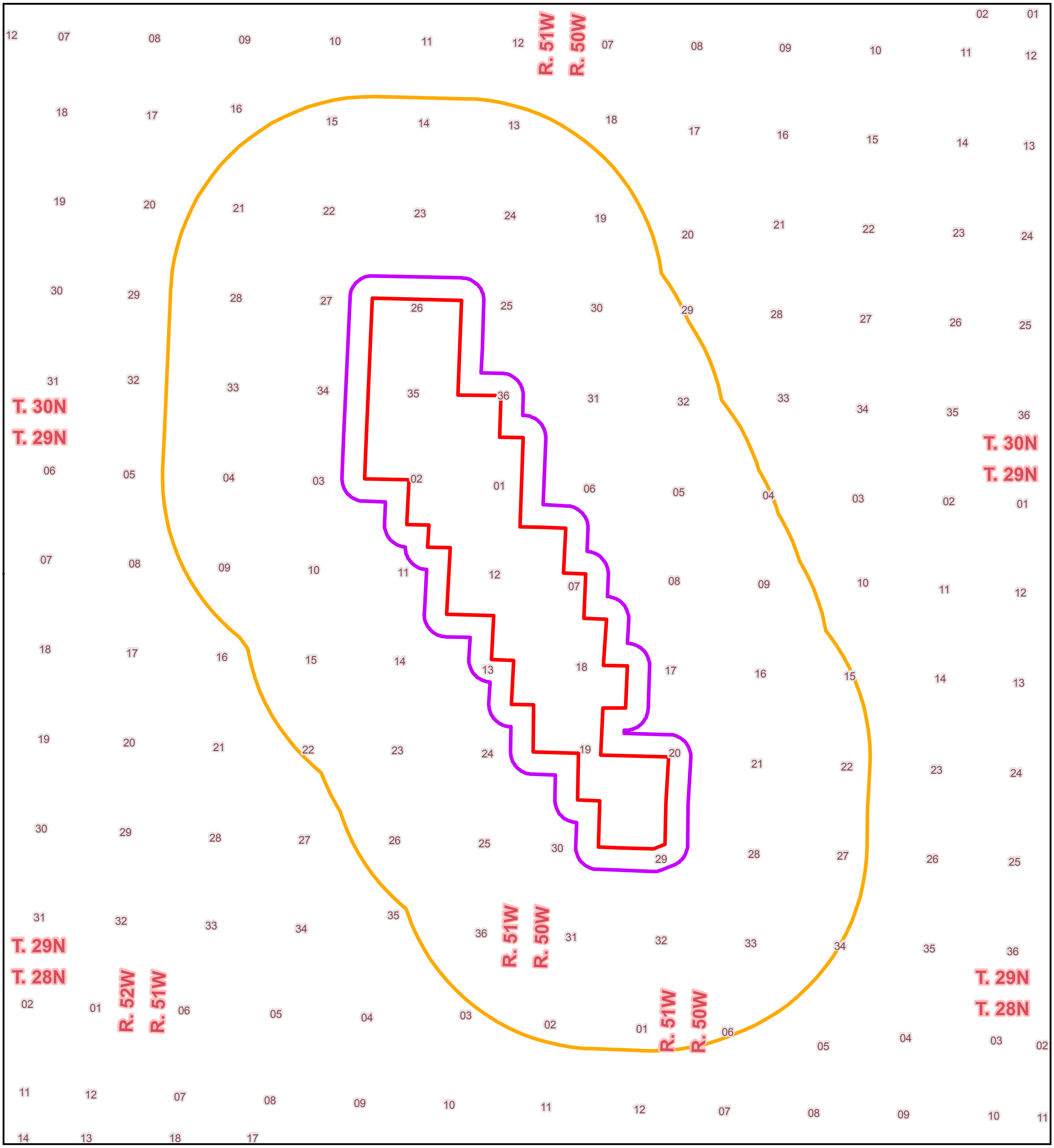


FIGURE 1.1-1
CURRENT LICENSE AREA
PROJECT LAYOUT
(REVISED APRIL 2014)

PROJECT: CO001396.00001 MAPPED BY: JC CHECKED BY: JEC

ARCADIS
630 Plaza Drive, Ste. 100
Highlands Ranch, CO 80129
P: 720-344-3500 F: 720-344-3535
www.arcadis-us.com

Figure 1.1-2 Project Location Map ZOEI and AOR



LEGEND

- Proposed Marsland Expansion Area
- ZOEI Boundary (1/4-mile fixed radius)
- AOR Boundary (2-mile fixed radius)

ZOEI = Zone of Endangering Influence

AOR = Area of Review

N

0 4,000 8,000

Feet

PROJECTION: NAD 1927,
STATE PLANE NEBRASKA NORTH, FIPS 2601
SOURCES: US TOPO MAPS, SERVICED
BY ESRI ARCGIS ONLINE

FIGURE 1.1-2
PROJECT LOCATION MAP
ZOEI AND AOR

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: J. CEARLEY

630 Plaza Drive, Ste. 100
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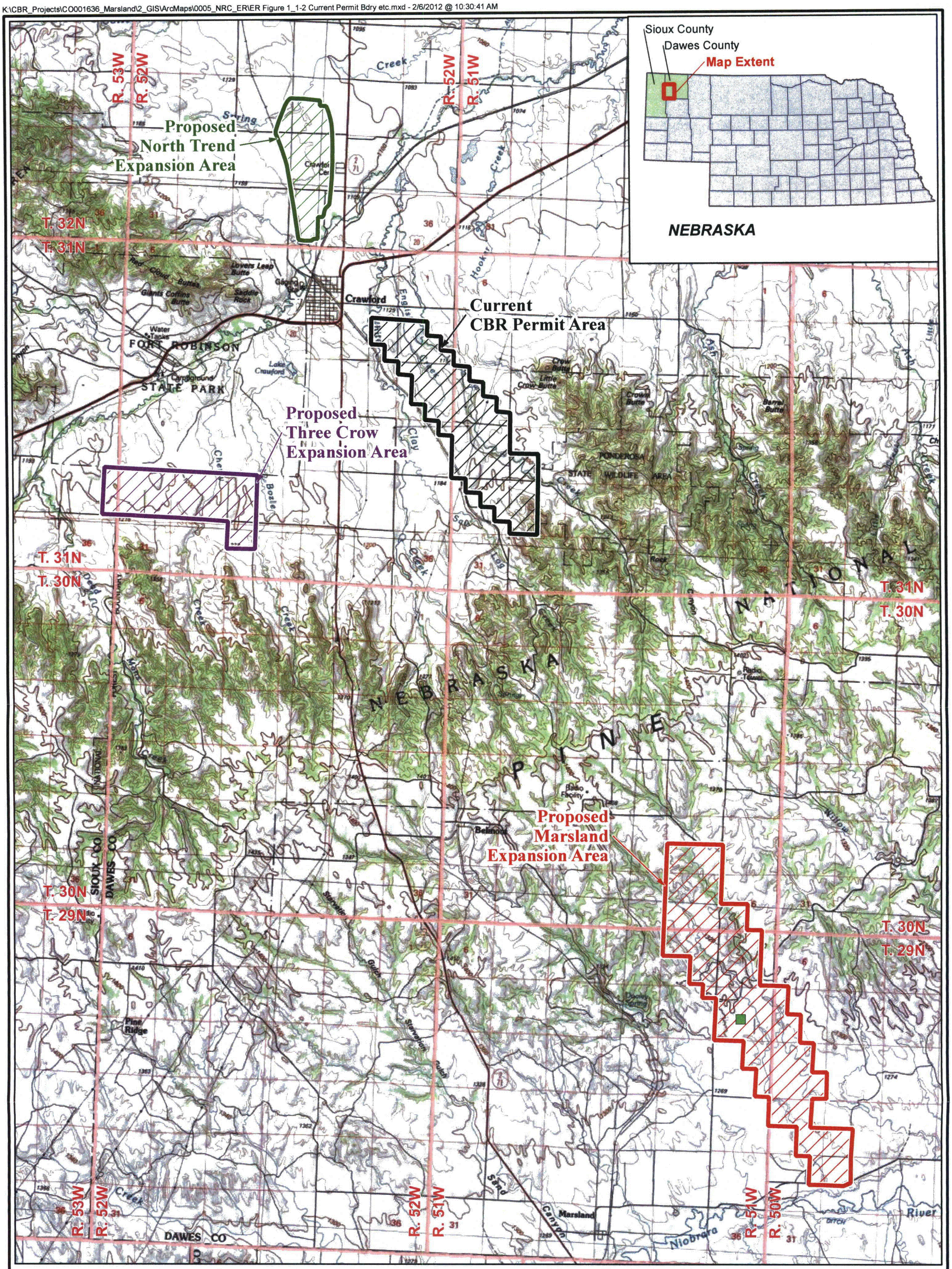
K:\CBR_Projects\CO001636_Marsland\2_GIS\ArcMaps\0005_NRC_ER\ER Figure 1_1-5 Project Loc_ ZOEI and AOR.mxd - 3/21/2012 @ 10:44:50 PM

Figure 1.1-3 Crow Butte Resources Inc. Current Permit Area and Proposed Expansion Areas

K:\CBR_Projects\CO001636_Marsland\2_GIS\ArcMaps\0005_NRC_ER\ER Figure 1_1-2 Current Permit Bdry etc.mxd - 2/6/2012 @ 10:30:41 AM



LEGEND

- Proposed Marsland Satellite Facility Site
- Proposed Marsland Expansion Area
- Proposed Three Crow Expansion Area
- Proposed North Trend Expansion Area
- Current CBR Permit Area

N

0 1 2 Miles

PROJECTION: NAD 1927, STATE PLANE NEBRASKA NORTH, FIPS 2601
SOURCES: US TOPO MAPS, SERVICED BY ESRI ARCGIS ONLINE

CROW BUTTE RESOURCES, INC.

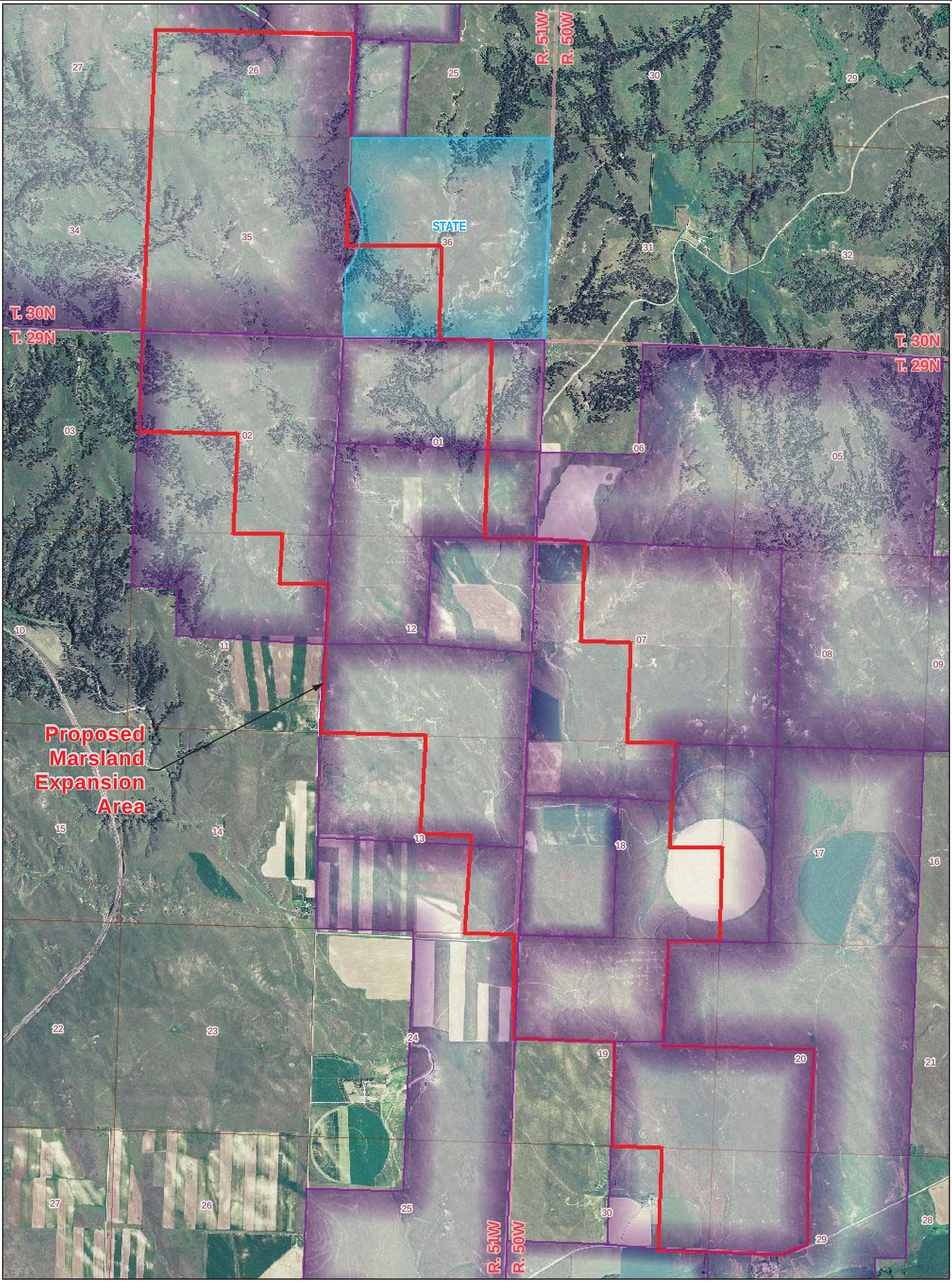
FIGURE 1.1-3
CROW BUTTE RESOURCES INC.
CURRENT PERMIT AREA
AND PROPOSED EXPANSION AREAS

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: J. CEARLEY

ARCADIS 630 Plaza Drive, Ste. 100 Highlands Ranch, CO 80129 P: 720-344-3500 F: 720-344-3535 www.arcadis-us.com

Figure 1.1-4 Marsland Expansion Area Land Ownership

K:\CBR_Projects\CO001636_Marsland\2_GIS\ArcMaps\0005_NRC_ER\ER Figure 1_1-4 MEA Land Ownership Map.mxd - 5/13/2012 @ 2:05:47 AM



LEGEND

- Proposed Marsland Expansion Area
- Private Land
- State Land

N

0 1,250 2,500

Feet

PROJECTION: NAD1927,
STATE PLANE NEBRASKA NORTH, FIPS 2601
SOURCES: USDA NAIP IMAGERY 2010

CROW BUTTE RESOURCES, INC.

FIGURE 1.1-4
MARSLAND EXPANSION AREA
LAND OWNERSHIP

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: MS

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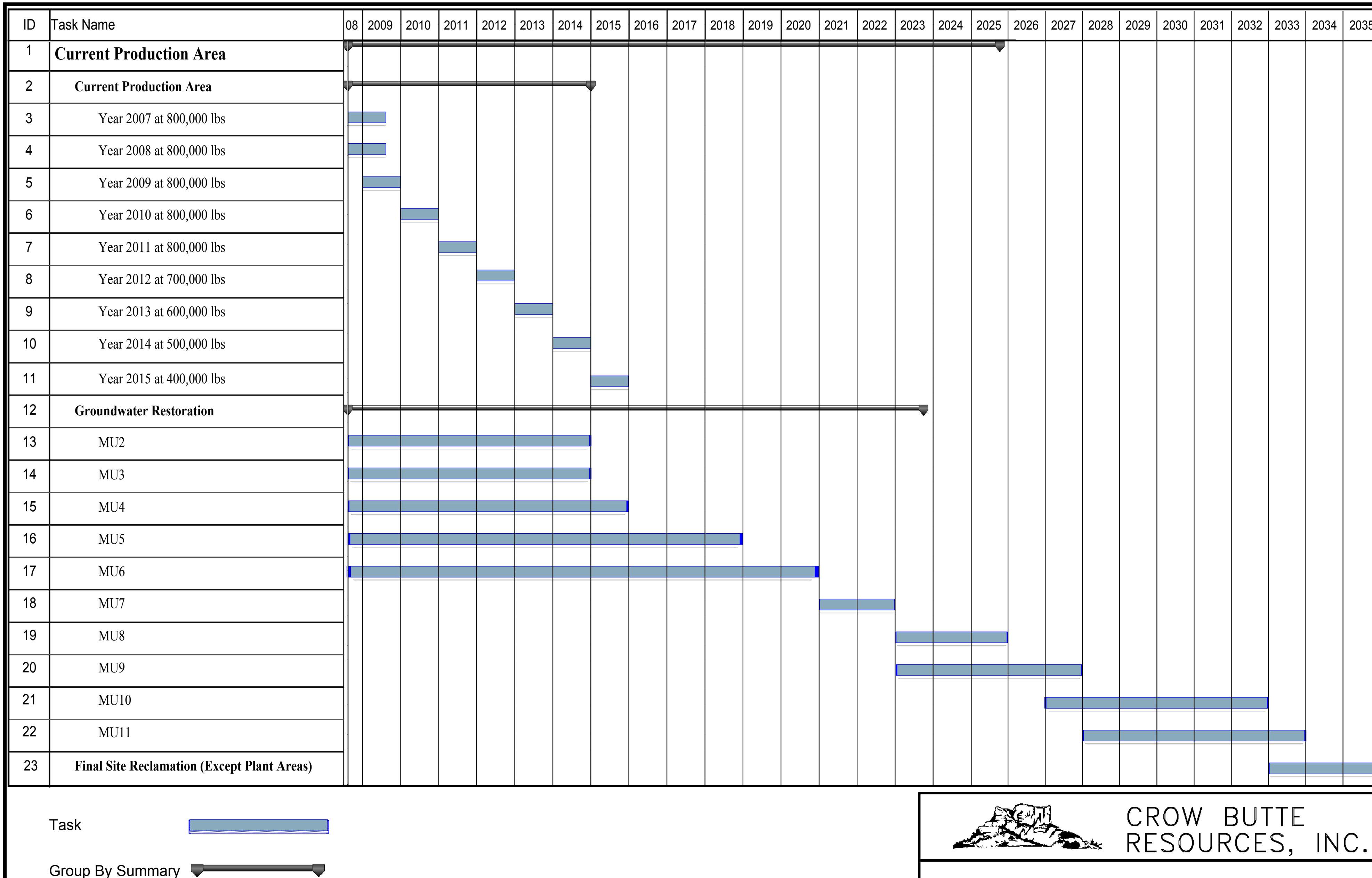
Figure 1.1-5 Current Production Area Mine Unit Timeline



CROW BUTTE RESOURCES, INC.

FIGURE 1.1-5
CURRENT PRODUCTION AREA
MINE UNIT TIMELINE
EFFECTIVE AS OF JULY 1, 2013

PROJECT: CO001636.00001 MAPPED BY: JC CHECKED BY: JEC

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Highlands Ranch, CO 80129
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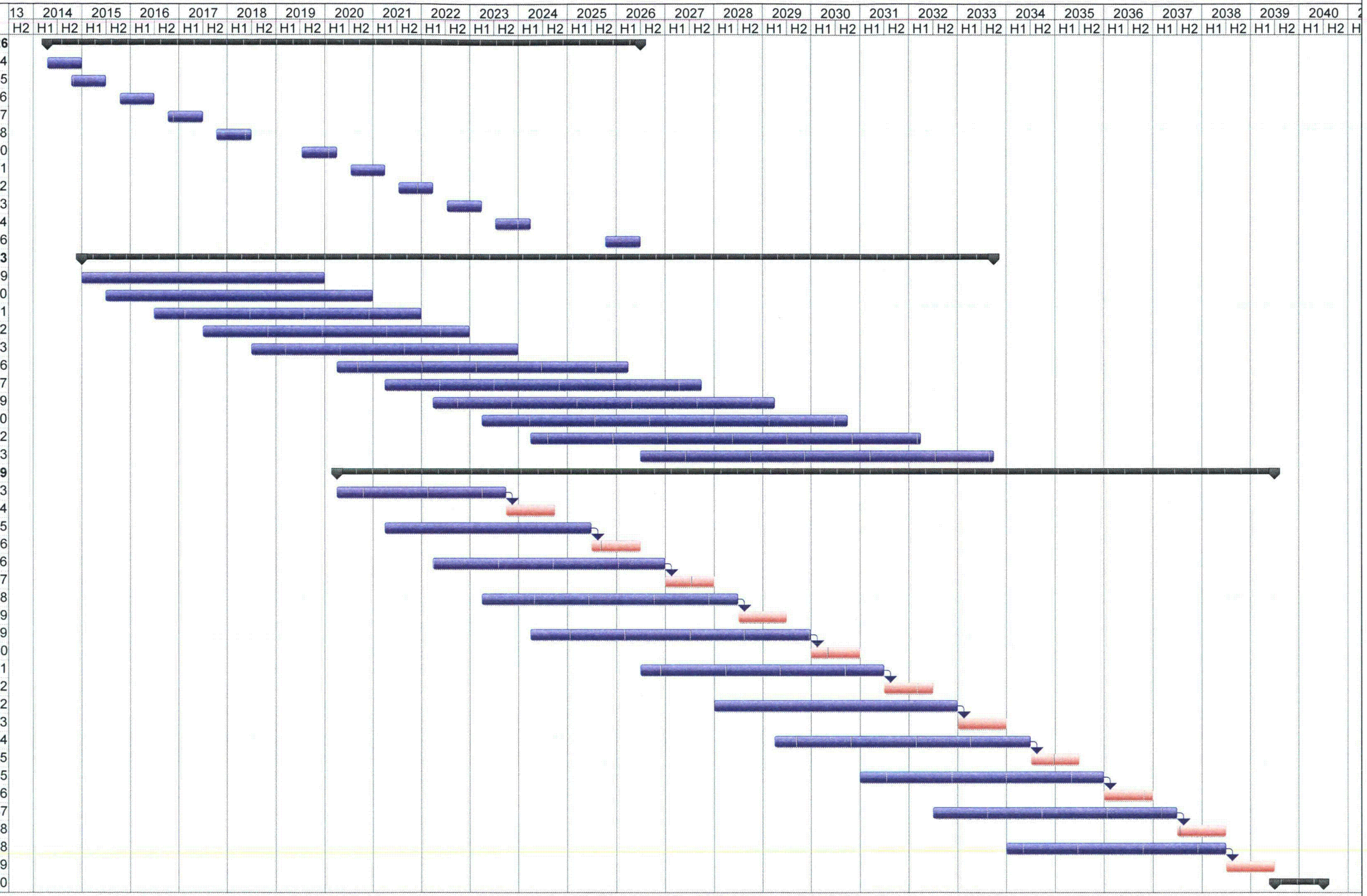
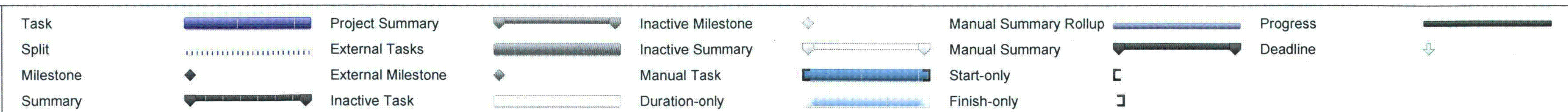
Figure 1.1-6 Marsland Expansion Area Mining and Restoration Timeline

Figure 1.1-6 Marsland Expansion Area Mining and Restoration Timeline

ID	Task Name	Duration	Start	Finish
1	**Facility Construction**	**3184 days**	**Thu 4/17/14**	**Tue 6/30/26**
2	MU-1	185 days	Thu 4/17/14	Wed 12/31/14
3	MU-2	185 days	Wed 10/15/14	Tue 6/30/15
4	MU-3	186 days	Thu 10/15/15	Thu 6/30/16
5	MU-4	186 days	Fri 10/14/16	Fri 6/30/17
6	MU-5	186 days	Fri 10/13/17	Sat 6/30/18
7	MU-A	186 days	Tue 7/16/19	Tue 3/31/20
8	MU-B	185 days	Thu 7/16/20	Wed 3/31/21
9	MU-C	186 days	Thu 7/15/21	Thu 3/31/22
10	MU-D	186 days	Fri 7/15/22	Fri 3/31/23
11	MU-E	186 days	Fri 7/14/23	Sun 3/31/24
12	MU-F	186 days	Tue 10/14/25	Tue 6/30/26
13	**Production**	**4892 days**	**Thu 1/1/15**	**Fri 9/30/33**
14	MU-1	1304 days	Thu 1/1/15	Tue 12/31/19
15	MU-2	1437 days	Wed 7/1/15	Thu 12/31/20
16	MU-3	1436 days	Fri 7/1/16	Fri 12/31/21
17	MU-4	1435 days	Mon 7/3/17	Sat 12/31/22
18	MU-5	1435 days	Mon 7/2/18	Sun 12/31/23
19	MU-A	1565 days	Wed 4/1/20	Tue 3/31/26
20	MU-B	1696 days	Thu 4/1/21	Thu 9/30/27
21	MU-C	1826 days	Fri 4/1/22	Sat 3/31/29
22	MU-D	1956 days	Mon 4/3/23	Mon 9/30/30
23	MU-E	2088 days	Mon 4/1/24	Wed 3/31/32
24	MU-F	1893 days	Wed 7/1/26	Fri 9/30/33
25	**Groundwater Restoration**	**5022 days**	**Wed 4/1/20**	**Thu 6/30/39**
26	MU-1	913 days	Wed 4/1/20	Sat 9/30/23
27	Stabilization Sampling	261 days	Mon 10/2/23	Mon 9/30/24
28	MU-2	1108 days	Thu 4/1/21	Mon 6/30/25
29	Stabilization Sampling	261 days	Tue 7/1/25	Tue 6/30/26
30	MU-3	1240 days	Fri 4/1/22	Thu 12/31/26
31	Stabilization Sampling	261 days	Fri 1/1/27	Fri 12/31/27
32	MU-4	1370 days	Mon 4/3/23	Fri 6/30/28
33	Stabilization Sampling	260 days	Mon 7/3/28	Fri 6/29/29
34	MU-5	1500 days	Mon 4/1/24	Sun 12/30/29
35	Stabilization Sampling	261 days	Tue 1/1/30	Tue 12/31/30
36	MU-A	1304 days	Wed 7/1/26	Mon 6/30/31
37	Stabilization Sampling	262 days	Tue 7/1/31	Wed 6/30/32
38	MU-B	1305 days	Mon 1/3/28	Fri 12/31/32
39	Stabilization Sampling	260 days	Mon 1/3/33	Sat 12/31/33
40	MU-C	1370 days	Mon 4/2/29	Fri 6/30/34
41	Stabilization Sampling	260 days	Mon 7/3/34	Sat 6/30/35
42	MU-D	1304 days	Wed 1/1/31	Mon 12/31/35
43	Stabilization Sampling	262 days	Tue 1/1/36	Wed 12/31/36
44	MU-E	1304 days	Thu 7/1/32	Tue 6/30/37
45	Stabilization Sampling	261 days	Wed 7/1/37	Wed 6/30/38
46	MU-F	1173 days	Mon 1/2/34	Wed 6/30/38
47	Stabilization Sampling	261 days	Thu 7/1/38	Thu 6/30/39
48	**Site Reclamation**	261 days	Fri 7/1/39	Sat 6/30/40



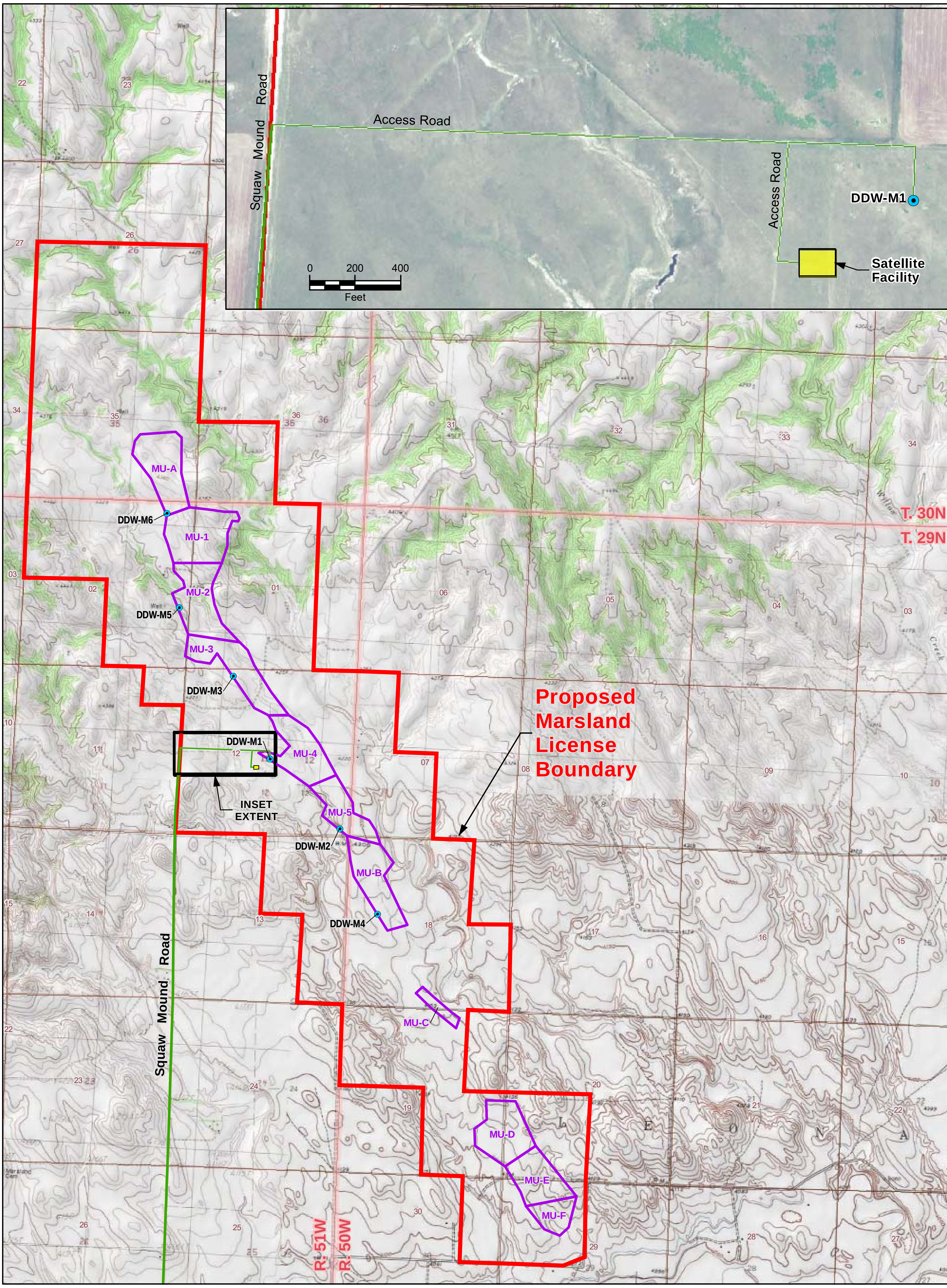
Project: Marsland Expansion Area
Date: Wed 5/22/13



Revised July 2013

Figure 1.1-7 General Arrangement Satellite Facility View

Path: C:\Users\jchen\Documents_PROJECTS\K_CBR_Projects\CO001636_Marsland\2_GIS\ArcMaps\005_NRC_ER\ER Figure 1_1-7 General Arrangement - Satellite Facility View.mxd | Last Saved By: jchen | Last Saved On: 4/24/2014



LEGEND

- Proposed Deep Disposal Well
- Squaw Mound Road
- Access Road
- Satellite Facility (Restricted Area)
- Mine Unit
- Proposed Marsland License Boundary

N

0 1,500 3,000
Feet

PROJECTION: NAD 1983, STATE PLANE NEBRASKA NORTH, FIPS 2600
SOURCES: US TOPO MAPS, SERVICED BY ESRI ARCGIS ONLINE

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FIGURE 1.1-7
GENERAL ARRANGEMENT
SATELLITE FACILITY VIEW
(REVISED APRIL 2014)

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: JEC

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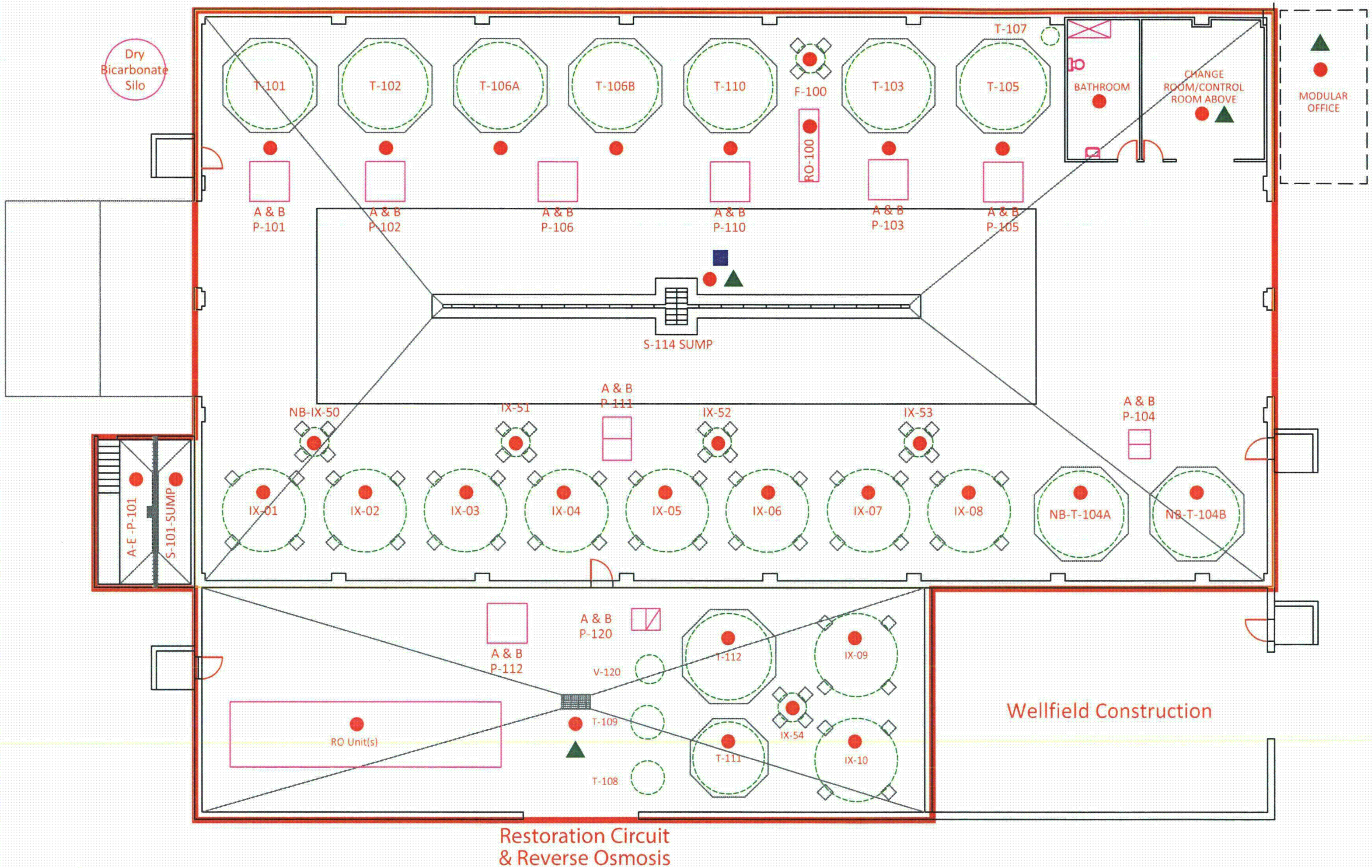
Figure 1.1-8 Marsland Expansion Area Satellite Building Layout



Tank (# Each)	Description
IX-01 through 08	Ion Exchange
IX-50 through 54	Ion Exchange Resin Trap
IX-09 through 10	Restoration IX Column
T-101	Bicarbonate Mix
T-102	Bicarbonate Storage
T-103	Reverse Osmosis Feed
T-104A	Resin Transfer
T-104B	Resin Transfer
T-105	Water supply/Make-up Water
T-106A	Wastewater
T-106B	Wastewater
T-107	Water Pressure Tank
T-108	Sodium Sulfide Day
T-109	Sodium Sulfide Mix
T-110	Well Work Over Fluid
T-111	RO Cleaning Tank
T-112	Permeate Tank
PV-119 through 122	RO Filter
V-120	Degaser
F-100	Sock filters
A-E-P-101	Injection pumps on trunk lines to wellfield

Legend:

- Gamma Survey Location
- Radon Testing Location
- Airborne Particulate Survey Location
- Restricted Area

Notes:

1. Illustration only, not to scale.
2. Adapted from Cameco Resources, 2011.

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FIGURE 1.1-8
MARSLAND EXPANSION AREA
SATELLITE BUILDING LAYOUT

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: JEC

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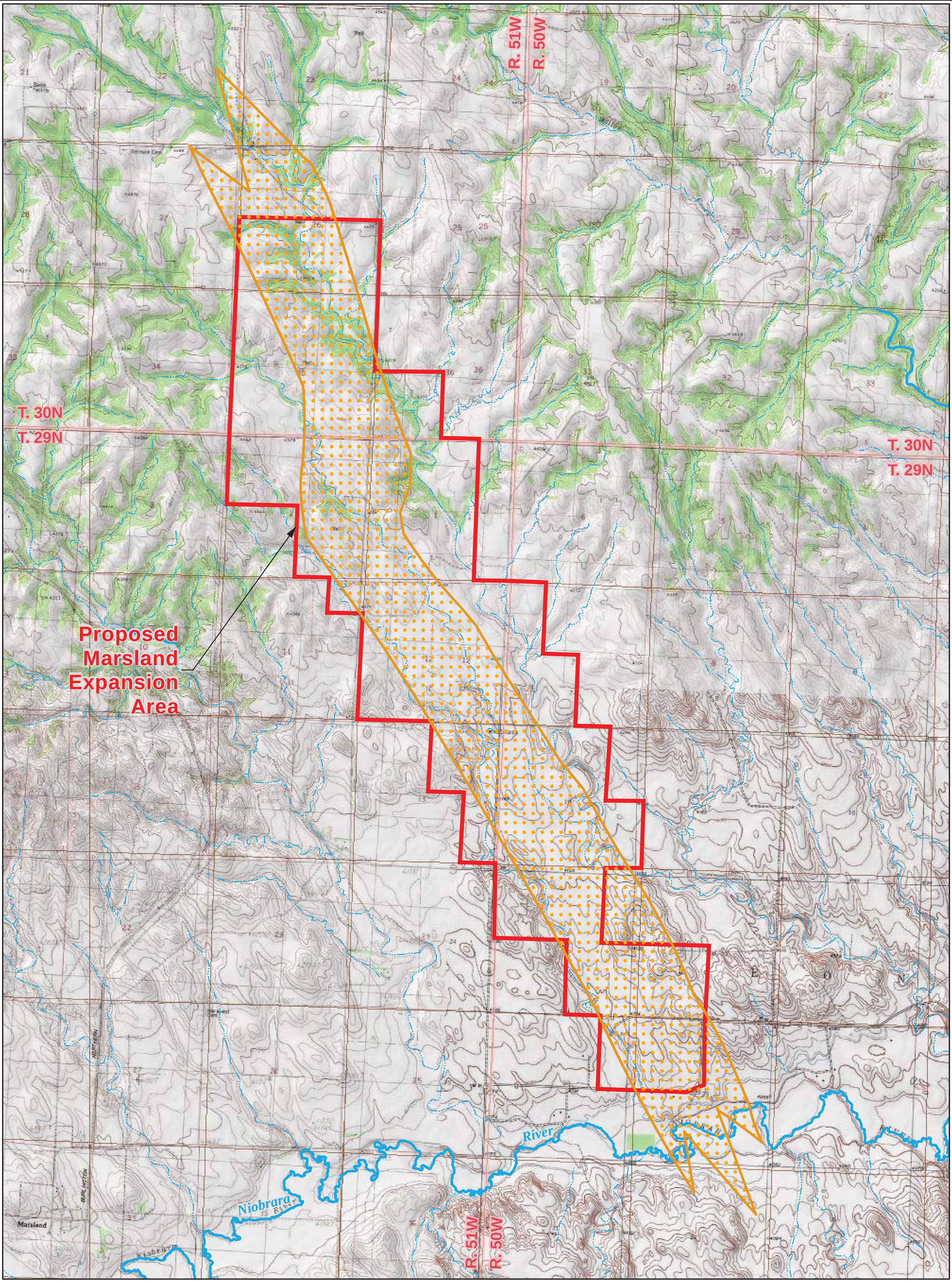
K:\CBR_Projects\CO001636_Marsland\3_IMAGES\Illustrator\ER Figure 1_1-8 MEA SAT Building Layout_Revised.ai @ 08/08/2013 By: J.Chen

Figure 1.3-1 Marsland Expansion Area Estimated Ore Body

K:\CBR_Projects\CO001636_Marsland\2_GIS\ArcMaps\0005_NRC_ER\ER Figure 1_3-1 Marsland Expansion Area Ore Body.mxd - 5/13/2012 @ 2:00:48 AM



LEGEND

- Estimated Ore Body
- Proposed Marsland Expansion Area
- Perennial Stream/River
- Intermittent Stream/River

N

0 1,750 3,500

Feet

PROJECTION: NAD1927,
STATE PLANE NEBRASKA NORTH, FIPS 2601
SOURCES: USA TOPO MAPS, SERVICED
BY ESRI ARCGIS ONLINE

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FIGURE 1.3-1
MARSLAND EXPANSION AREA
ESTIMATED ORE BODY

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: MS

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Figure 1.3-2 Typical Mineralized Zone Completion for Injection/Production Wells – Method No. 1

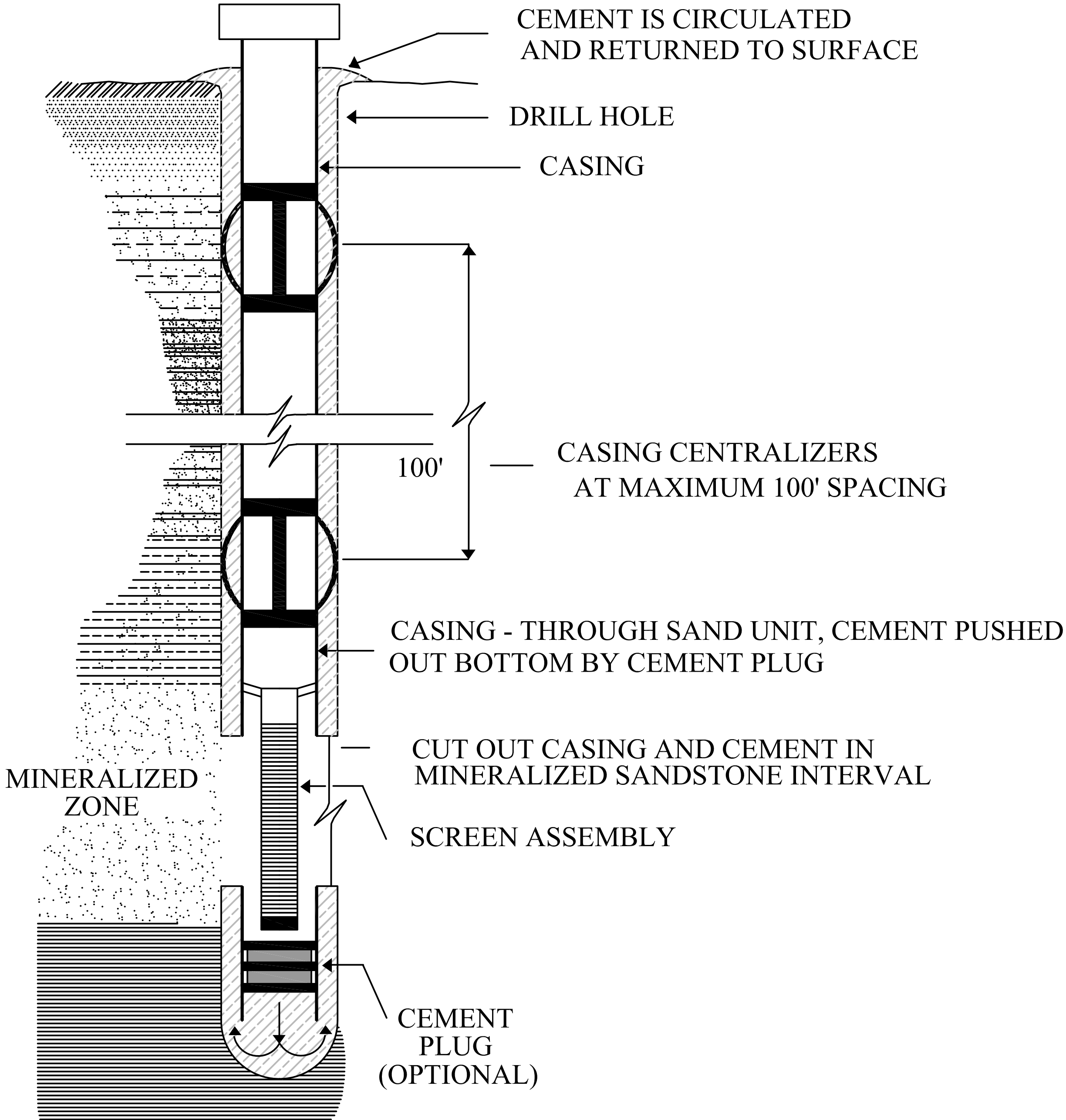

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FIGURE 1.3-2

TYPICAL MINERALIZED ZONE COMPLETION FOR INJECTION/PRODUCTION WELLS

METHOD NO.1

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PATH: K:\CBR_Projects\CO001396_ThreeCrow\1_ACAD\ARCADIS_NewDrawings\WellCompletionMethods.dwg LAYOUT: ER_1 DATE/TIME: 7/9/2010 11:43 AM

Figure 1.3-3 Typical Mineralized Zone Completion for Injection/Production Wells – Method No. 2

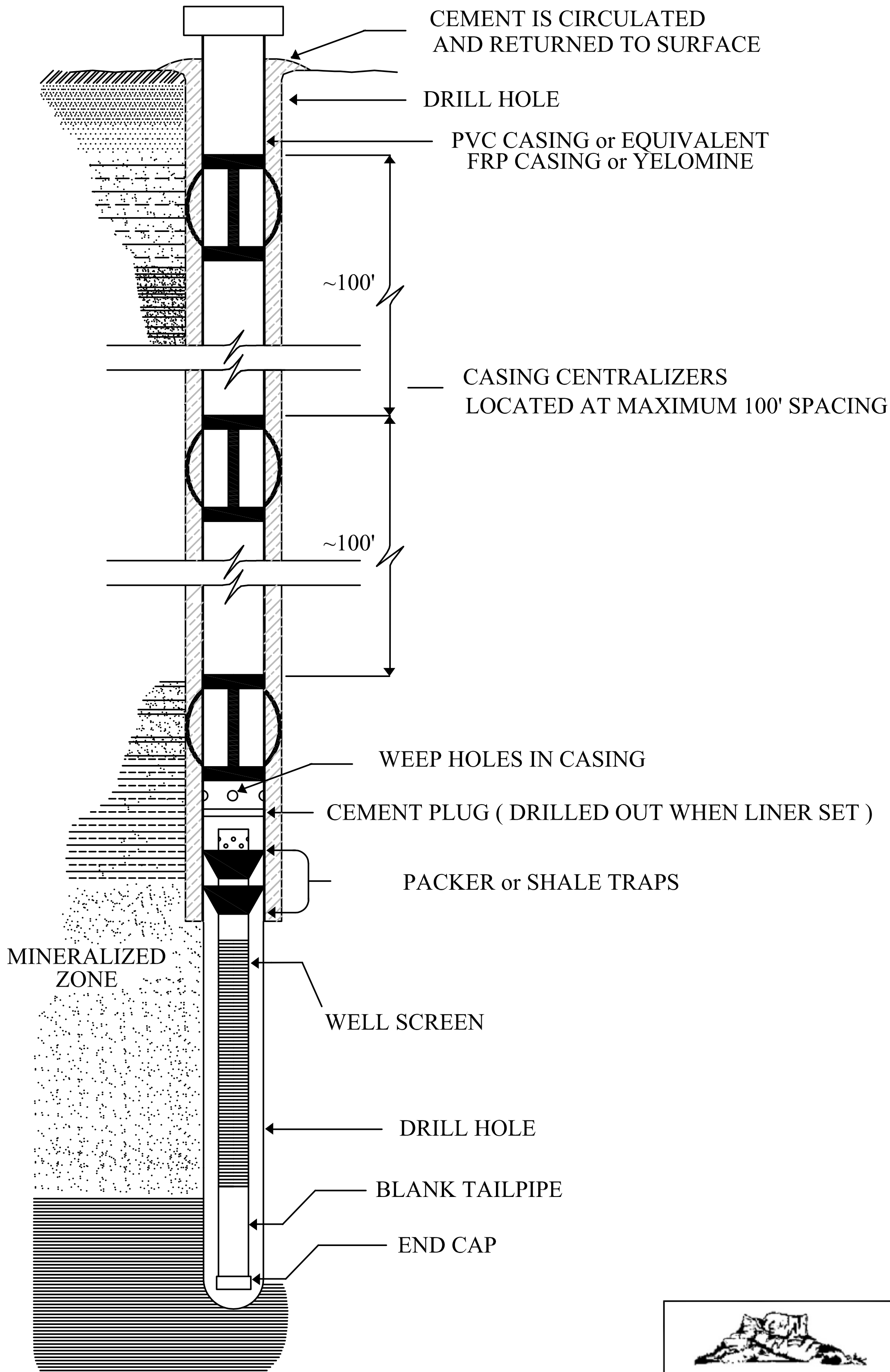

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FIGURE 1.3-3

TYPICAL LINER COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS

METHOD NO.2

PROJECT: CO001396.02 MAPPED BY: JC CHECKED BY: JEC

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PATH: K:\CBR_Projects\CO001396_ThreeCrow\1_ACAD\ARCADIS_NewDrawings\WellCompletionMethods.dwg LAYOUT: ER_2 DATE/TIME: 7/9/2010 11:43 AM

Figure 1.3-4 Typical Mineralized Zone Completion for Injection/Production Wells – Method No. 3

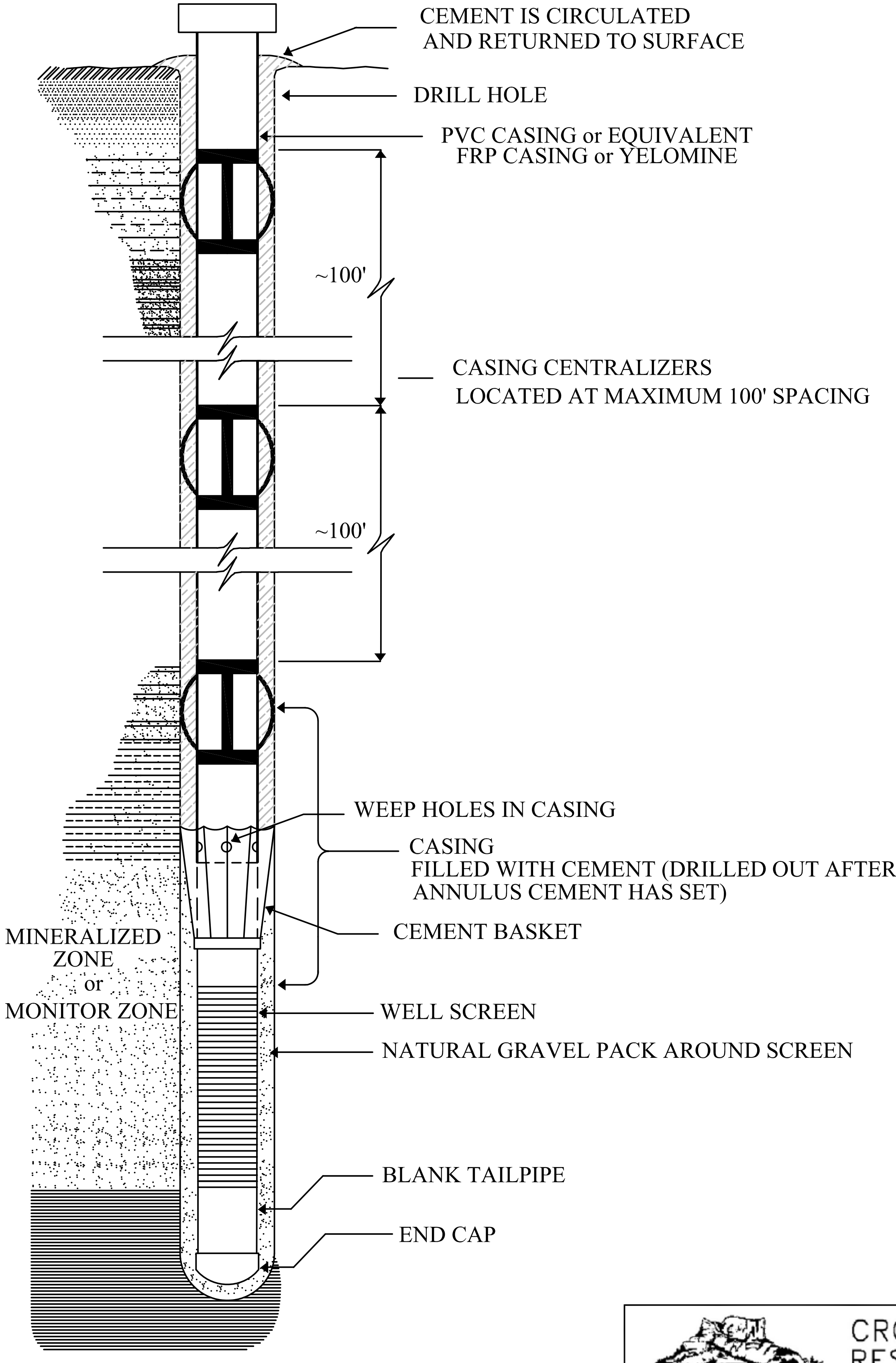

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FIGURE 1.3-4

TYPICAL CEMENT BASKET COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS

METHOD NO.3

PROJECT: CO001396.02 MAPPED BY: JC CHECKED BY: JEC

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PATH: C:\Users\jchen\Documents_PROJECTS\KCBR_Projects\CO001636_Marsland\1_ACAD\WellCompletionMethods.dwg LAYOUT: UIC_3 DATE/TIME: 10/21/2011 11:46 AM

Figure 1.3-5 Marsland Expansion Area Satellite Facility and Current CBR Production Facility Process Flow Diagram

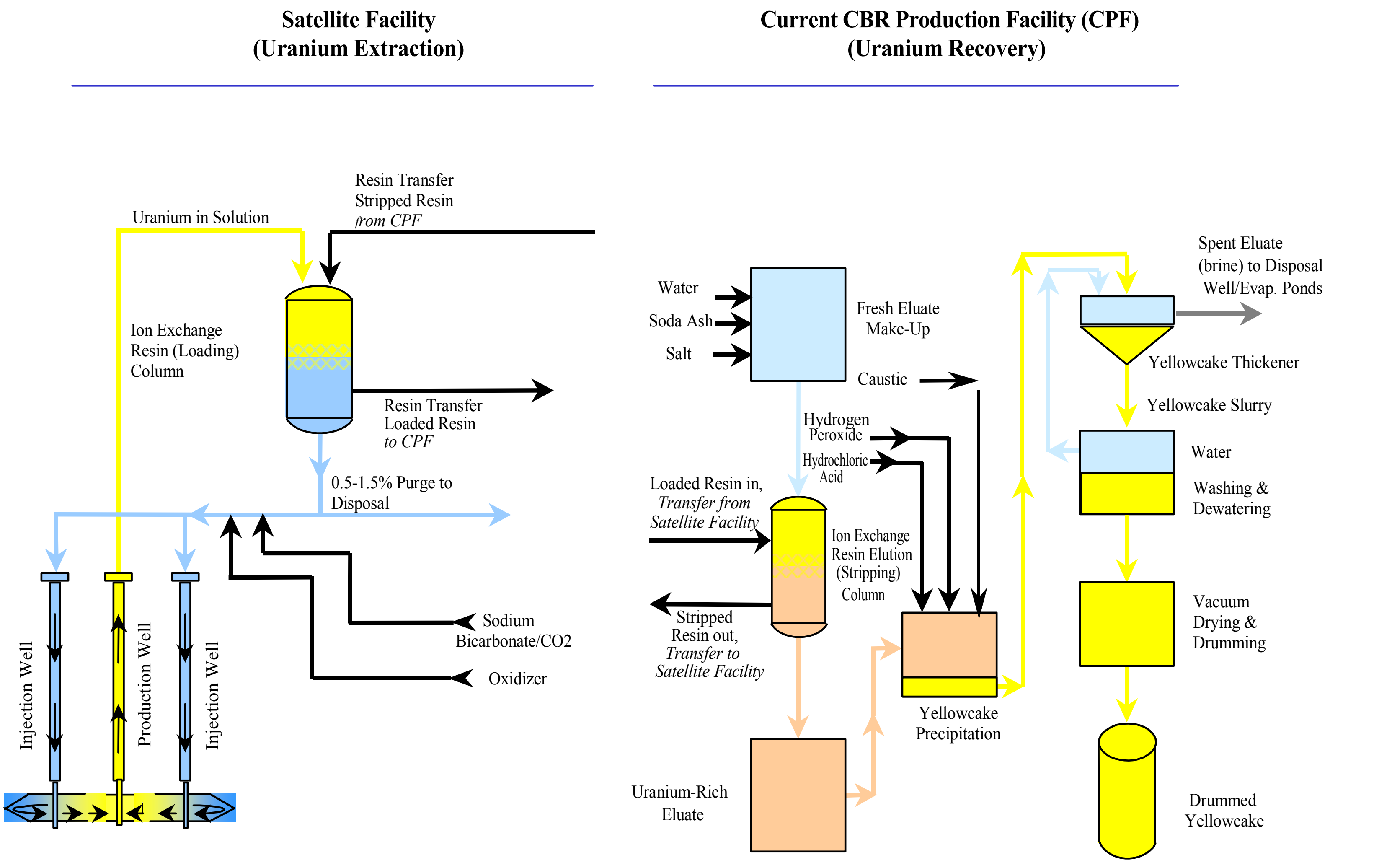

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FIGURE 1.3-5
MARSLAND EXPANSION AREA
SATELLITE FACILITY AND
CURRENT CBR PRODUCTION FACILITY
PROCESS FLOW DIAGRAM

PROJECT: CO001636.00001 MAPPED BY: JC CHECKED BY: JEC

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K:\CBR_Projects\CO001636_Marsland\3_IMAGES\Illustrator\TR Figure 3_6-1 Process Flow Diagram.ai @ 10/21/2011 BY: J.CHEN @ Boulder, CO

Figure 1.3-6 Typical Wellfield Layout

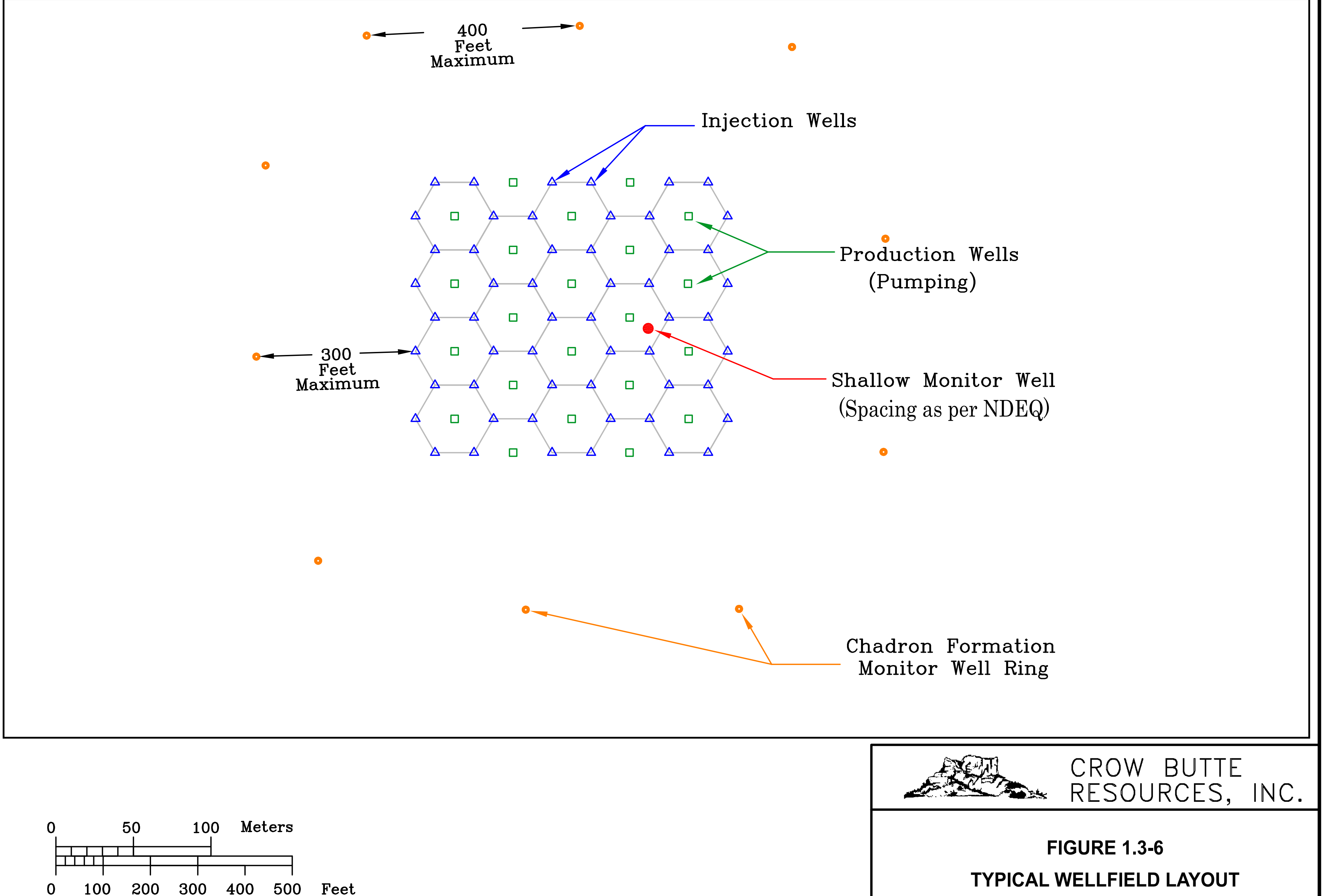

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FIGURE 1.3-6

TYPICAL WELLFIELD LAYOUT

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: JEC

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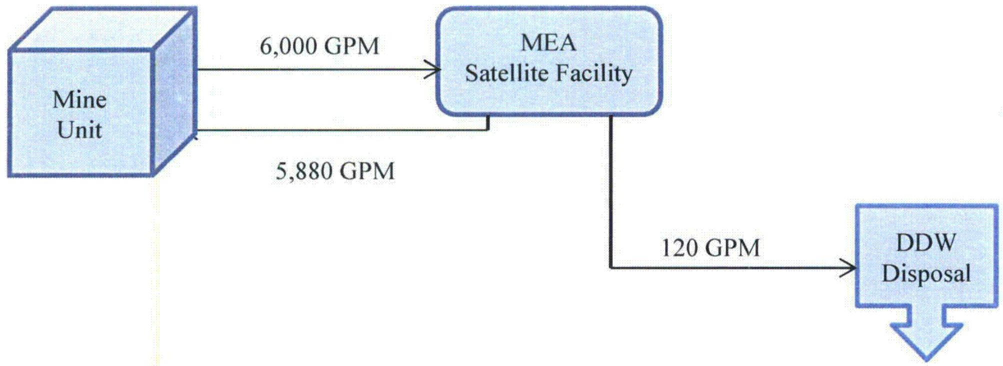
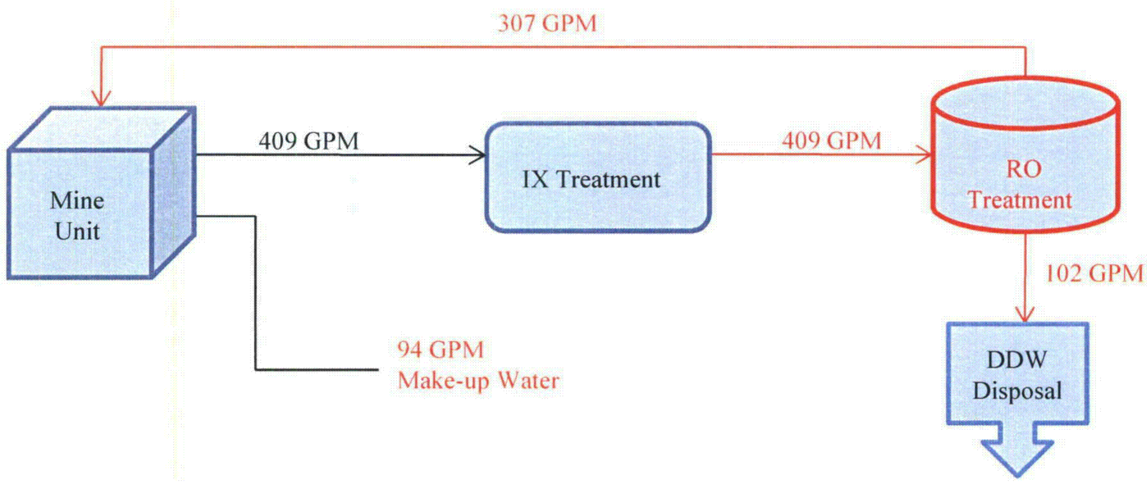
Figure 1.3-7 Water Balance for Marsland Satellite Facility



Water Balance Flow Example for Production



Water Balance Flow Example: Restoration – IX Treatment & RO Treatment Phase

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FIGURE 1.3-7
WATER BALANCE FOR MARSLAND FACILITY

PROJECT: CO001636.00001 MAPPED BY: JC CHECKED BY: JEC

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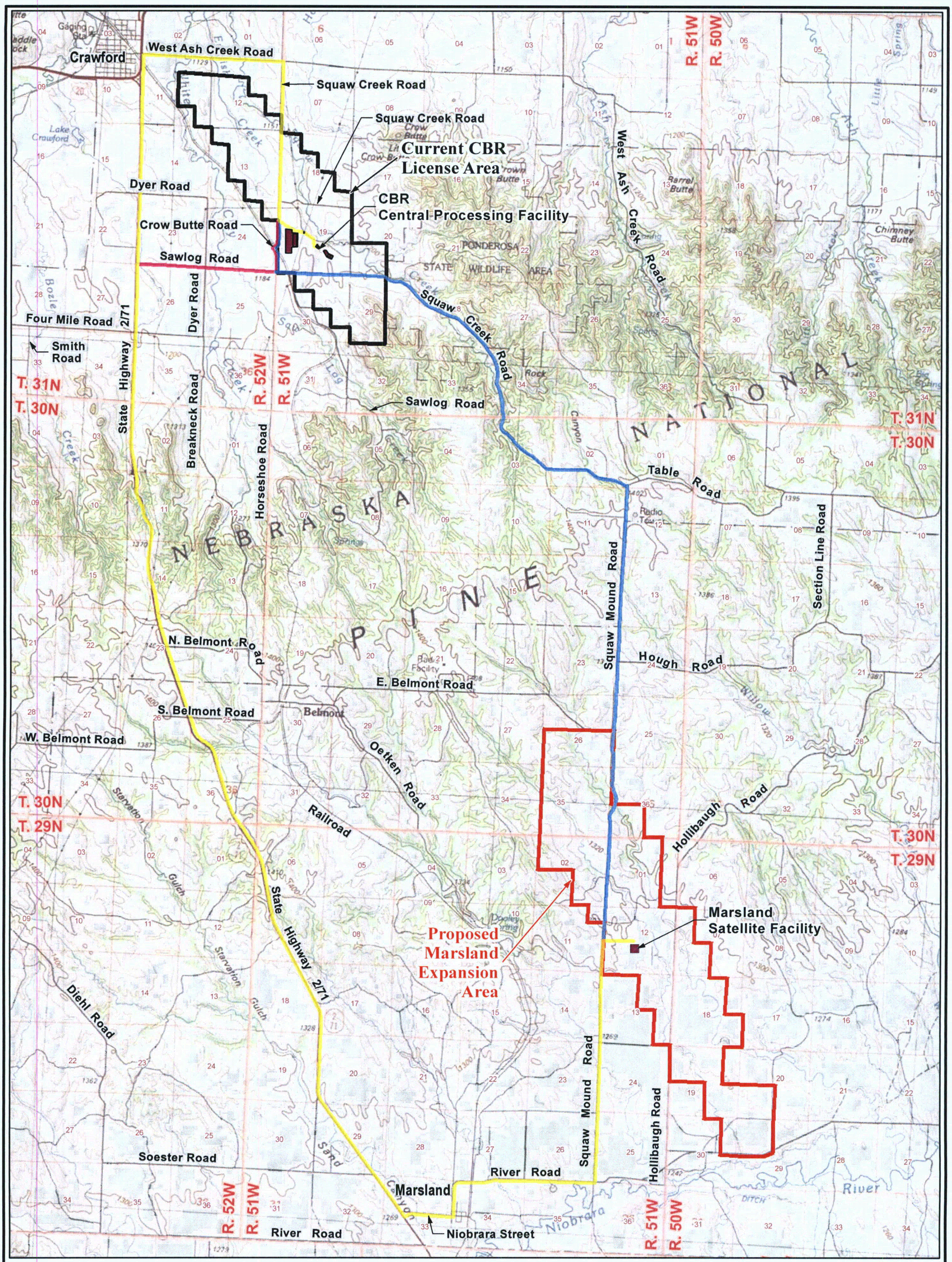
Figure 1.4-1 Proposed Access Route Between Marsland Expansion Area Satellite Facility and Crow Butte Central Processing Facility



LEGEND

- Primary Access Route
- Alternative Route A
- Alternative Route B

N

0 3,500 7,000 Feet

PROJECTION: NAD1927,
STATE PLANE NEBRASKA NORTH, FIPS 2601
SOURCES: USA TOPO MAPS, SERVICED
BY ESRI ARCGIS ONLINE

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FIGURE 1.4-1
PROPOSED ACCESS ROUTE BETWEEN MARSLAND EXPANSION AREA SATELLITE FACILITY AND CROW BUTTE CENTRAL PROCESSING FACILITY

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: JEC

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2 ALTERNATIVES TO PROPOSED ACTION

2.1 No-Action Alternative

2.1.1 Summary of Current Activity

CBR currently operates the CPF, a commercial ISR uranium mining operation located approximately 4 miles (6.4 km) southeast of the City of Crawford in Dawes County, Nebraska. Operation is allowed under NRC Source Materials License SUA-1534. The CPF is located approximately 11.1 miles (17.9 km) to the north-northwest of the proposed MEA (centerpoint of CPF processing building to centerpoint of MEA satellite building).

An R&D facility was operated in 1986 and 1987. Construction of the commercial process facility began in 1988, with production beginning in April of 1991. The total license area is 2,861 acres, and the surface area affected by the current commercial project is approximately 2,000 acres. Facilities include the R&D facility (which now houses the Restoration Circuit), the CPF and office building, solar evaporation ponds, parking, access roads, and wellfields.

In the CPF license area, uranium is recovered by in-situ leaching from the basal sandstone of the Chadron Formation at depths that vary from 400 to 900 feet. The overall width of the mineralized area varies from 1,000 to 5,000 feet. The ore body ranges in grade from less than 0.05 percent to more than 0.5 percent U_3O_8, with an average grade estimated at 0.27 percent U_3O_8. Production is currently in progress in MUs 6 through 11. Groundwater restoration has been completed and regulatory approval has been received in MU 1. Groundwater restoration is currently underway in MUs 2 through 6.

The CPF is operating with a licensed flowrate of 9,000 gpm. Maximum allowable throughput from the facility under SUA-1534 is currently 2,000,000 pounds of U_3O_8 per year.

2.1.2 Impacts of the No-Action Alternative

The no-action alternative would allow CBR to continue mining operations in the CPF license area, with mining limited to remaining reserves at the CPF site. Based on current plans and mining timelines discussed in Section 1 (**Table 1.1-1** and **Figure 1.1-5**), CBR could continue production at the CPF license area until 2014, when reserves are expected to be depleted to the point where commercial production would no longer be economical and would be discontinued shortly thereafter. Groundwater restoration and reclamation would become the primary activities, with final groundwater restoration in 2023 and reclamation completed in 2025.

Assuming favorable regulatory action by the NRC and State of Nebraska and, that the MEA is licensed, and commercial production remains economical, mining operations are estimated to begin at the proposed NTEA satellite facilities in 2024 and last for approximately 8 years (until 2032). As discussed in the NTEA Technical Report (Application for Amendment of NRC Source Materials License SUA-1534; CBR 2007), NTEA reserves would be depleted in 2032.

When commercially recoverable resources are depleted in the CPF license area, all activities at the site not associated with groundwater restoration and decommissioning will be completed, resulting in the loss of a significant portion of the total employment at the site. In actuality, some of these jobs would be lost before 2014. For example, the well drilling, installation, and wellfield

construction activities would be completed several years before the completion of mining activities, and these positions would no longer be necessary. At the completion of decommissioning, all employment opportunities at the mine would be terminated. If approved, mining operations at the MEA would extend current employment levels through 2023, at which time the NTEA would be ready to start producing. The impacts to the local economy from the approval of mining operations at MEA, including employment opportunities, are evaluated in the MEA Technical Report (CBR 2007).

In addition to the loss of significant employment opportunities in the City of Crawford and Dawes County, the premature closing of the CPF before commercially viable resources are recovered would adversely affect the economic base of Dawes County. As discussed in further detail in Sections 4.10.3 and 7, the CPF currently provides a significant economic impact to the local Dawes County economy as shown in **Table 4.10-2**.

If this amendment request is denied, the negative impact on the Dawes County economy would be felt as early as 2013, when employment levels for drilling and construction activities would be cut, and purchases of services and materials would diminish. In the event that NTEA, TCEA, and MEA are approved, employment would continue at current levels. The potential positive economic impact to the local economy from construction and operation of the MEA is demonstrated in **Table 4.10-2**.

A decision to not amend SUA-1534 to allow mining in the MEA would leave a large resource unavailable for energy production supplies. Although CBR is continuing to develop estimates of the reserves at MEA, the current indicated ore reserves as U_3O_8 for the MEA are 6,161,679 lbs, with an additional inferred estimate of 3,389,518 lbs. Total reserves for the MEA are currently estimated at 9,551,197 lbs. The MEA will operate with an expected annual production rate of approximately 600,000 lbs U_3O_8.

In 2012, total domestic U.S. uranium concentrate production was approximately 4,100,000 pounds U_3O_8, of which approximately 800,000 pounds (or approximately 20 percent) was produced at the CPF (EIA 2013a). During the same year, purchases of domestic U.S. uranium by U.S. civilian nuclear power reactors from U.S. and foreign suppliers were approximately 58,000,000 pounds U_3O_8e (equivalent) with approximately 17 percent supplied by domestic producers (EIA 2013b). Foreign-origin uranium accounted for the remaining 83 percent of deliveries. The CPF (including the MEA, TCEA, and NTEA) represents an important source of new domestic uranium supplies essential to providing a continuing source of fuel to power generation facilities.

In addition to leaving a large deposit of valuable mineral resources untapped, a denial of this amendment request would result in the loss of a large investment in time and money made by CBR for the rights to and development of these valuable deposits.

Denial of the amendment request would have an adverse economic effect on the individuals that have surface leases with CBR and own the mineral rights in the MEA.

2.2 Proposed Action

The proposed MEA timeline and MU map are shown on **Figures 1.1-6** and **1.1-7,** respectively. There will be a total of 11 MUs, with construction for MU 1 to commence in 2014. Production for the project will start in 2015 and terminate in the year 2039. Restoration in designated MUs will commence in the year 2020 and will be completed in 2044. Site reclamation will be completed in 2046. The ore grade as U_3O_8 ranges from 0.11 to 0.33 percent with an average ore grade of 0.22 percent.

The proposed MEA contains a licensed area of approximately 4,622.3 acres. Of this potential licensed area, the total surface area to be affected by mining operations will be approximately ~~591~~592 acres for the proposed MUs, processing facility, disposal well, well sites, and access roads. Currently, these areas are cropland (~~71.7~~71.9 acres) and livestock range (~~491.2~~491 acres).

The proposed satellite facility will be located within a 1.8-acre area in sections 26, 35 of T30N; R51W; sections 1, 2, 12, 13 of T29N R51W; and sections 7, 18, 19, 20 29, 30 of T29N, R50W. This area will also contain the chemical storage area. There could be as many as six onsite DDWs, with the nearest DDW (DDW-M1) being ~~will be~~ located approximately 0.3 mile (0.48 km) north-northwest of the satellite facilities (**Figure 1.1-7**). **Figure 1.1-8** shows the plan view of the satellite building.

Figure 1.1-3 shows the locations of the current license area and the proposed MEA.

The MEA will be developed and operated by CBR. All land within the proposed license boundary of the MEA is privately owned. CBR has obtained surface and mineral leases from the appropriate landowners necessary to construct and operate the required ISR facilities.

Commercial production at the CPF is expected to extend for the next several years, with the uranium reserves largely depleted by 2014. Commercial production at the proposed MEA would occur over 24 years between 2015 and 2039. The aquifer will be restored and reclaimed concurrent with operations, plus an additional period at the end of the project for final decommissioning and surface reclamation. The combined CPF and MEA projects would be completely restored and reclaimed by 2046. More detailed timelines are provided in Section 1.

The CPF recovers uranium from the basal sandstone of the Chadron Formation. In the MEA, uranium will also be recovered from the basal sandstone of the Chadron Formation. The depth in the MEA ranges from 800 to 1,250 feet. The width varies from 1,000 to 4,000 feet.

The satellite facility process structure will be a building approximately 130 feet long by 100 feet wide. The proposed satellite facility equipment will include the following systems:

- IX
- Filtration
- Resin transfer
- Chemical addition

The in-situ process consists of an oxidation step and a dissolution step. The oxidants used in the facility are H_2O_2 and/or O_2. A $NaHCO_3$ lixiviant is used for the dissolution step.

The uranium-bearing solution resulting from the leaching of uranium underground is recovered from the wellfield and piped to the satellite facility for extraction. The satellite facility process employs the following steps:

- Loading of uranium complexes onto an IX resin
- Reconstitution of the solution by the addition of $NaHCO_3$ and O_2
- Shipment of loaded IX resin to the CPF
- Restoration of groundwater following mining activities

The satellite facility will be designed for a maximum flowrate, excluding restoration flow, of 6,000 gpm (restoration would account for another 1,500 gpm). Uranium-bearing resin will be transported to the CPF for elution and packaging of yellowcake.

The operation of the satellite facility results in a number of effluent streams. Airborne effluents are limited to the release of radon-222 gas during the uranium recovery process. Liquid wastes are handled through evaporation and/or deep well injection.

Groundwater restoration activities consist of four steps:

- Groundwater transfer
- Groundwater sweep
- Groundwater treatment
- Aquifer recirculation

Groundwater restoration will take place concurrently with development and production. The primary goal of the groundwater restoration is to return the water quality of the affected zone to a chemical quality consistent with baseline conditions required by 10 CFR 40, Appendix A, Criterion 5(B)(5) (or an approved alternate concentration limit [ACL] under 5[B][5][c]); or, as a secondary goal, to the quality level specified by the NDEQ.

Following groundwater restoration, all injection and recovery wells will be reclaimed using appropriate plugging and abandonment procedures. In addition, a sequential land reclamation and revegetation program will be implemented on the site. This reclamation will be performed on all disturbed areas, including the satellite facility, wellfields, and roads. The current estimate of the total acreage that may be affected over the life of the project is ~~1,760~~1,754 acres.

CBR will maintain financial responsibility for groundwater restoration, facility decommissioning, and surface reclamation. Currently, an irrevocable letter of credit is maintained based on the estimated costs of the aforementioned activities.

The environmental impacts of the requested action will be minimal as discussed in Section 4. The primary radiological air impacts will be from the release of radon gas during production and will be minimized by the use of pressurized downflow IX columns. In addition, radon gas quickly dissipates in the atmosphere and results in a minimal additional exposure to the public as discussed in Section 4.12. All drying and packaging will be performed at the CPF using a vacuum drying system, thereby minimizing the potential for radioactive air particulate releases at MEA.

ISR alters the geochemistry and the water quality in the mining zone. CBR has proven in the current licensed area that impacts to groundwater can be controlled through stringent well construction techniques, wellfield operating methodologies that minimize excursions, and the use of best practicable technologies (BPTs) to restore the groundwater to premining baseline or class of use after mining activities are complete.

The impacts discussed in Section 4 include short-term and long-term impacts. However, it should be noted that the uranium ISR mining technique allows the entire mine site to be decommissioned and returned to unrestricted use within a relatively short time.

Commercial production at the CPF including the proposed MEA and NTEA is expected to extend over the next 27 years with the uranium reserves at both areas depleted by 2039. The MEA site alone will produce U_3O_8 from 2014 through 2039. Commercial production at the proposed MEA would occur over 24 years from late 2015 through 2039. Aquifer restoration and reclamation will be done concurrent with operations, plus an additional period at the end of the project for final decommissioning activities and surface reclamation. All three projects would be completely restored and reclaimed by 2046. More detailed timelines are provided in Section 1.

2.3 Reasonable Alternatives

2.3.1 Process Alternatives

2.3.1.1 Lixiviant Chemistry

CBR is employing a $NaHCO_3$ lixiviant that is an alkaline solution. Where the groundwater contains carbonate, as it does at CBR, an alkaline lixiviant will mobilize fewer hazardous elements from the ore body and will require less chemical addition than an acidic lixiviant. Also, test results at other projects indicate only limited success with acidic lixiviants, while the $NaHCO_3$ has proven highly successful to date at the CBR operations. Alternate leach solutions include ammonium carbonate solutions and acidic leach solutions. These solutions have been used in solution mining programs in other locations; however, operators have experienced difficulty in restoring and stabilizing the aquifer. Consequently, these solutions were excluded from consideration.

2.3.1.2 Groundwater Restoration

The restoration of the R&D project, the successful completion of restoration in MU 1, and the current restoration activities in MUs 2 through 6 at the current licensed CPF demonstrate the effectiveness of the restoration methods. These methods (groundwater sweep, permeate/reductant injection, and aquifer recirculation) have been shown to restore groundwater to premining quality. No feasible alternative groundwater restoration method is currently available for the CPF and proposed MEA. The NRC and NDEQ consider the method currently employed at the CPF as the BPT.

2.3.1.3 Waste Management

<u>Liquid Waste</u>

Liquid wastes generated from in situ production and restoration activities are typically handled by one of three methods: solar evaporation in ponds, DDW injection, or land application. All three

methods are permitted at the CPF. The use of DDWs in conjunction with storage/evaporation ponds to dispose of the high TDS liquid wastes that primarily result from the yellowcake processing and drying facilities is considered the best alternative to dispose of these types of wastes. Alternative wastewater disposal options that were considered for MEA were DDW injection, surge/evaporation ponds, point source discharge and/or land application. In addition, surge tanks were evaluated as waste management facilities to support the selected DDW alternative.

The proposed method of liquid waste disposal at MEA will be DDW injection without the need for supporting surge/evaporation ponds or surge tanks. The justification for this proposed action is discussed in Section 3.12.2.1. There are currently no plans for any point source discharges or land application of wastewaters. However, the land application option could be applied in the future if such disposal is deemed feasible and more beneficial for a specific wastewater stream. Any such action would require an NRC license amendment and a discharge permit from the NDEQ.

Based on the proposed project development schedule and the water balance of the MEA project, additional liquid waste disposal methods will be phased for the MEA operations. For approximately the first 6 years of operation (2015 through 2020), the MEA operations will send wastewaters to storage tanks located in the satellite building, which will then be discharged to two onsite DDWs. As discussed in Section 3.12.2.2, it is estimated that an additional four DDWs (for a total of six DDWs) may be needed to address wastewater disposal over the life of the project. There will be no evaporation ponds or large surge tanks located outside the satellite building. The proposed waste management system will be sufficient to handle the total quantities of wastewaters that will be generated during startup. Production and restoration flows will increase in 2021 to the extent that additional wastewater management and controls will be needed because the increased flows may exceed the capacity of two DDWs.

During the first 6 years of operations, CBR will assess the maximum injection rates of the DDWs and the overall efficiency of the waste management system. Efforts will be made to maximize the DDW injection rates, minimize the amounts of wastewaters generated during production and restoration that require disposal, better quantify actual site wastewater flows, and assess viable waste management alternatives and environmental implications. This time period will allow CBR time to develop an updated waste management system that will be the most optimum for handling the increasing wastewater flows. Additional wastewater management systems to be evaluated will include additional DDWs, surge tanks, surge/evaporation ponds, and process modifications to minimize liquid waste generation.

As stated above, CBR considered and rejected using either surge/evaporation ponds, point source discharge, or land application as a disposal method for currently planned operations at Marsland due to required treatment and monitoring costs and potential environmental impacts. However, as the project develops, a determination will be made as to the extent of additional wastewater management alternatives that may be needed in addition to the DDWs to handle all of the generated wastewater streams amenable to disposal by DDW. Additional alternative evaluations will consider options such as additional DDWs, surge tanks, surge/evaporation ponds, land application, or treated wastewater discharge. CBR will be able to assess the maximum injection rates for the two initial DDWs, and the resulting information will be of value in planning future DDWs and/or other disposal options. CBR will submit the necessary license amendment(s) and

waste alternative analyses to the NRC and request approval as per applicable license condition(s), as well as permits required by the NDEQ and other appropriate state agencies.

Surge Tanks

Surge tanks may be a viable option in the future in addressing increased production and restoration flows. If a reasonable number of surge tanks can handle the proposed wastewater volumes, then that may be the only option required. This would assume that additional DDWs would be added and the overall disposal capacity was sufficient.

Surge tanks offer the following advantages over evaporation ponds:

- Less waste solids would be generated with tanks because the tanks would be enclosed, and windblown dust and dirt would not enter the tanks as it would with open evaporation ponds.
- Tank sediments could be managed and removed in a more environmentally acceptable manner compared to evaporation ponds.
- Tanks would eliminate the potential for exposure of wildlife (birds, small mammals, amphibians, and reptiles) to the open evaporation ponds.
- Tanks would have less potential of contamination to the surrounding area compared to the potential of spray via enhanced evaporation (sprayers) from the evaporation ponds.
- Tanks (mounted on concrete foundations with spill contaminant) would have less potential of contamination of the soils underneath and around the tanks (e.g., liner leaks of ponds).
- Potential radon emissions would be less of a risk with enclosed tanks (vented in a manner to minimize employee/public exposures) compared to large, open ponds (e.g., evaporation spray systems).
- Tanks would require a smaller footprint than evaporation pond(s).
- Waste volumes of tanks would be less than for evaporation ponds (ponds will generate liners and additional expected contaminated soils to be disposed of as byproduct material).

Surge/Evaporation Ponds

Surge/evaporation ponds could be a viable alternative in the future if additional surge capacity requirements exceed what could be reasonably handled with additional storage tanks (e.g., size constraints) and DDWs. The surge/evaporation ponds would allow for additional wastewater disposal through passive or enhanced (spray systems) evaporation, especially during the warmer times of the year. Additional surge tanks could be used to the extent possible to minimize the size of any required surge/evaporation ponds. A stated above, prior to the increase in wastewater flows that would result in two DDWs not being able to adequately dispose of the generated wastewaters, viable waste management alternatives will be evaluated in detail. The objective of the alternatives evaluation will be to select options that will adequately handle the maximum amounts of produced wastewaters, while providing for protection of the environment and safe operations by the employees.

Evaporation ponds are commonly used at ISR facilities for the disposal of liquid wastes, which involves pumping liquids into one or more ponds and allowing natural solar radiation to reduce the volume through evaporation. Wastewaters discharged to evaporation ponds are not always treated prior to discharge to the ponds, which can result in concentration of radionuclides and other metals as the liquids evaporate. The basic design criteria for an evaporation pond system are contained in 10 CFR Part 40, Appendix A, Criteria 5A and 5E. The NRC has established standards for the location of pond(s), design and construction of the required clay or geosynthetic liner systems, pond embankments, and leak detection systems (NRC 2003, NRC 2008). Pond inspection and maintenance criteria are also established by NRC regulations.

Evaporation pond effectiveness depends on how much waste is being generated over a given time period, evaporation rates for the area being used, and how quickly liquid wastes are generated. Evaporation rates will vary seasonally, being dependent largely upon temperature and relative humidity, with the rate of evaporation being highest during warm, dry conditions and lower during cool, humid conditions. The pond size and surface area can be increased in order to enhance evaporation when the evaporation rates are low or seasonal conditions reduce evaporation.

NRC recommends that evaporation ponds include sufficient freeboard and reserve capacity. The NRC recommends a freeboard of approximately 3 to 6 feet (distance from water level to top of embankment) and a reserve capacity that will allow the entire contents of one or more ponds to be transferred to other ponds in the event of a leak requiring repair or to handle additional wastewater volumes.

With ponds being open to the atmosphere, dust and dirt can be blown into the ponds, with the concentrations of dissolved solids increasing due to evaporation. This could result in the precipitation of salts form the solution. Periodic cleaning of the ponds may be required in order to maintain good repair and the necessary freeboard. The accumulated pond sediments may need to be disposed of as byproduct material at a licensed disposal facility. When the site is permanently closed, pond liners, accumulated materials, and any contaminated solid underlying or adjacent to the pond liner may need to be disposed of as byproduct material.

During the winter months in northwest Nebraska, ponds can ice over, resulting in reduced evaporation rates. In order to adequately manage wastewaters year-round in this region, additional storage capacity or additional disposal options would be needed for a typical ISR facility (e.g., land application and/or point source discharge).

Land Application

In general, liquid waste disposal using the land application alternative would involve pre-treatment of liquid waste in lined settling ponds followed by application of treated waste through center pivot or other types of irrigation sprinklers to agricultural production areas. Application would be seasonally restricted to the approximately mid-March through early-July winter wheat growing season. Treatment may require IX columns, RO, and barium/radium sulfate precipitation to decrease uranium and radium levels in the wastewater below the permitted discharge limits. Until the site and facilities are decommissioned, any byproduct material in storage facilities and within tanks, ponds, and radium-settling basins would need to be managed to prevent any releases (NRC 2003).

Land application would require the construction of additional facilities, including radium settling pond(s), outlet pond(s) to intercept treated water from the radium settling pond(s), storage pond(s) to store treated water during the non-irrigation season, and emergency containment pond(s). Storage tanks could alternatively be used in place of the settling, storage, and emergency containment ponds.

Although not a preferred option at this time, land application may be a feasible option in the future when used in conjunction with other disposal options such as disposal via DDW with support facilities such as surge tanks or ponds. If land application disposal is determined to be needed in the future, a facility specific land application plan under a license amendment application will be submitted to the NRC for review and approval. In addition, required permits/approvals from the NDEQ and other applicable state agencies will be obtained.

Discharge to Surface Drainage

Discharge of wastewater would be expected to require treatment similar to what is described above for land application. Radionuclides and specific radionuclide parameters would have to meet applicable NDEQ and NRC discharge standards. An NPDES permit would have to be obtained from the NDEQ, and a license condition allowing the activity issued by the NRC. Although not a preferred option at this time, it may viable for future disposal if warranted due to capacity issues.

See additional discussions of liquid waste disposal in Section 3.12.2.1 and the project water balance in Section 3.12.2.2.

Solid Waste

All solid wastes are transported from the site for disposal. Non-contaminated waste is shipped to an approved sanitary landfill. Contaminated wastes are shipped to an NRC-approved facility for disposal. Should an NRC (or Agreement State)-licensed disposal facility not be available to CBR at the time of decommissioning, on-site burial may be necessary. This alternative could incur long-term monitoring requirements and higher reclamation costs. At this time, CBR believes that off-site disposal of 11(e)2 byproduct material from the MEA at a licensed disposal facility is the best alternative, and there are no plans for on-site disposal.

2.4 Alternatives Considered but Eliminated

As a part of the alternatives analysis conducted by CBR, several mining alternatives were considered. Due to the significant environmental impacts and cost associated with these alternative mining methods in relation to the MEA ore body, they were eliminated from further consideration.

2.4.1 Mining Alternatives

Underground and open pit mining represent the two currently available alternatives to IRM mining for the uranium deposits in the project area. Neither of these methods is economically viable for producing the MEA reserves at this time for several reasons, including the spatial characteristics of the mineral deposit and environmental factors. The depth of the deposit and subsequent overburden ratio make surface mining impractical. Surface mining is commonly

undertaken on large, shallow (less than 300 feet) ore deposits. At the MEA, uranium is recovered from depths ranging from about 800 to 1,250 feet bgs.

In addition, the physical characteristics of the deposit and the overlying materials make underground mining infeasible for the MEA. The costs of mine development, including surface facilities, shaft, subsurface stations, ventilation systems, and drifting, would decrease the economic efficiency of the project.

From an environmental perspective, open-pit mining or underground mining and the associated milling process involve higher risks to employees, the public, and the environment. Radiological exposure to the personnel in these processes is increased not only from the mining process but also from milling and the resultant mill tailings. Moreover, the personnel injury rate is historically much higher in open-pit and underground mines than at ISR solution mining operations.

Both open-pit and underground mining methods would require substantial dewatering to depress the potentiometric surface of the local aquifers and provide access to the ore. The groundwater would contain naturally high levels of radium-226 that would have to be removed prior to discharge, resulting in additional radioactive solids that would have to be disposed. For conventional mining, a mill tailings pond containing 5,000,000 to 10,000,000 tons of solid tailings waste from the uranium mill would also be required.

In a comparison of the overall impacts of uranium ISR with conventional mining, an NRC evaluation (NRC 1982) concluded that environmental and socioeconomic advantages of ISR include the following:

1. Significantly less surface area is disturbed than in surface mining, and the degree of disruption is much lower.
2. No mill tailings are produced, and the volume of solid wastes is reduced significantly. The gross quantity of solid wastes produced by ISR is generally less than 1 percent of that produced by conventional milling methods (more than 948 kg [2,090 lb] of tailings usually result from processing each metric ton [2,200 lb] of ore).
3. Because no ore and overburden stockpiles or tailings pile(s) are created and the crushing and grinding ore-processing operations are not needed, the air pollution problems caused by windblown dusts from these sources are eliminated.
4. The tailings produced by conventional mills contain essentially all of the radium-226 originally present in the ore. By comparison, less than 5 percent of the radium in an ore body is brought to the surface when ISR methods are used. Consequently, operating personnel are not exposed to the radionuclides present in and emanating from the ore and tailings, and the potential for radiation exposure is significantly lower than that associated with conventional mining and milling.
5. By removing the solid wastes from the site to a licensed waste disposal site and otherwise restricting them from contaminating the surface and subsurface environment, the entire mine site can be returned to unrestricted use within a relatively short time.
6. Solution mining results in significantly less water consumption than conventional mining and milling.
7. The socioeconomic advantages of uranium ISR include:

- The ability to mine a lower grade ore
- A lower capital investment
- Less risk to the miner
- Shorter lead time before production begins
- Lower manpower requirements

Finally, and perhaps most important, because CBR is an established commercial solution mining site, there are no viable alternative mining methods at this time. The current market price of uranium makes an established solution mining operation the most economically viable method of mining uranium at the MEA at this time.

The uranium ISR process is used when specific conditions exist, including the following (EPA 2008):

- *The ore is too deep to be mined economically by conventional means.*
- *The uranium is present in multiple-layered roll fronts.*
- *The ore body is below the water table.*
- *The ore grade is low, and the ore body is too thin to mine by conventional means.*
- *A highly permeable rock formation exists in which uranium can be economically produced.*

These conditions exist at the MEA site.

2.4.2 Production Facility Alternatives

The option existed for CBR to construct a new yellowcake production facility for the MEA project rather than the proposed satellite facility. The selected option was the construction of a new satellite facility instead because the existing CBR production facility is only approximately11.1 miles (17.9 km) to the north-northwest of the proposed MEA site (centerpoint of CPF processing building to centerpoint of MEA satellite building).

The use of the existing facility as a centralized processing facility will allow processing of uranium-loaded resin from the CBR's proposed MEA satellite facility and two other nearby proposed satellite facilities (NTEA and TCEA). Such a centralized design enhances the economics of uranium production in the region by maximizing production capacity while minimizing further capital expenditures on processing facilities. The construction and operational cost of a satellite facility would be significantly lower than that of a new production facility. The potential for release of radiological particulates would be lower for a satellite facility due to it being a "wet" process because no yellowcake would be produced. Other advantages include: less land disturbance for the operating assets; non-radiological air emissions (e.g., fugitive dust, diesel, and gasoline emissions) during operations would be lower; fewer employees working at the site would be potentially exposed to radiation; there would be less byproduct and other types of waste generated that would need to be handled and disposed of; smaller deposits located within the MEA can be mined with the resin trucked to the CPF; and the front end of the "milling" process can begin independent of the larger CPF.

In summary, the construction and operation of a new processing facility was not deemed to be a viable economical alternative and would result in more environmental impacts than a new satellite facility. Transportation of the uranium-loaded resin from the satellite facility to the CPF would serve as an additional risk. However, such risk is deemed minimal with the use of trucks designed for hauling resin, trained drivers, required speed of the vehicles, conditions of the roadways, minimal amount of road traffic in the area, and relative short distance between the two facilities.

2.5 Cumulative Effects

2.5.1 Cumulative Radiological Impacts

On October 17, 2006, CBR submitted a license amendment request to the NRC requesting an increase in the licensed flow at the CPF. License Condition 10.5 of SUA-1534 limited current operation to an annual facility throughput of 5,000 gpm exclusive of restoration flow. CBR requested an amendment to this license condition to increase production and assist restoration efforts. The production increase was to be accomplished by expanding the existing facility and mining existing wellfields to lower levels of soluble uranium. CBR requested approval to increase the annual facility throughput to 9,000 gpm exclusive of restoration flow. The amendment request did not change the annual licensed production rate of 2,000,000 pounds of U_3O_8 per year. NRC issued the license amendment on November 30, 2007.

The only environmental impact of the increased flowrate at the current operation is a corresponding increase in the emission of radon-222 from the current operation. The amendment estimated a 22 percent increase in the maximum public dose, and that the maximum public dose would remain well below the limit found in 10 CFR § 20.1301.

2.5.2 Future Development

CBR has identified several additional areas in the region near the CPF that are being considered for development. Licensing and permitting efforts are ongoing for two additional satellite facilities (NTEA and TCEA). Development of additional facilities is not currently planned, although such development depends on further site investigations by CBR and the future of the uranium market. If conditions warrant, CBR could submit additional license amendment requests to permit development of these additional resources. However, CBR currently projects that development of these areas would be primarily intended to maintain production allowed under the current license as reserves in the current licensed area and at the MEA are depleted.

2.6 Comparison of the Predicted Environmental Impacts

Table 2.6-1 summarizes the environmental impacts for the no-action alternative (Section 2.1), the preferred alternative (Section 2.2), and the process alternatives (Section 2.3.1). The predicted impacts for the mining alternatives discussed in Section 2.4 are not included for comparison because these alternatives were rejected due to significant environmental and economic impacts. Environmental impacts are discussed in greater detail in Section 4.

Table 2.6-1 Comparison of Predicted Environmental Impacts

Table 2.6-1 Comparison of Predicted Environmental Impacts

Impacts of Operation	No-Action Alternative	Preferred Alternative	Process Alternatives	
			Alternate Lixiviant Chemistry	Alternate Waste Management
Land Surface Impacts	None	Minimal temporary impacts in wellfield areas, significant surface and subsurface disturbance confined to a portion of the ~12 acre satellite facility site.	Same as Preferred Alternative.	Same as Preferred Alternative. Potential additional impacts from land application of treated waste water.
Land Use Impacts	None	Loss of crop and cattle production in 562 acre area for duration of project.	Same as Preferred Alternative.	Same as Preferred Alternative plus a potential long term land use impact from on-site disposal of 11(e)2 byproduct material.
Transportation Impacts	None	Minimal impact on current traffic levels. Estimated additional heavy truck traffic of delivery trucks (`7 day) & resin truck (`2/day)	Same as Preferred Alternative.	Same as Preferred Alternative.
Geology and Soil Impacts	None	None	None	None
Surface Water Impacts	None	None	None	None
Groundwater Impacts	None	Consumption of Chadron groundwater for control of mining solutions and restoration (estimated at 315 gpm average)	Same as Preferred Alternative. Increased difficulty with groundwater restoration and stabilization.	Same as Preferred Alternative.
Ecological Impacts	None	No substantive impairment of ecological stability or diminishing of biological diversity.	Same as Preferred Alternative.	Same as Preferred Alternative.
Air Quality Impacts	None	Additional 28.9 tons per year for offsite unpaved roads (uncontrolled) and 14.5 tons per year for onsite unpaved roads (uncontrolled).	Same as Preferred Alternative.	Same as Preferred Alternative.
Noise Impacts	None	Barely perceptible increase over background noise levels in the area.	Same as Preferred Alternative.	Same as Preferred Alternative.

Table 2.6-1 Comparison of Predicted Environmental Impacts

Impacts of Operation	No-Action Alternative	Preferred Alternative	Process Alternatives	
			Alternate Lixiviant Chemistry	Alternate Waste Management
Historic and Cultural Impacts	None	None	None	None
Visual/Scenic Impacts	None	Moderate impact; noticeable minor industrial component in sensitive viewing areas.	Same as Preferred Alternative.	Same as Preferred Alternative plus possible long term visual and scenic impacts from on-site disposal cell for 11(e)2 byproduct material
Socioeconomic Impacts	Eventual loss over the next 5 to 10 years of positive economic impact of $10.4M to the local area as reserves deplete in the current licensed operation	Extension of the current annual direct economic impact of $10.4M plus the addition of between $5.3M and $6.1M annual direct economic impact to local area	Same as Preferred Alternative.	Same as Preferred Alternative.
Nonradiological Health Impacts	None	None	None	None
Radiological Health Impacts	None	The estimated additional maximum dose rate within 80 km of MEA was 1.6 person-rem/yr and 0 person-rem/yr beyond 80 km	Same as Preferred Alternative.	Same as Preferred Alternative.
Waste Management Impacts	None	Generation of additional liquid and solid waste for proper disposal.	Same as Preferred Alternative. Mobilization of additional hazardous elements in lixiviant requiring disposal.	Same as Preferred Alternative. Potential additional long term impact from on-site disposal of 11(e)2 byproduct material.

Table 2.6-1 Comparison of Predicted Environmental Impacts

Impacts of Operation	No-Action Alternative	Preferred Alternative	Process Alternatives	
			Alternate Lixiviant Chemistry	Alternate Waste Management
Mineral Resource Recovery Impacts	Loss of a valuable domestic energy resource. CBR estimated reserves are under development but the current estimated recoverable resource is 9.5 million pounds with a current spot market value (8/2011) of $475 million.	Recovery and use of a domestic energy resource.	Same as Preferred Alternative.	Same as Preferred Alternative.

3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1 Land Use

This section evaluates the effects of the proposed uranium mining on the physical, ecological, and social characteristics of the surrounding environments. Land and water use in the current CBR license area are discussed in the license renewal application previously submitted for NRC License Number SUA-1534 (NRC 2007a). Land and water use for the proposed NTEA are discussed in a license amendment application submitted to the NRC on May 30, 2007 (NRC 2007b). In addition, land and water use are discussed in a license amendment application for the proposed TCEA (NRC 2010), which is pending.

This section describes the nature and extent of present and projected land and water use and trends in population or industrial patterns. The information for the CPF was initially developed over a 9-month period in 1982 as part of the R&D License Application, updated in 1987 for the Commercial License Application, and in 1997 and 2007 during license renewal. The information for the MEA was developed in 2011. Preliminary data were obtained from several sources including previous licensing documents supported by field studies and interviews with various state and local officials.

RG 1569 requires a discussion of land and water use in the proposed MEA, and within a 2-mile (3.3 km) distance from the site boundary. The NDEQ requires an assessment of a 2.25-mile (3.62 km) radius of the proposed project site boundary (AOR) for the Class III UIC application. Therefore, the NRC's 2-mile (3.2 km) radius has been extended to 2.25 miles (3.62 km) for consistency. Land use within the MEA and the 2.25-mile (3.62 km) AOR is illustrated on **Figure 3.1-1**

Land use and water use data were updated from previous license applications by additional data collection and review, personal communications, and site reconnaissance. Population distribution characteristics were updated using current 2010 Census data and other applicable sources (USCB 2011).

Little change in land use has been noted in recent decades, reflecting the stagnant nature of economic activity and a slight decline in the populations of the City of Crawford and Dawes County.

3.1.1 General Setting

The MEA is located in southwestern Dawes County, Nebraska, just south of the Pine Ridge. The centerpoint of the MEA satellite building is located approximately 4.6 miles (7.4 km) north-northeast of the centerpoint of the community of Marsland (**Figures 1.1-3** and **3.1-1**). The main access route to the MEA is via State Highway (SH) 2/71 west of Marsland, then east along Niobrara Street and River Road, and then north on either Squaw Mound Road or Hollibaugh Road.

3.1.2 Land Use

Land use of the MEA and surrounding AOR is dominated by agricultural uses (**Figures 3.1-1** and **3.5-1**). **Table 3.1-1** describes major land use types, including those depicted on **Figure 3.1-1**. Land use acreages for the AOR (**Table 3.1-2**) and MEA (**Table 3.1-3**) are presented in **Figure 3.1-1** in 22.5 sectors centered on each of 16 compass points radiating out from the proposed satellite facility. Major land uses within the MEA and AOR are further discussed below.

Rangeland comprises the greatest land cover within the 2.25-mile (3.62 km) AOR (73 percent). Forest lands (13.4 percent), cropland (7.8 percent), and recreational land (3.3 percent) are the other significant

land cover types. Less than 0.07 percent (30 acres) of the AOR is accounted for by wetlands. Scattered rural residences are mostly associated with agricultural operations.

Residential and commercial land uses in Dawes County are concentrated within the city limits of Crawford and Chadron and in the communities of Whitney and Marsland. Industrial land uses within the city limits of Crawford are generally associated with railroad facilities.

Within the MEA, rangeland is the dominant land use (80 percent), with cropland (10 percent) and forestland (7.8 percent) accounting for smaller areas (**Table 3.1-3**).

3.1.2.1 Agriculture

Several of the soil types found in the vicinity of the MEA are classified as prime farmland. However, in Dawes County, soils are classified by the U.S. Natural Resource Conservation Service (NRCS) as prime farmland only if irrigated. According to 2009 Census of Agriculture for Nebraska, nearly 9 percent of Dawes County agricultural land is irrigated, and about 16 percent of harvested cropland acreage is irrigated (NASS 2009a). The remainder of the irrigated land is used for pasture, habitat, or rangeland (NASS 2009b). Irrigated land is found in both the MEA and the AOR.

Tables 3.1-4 and **3.1-5** show agricultural productivity and livestock inventory, respectively, within Dawes County. Wheat and forage are the major crops grown on croplands in Dawes County. Most of these crops are used for livestock feed, while the remaining crops are commercially sold. In 2010, total wheat production in Dawes County was 1,195,000 bushels, a decrease of 24 percent from 2009 production (NASS 2011). In 2010, 96,600 tons of forage was grown; this was a decrease of approximately 11 percent from the 2009 harvest. Non-livestock agricultural lands in Dawes County had a value of $13.61 per acre, indicating that crop production on existing farmed lands in the AOR have a potential value (assuming full use of lands) of $39,801, and $6,041 in the MEA (NASS 2009a).

In 2007, 69,429 head of livestock was reported in Dawes County (NASS 2009a). The livestock inventory for Dawes County indicates that cattle account for more than 90 percent of all livestock. Livestock, poultry, and their products account for approximately 75 percent of the total market value of all agricultural products sold in 2007; this is a slight decrease from 2002, when livestock accounted for approximately 86 percent of market value. In 2007, cash receipts for livestock and products totaled $34.3 million in Dawes County (NASS 2009a). Livestock, poultry, and their products carried a value of $40.40 per acre, indicating that livestock production on rangeland within the AOR has a potential value (assuming full use of lands) of approximately $1.1 million, and $145,448 in the MEA (NASS 2009a).

The market value of crops of $13.61 per acre was calculated as follows:

> Market value of crops, including nursery and greenhouse crops ÷ Land in Farms: $11,550,000 ÷848,753 acres = $13.61/acre.

The market value of livestock, poultry, and their products of $40.40 was calculated as follows:

> Market value of livestock, poultry, and their products ÷ Land in farms
>
> $34,286,000 ÷ 848,753 acres = $40.40/acre

These values were calculated using the data from Table 1. County Summary Highlights: 2007 for Dawes County (NASS 2009a). The methodology used for the calculations was from a publication by Doris N. Petersan (Petersan 2005).

3.1.2.2 Recreation

Recreational opportunities provided by federal and state lands in Dawes County have become an increasingly important component of the local economy. There are no developed recreation facilities within the MEA or the AOR. Nearby recreational facilities in Dawes County include the Ponderosa State Wildlife Management Area (SWMA), Chadron State Park, Soldier Creek Wilderness Area, the Red Cloud Picnic Area, trails in the Nebraska National Forest, Box Butte Reservoir State Recreation Area, and Fort Robinson State Park (DeLorme Maps 2005). Approximate distances from the proposed MEA satellite facility to local and regional recreational facilities are presented in **Table 3.1-6**.

3.1.2.3 Residential

In 2010, there were a total of 567 houses in the City of Crawford, with 470 occupied (334 by owners and 136 by renters), and 418 houses in the Town of Hemingford, with 315 occupied (253 by owners and 82 by renters) (USCB 2011).

Based on site reconnaissance in May 2011 and a combination of Google Earth and Nebraska Department of Natural Resources (NDNR) aerial imagery of the area, there are two housing units in the MEA, only one of which was occupied at the time of the reconnaissance. The occupied residence is located in SW¼ NW¼ section 7, and the unoccupied residence is located in T29N, R50W and SE ¼ NE¼ section 2, T29N, R51W, as shown on **Figure 3.1-2**. The AOR contains an additional 25 structures, of which seven are occupied. There are a total of eight occupied housing units within the MEA and the 2.25-mile (3.62 km) AOR.

3.1.2.4 Habitat

Habitat lands are those dedicated wholly or partially to the production, protection, or management of species of fish or wildlife. Significant areas classified as habitat nearest to the MEA include the Ponderosa SWMA, located approximately 5.2 miles (8.4 km) north of the MEA boundary; the Fort Robinson SWMA, located 13.7 miles (22.0 km) northwest of the MEA boundary; and the Petersen SWMA, located 13.8 miles (22.2 km) north-northwest. There is no land within the MEA used primarily for wildlife habitat. Wildlife habitat is a secondary use of rangeland, forestland, and recreational land within the MEA and the 2.25-mile (3.62 km) AOR. An evaluation of habitat in the MEA is included in Section 3.5, with habitat types in the MEA shown in **Figure 3.5-1**.

3.1.2.5 Industrial and Mining

Numerous exploratory wells targeting mineral resources and hydrocarbons have been drilled in the MEA and the AOR. CBR has an ongoing exploratory drilling program that, to date, has completed more than 1,800 drill holes in the MEA. Besides CBR, Conoco, Amoco Minerals, Santa Fe Mining, and Union Carbide have also drilled exploratory test holes for uranium resources in the general area. With the exception of these exploratory wells, there are no other industrial facilities within the 2.25-mile (3.62 km) AOR.

There is one abandoned oil and gas exploratory well located within the MEA or the 0.25-mile (0.4 km) ZOEI, but four abandoned wells are present within the 2.25-mile (3.62 km) AOR (**Figure 3.1-3**). Based upon review of public records, all referenced oil and gas wells have been properly plugged and abandoned in accordance with the Nebraska Oil and Gas Conservation Commission regulations (NOGCC 2011). A discussion of oil and gas test holes pertinent to the MEA is presented in Section 3.3.1.1 (see Pierre Shale subheading under Montana Group).

The nearest operating uranium recovery is the CBR operations located approximately 11.1 miles (17.9 km) to the north-northwest of the MEA (centerpoint to centerpoint; NRC 2011a). The location of the MEA site in relation to other proposed CBR satellite facilities is shown in **Figure 1.1-3**.

Project descriptions and locations of operating and proposed uranium recovery facilities in neighboring Wyoming and South Dakota can be found at the NRC website (NRC 2011a). The other uranium in-situ facilities nearest to the MEA in eastern Wyoming and western South Dakota in different stages of development are identified in **Table 3.1-7**. There are no existing or proposed uranium recovery facilities located within 75 miles (120.7 km) of the proposed MEA project. The nearest operating uranium recovery facility is the Power Resources, Inc. Smith Ranch/Highland Central Processing Plant in Wyoming, and the nearest proposed uranium in-situ facilities are Powertech Uranium Corporation's Dewey-Burdock facility located in Fall River and Custer Counties of South Dakota, and the Uranium One's Moore Ranch project located in Converse County, Wyoming. The NRC maintains a status of major uranium recovery licensing applications in the U.S., which is periodically updated (NRC 2013).

Other than CBR uranium recovery activities, there are no other known planned uranium recovery operations in Nebraska (NRC 2011b). There are two nuclear power reactors located in extreme eastern Nebraska that are more than 300 miles (482.8 km) from the proposed MEA project site. The nearest licensed nuclear fuel cycle facility (a gas centrifuge uranium enrichment facility) is located in Idaho Falls, Idaho and operated by AREVA Enrichment Services.

3.1.2.6 Commercial and Services

There are no known retail or commercial establishments within the MEA or the 2.25-mile (3.62 km) AOR. The nearest retail and commercial establishments are located in Crawford and Hemingford, which are approximately 15.1 miles (24.3 km) and 15.4 miles (24.8 km), respectively, from the centerpoint of the MEA satellite building.

3.2 Transportation and Utilities

SH 2/71 runs to the west of the MEA. It converges with U.S. Highway 20 in the City of Crawford north-northwest of the MEA. The northern portion of the MEA is accessed from SH 2/71 via East Belmont Road; the southern portion of the MEA is accessed from SH 2/71 via River Road and Hollibaugh Road. The 2010 average daily traffic counts for a segment of SH 2/71 near Marsland at the southern end of the MEA was 675 total vehicles, including 90 heavy commercial vehicles. Traffic levels on SH 2/71 increase to 695 total vehicles, including 90 heavy commercial vehicles in the vicinity of East Belmont Road (NDOR 2010). Secondary and private roads connect with East Belmont Road, River Road, Hollibaugh Road, and Squaw Mound Road to provide access to residences and agricultural lands within the MEA. No railways cross the MEA; a Burlington Northern Santa Fe rail line runs to the west of the MEA and through a small portion of the 2.25-mile (3.62 km) AOR between the MEA and SH 2/71.

3.3 Geology, Seismology and Soils

This section describes the regional and local geology, seismology, and soils related to the MEA and area. The geology of the CPF, NTEA, and TCEA has been discussed in previous license applications submitted to the NRC. Detailed information contained in these reports (e.g., laboratory results and field data that describe formation characteristics [lithology, mineralogy, permeability] for the Pierre Shale, Chadron Formation, and the Brule Formation at the CPF), also applies in a general sense to the MEA. These data,

in addition to new information from exploratory drilling/logging activities within the MEA, are used to describe the geology and seismology in this section.

3.3.1 Geology and Seismology

3.3.1.1 Regional Setting

As shown on **Figure 1.1-3**, the centerpoint of the proposed MEA satellite building is approximately 11.1 miles (17.9 km) south-southeast to the centerpoint of the City of Crawford, Nebraska in sections 26, 35, 36 (SW ¼) of Township 30 North, Range 51 West; sections 1, 2, 11, 12, 13 of Township 29 North, Range 51 West; and sections 7, 18, 19, 20, 29, 30 of Township 29 North, Range 50 West. The City of Crawford is 25 miles (40.2 km) west of Chadron, Nebraska and 70 miles (112.6 km) north of Scottsbluff, Nebraska. The City of Crawford is 21 miles (33.8 km) south of the South Dakota state line and 33 miles (53.1 km) east of the Wyoming state line. The Marsland area is located near the northern limits of the High Plains section of the Great Plains physiographic province. Topography of the Marsland area includes gently sloping, rolling hills with outlying, broad ridges dissected by intermittent and perennial streams. The most prominent physiographic feature in the region is the Pine Ridge Escarpment, which rises roughly 300 to 900 feet above the basal plain and bounds three sides of the Crawford Basin. Colluvial and alluvial deposits originating from this escarpment cover the permit area. The elevation of the MEA ranges from 3,880 to 4,400 feet above mean sea level (amsl).

- Regional Stratigraphy

Table 3.3-1 summarizes the regional stratigraphic section for northwest Nebraska that includes the White River Group (Brule Formation through basal sandstone of the Chadron Formation). A geologic map of bedrock in northwestern Nebraska is shown on **Figure 3.3-1**. The bedrock map depicts the occurrence of the Miocene Ogallala Group, Miocene Arikaree Group, the Eocene-Oligocene White River Group, and Upper Cretaceous strata belonging to the Montana Group and Colorado Group. The Upper Cretaceous Pierre Shale, the unconformably overlying White River Group (Brule Formation, Chadron Formation, and Chamberlain Pass Formation), and the Arikaree Group outcrop in the vicinity of the City of Crawford and MEA (**Figure 3.3-1**, see inset). In general, the stratigraphic nomenclature of Schultz and Stout (1955) is employed in this application for consistency with historical permitting.

- MEA Stratigraphy

The local stratigraphy of the MEA consists of the following geological units in descending order: alluvial sediments, upper Harrison Beds, Monroe Creek - Harrison Formation, Gering Formation, Brule Formation, upper Chadron Formation, upper/middle Chadron Formation, middle Chadron Formation, basal sandstone of the Chadron Formation, and Pierre Shale. The channel sandstone facies of the basal sandstone of the Chadron Formation represents the production zone and target of solution mining in the MEA. The general stratigraphic section for the MEA is summarized in **Table 3.3-2**. In general, the stratigraphic nomenclature of Schultz and Stout (1955) is employed in this document for consistency with historical permitting. **Figure 3.3-2** is a cross-section index map depicting the locations of 14 north-south and east-west cross-sections through the MEA depicted on **Figures 3.3-3a** through **3.3-3n**. Expanded views of two cross-sections are presented as **Figure 3-3o** through **Figure 3-3u** to provide more detailed examples of the geophysical logs within the basal sandstone of the Chadron Formation. Typical geophysical log responses for the geologic units encountered within the MEA are shown on a typical (i.e., type) log on **Figure 3.3-4.**

CBR completed coring programs in 2011 and 2013 across the MEA. Two core holes were completed in 2011, and an additional five drill holes were completed in 2013. Data were collected from these cores to provide site-specific information across the project area. The site-specific results of the coring programs have been incorporated into discussions of stratigraphy, lithology, and hydraulic properties throughout the document. A summary of the coring programs is presented in **Table 3.3-3,** and coring locations are illustrated on **Figure 3.3-5**.

A thick (approximately 1,200 to 1,500 feet), regionally extensive stratigraphic section of sedimentary units underlies the Pierre Shale; however, those units are not relevant to this proposal. The absence of sandstone units for more than 1,000 feet below the top of the Pierre Shale precludes the need for monitoring zones below the surface of the Pierre Shale. Discussion in this report is limited to the Arikaree Group, White River Group, and Pierre Shale (Petrotek 2004; Wyoming Fuel Company 1983).

This section provides a detailed description of the stratigraphy of the MEA based on an extensive review of existing site-specific drilling logs and published literature. Geological units are described from stratigraphically youngest to stratigraphically oldest. Revised nomenclature for these stratigraphic units is discussed, where applicable, and referred to throughout this application. To be consistent with historical permitting, the majority of stratigraphic nomenclature used in previous submittals to the NRC and the NDEQ has been preserved.

The cross-sections shown in **Figures 3.3-2 and Figures 3.3-3a** through **3.3-3n** are based on 57 boreholes. There were a total of over 2,180 pre-mining boreholes drilled within the MEA AOR.

All exploration holes are logged using down hole geophysical methods. Resistivity, Spontaneous Potential, Gamma, and drill hole Deviation are measured along with depth to provide the data logs. Logs are printed out as well as saved onto compact disc (CD) for data storage. Logging procedures have been described in detail in Section 3.1.2.4 of the MEA Technical Report.

Additionally, Cameco Resources' geologists evaluate the drill cuttings removed during the drilling process (if available), and write a description of the observed lithology for each drill hole. These "Lithologic Log" descriptions include observed depths of identified strata, color, textures, oxidation state, minerals observed and other uranium markers. These lithology log descriptions are correlated to the geophysical logs to provide better understanding of the borehole.

All exploration and development holes drilled in the MEA have been abandoned in accordance with the requirements of State of Nebraska Title 135, Chapter 5.002 and the Mineral Exploration Permit as approved by NDEQ. The Hole Plugging Plan as outlined in Attachment 2 of the approved Application for Mineral Exploration Holes for Mineral Exploration Permit NE#0210824 is shown below (NDEQ 2009).

The locations for all drill holes have been surveyed either by certified public land surveyors, or have been located through the use of differentially corrected Global Positioning System (GPS) by Cameco Resources personnel for positional and elevation data. All drill holes are capped with an aluminum cap stamped with the hole ID number, Section, Township and Range and "CBR" on the surface.

- Alluvium

Quaternary alluvium as thick as 30 feet overlies the Arikaree Group along drainages in the study area. In general, the alluvium consists of fragments of locally outcropping Oligocene-Miocene sedimentary rocks,

sand, gravel, sandy soil horizons, and may include weathered portions of the Arikaree Group. Because alluvium is unconsolidated and may incorporate one or both of the vadose and phreatic (shallow groundwater) zones, log signatures within this unit vary in comparison with those of geologic units in the underlying units. On most MEA logs, resistivity values for alluvium are very high, beyond the log scale, indicating the presence of either soil vapor or fresh water (**Figure 3.3-4)**.

In general, shallow zones with elevated resistivity are also distinguished by a negatively deflected SP curve, suggesting the presence of a permeable zone and formation fluid with lower resistivity than the fluid within the borehole. Although these log signatures suggest that the base of the alluvium can be readily identified in geophysical logs, the base of the alluvium is best defined by observations of drill cuttings. Therefore, the alluvium-Arikaree Group contact illustrated on cross-sections **Figures 3.3-3a** through **3.3-3n** is based on lithologic descriptions of drill cuttings recovered from individual boreholes.

- Arikaree Group (Oligocene-Miocene)

The Oligocene–Miocene Arikaree Group lies unconformably above the Brule Formation and is subdivided, from youngest to oldest, into the upper Harrison Beds, Harrison-Monroe Creek, and Gering Formations, respectively (**Table 3.3-2;** Collings and Knode 1984; Swinehart et al. 1985; LaGarry 1998; McFadden and Hunt 1998)**.**

Literature has named the upper Harrison Beds the Marsland Formation or split into the Harrison and Monroe Creek Formations. This application uses nomenclature presented in Swinehart et al. (1985), which uses the upper Harrison Beds, Harrison-Monroe Creek, and Gering Formations.

The Arikaree Group contains numerous interbedded channel and floodplain deposits, along with the eolian volcaniclastics. Grain size analyses of core samples (**Appendix G-2**) support observations of drill cuttings and cores, which demonstrate the presence of a wide range of interbedded lithologies within the Arikaree Group, including illite/smectite-dominated mudstones (e.g., M-533C Run 5 Sample 1), siltstones (e.g., M-533 Run 1 Sample 2), and fine-grained sandstones (e.g., M-1912C Run 1 Sample 1). Grain size varies from very fine to fine to medium. The coarsest materials are epiclasts from the White River Group and the Rocky Mountains (Bradley and Rainwater 1956; Tedford et al. 1985; Hoganson et al. 1998).

An isopach map of the undifferentiated Arikaree Group is shown on **Figure 3.3-6**. Within the license boundary, the thickness of the Arikaree Group ranges from approximately 40 to 160 feet and averages about 105 feet. The unit is thickest in the northern throughout the central portions of the license boundary, and generally thins southward. The unit is stratigraphically continuous across the MEA. All three subunits of the Arikaree Group are represented on the northern end of the project, but due to stratigraphic pinch-out and erosion from the Niobrara River, it is likely that only portions of the Monroe Creek and Gering Formations are present on the south end of the project.

On geophysical logs, the Arikaree Group is characterized by an off-scale resistivity signature (**Figure 3.3-4)**. The SP curve can also be off the scale. The gamma curve indicates no anomalous radioactivity. No distinguishing features are seen within the geophysical logs to ascertain contacts within the Arikaree Group. The contact between the Arikaree Group and the overlying alluvium is difficult to ascertain. Often the SP curve will begin on scale near the base of the alluvium, and resistivity will remain off scale. The contact between the Arikaree Group and Brule Formation will remain off scale. The contact between the Arikaree Group and Brule Formation is characterized by a decrease in resistivity from the overlying coarser-grained Arikaree Group. A corresponding decrease in the SP curve is often observed from the Arikaree Group to the Brule Formation, and the SP curve typically fluctuates due to interbedded fluvial

sediments within the Arikaree Group. Little distinction can be made within the gamma curves between the Arikaree Group and Brule Formation.

Upper Harrison Beds

Lithologically, the Upper Harrison Beds are composed of aeolian volcaniclastic sandstones interbedded with lenticular freshwater limestones. Regionally, thickness of this unit can be up to 150 feet. The thickness of this unit at MEA is interpreted to be significantly thinner than 150 feet within the MEA license boundary based on observations of outcrops in the northern MEA; however, distinction between the Upper Harrison Beds and underlying Harrison-Monroe Creek Formation based on geophysical logs is difficult. Published grain size and mineralogic analysis indicate that the upper Harrison Beds contain three dominant units of buff to gray fine sand without abundant silt and clay, white sand with abundant silt and clay, and a siliceous pedogenic horizon.

Convolute laminae occur within the fine sand and contain very little silt or clay. The massive unlaminated white sand has been previously interpreted to have been deposited by sheet flow following rains and/or flooding after a heavy ash fall. The lower part of the upper Harrison Beds contains large blocks of sandstone derived from underlying strata, indicating fluvial channel deposition. Cross-stratified beds are also found (Cook 1915; Witzel 1974; Hunt 1981; Vicars and Breyer 1981).

The Upper Harrison Beds also contain silica-cemented paleosols, some of which (e.g., Agate paleosurface) have preserved paleotopographic features due to the resistant nature of the silica cement. Freshwater ostracods have been observed within limestone units, whereas abundant animal burrows and root casts characterize paleosols within the Upper Harrison Beds (Hunt 1981).

Harrison - Monroe Creek Formation

Upper and middle portions of the formation consist of fine-grained grey sandstone. In the northern MEA, outcrops of this formation consist of massively bedded, fine-grained grey, poorly consolidated sandstone. Grey concretions, which weather into elongated irregular masses, are common. The massive grey sandstones of the Harrison-Monroe Creek Formation are interpreted to represent channel fill deposits (McFadden and Hunt Jr. 1998).

The lower portion of the formation is composed of compact fine sandy silt and clay, pinkish to buff in color, and a fine to medium grained gray sand (McFadden and Hunt 1998).Grey concretions composed of long, irregular, fine-grained cylindrical masses, are found in the middle and lower portions of the Harrison-Monroe Creek Formation (Lugn 1939; Collings and Knode 1984). According to Schultz (1941) and Svoboda (1950), the concretions were formed when groundwater enriched with calcium carbonate flowed through deposited sediments and calcite was precipitated "...in a situation similar to stalactite formation only in a horizontal direction…" (Svoboda 1950). Schultz (1941) mapped the orientations of the concretions and found that, within northwest Nebraska, the orientation trend was to the southeast and away from uplift.

Grey concretions composed of long, irregular fine grained cylindrical masses are found in the middle and lower portions of the Harrison-Monroe Creek Formation (Lugn 1939; Collings and Knode 1984). According to Schultz (1941) and Svoboda (1950), the concretions were formed when groundwater enriched with calcium carbonate ($CaCO_{3)}$ flowed through deposited sediments and calcite was precipitated "...in a situation similar to stalactite formation only in a horizontal direction" (Svoboda

1950). Schultz (1941) mapped the orientations of the concretions and found that, within northwest Nebraska, the orientation trend was to the southeast and away from uplift.

Gering Formation

The Gering Formation is mainly composed of gray, grayish-brown volcaniclastic fine to medium grained sandstones, silty sandstones, silt and local beds of ash, coarse sand, and fine gravel. Most of the sand is laminated and contains local cross beds. Beds of greenish-white bentonitic diatomaceous earth, which weathers into hard white layers, are found throughout most of the Gering. Wellman (1964) divided the Gering into upper and lower units. The two portions of the Gering Formation are separated by a volcanic ash that is up to 6 feet thick (Cady and Scherer 1946; Collings and Knode 1984; McFadden and Hunt 1998).

The upper portion of the Gering is finer grained than the lower portion. It is composed of sandy siltstones and silty, fine grained sandstones deposited by floodplains. Some clay pebble congloerates and clay lenses are present.

The lower portion of the Gering contains coarse to fine grained sandstone, silty fine grained sandstone, sandy siltstone, and silty claystone. Coarse to fine grained sandstones are interpreted to have been deposited in fluvial channels, whereas the sandy siltstone and silty claystone units are interpreted to have been deposited on proximal and distal floodplains, respectively. Lithologic observations of outcrops in the northern MEA and Pine Ridge area north of MEA, drill cuttings, and interpretation of geophysical logs indicate that the Gering Formation makes up the majority of the stratigraphic thickness of the Arikaree Group at MEA.

The unconformable contact between the Brule and Gering Formations is readily observed when coarse sediments of the Gering Formation are in contact with the finer grained Brule Formation. When the sediments of the Gering are fine grained, the contact is more difficult to discern based on observations of drill cuttings.

White River Group (Eocene-Oligocene)

At the MEA, the Eocene-Oligocene White River Group consists of the Chadron Formation overlain by the Brule Formation (**Table 3.3-2**). Strata assigned to this group were deposited within fluvial, lacustrine, and eolian environments (Terry and LaGarry 1998). In northwest Nebraska, the White River Group rests unconformably on weathered Pierre Shale. The bulk of the White River Group consists of air fall and reworked volcaniclastics derived from sources in Nevada and Utah (Larson and Evanoff 1998; Terry and LaGarry 1998).

There have been various interpretations of the history of stratigraphic nomenclature for the White River Group of Nebraska and South Dakota as described by Harksen and Macdonald (1969). The following stratigraphic nomenclature retains the formal and informal members based on nomenclature by Schultz and Stout (1955), but also includes more recent nomenclature (Terry and LaGarry 1998; Terry 1998; LaGarry 1998; Hoganson et al. 1998).

Brule Formation

The Oligocene Brule Formation represents the youngest unit within the White River Group present in the subsurface of the MEA. The Brule Formation conformably overlies the Chadron Formation and is unconformably overlain by the Arikaree Group (**Figure 3.3-1**). The Brule Formation was originally

subdivided by Swinehart et al. (1985) and later revised by LaGarry (1998) into three members, from youngest to oldest: the “brown siltstone” member, the Whitney Member, and underlying Orella Member (**Table 3.3-2**). The “brown siltstone” member consists of pale brown and brown, nodular, cross bedded eolian volcaniclastic siltstones and sandy siltstones.

The contact with the underlying Whitney Member varies from a gradational contact to a sharp disconformity where the “brown siltstone” fills valleys incised into the older strata of the Whitney Member. As observed in the drill cuttings, the Whitney Member consists mostly of pale brown, massive, typically nodular eolian siltstones with rare thin interbeds of brown and bluish-green sandstone and volcanic ash. The basal 10 meters of the Whitney Member consist of white or green laminated fluvial siltstones and thin sheet sandstones. The contact between the Whitney Member and the underlying Orella Member is intertonguing. The Orella Member consists of pale brown, brown, and brownish-orange volcaniclastic overbank clayey siltstones and silty claystones, brown and bluish-green overbank sheet sandstones, and thin volcanic ashes. Thick, fine to medium grained, channelized sandstones appear near the base of the Orella Member. These sandstones are present across the MEA. The overall thickness of the Brule Formation within the MEA ranges from approximately 100 to 320 feet. In approximately the northern third of the MEA, the Brule Formation is generally 200 feet thick or more, whereas in the southern two thirds of the MEA, the thickness is generally between 70 and 150 feet. An isopach map of the undifferentiated Brule Formation is shown on **Figure 3.3-7**. **Figure 3.3-10** illustrates the elevation of the top of the Brule Formation across the MEA.

The contact between the Brule Formation and underlying Chadron Formation is difficult to identify in some places, as it is intertonguing (LaGarry 1998). Regionally, the contact is recognized as the lithologic change from thinly interbedded and less pedogenically modified brown, orange, and tan volcaniclastic clayey siltstones and sheet sandstones of the Orella Member to pedogenically modified green, red, and pink volcaniclastic silty claystones of Big Cottonwood Creek Member in the upper Chadron Formation (Terry and LaGarry 1998).

On geophysical logs, the Brule Formation is characterized by rapidly fluctuating geophysical log curves, or “log chatter” (**Figure 3.3-4**). This response is recognized in resistivity curves, and to a lesser extent in SP curves, throughout the MEA. Such fluctuations result from resistivity contrasts between the thinly interbedded siltstones and sandstones of the Orella Member. Because the sandstones are porous and constitute a part of the regional aquifer, the contacts with the interbedded, dry siltstones are sharp and easily recognized on logs (Gutentag et al. 1984). These interbedded sandstones and siltstones are present across the entire MEA project area, and constitute the first overlying aquifer above the production zone. Lateral correlation of most individual water-bearing sandstones within the Brule Formation is difficult due to thinness and spatial variability of these braided channel deposits. However, a water-bearing sandstone present at the base of the Brule Formation is laterally continuous across the MEA. This lithologic unit is interpreted to represent the base of the first overlying aquifer above the production zone. **Figures 3.3-7** and **3.3-10** depict the thickness and elevation of the top of the Brule Formation across the MEA, respectively.

The contact between the interbedded siltstones and sandstone of the Brule Formation and the underlying silty claystones of the Upper Chadron Formation is distinguished by a change from highly variable log readings (i.e., “log chatter”) to relatively flat or straight curves (i.e., the shale baseline) on both resistivity and SP logs (**Figure 3.3-4**). Because of the intertonguing nature of the lower Brule and upper Chadron Formations, thin, isolated sandstones and siltstones may be present in the upper Chadron. As a result, the formation contact appears deeper on some geophysical logs and varies locally on the Brule Formation

isopach map (**Figure 3.3-7**).. **Figures 3.3-3a** through **3.3-3n** depict the subsurface geology of the Brule Formation within the MEA.

Chadron Formation

The Eocene-Oligocene Chadron Formation is in the lower part of the White River Group (**Table 3.3-2**). The Chadron Formation unconformably overlies the Cretaceous Pierre Shale. From top to bottom, the Chadron Formation historically consists of the following stratigraphic units: Big Cottonwood Creek Member (herein referred to as the informal upper Chadron and upper/middle Chadron to be consistent with historical permitting), Peanut Peak Member (herein referred to as the informal middle Chadron to also be consistent with historical permitting), and basal sandstone of the Chadron Formation (also known formally as the Chamberlain Pass Formation). The basal sandstone of the Chadron Formation represents the production zone and target of ISR mining within the MEA. **Figures 3.3-3a** through **3.3-3n** depict the subsurface geology of the Chadron Formation within the MEA. **Figure 3.3-11** illustrates the elevation of the top of the Chadron Formation across the MEA. A unit locally referred to as the upper/middle Chadron has been observed in regional outcrops and in the subsurface at other CBR operations (e.g., Three Crow Expansion Area); however, this unit has been determined to be absent at MEA based on geophysical logs and observations of cores and drill cuttings, and is not discussed in this application.

Upper Chadron Formation

The upper Chadron is the youngest subdivision of the Chadron Formation recognized at MEA (**Table 3.3-2**). Description of the upper Chadron Formation at Toadstool Park (approximately 22 miles [35.4 km] northwest of MEA) indicate that the unit is composed primarily of volcaniclastic overbank silty claystones interbedded with tabular and lenticular channel sandstones, lacustrine limestones, pedogenic calcretes, marls, volcanic ashes, and gypsum (Terry and LaGarry 1998). Drill cuttings, cores, and geophysical logs from MEA support these observations, except for the presence of limestones, which have not been observed. At MEA, the upper part of the upper Chadron is light green-gray bentonitic clay grading downward to green and frequently red clay, though thin interbedded sheet sandstones also occur. This observation is consistent with Terry and LaGarry's (1998) observation of thin (0.1 to 0.15 meter) sandstones at Toadstool Park. Water has not been observed in upper Chadron sandstones at MEA. Tuffs in the Toadstool Park area that occur in the upper Chadron were dated by 40Ar/39Ar methods as late Eocene (~34 million years ago [Ma]) in age (Terry and LaGarry 1998). Based on available well control data, the upper Chadron is continuous across the MEA. The available data suggest that the upper Chadron ranges in stratigraphic thickness from approximately 480 to 520 feet and averages about 510 feet across the MEA (**Figure 3-3a** through **Figure 3-3n**).

As supported by observations at the MEA, the lower boundary of this unit is an intertonguing contact with the underlying middle Chadron, or is a local unconformity where the upper/middle Chadron fills valleys and depressions (Terry and LaGarry 1998; **Table 3.3-2**). The upper boundary is recognized by a lithologic change from thinly bedded and less pedogenically modified brown, orange, and tan volcaniclastic clayey siltstones and sheet sandstones of the overlying Orella Member of the Brule Formation to more pedogenically modified green, red, and pink volcaniclastic silty claystones of the upper Chadron Formation to thinly interbedded and less pedogenically modified brown, orange, and tan volcaniclastic clayey siltstones and sheet sandstones of the Orella Member of the Brule Formation (Terry and LaGarry 1998; **Table 3.3-2**).

Four core samples (M-1454c, Run 1, M-1624c, Run 1, M-1635c Run 3 Sample 1; and M-2169c Run 5 Sample 1) were collected from the upper Chadron by CBR at boreholes M-1454c, M1624c, M-2169c, and

M-1635c (**Figure 3.3-2; Appendix G-1** and **G-2**). X-ray diffraction (XRD) analyses of upper Chadron core samples indicate varied mineralogical compositions. Sample M-1454c Run 1 was primarily composed of calcite, montmorillonite, and quartz with minor amounts of plagioclase, potassium feldspar, and illite/mica. The samples from M-1635c and M-2169c were both primarily composed of montmorillonite, calcite, quartz, and plagioclase, with minor amounts of illite/mica and potassium feldspar.

Particle size distribution analysis of all four upper Chadron core samples exhibited median grain sizes between 0.056 and 0.040 millimeter (mm), which are within the silt size range. The weight percent of sand in these samples ranged from 28.79 (M-1635c) to 43.11 (M-1454c). The samples from M-2169c and M-1454c contained significant proportions of medium sand (13.87 and 24.31 weight percent, respectively). The weight percent of clay in the upper Chadron samples ranged from 8.73 percent (M-1624c) to 10.20 percent (M-2169c). M-1454c Run 1 and M-1624c Run 1 yield median grain sizes of 0.056 millimeter (mm; silt) and 0.049 mm (silt), respectively. Both samples are dominated by silt-sized grains; however, M-1454c Run 1 contained more medium sand than M-1624c, which increased the median grain size. M-1454c Run 1 contained 47.25 percent silt and 9.64 percent clay. M-1624c Run 1 contained 54.65 percent silt and 8.73 percent clay. All upper Chadron samples contained 54.65 percent silt and 8.73 percent clay. As M-1454c Run 1 and M-1624c Run 1 both contain greater than 50 percent combined silt and clay-sized particles, and because greater than 67 percent of the silt+clay component was silt in each sample, they are classified as siltstones (Brown and Harrell 1991). Hydraulic properties of the upper Chadron based on grain size analysis of core samples are discussed in Section 3.4.3.3 (confining layers)

Typical gamma ray (GR), SP, and resistivity log signatures for the upper Chadron exhibit curves representative of the relatively flat shale baseline (**Figure 3.3-4**). Fluctuations are present among upper Chadron log curves, representing interbedded siltstones, sandstones, limestones, and volcanic ash deposits that occur less commonly than in the overlying Brule Formation.

Middle Chadron Formation

The middle Chadron is a variegated clay-rich interval that may be red, grey, grey-green, or bluish-green in color with interbedded bentonitic clay and sands. A light green-gray "sticky" clay within this unit serves as an excellent marker bed in drill cuttings and has been observed in virtually all regional test holes within the MEA, TCEA, NTEA, and the CPF. The middle Chadron unconformably overlies the basal sandstone of the Chadron Formation (Chamberlain Pass Formation) in South Dakota and Nebraska (Terry 1998; **Table 3.3-2**). As described above, this unit is overlain by the upper Chadron in the MEA (**Table 3.3-2**).

The middle Chadron differs from the overlying upper Chadron in that the middle Chadron is composed of bluish-green, smectite-rich mudstone and claystone; is less variegated in color; and contains less silt (Terry 1998). The predominantly clay lithology of the middle Chadron represents a distinct and rapid facies change from the underlying basal sandstone of the Chadron Formation. The available data suggest that the middle Chadron typically ranges in thickness from approximately 150 to 290 feet and averages about 180 feet across the MEA.

Two core samples (M-1454c, Run 2 and M-1624c, Run 2) were collected from the middle Chadron by CBR at boreholes M-1454c and M1624c (**Figure 3.3-2** and **3.3-5; Appendix G-2**). XRD analyses of M-1454c Run 2 and M-1624 Run 2 samples indicate varied compositions. Samples M-1454c Run 2 and M-1624c Run 2 are primarily composed of mixed layered illite/smectite; however, M-1454c Run 2 also

contains a high amount of calcite. Other minor minerals found within the samples include quartz, plagioclase, potassium feldspar, chlorite, and illite/mica. Particle size distribution analyses of M-1454c Run 2 and M-1624c Run 2 give median grain sizes of 0.027 mm (silt) and 0.065 (very fine sand) mm, respectively. Both were mainly composed of silt sized particles; however, M-1624c Run 2 contained more medium sand than M-1454c Run 2, which increased the median grain size. M-1454c Run 2 contained 46.36 percent silt and 20.65 percent clay. M1624c Run 2 contained 34.6 percent silt and 16.54 percent clay. Both are classified as siltstones (Brown and Harrell 1991). Hydraulic properties of the middle Chadron, based on grain size analysis of core samples, are discussed in Section 3.4.3.3 (confining layers).

Typical GR, SP, and resistivity log signatures for the middle Chadron exhibit curves representative of the shale baseline (**Figure 3.3-4**). At the MEA, the contact between the top of the middle Chadron and the overlying upper Chadron is difficult to ascertain due to similarities in grain size and geophysical log responses. At MEA, due to like lithology and geophysical log responses between the upper/middle and middle Chadron Formation, it is difficult to define the contact between these units. Therefore, **Figures 3.3-3a** through **3.3-3n** show an inferred stratigraphic location for the contact between the upper/middle Chadron and middle Chadron contact across the permit area, based on lithologic report observations of drill cuttings.

Together, the upper and middle Chadron units represent the upper confining zone for the basal sandstone of the Chadron Formation within the MEA (see detailed discussion in Section 3.4.3.3). An isopach map created for the combined upper and middle Chadron Formation that comprise the upper confining zone is presented on **Figure 3.3-8.** The total thickness of the upper confining zone ranges from approximately 650 to 710 feet and averages about 690 feet, and generally appears to thicken toward the south and southwest across the MEA.

Basal Sandstone of the Chadron Formation – Mining Unit

The basal sandstone of the Chadron Formation is the oldest unit in the White River Group. The Upper Interior Paleosol, occurring as a persistent clay horizon, typically brick red in color (referred to locally as the "red clay"), developed on top of the basal sandstone of the Chadron Formation and generally marks the upper limit of the basal sandstone of the Chadron Formation (**Table 3.3-2**). **Figure 3.3-12** illustrates the elevation of the top of the basal sandstone of the Chadron Formation across the MEA. The "red clay" horizon is indicated on more than half of the geophysical logs and driller's notes reviewed. The Upper Interior Paleosol is interpreted to represent pedogenically modified distal overbank deposits of a distinct fluvial system developed on the surface of the basal sandstone of the Chadron Formation prior to deposition of the remainder of the Chadron Formation (Terry 1998).

Below the Upper Interior Paleosol, the basal sandstone of the Chadron Formation consists of coarse grained, arkosic sandstone with common, discontinuous interbedded thin silt and clay lenses of varying thickness. Cross-sections providing a more detailed view of the basal sandstone of the Chadron Formation are presented as **Figure 3.3-3o** through **Figure 3.3-3u**.

The basal sandstone of the Chadron Formation overlies a distinct regional unconformity with the underlying Yellow Mounds Paleosol (Terry 1998). The lower contact is easily recognized as a change from the underlying black or bright yellow, pedogenically modified surface of the Pierre Shale (i.e., the Yellow Mounds Paleosol) to white channel sandstone. In places, the basal sandstone of the Chadron Formation grades upward to fine sandstone containing varying amounts of interstitial clay and persistent clay interbeds. Vertebrate fossils from the basal sandstone of the Chadron Formation in northwestern

Nebraska and South Dakota indicate a late Eocene age (Chadronian; Clark et al. 1967; LaGarry et al. 1996; Lillegraven 1970; Vondra 1958).

The basal sandstone of the Chadron Formation occurs at depths ranging from about 817 to 1,130 feet bgs and was encountered in all exploration holes. An isopach map of the basal sandstone of the Chadron Formation across the MEA is presented on **Figure 3.3-9**. Stratigraphic thickness of the unit within the MEA ranges from approximately 25 to 90 feet and averages about 55 feet. The thickest sections of the unit occur in the western portions of the MEA (**Figure 3.3-9**). Up to four distinct sandstone packages are present in the thickest portions of this unit and are separated by variable amounts of interbedded clay. Cross-sections depicting the basal sandstone of the Chadron Formation in detail are presented as **Figures 3.3-3o** through **3.3-3u**. Variations in the number and thickness of individual sandstone packages present in individual boreholes are interpreted to have resulted from facies changes and from varying degrees of erosion of fine-grained interbedded sediments and stacking of multiple channel deposits.

A structure contour map was generated of the contact between the basal sandstone of the Chadron Formation and the Pierre Shale (**Figure 3.3-13**). The structure map indicates that the elevation of the unconformity separating the Chadron Formation from the underlying Pierre Shale decreases to the south-southeast across the MEA from approximately 3,240 to 3,160 feet amsl (**Figure 3.3-13**).

The greenish-white channel sandstones of the basal sandstone of the Chadron Formation are the target of ISR mining activities in the MEA. Regionally, deposition of the basal sandstone of the Chadron Formation has been attributed to large, high-energy braided streams (Collings and Knode 1984; Hansley et al;. 1989; Hansley and Dickinson 1990). This depositional environment produced lenticular sandstone deposits with numerous facies changes occurring within short distances. Interbedded thin silt and clay lenses most likely represent flood plain or low velocity deposits normally associated with fluvial sedimentation.

Core samples (M-1454C, Runs 3 and 4, and M-1624C, Runs 3 and 4) were collected from the basal sandstone of the Chadron Formation by CBR at boreholes M-1454c and M-1624c in sections 1 and 7, T29N, R51W (**Figures 3.3-2** and **3.3-5**). A core sample was also collected in 2013 from the basal sandstone of the Chadron Formation at borehole M-1912C (M-1912C Run 4 Sample 2). However, three separate analyses of the same sample exhibited median grain sizes ranging from 0.003 mm (clay) to 0.850 mm (medium sand); therefore, the results from grain size analysis of this sample are not included in this document. Particle size distribution analyses of M-1454c, Run 3 and M-1624c, Run 4 yield median grain sizes of 0.075 mm (very fine sand) and 0.711 mm (coarse sand), respectively. M-1454c, Run 3 contained 29.85 percent silt and 19.92 percent clay. M1624c, Run 4 contained 11.56 percent silt and 4.5 percent clay. Both are classified as sandstones (Brown and Harrell 1991).

XRD analysis of the M1454c sample indicates a varied composition. Run 3 is mainly composed of quartz, whereas Run 4 is mainly composed of mixed-layered smectite. Minor amounts of plagioclase feldspar, potassium feldspar, kaolinite, and illite/mica were found in both samples. Run 3 also yielded trace amounts of calcite, siderite, pyrite, magnetite, and magnesium vanadium oxide, while Run 4 had minor amounts of dolomite and chlorite. The sample from M-1912c was primarily composed of quartz and mixed-layered illite/smectite with minor amounts of potassium and plagioclase feldspars, illite/mica, calcite, and ferroan dolomite. The sandstones of the basal sandstone of the Chadron Formation within the CPF are dominated by quartz (50 percent monochrystalline) and feldspar (30 to 40 percent undifferentiated feldspar) with the remainder made up of chert, pyrite, and various heavy metals and polycrystalline and chalcedonic quartz (Collings and Knode 1984). XRD analyses indicate that the basal

sandstone of the Chadron Formation within the area of the CPF is 75 percent quartz with the remaining 25 percent consisting of a combination of potassium feldspar, plagioclase, illite, smectite, expandable mixed layer illite-smectite, and kaolinite (Collings and Knode 1984).

Geophysical logs record a unique signature for the basal sandstone of the Chadron Formation (**Figure 3.3-4**). A distinct GR spike is often present at the base of the unit in most of the MEA exploration boreholes, indicating an abundance of radioactive material. Increased resistivity (i.e., log curve shift to the right) and a decreased SP (i.e., log curve shift to the left) are often associated with GR spikes. These log signatures support interpretations of a uranium-bearing, fluid-filled sandstone interval. Other channel sandstone intervals present in the unit may have lower GR readings, indicative of both lower amounts of radioactive materials and potentially non-uranium-bearing intervals. Such intervals are typically marked by increased resistivity and decreased SP curve deviations (log curves shift to the left) without the associated GR spike. Pervasive interbedded clay intervals are indicated by high GR responses accompanied by lower resistivity (i.e., reduced porosity and decrease in water content), an interpretation further supported by driller or geologist’s notes. The high radioactivity of these clay-rich units suggests the presence of rhyolitic ash (Hansley and Dickinson 1990). The top of the formation is marked by a gradual return of SP and resistivity curves to the shale baseline.

Sediments rich in rhyolitic ash contained both within and above the Basal Sandstone are considered to be the most likely source of the uranium compounds that make up the ore body (Gjelsteen and Collings 1988). Larson and Evanoff (1998) used 40AR/39AR dating methods on nine known White River tuff deposits. The ages ranged from 35.97 Ma to 30.05 Ma. Dissolution of these uranium compounds most likely occurred shortly after deposition. This period represents the time of greatest permeability for solutions to liberate the uranium compounds as they moved through the various ash-rich zones prior to compaction and alteration.

The White River volcaniclasts were first described by Darton (1901), who proposed the Black Hills uplift as the source for the material (Darton 1912). Further study by Wanlass (1923) argued that the Black Hills plutons were too small to have produced the volume of material seen throughout the White River Formation. Other studies have continued to pursue the source area of the volcaniclastic material. Larson and Evanoff (1998) identified the Great Basin in eastern Nevada and western Utah as the most likely source area based on age, grain size, and thickness observations. The Great Basin region was active with explosive rhyolitic volcanism during the ~36 to 29 mya time period of White River deposition.

- Montana Group

Interior Paleosol (Yellow Mounds Paleosol)

The Interior Paleosol of Schultz and Stout (1955) was subsequently divided into the younger Eocene Upper Interior Paleosol and the older Cretaceous Yellow Mounds Paleosol (Pierre Shale) (Terry 1991; Evans and Terry 1994; Terry and Evans 1994; Terry 1998; **Table 3.3-2**). As noted above, the Upper Interior Paleosol is interpreted to represent pedogenically modified distal overbank deposits of a distinct fluvial system developed on the surface of the basal sandstone of the Chadron Formation which predates deposition of the middle Chadron Formation. The Yellow Mounds Paleosol developed on the Cretaceous Pierre Shale and altered the normally black marine shale to bright yellow, purple, light bluish-grey, and orange.

Review of available data for the MEA indicates that neither of the two paleosol units could be consistently interpreted based solely on geophysical logs. For simplicity, these units are not represented on the type log or cross-sections.

Pierre Shale

Offshore deposition in the Cretaceous Interior Seaway produced the late Cretaceous Pierre Shale (**Table 3.3-2**). The Pierre Shale is a thick, homogenous black marine shale with low permeability that represents one of the most laterally extensive formations of northwest Nebraska. Regional geologic data indicate that this formation can be up to 1,500 feet thick in the Dawes County area (Wyoming Fuel Company 1983; Petrotek 2004). The southward retreat of the Cretaceous Interior Seaway resulted in the subaerial exposure and weathering of rock units from Early Cretaceous to Eocene age across the northern Great Plains (Lisenbee 1988). This event resulted in the erosion and pedogenic modification of the surface of the Pierre Shale and formation of the brightly colored Yellow Mounds Paleosol (Terry and LaGarry 1998; **Table 3.3-2**). Consequently, the pedogenically modified surface of the Pierre Shale marks a major unconformity with the overlying White River Group and exhibits a paleotopography with considerable relief (DeGraw 1969). The Pierre Shale is underlain by organic-rich shale and marl with minor amounts of sandstone, siltstone, limestone, and chalk of the Niobrara Formation (**Table 3.3-1**). The structure contour map of the top of the Pierre Shale indicates that the contact between the Pierre Shale and the overlying basal sandstone of the Chadron Formation dips slightly to the south-southeast across the MEA (**Figure 3.3-13**). This sloping surface is consistent with the surface described by DeGraw (1971) and rises to the axial crest of the Cochran Arch located north of the MEA.

Seven core samples were collected from the Pierre Shale by CBR at boreholes M-1454c, M-1624c, M-2169c, M-533c, Mi1956c, M-1912c, and M-1635c, as summarized in **Table 3.3-3** (**Figure 3.3-2** and **Appendix G-1** and **G-2**). XRD analysis of the samples indicated a primary composition of mixed layered illite/smectite and quartz, with minor amounts of plagioclase, potassium feldspar, dolomite, pyrite, kaolinite, chlorite, and illite/mica. Particle size distribution analyses of the samples indicated that clay weight percentages ranging from 30.40 (M-1454c Run 4) to 75.95 (M-1635c Run 6 Sample 1). Median grain sizes for four of the seven samples were within the range for clay, and three were within the range of silt (**Appendix G-1** and **G-2**). Fine-grained sand was only detected in the two samples collected in 2011, with a maximum weight percent of 1.28 in the sample collected from core M-1624c. All samples from the Pierre Shale submitted for particle size analysis are classified as claystones (Brown and Harrell 1991).

Typical geophysical log responses for the Pierre Shale exhibit shale baseline curves that are relatively flat or straight (**Figure 3.3-4**; **Appendix C**). On resistance logs, the top of the Pierre Shale is noted where the curves break either sharply to the left (SP) or to the right (resistivity) and represent the occurrence of the basal sandstone of the Chadron Formation. SP and resistivity curves qualitatively indicate a lack of permeable water-bearing zones within the Pierre Shale.

Six deep oil and gas exploration wells were drilled in the vicinity of the MEA: Chicoine 1, Chiocoine 1A, Hollibaugh No. 1, Porter, Roscoe Royal #1, and #1-A Smith. (**Appendix C**). Oil and gas exploration wells have typically been drilled to depths much greater than on-lease uranium exploration wells. The character of the entire Pierre Shale in the vicinity of the MEA can best be observed in geophysical logs from three of the six nearby abandoned oil and gas wells (Hollibaugh No. 1, Roscoe Royal #1, and #1-A Smith), and the CBR DDW-1 ~~(CBR UIC #1)~~, which were completed through the entire thickness of the

unit. Based on observations from logging, the thickness of the Pierre Shale in the vicinity of the MEA ranges from approximately 750 to more than 1,000 feet.

The top of the Pierre Shale was encountered in all wells at depths ranging from approximately 925 to 1,200 feet bgs. The Hollibaugh No. 1 well is located within the license boundary (T29N, R51W, section 12) and has a total depth of 3,283 feet bgs. The Pierre Shale was encountered at 1,025 to 1,915 feet bgs. The Roscoe Royal #1 is located about 0.5 mile (0.8 km) north of the license boundary (T30N, R51W, section 23) and has a total depth of 3,956 feet bgs. The Pierre Shale was encountered at 1,200 to 2,287 feet bgs. The #1-A Smith well is located about 0.25 mile (0.4 km) east of the license boundary (T29N, R50W, section 29) and has a total depth of 2,902 feet bgs. The Pierre Shale was encountered at 947 to 1,716 feet bgs. CBR DDW-1 ~~CBR UIC #1~~ (T31N R52W section 19) is located approximately 10.7 miles (17.2 km) northwest of the MEA license boundary and has a total depth of 3,910 feet bgs. At ~~UIC #1~~CBR DDW-1, the Pierre Shale was encountered from 925 to 1,560 feet bgs, where the base of the Pierre Shale is indicated by an increase in resistivity at the contact with the underlying Niobrara Formation (**Appendix C**). Plugging records for these wells are shown in **Appendix D-1.**

- Stratigraphy of Units Below the Pierre Shale

Underlying the Pierre Shale is a thick sequence of Mississippian through Cretaceous age strata that unconformably overlie Precambrian granite (**Table 3.3-1**). Together with the Pierre Shale, the underlying Niobrara Formation, Carlile Shale, Greenhorn Limestone, and Graneros Shale compose a composite lower confining interval approximately 2,500 feet thick which immediately underlies the basal sandstone of the Chadron Formation. With the exception of the hydrocarbon-bearing “D”, “G”, and “J” sandstones of the Dakota Group (occasionally interbedded with the Graneros and Huntsman Shales; **Table 3.3-1**), there do not appear to be significant sandstone units within this thick sequence of low-permeability strata.

All geologic units encountered during the drilling of oil and gas exploration wells in the vicinity of the MEA appear to be consistent with known regional stratigraphy. Geologic units that are consistently identified in all wells include the Niobrara Formation, Carlile Shale, Greenhorn Limestone, “D” and “J” sandstones of the Dakota Group, and the Skull Creek Formation (**Table 3.3-1**).

3.3.1.2 Geochemical Description of the Mineralized Zone

The depth to the ore body within the basal sandstone of the Chadron Formation in the MEA ranges from approximately 800 to 1,250 feet bgs (**Table 3.3-2**). The ore grade as U_3O_8 ranges from 0.11 to 0.33 percent with an average ore grade of 0.17 percent.

Hansley et al. (1989) conducted detailed geochemical analysis of the Crow Butte uranium ore to assess both ore genesis and composition. The Crow Butte deposits, including Marsland, the current Crow Butte site, NTEA, and TCEA are roll-type deposits with coffinite being the predominant uranium mineral species present. The origin of the uranium is rhyolitic ash, which is abundant within the matrix of the basal sandstone of the Chadron Formation (Hansley et al. 1989). Coffinite is associated with pyrite and high silica activity due to dissolution of the rhyolitic ash which favored formation of coffinite over uraninite in most parts of this sandstone. In addition, smectite is present in the samples examined, with the most common minerals in the sandstone being quartz, plagioclase, potassium feldspar, coffinite, pyrite, marcasite, calcite, illite/smectite, and tyuyamunite. The heavy mineral portion of the samples contained several minerals including those above as well as garnet, magnetite, marcasite, and illmenite. Vanadium was detected in the samples primarily as an amorphous species presumed to have originated

from the in-situ ash. Hansley et al. state that at least some uranium and vanadium remain bound to amorphous volcanic material and/or smectite rather than as discrete mineral phases.

Petrographic data obtained and examined by Hansley et al. (1989) suggest that uranium mineralization occurred before lithification of the basal sandstone of the Chadron formation. Hansley states: *"Dissolution of abundant rhyolitic volcanic ash produced uranium (U) and silicon (Si) rich ground waters that were channeled through permeable sandstone at the base of the Chadron by relatively impermeable overlying and underlying beds. The precipitation of early authigenic pyrite created a reducing environment favorable for precipitation and accumulation of U in the basal sandstone. The U has remained in a reduced state, as evidenced by the fact that the unoxidized minerals, coffinite and uraninite, comprise the bulk of the ore."*

Based on similar regional deposition, the MEA ore body is expected to be similar mineralogically and geochemically to that of the ore body at the CPF. The ore bodies in the two areas are within the same geologic unit (the basal sandstone of the Chadron Formation) and have the same mineralization source. The sites are separated by only a few miles, and the cause of mineral deposition in the two areas appears to be similar. Neither site is anticipated to be significantly affected by recharge or other processes.

3.3.1.3 Structural Geology

Regional uplift during the Laramide Orogeny forced the southward retreat of the Cretaceous Interior Seaway, resulting in the subaerial exposure and weathering of rock units from Early Cretaceous to Eocene age across the northern Great Plains (including the Pierre Shale). The depositional basin associated with deformation of the Wyoming thrust belt and initial Laramide uplifts to the west of Nebraska, represented a structural foredeep. The greatest uplift occurred in the Black Hills, which lie north of Sioux and Dawes Counties in southwestern South Dakota. Lisenbee (1988) provides a comprehensive summary of the tectonic history of the Black Hills uplift. The pre-Oligocene Black Hills uplift (<37 million years [Ma]) occurred prior to the deposition of the Eocene-Oligocene strata of the White River Group. Strata of the White River Group cover most of the eroded roots of the Black Hills uplift as well as the syntectonic sedimentary rocks in the Powder River and Williston basins. The Hartville, Laramie, and Black Hills uplifts supplied sediment for rivers that flowed east-southeast across the study area (Clark 1975; Stanley and Benson 1979; Swinehart et al. 1985).

The most prominent structural expression in northwest Nebraska is the Chadron Arch (**Figures 3.3-15** and **3.3-16**). Together with the Chadron Arch, the Black Hills Uplift produced many of the prominent structural features presently observed in the region. The Chadron Arch represents an anticlinal feature that strikes roughly northwest-southeast along the northeastern boundary of Dawes County. Swinehart et al. (1985) suggested multiple phases of probable uplift in northwestern Nebraska near the Chadron Arch between c.a. 28 Ma and <5 Ma. The only known surficial expressions of the Chadron Arch are outcroppings of Cretaceous rocks that predate deposition of the Pierre Shale in the northeastern corner of Dawes County, as well as in small portions of Sheridan County, Nebraska and Shannon County, South Dakota. The general locations of faults in northwest Nebraska are depicted on the State Geologic Map shown on **Figure 3.3-1**.

The 230-mile (370.1 km) long Pine Ridge escarpment exhibits an average of 1,200 feet of relief (Nixon 1995). The Pine Ridge is an arc roughly concentric to the Black Hills Dome, which suggests an apparent structural relationship. Nixon (1995) interpreted the escarpment as representing the southern outermost cuesta of the Black Hills Dome. The escarpment is capped by sandstone of the Arikaree Group with

exposed deposits of the White River Group mapped along the topographically lower, northern side of the escarpment.

Crow Butte operations, including the CPF, NTEA, and TCEA, are within the Crawford Basin (DeGraw 1969). The proposed MEA lies just outside of the southern boundary of the basin along the Cochran Arch. DeGraw (1969) substantiated known structural features and proposed several previously unrecognized structures in western Nebraska based on detailed studies of primarily deep oil test hole data collected from pre-Tertiary subsurface geology. The Crawford Basin was defined by DeGraw (1969) as a triangular asymmetrical basin about 50 miles (80 km) long in an east-west direction and 25 miles (40.2 km) to 30 miles (48.3 km) wide. The basin is bounded by the Toadstool Park Fault on the northwest, the Chadron Arch and Bordeaux Fault to the east, and the Cochran Arch and Pine Ridge Fault to the south (**Figures 3.3-15** and **3.3-16**). The Crawford Basin is structurally folded into a westward-plunging syncline that trends roughly east-west. Note that the Bordeaux Fault, Pine Ridge Fault, and Toadstool Park Fault proposed by DeGraw (1969) are not presented on the State Geologic Map (**Figure 3.3-1**). The Toadstool Park Fault has been mapped at one location (T33N, R53W) and is estimated to have had approximately 60 feet of displacement (Singler and Picard 1980). The City of Crawford is located near the axis of the Crawford Basin. More recent fault interpretations by Hunt (1990) for northwest Nebraska are also shown on **Figure 3.3-16**, which include the Whetstone Fault, Eagle Crag Fault, Niobrara Canyon Fault, and Ranch 33 Fault in the vicinity of the Town of Harrison in Sioux County. The faults identified by Hunt (1990) all trend to the northeast-southwest, sub-parallel to the Pine Ridge Fault (**Figure 3.3-16**).

Niobrara River Fault

The structural map by DeGraw (1969) referenced above was subsequently modified by DeGraw (1971) to include additional features. Of these, the Niobrara River Fault is most relevant to the MEA. DeGraw (1971) mapped the Niobrara River Fault as occurring parallel to the Niobrara River in southernmost Dawes County and northernmost Box Butte County (**Figure 3.3-16**). No description of the Niobrara River Fault is provided, nor is evidence provided in DeGraw (1971) to support the interpretation of its location. As described above, many of the fault locations (e.g., Pine Ridge Fault) interpreted by DeGraw (1969), were based on the apparent displacement of the pre-Tertiary geologic surface (e.g., top of Pierre Shale) or an unpublished structural contour map of western Nebraska. It is unknown whether the published location of the Niobrara River Fault (DeGraw 1971) is based on an unpublished revision of the pre-Tertiary geologic surface provided in DeGraw (1969) or other data sources. Structural contour mapping of the pre-Tertiary surface by CBR does not provide evidence of displacement by the Niobrara River Fault within the MEA.

As presented by DeGraw (1971), the Niobrara River Fault appears to be a western extension of the Hyannis-North Platte Fault and forms the northern boundary of a graben which contains the Niobrara River valley. An unnamed fault forms the southern boundary of the graben. These faults appear to be generally continuous with the Agate Spring Fault complex of eastern Sioux County (Hunt 1990; **Figure 3.3-16**). Approximately 60 feet of vertical displacement of Arikaree Group sediments has occurred along the Agate Springs Fault in T28N, R55W. Radiometric dating of volcanic tuff displaced by the Agate Springs Fault indicates a maximum age of approximately 19.2 million years for the Agate Springs Fault, and by extension, the Niobrara River Fault (Hunt 1990). Because the Agate Springs and Niobrara River Faults are not included in the USGS Quaternary Fold and Fault Database (USGS 2010), a compendium of faults with evidence of movement between 1.6 million years and ago and the present), it can be inferred that the most recent movement along both faults was between 19.2 and 1.6 million years ago. Neither the exact location of the Niobrara River Fault nor the amount of potential offset of the fault at depth in the vicinity of the MEA can be determined based on known information.

Cameco geophysical data were reviewed to determine if additional data support the location of the Niobrara River Fault and associated graben proposed by Stout et al. (1971). **Figure 3.3-14** presents a regional structural contour map of the top of the Pierre Shale. Boring data indicate the presence of a west-east trending structural trough along the top of the Pierre Shale in the vicinity of the Niobrara River. This trough is generally parallel to, but slightly to the north of the proposed graben location (**Figure 3.3-16**). The best evidence of the structural trough is from CBR exploration borings located west of the MEA license boundary, and the feature may extend to the southern portion of the MEA license boundary. Due to lithologic similarities between the lower Arikaree Group and upper Brule Formation, identifying the geologic contact between those units based on geophysical logs or drill cuttings observation is tenuous; therefore, potential offset of the Arikaree Group correlative to that observed in outcrop at the Agate Springs Fault has not been assessed.

It cannot be determined from existing data whether the structural trough represents a graben related to the proposed Niobrara River Fault, a synclinal feature related to the southern limb of the Cochran Arch, or a paleotopographical feature. As further work is completed at MEA, more data will become available regarding the potential presence of the proposed Niobrara River Fault. Additional aquifer pumping tests will be conducted to cover all areas to be mined and to demonstrate the natural confinement of the basal sandstone of the Chadron Formation in the southern portion of the MEA.

Diffendal (1994) performed lineament analyses on a mosaic of early Miocene synthetic-aperture radar images and largely confirmed known faults in the vicinity of Chadron. Lineaments in the radar image along Pine Ridge, located to the south of Chadron, are attributed to jointing or faulting and trend N40E and N50W (Diffendal 1982). Similar features were also noted west of Fort Robinson. Swinehart et al. (1985) report that these features are likely an extension of the Wheatland-Whalen trend in Wyoming (Hunt 1981; Wheeler and Crone 2001).

Structural features, such as faults and folds, can be identified and characterized using borehole geophysical data. These data, when correlated and combined with additional borehole data from other nearby holes, provides one of the best methods for identifying and describing the subsurface features. Drill hole density (distance between successive drill holes) must be high enough to provide confidence that any observed potential structure seen between two drill holes is the result of movement along a fault and not the result of erosion, depositional variation, or lateral discontinuity. It is only when many of these individual data points (drill holes) are plotted together along with other observations that they can be interpreted to discover the presence of these hidden features. As drilling density increases, the minimum size of offset required for detection decreases. Within MEA, the drill holes are located mostly on 100-foot centers with scattered areas of greater density. CBR estimates that with this density of drilling, it would require an offset of at least 10 to 15 feet to be obviously notable, and the offsets would need to be noted within multiple holes across more than a single horizon.

Former drilling activities at the Crow Butte Project identified a structural feature, referred to as the White River Fault, located between the CPF Class III permit area and the NTEA (**Figure 3.3-16**). Evidence of a fault was identified during the exploration drilling phase of the Crow Butte Project (Collings and Knode 1984). The fault is manifested in the vicinity of the NTEA as a significant northeast-trending, subsurface fold. The detailed kinematics of the White River Fault were investigated during preparation of the NTEA Petition for Aquifer Exemption. An extensive review of drilling and logging data determined that, while the White River Fault may cut the Pierre Shale at depth along with stratigraphically lower units, there is no evidence that a fault offsets the geologic contact between the Pierre Shale and overlying White River

Group or individual members of the White River Group. This fault does not appear to be present in the vicinity of the MEA.

Pine Ridge Fault

Approximately 5 miles (8 km) north of the MEA is the inferred Pine Ridge Fault, located along the northern edge of the Pine Ridge Escarpment (**Figure 3.3-16**). The east-west trending fault is inferred from several lines of evidence, but no detailed study of it has yet been published. The fault was initially proposed by DeGraw (1969) based on subsurface data, which indicated the presence of a normal fault with north side down displacement of about 300 feet. The fault is sub-parallel to the Cochran Arch (**Figure 3.3-16**). Swinehart et al. (1985) reported normal faulting along the feature that post-dates the Upper Harrison (Arikaree Group).

CBR geologists have reviewed the available drill data in an attempt to substantiate the presence of the inferred Pine Ridge Fault, and if present, to determine the extent and impact of this fault on operations. The depth to the contact between the Pierre Shale and overlying Chadron Formation was determined using the single point resistance on geophysical logs. Cross-sections were prepared for the TCEA Class III UIC Permit application, are 9 to 10 miles (14.5 and 16 km, respectively) northwest of the MEA, and show the contact surface elevations.

Three of the five the cross-sections constructed south of the CPF and TCEA permit boundaries do not support the presence of the Pine Ridge Fault within the AOR for the TCEA permit as inferred by DeGraw (1969), nor do they support the presence within the MEA AOR. These cross-sections are included in this application as **Appendix X**. The cross-sections do not substantiate a reported north side down vertical displacement of 300 feet, and in two of the cross-sections, the top of the Pierre Shale surface elevations decrease southward, which is contradictory to a north side down vertical displacement. The cross-sections presented in **Appendix X** show that gentle increases in the elevation for the top of the Pierre Shale are most likely a result of topographic lows on the eroded surface of the Pierre Shale or structural dip due to flexing associated with the formation of the Crawford Basin. Given the magnitude of folding observed elsewhere in the Crawford Basin, it is entirely feasible that displacement along an inferred fault would not be required to explain observed elevation changes for the top surface of the Pierre Shale. As none of the cross-sections completed for the TCEA Class III UIC Permit, nor do those completed for the MEA show indications of the Pine Ridge Fault, it is logical to conclude that the MEA and the MEA AOR are not affected by this supposed fault.

3.3.1.4 Seismology

National Seismic Hazard Maps and Risks

The USGS updated the National Seismic Hazard Maps in 2008, which includes changes in the methodology used to model potential seismicity in any given region (Petersen et al. 2008). Wheeler and Crone (2001) described Quaternary fault zones and their potential seismic activity. Their findings were used to develop the prior National Seismic Hazard Map. The revised maps incorporate new seismic, geologic, and geodetic information on earthquake rates and associated ground shaking. The maps supersede versions released in 1996 and 2002. The next update to the National Seismic Hazard Maps is scheduled for 2014.

The National Hazard Maps show the distribution of earthquake shaking levels that have a certain probability of occurring in the U.S. (**Figure 3.3-17**; USGS 2009g). The hazard rating ranges from the lowest hazard (0.4 %g) to the highest (64+ %g), with the City of Crawford area and the majority of

Nebraska being located in a low hazard ranking level of 4 to 8 %g. The term "%g" is a unit of acceleration (movement of earth) measured in terms of gravity (g) (i.e., acceleration due to gravity). Peak acceleration (%g) refers to the maximum acceleration (movement) experienced during a non-uniform earthquake event (i.e., starts off small, achieves a maximum, and then decreases).

The seismic hazard map for Nebraska (**Figure 3.3-18)**, represents the %g with a 2 percent probability of exceedances in 50 years (USGS 2009a), meaning that, in a given 50-year period, there is only a 2 percent chance of seismic shaking exceeding any given equivalent percentage of acceleration due to Earth's gravity. **Figure 3.3-18** also shows that the modeled peak acceleration due to seismic shaking in the City of Crawford area is very low (6 to 8 %g for the majority of the immediate area and 8 to 10 %g in a much smaller area), meaning that the maximum shaking due to any given earthquake in the region during a 50-year period would be equivalent to only 10 percent or less of the force of gravity at Earth's surface. These estimates demonstrate that the Marsland and City of Crawford area are at the low end of the USGS' hazard ranking system for earthquake risks. Note that the differences between **Figures 3.3-17** and 3**.3-18** in hazard ranking values are due to the use of different scales (i.e., 4 to 8 versus 6 to 8, respectively).

Earthquake Magnitude and Intensity

Earthquakes release different amounts of energy and the strength of this energy can be measured by magnitude and intensity (CDERA 2009*)*. A comparison of the magnitude and intensity scales is shown in **Table 3.3-4** as well as the USGS abbreviated descriptions of the 12 levels on the Modified Mercalli (MM) scale. The Richter Scale is used to measure the magnitude of an earthquake and is a measure of the physical energy released or the vibrational energy associated with the earthquake. In general, earthquakes below 4.0 on the Richter scale do not cause damage, and earthquakes below 2.0 usually cannot be felt. However, earthquakes rated higher than 5.0 on the Richter Scale can cause damage. An earthquake of a magnitude 6.0 is considered strong, and a magnitude of 7.0 is considered a major earthquake.

The MM scale measures the intensity of an earthquake, and consists of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction (USGS 2009b). It is an arbitrary ranking by the USGS based on observed effects rather than mathematics.

For states in the U.S. that had reported earthquakes with a magnitude of 3.5 or greater from 1974 to 2003, the State of Nebraska had a total of eight (less than 0.05 percent of the total of 21,080 earthquakes occurring in the U.S; USGS 2009d). **Figure 3.3-18** is a seismic hazard map of Nebraska (USGS 2009e). A seismicity map of Nebraska that shows the distribution of earthquakes from 1973 to 2013 is shown on **Figure 3.3-19**.

The first significant earthquake recorded in Nebraska occurred on April 24, 1867, apparently centered near Lawrence, Kansas. It affected an estimated area of 301,159 square miles (mi^2) (780,000 square kilometers [km^2]) including much of Nebraska. Since 1867, there have been at least seven earthquakes of MM Intensity V or greater originating within Nebraska's boundaries. It is thought that the strongest earthquake in Nebraska occurred on November 15, 1877. The total area affected was approximately 138,996 mi^2 (360,000 km^2) including most of Nebraska. The most recent earthquake occurred on November 18, 2010 (depth of 3.1 miles [5 km]), approximately 15 miles (24.1 km) east-southeast of Columbus, Nebraska in Platte County, east central Nebraska (lat. 41.37N long. 97.07W). The magnitude of this earthquake was 3.3 on the Richter Scale. The epicenter was approximately 326 miles (525 km) east southeast of the City of Crawford.

Earthquakes along the Chadron and Cambridge Arches in Western Nebraska

The locations of the Chadron and Cambridge Arches in Nebraska are shown on **Figure 3.3-15**. Earthquakes that have occurred in Nebraska in the vicinity of the Chadron and Cambridge Arches from 1884 to 2009 are identified in **Table 3.3-5** The MM Intensity of these earthquakes ranged from I to VI, with the majority between I and III. The strongest of these earthquakes centered in Dawes County (near Chadron) occurred July 30, 1934 with an intensity of VI. It affected an estimated area of approximately 23,166 mi^2 (60,000 km^2) in Nebraska, South Dakota, and Wyoming. This earthquake resulted in damaged chimneys, plaster, and china. An earthquake that occurred on March 24, 1938 near Fort Robinson had an intensity of IV; no additional information is available. An Intensity IV earthquake should be felt indoors by many and cause dishes, windows, and doors to be disturbed. An earthquake occurred on March 9, 1963 near Chadron and was reported to last about 1 second. It was not accompanied by any damage or noise and was not even noticed by many of the residents of Chadron. An earthquake occurred on March 28, 1964 near Merriman, the vibrations from which lasted about 1 minute and caused much alarm, but no major damage occurred. Books were knocked off shelves, and closet and cupboard doors swung open. On May 7, 1978, an earthquake with Intensity V occurred in southwestern Cherry County, also near the Chadron Arch. No major damage was reported from this earthquake.

Earthquakes occurring from 1992 through 2007 within 125 miles (201.2 km) of the City of Crawford, in Wyoming, and South Dakota are shown in **Table 3.3-6**. The Richter Scale measurements ranged from 3.0 to 3.8 for Wyoming and 2.5 to 4.0 for South Dakota. The MM Intensity values for Wyoming ranged from II to IV, with all but one of the nine observations ranging from II to III. The MM Intensity values for South Dakota ranged from I to IV, with all but one of the total observations ranging from I to III. The most recent earthquake within the region occurred on November 19, 2011, in South Dakota with the epicenter located 30 miles (48.3 km) west-northwest of the City of Chadron. The earthquake had a magnitude of 2.8 with a depth of approximately 3.0 miles (4.9 km). The most recent earthquake in Wyoming occurred on November 19, 2011 and was located 69 miles (111.0 km) north of Jackson, Wyoming, a significant distance from the City of Crawford. It had a magnitude reading of 1.7 with a depth of approximately 1.0 mile (1.2 km).

Although the risk of major earthquakes in Dawes County and the State of Nebraska is low (Burchett 1990), some low to moderate tectonic activity has occurred (Rothe 1981). This tectonic movement is also suggested by geomorphic and sedimentation patterns during the Pleistocene (Rothe 1981), which reflect such movement. Previous seismic activity along the Cambridge Arch has been reported as possibly related secondary recovery of oil in the Sleepy Hollow oil field located in Red Willow County in southwest Nebraska (Rothe et al. 1981). However, deeper events suggest more recent low-level tectonic activity on the Chadron and Cambridge Arches.

Based on information discussed above, and the historical records for the proposed MEA in northwest Nebraska, no major effects would be expected from earthquakes on ISR activities in the MEA area.

3.3.1.5 Inventory of Economically Significant Deposits and Paleontological Resources

According to the NOGCC there has never been any oil and gas production in Dawes County (NOGCC 2013a). There are no current applications for permits to drill in Dawes County. Two wells are currently producing in Sioux County, but are located at a significant distance southwest of MEA in section 8 Township 25 North, Range 55 West and section 11 Township 25 North, Range 56 West (NOGCC 2011). The only non-fuel mineral produced in Dawes County is sand and gravel. Coal is not produced anywhere

in Nebraska (NOGCC 2013b), nor are coal beds expected to be encountered during drilling within the MEA.

Significant fossil resources, particularly mammalian, are recognized from the Arikaree Group and White River Group in northwestern Nebraska (Hunt 1981; LaGarry et al. 1996; Terry and LaGarry 1998; Tedford et al. 2004). The White River Group, Arikaree Group, and Ogallala Formation are all ranked as Class 5 geologic units in Wyoming under the Potential Fossil Yield Classification (PFYC) System (BLM 2008). Class 5 units are highly fossiliferous geologic units that predictably produce vertebrate fossils or scientifically significant invertebrate or plant fossils that are at risk of human-caused adverse impacts or natural degradation (BLM 2009). PFYC rankings have not been assigned for Nebraska, but due to the abundance of fossils known from these units nearby, similar potential for scientifically significant paleontological resources can be reasonably inferred.

Several quarries near Agate Fossil Beds National Monument, located in Sioux County, contain Miocene mammals. The sites are located about 25 miles (40.2 km) from the MEA. Mammalian orders represented within the upper Harrison Beds and the Harrison-Monroe Creek Formation include Carnivora, Canidae, Amphicyonidae, Ursidae, Mustelidae, Perissodactyla, and Artiodactyla. Fossilized terrestrial beaver burrows called *Daemonelix* are also found in these units (Hunt 1981; NPS 2010). Brontothere (ancient rhinoceros) fossils have been identified in the basal sandstone of the Chadron Formation (Chamberlin Pass Formation) of Sioux County (LaGarry et al. 1996).

3.3.1.6 Soils

The current Crow Butte License Area and the MEA are located in the semiarid northwest region of Nebraska in southern Dawes County. Climate is semiarid (precipitation averages approximately 18 inches per year; SCS 1977). Physiographically, the MEA is located along the southern flank of Pine Ridge, an area of steep, dissected terrain. The numerous drainages present within and adjacent to the MEA are tributary to the Niobrara River, located immediately to the south. Box Butte is located south of the Niobrara River and is slightly lower than but topographically similar to Pine Ridge. Native vegetative cover in the Pine Ridge region is typically mixed-grass prairie and Ponderosa pine trees, but varies across the MEA, with significant areas that are currently cultivated or are degraded rangeland.

An investigation of MEA soils included review of available published soils data. Soils data for the MEA were obtained from the United States Department of Agriculture (USDA), NRCS Web Soil Survey (SSS 2011). The sources for the Dawes County soils data available from the Web Soil Survey include the Soil Survey of Dawes County, Nebraska, published in February 1977 (SCS 1977), and updated unpublished materials derived from remote sensing images and other digitized soils mapping of Dawes County. Thirty-one soil map units are identified in the project area. Their spatial distributions are illustrated on **Figure 3.3-20**, and their aerial extents summarized in **Table 3.3-7**.

Soils in the MEA formed through the weathering of Tertiary bedrock material, loess (windblown silt), colluvium, or unconsolidated alluvium. Soils in the project area are shallow to deep silt loams and loamy very fine sands. Soil depth, grain size, and drainage typically increase closer to the Niobrara River and away from the steeper uplands of the MEA (SCS 1977).

Due to the loamy and fine sandy texture of most soils in the MEA, wind and water erosion pose the most significant risks to soil health and productivity, especially where vegetation has been disturbed. These soil textures also dictate the good drainage and high infiltration rates characteristic of most soils in the MEA.

From specific to general, the MEA landscape is composed of various soil series (soils with similar profiles), complexes (two or more series or miscellaneous areas that cannot be mapped separately), and associations (two or more geographically associated series or miscellaneous areas that have a consistent pattern and relative proportion of soils). In certain areas, the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These areas are called land types and are given descriptive names. An example of this is "sandy alluvial land" found within the Busher-Tassel-Vetal association. The General Soil Map of Dawes County, Nebraska (SCS 1977) illustrates the three soil associations that dominate the MEA, which are generally segregated north-to-south according to topographic and physiographic regimes and parent material. The three soil associations described below are not depicted on **Figure 3.3-20**; however, the individual components of each association are illustrated and described fully later in this section.

The Canyon-Alliance-Rosebud soil association is generally found in the northern portion of the MEA and makes up approximately 40 percent of the project area. This upland soil association consists of "deep to shallow, gently sloping to steep, well-drained loamy and silty soils that formed in material weathered from sandstone" (SCS 1977). Canyon series soils make up about 25 percent of this association, Alliance series soils about 24 percent, and Rosebud series soils about 16 percent. Minor soils and land types make up the remaining 35 percent (SCS 1977).

The Busher-Tassel-Vetal soil association is the most extensive within the MEA (35 percent of the project area) and is found on uplands and footslopes. This soil association consists of "deep and shallow, very gently sloping to steep, well-drained to somewhat excessively-drained, sandy soils that formed in colluvium and in material weathered from sandstone". Busher series soils make up about 35 percent of this association, Tassel series soils about 32 percent, and Vetal series soils about 15 percent. Minor soils and land types make up the remaining 18 percent (SCS 1977).

The Valent-Dwyer-Jayem soil association makes up about 25 percent of the project area and is typically found in uplands adjacent to the Niobrara River in the southern portion of the MEA. This soil association consists of "deep, gently sloping to steep, well-drained to excessively-drained sandy soils". Together, the Valent and Dwyer series soils (which are typically mapped as one unit) make up 68 percent of the association, with Jayem series soils and minor soils and land types both making up about 16 percent each (SCS 1977).

Soil Limitation

The NRCS characterizes soil mapping units and their limitations for a variety of uses based on a wide range of properties such as soil texture, slope, and thickness. In general, MEA soils are moderately to highly susceptible to water erosion, with K-factors (for all soil horizons) of dominant soil map units ranging from 0.15 to 0.55. Hazards for water erosion are lowest in the southern MEA and generally increase uphill and away from the Niobrara River. Hazards for wind erosion are generally high to moderately high within the proposed MUs. Exceptions include MU 6 and portions of MU 1, where the hazard is moderate. MEA soils are particularly susceptible to wind erosion where vegetation cover has been removed.

Almost all soils in the MEA have severe or moderate potential for rutting and compaction, and have limited suitability as natural road surfaces. Due to the high susceptibilities for wind and water erosion prevalent across the MEA, most soils are susceptible to degradation during disturbance. However, almost all MEA soils likely to be disturbed by project activities are also considered highly resilient (i.e., inherent ability to recover degradation) and have high potential for successful restoration. The Tassel soils and

Canyon soils in the northern MEA have moderate, or generally favorable, characteristics for restoration. Soil resilience and restoration potential is dependent upon adequate organic matter content, soil structure, low sodium levels, and other factors (SSS 2011).

Soil Range Classifications

Most land within the MEA is currently used for rangeland. Different soil units support different types and proportions of rangeland vegetation. Knowledge of which types of vegetation represent healthy or poor rangeland conditions facilitates evaluation of restoration efforts and selection of revegetation seed mixes. Five major rangeland site classifications are present within the MEA and are described below: sandy, savannah, shallow limey, silty, and subirrigated. Minor acreages of sandy lowland, shallow to gravel, silty overflow, and mixed rangelands are also present but are not described. Decreaser plants form the majority of climax cover in all range sites (SCS 1977).

Sandy Range Site

Map units 1881, 1882, 5070, 5978, 6091, and portions of unit 5118 are classified as sandy range. Moderately rapid to rapid permeability of the soils heavily influences vegetation types on these soils. A typical climax plant community is about a 50 percent mixture of decreaser plants such as sand bluestem, little bluestem, and prairie junegrass. The remaining 50 percent is perennial grass, forbs, and shrubs. The principal increasers are blue grama, threadleaf sedge, prairie sandreed, needle-and-thread, sand dropseed, western wheatgrass, fringed sagewort, and small soapweed. A site in poor condition will commonly have blue grama, threadleaf sage, sand dropseed, and western ragweed.

Savannah Range Site

Only map unit 5153 is classified as savannah range; however, this range site makes up approximately 10 percent of the MEA. The types of vegetation that occur on this range site are primarily influenced by the wide variations in soil depth, available water capacity, and relief. About 65 percent of climax plant cover is a mixture of such decreaser grasses as little bluestem, big bluestem, side-oats grama, plains muhly, green needlegrass, prairie junegrass, slender wheatgrass, bearded wheatgrass, and western wheatgrass. About 35 percent consists of other perennial grasses, forbs, shrubs, and trees. A site in poor condition typically consists of Ponderosa pine and various species of shrubs and vines.

Shallow Limey Range Site

Map units 5152; 6028; and portions of units 1742, 5118, 5211, and 6043 are classified as shallow limey range sites. The alkaline nature of these soils, along with very low to low available water capacity and shallow rooting depths, influences vegetation types on these soils. Approximately 75 percent of climax plant cover is a mixture of decreaser grasses such as little bluestem, sand bluestem, side-oats grama, needle-and-thread, prairie sandreed, plains muhly, and western wheatgrass. Perennial grasses, forbs, and shrubs make up the remaining 25 percent. These increasers include blue grama, hairy grama, threadleaf sedge, fringed sagewort, common prickly pear, broom snakeweed, skunkbush sumac, and western snowberry.

Silty Range Site

Map units 1356, 1357, 1620, 5105, 5106, 5107, 5200, 5871, and 5947 are classified as silty range sites. The vegetation which grows on these sites is influenced mainly by the moderately slow or moderate permeability of the soils and by their moderate to high available water capacity. About 50 percent of the climax plant cover is a mixture of such decreaser grasses as big bluestem, little bluestem, side-oats grama,

western wheatgrass, and prairie junegrass. About 50 percent consists of other perennial grasses, forbs, and shrubs. Blue grama; buffalograss; threadleaf sedge; needle-and-thread; Arkansas rose; and numerous forbs such as dotted gayfeather, false boneset, heath aster, skeletonplant, and scarlet globemallow are the principal increasers. A site in poor condition will typically have blue grama, buffalograss, threadleaf sedge, and sand dropseed.

Subirrigated Range Site

Bankard series soils within the MEA (units 1013 and 1014) are classified as subirrigated range sites. The water table in this range site is typically at a depth of 2 feet in the spring and 6 feet in the early fall. Moisture available from the high water table during the growing season is the main influence on vegetation types on these sites. About 70 percent of the climax cover is a mixture of such decreaser grasses as big bluestem, little bluestem, indiangrass, switchgrass, prairie cordgrass, and Canada wildrye. About 30 percent consists of other perennial grasses such as Kentucky bluegrass, green muhly, western wheatgrass, and sedges. A site in poor condition will typically have Kentucky bluegrass, redtop, foxtail barley, dandelion, western ragweed, blue verbena, and lesser amounts of western wheatgrass and sedges.

Soil Mapping Units

As defined by the NRCS, a map unit is identified and named according to the taxonomic classification of the dominant soils. Map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. **Table 3.3-7** summarizes the soils in map units found within the MEA. The table provides the map unit symbols, map unit names, and estimated acres of the dominant soils in the MEA. The description of each soil mapping unit includes the potential for wind erosion, water erosion, the farmland classification, and the hydric rating. The farmland classification identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland by identifying which soils are best suited to food, feed, fiber, forage, and oilseed crops. The hydric rating indicates the proportion of the map units that meets the criteria for hydric soils, which are an indicator for wetlands. The soils in the MEA are also shown as soil map units on **Figure 3.3-20**.

Soil map units illustrated on **Figure 3.3-20** consist of soil series, soil complexes, and soil associations, as described above. In addition, certain soil map units represent undifferentiated soil groups made up of two or more soils that could be delineated individually but are shown as one unit because similar interpretations can be made for use and management. The name states the two dominant soil series represented in the group, joined by “and”. Four soil map units within the MEA (1742, 5118, 5211, and 6043) are soil complexes, two soil map units (1882 and 5070) are undifferentiated soil groups, and one soil map unit (6043) is a soil association with minor distribution within the MEA (**Figure 3.3-20)**. The remaining soil map units represent soil series.

The following section describes the soil series and mapping units for those soils in Dawes County which occur within the MEA as shown on **Figure 3.3-20**. Soil map units 1014, 1356, 1882, 5105, 5126, and 5153 (depicted on **Figure 3.3-20**) are composite map units consisting of multiple NRCS units. All units combined are either divisions of the same soil series, complex, group, or association and were combined to provide a less complex soil map. The map unit number used to label composite map units on **Figure 3.3-20**represents the NRCS map unit with the greatest extent within the Proposed MEA. Soil map units that represent combined NRCS map units are noted below, and their constituent NRCS map units are described individually. The descriptions of soil map units that occur within the MEA, as shown on **Figure 3.3-20** and listed in **Table 3.3-7** are extracted from the NRCS custom Soil Resource Report as provided by the NRCS Web Soil Survey.

Bankard Series Soils

The Bankard series consists of deep, somewhat poorly drained soils that formed in sandy alluvium on bottom lands along tributaries to the Niobrara River. Slopes range from 0 to 2 percent. Within the MEA, the water table is typically at a depth of 2 to 4 feet, and soils are occasionally frequently flooded. Permeability is rapid, and available water capacity is low. Natural fertility is medium to low, and organic matter content is low. Runoff is slow. Although suited for irrigation, most areas of Bankard series soils are in areas of native grass used for hay or grazing. These soils are not considered prime farmland. They are partially hydric. Bankard soils comprise approximately 7 percent of the MEA. They are mapped as composite unit 1014 on **Figure 3.3-20** and include the following map units:

1013 – Bankard loamy coarse sand, frequently flooded

This soil is found in bottom lands in the southern portion of the MEA. It is similar to unit 1014 as described below, but is formed in coarser grained alluvial material. Approximately 127 acres of this soil unit are present in the MEA.

1014 – Bankard loamy fine sand, frequently flooded

This soil is found in bottom lands in the MEA. It is similar to other frequently flooded Bankard soils. Some areas are strongly affected by salts and alkali, and salts are visible on the surface in early spring. This soil is marginal for cultivation of alfalfa and forage crops, and drainage systems are necessary to lower the water table in this unit prior to irrigation. Deep-rooted dryfarmed crops benefit from the high water table during dry periods. Soil blowing is a hazard if the soil surface is not protected. Approximately 189 acres of this soil unit are present in the MEA.

Glenberg Series Soils

The Glenberg series consists of very deep, well drained soils that formed in stratified calcareous alluvium on floodplains and river terraces. Slopes range from 0 to 8 percent. Permeability is rapid, and available water capacity is moderate. Natural fertility and organic content are moderate to low. Glenberg series soils are suitable for dryfarming and irrigated farming. Because they are restricted to steeper areas near drainages, only portions of the Glenberg soils within the MEA are currently cultivated. Glenberg soils comprise less than 1 percent of the MEA and include the following map unit:

1036 – Glenberg loamy very fine sand, 0 to 3 percent slopes

This map unit is located on high bottom land areas that are seldom flooded. A lime layer may be present at the surface, and stratification may be less distinct than in other Glenberg soils. Soil blowing is a hazard if the soil is unprotected. Runoff is slow. This map unit is dryfarmed for wheat, oats, and alfalfa and irrigated for alfalfa to a lesser extent. This map unit occurs in areas as large as 100 acres. Approximately 8.5 acres of this soil unit are present within the MEA.

Bridget Series Soils

The Bridget series consists of deep, well drained soils that formed in loamy colluvial and alluvial sediment on foot slopes and stream terraces. Permeability is moderate, and available water capacity is high. Natural fertility is medium, and organic matter content is moderate. In areas where slopes are less than 9 percent, these soils are used mostly for cultivated dryfarmed wheat, oats, or alfalfa. These soils are prime farmland if irrigated. The Bridget soils present within the MEA are partially hydric. Bridget series soils comprise approximately 8 percent of the MEA. They are mapped as composite map unit 1356 on **Figure 3.3-17** and include the following map units:

1356 – Bridget silt loam, 1 to 3 percent slopes

This soil occurs in areas as large as 500 acres on foot slopes and stream terraces near large drainages. Minor areas in higher landscape positions may have a fine sandy loam surface layer or transitional horizon. This soil is partially hydric. Water erosion and gullying are hazards in areas that receive runoff from adjacent slopes. Soil blowing is a hazard if the soil surface is unprotected. Runoff is slow to medium. Approximately 269 acres of this soil unit are present within the MEA.

1357 – Bridget silt loam, 3 to 6 percent slopes

This soil occurs in areas as large as 200 acres on colluvial foot slopes and uplands. It is similar to map unit 1356, but has a thinner surface layer and occurs on steeper slopes. Bayard, Keith, or Rosebud series soils may make up 25 percent of this unit in the Pine Ridge area. Water erosion is a hazard due to runoff received from adjacent higher areas. Soil blowing is a hazard if the soil surface is unprotected. Runoff is medium. Approximately 105 acres of this soil unit are present within the MEA.

Keith Series Soils

The Keith series consists of deep, well drained soils that formed in loess on uplands and tablelands. Permeability is moderate, and available water capacity is high. Natural fertility is medium, and organic matter content is moderate. Keith series soils are suited for dryfarmed and irrigated crops, primarily winter wheat and alfalfa. These soils are prime farmland if irrigated. Keith series soils comprise approximately 1 percent of the MEA and include the following map unit:

1620 – Keith silt loam, 1 to 3 percent slopes

This soil occurs in areas as large as 500 acres on uplands. The soil profile of this unit is similar to other Keith series soils but has a thicker subsoil and may have a loam or fine sandy loam surface layer. Small areas of Alliance, Duroc, and Richfield soils may be present within this map unit. Water erosion is a hazard in some areas, but soil blowing is the main hazard. Runoff is slow. This soil unit is partially hydric. Approximately 53 acres of this soil unit are present in the MEA.

Rosebud-Canyon Complex Soils

The Rosebud-Canyon soil complex consists of intricately adjoining areas of Rosebud series and Canyon series soils. Rosebud soils are moderately deep, well drained soils that formed in material weathered from sandstone on upland areas. Permeability is moderate, and available water capacity is moderate. Natural fertility is medium, and organic matter content immoderate (excessive). Rosebud soils are suited to both dryfarmed and irrigated crops, such as wheat, oats, and alfalfa. Canyon series soils are described further below. Rosebud-Canyon complex soils comprise approximately 4 percent of the MEA and include the following map unit:

1742 – Rosebud-Canyon loams, 3 to 9 percent slopes

These soils occur in areas as large as 500 acres on gently rolling and rolling uplands. Rosebud soils make up approximately 50 to 70 percent of the map unit, and Canyon soils approximately 15 to 30 percent. Lesser amounts of other soil series make up 10 to 25 percent. Rosebud soils are found on side slopes, and the Canyon soils are on ridgetops and knolls. Soil blowing and water erosion are hazards if these soils are cultivated and the soil surface is not protected. Runoff is medium to rapid, depending on slope gradient and the type and amount of vegetative cover. Canyon soils are shallow, but may be cultivated where adjacent to deeper soils. This soil unit is partially hydric. Approximately 188 acres of this soil unit are present in the MEA.

Valent and Dwyer Group Soils

The Valent and Dwyer soil group consists of intermingled areas of Valent series and Dwyer series soils. Both Valent and Dwyer soils are deep, excessively drained soils that formed in eolian sands on uplands and stream terraces. Both soils have rapid permeability and low available water capacity. Natural fertility and organic matter content of both soils are low. Runoff is slow because both soils absorb water rapidly. Dwyer soils have lime higher in the profile than Valent soils, but are otherwise very similar. These soils are best suited for rangeland grasses, but not for dryland farming. Some irrigated alfalfa is grown in these soils. Both Valent and Dwyer soil units present within the MEA are partially hydric. These soils comprise approximately 23 percent of the MEA. Valent and Dwyer group soils are mapped as composite unit 1882 on **Figure 3.3-20** and include the following units:

1881 – Valent and Dwyer loamy fine sands, 0 to 3 percent slopes

This map unit occurs in areas as large as 200 acres on uplands and stream terraces, either of which may be hummocky. Soil component distribution varies, and some areas consist almost entirely of either soil series or may have both. Dwyer soils may have pebbles on the surface and throughout the profile. Soil blowing is a hazard in cultivated areas. Approximately 284 acres of this soil unit are present in the MEA.

1882 – Valent and Dwyer loamy fine sands, 3 to 20 percent slopes

This map unit occurs in areas as large as 1,000 acres on uplands. It is very similar to map unit 1881, but occurs on steeper slopes. Wind erosion is a very severe hazard if grass is removed, and blowouts occur in some areas. Approximately 786 acres of this soil unit are present in the MEA.

Vetal and Bayard Group Soils

The Vetal and Bayard soil group consists of intermingled areas of Vetal series and Bayard series soils. Both Vetal and Bayard soils are deep, well drained soils that formed in sandy alluvium and colluvium on foot slopes. Vetal soils are found on upland swales, and Bayard soils may be found on stream terraces as well as foot slopes. Both soils have moderately rapid permeability and moderate available water capacity. Natural fertility and organic matter content of both soils are moderate. Bayer soils have a thinner surface horizon than Vetal soils. Both soils are suited for dryfarmed and irrigated crops such as wheat, oats, and alfalfa. These soils are prime farmland if irrigated. Vetal and Bayard group soils comprise approximately 2.4 percent of the MEA and include the following map unit:

5070 – Vetal and Bayard soils, 1 to 6 percent slopes

This map unit occurs in areas as large as 300 acres on foot slopes and stream terraces. Vetal soils make up 55 to 75 percent of the map unit and Bayard soils make up 25 to 45 percent. Areas may be dominated by a single component or may have both present. Soil blowing is a hazard in cultivated areas, and runoff is slow due to rapid absorption of rainfall. Approximately 111 acres of this soil unit are present in the MEA.

Alliance Series Soils

The Alliance series consists of deep, well drained soils that formed in material weathered from sandstone on uplands. Permeability is moderate, and available water capacity is high. Natural fertility is medium, and organic matter content is moderate. These soils are generally suited for dryfarmed and irrigated crops and are prime farmland if irrigated. All Alliance series soils present within the MEA are partially hydric. Alliance series soils comprise approximately 8 percent of the MEA. Alliance series soils are mapped as composite unit 5105 on **Figure 3.3-20** and include the following map units:

5105 – Alliance silt loam, 1 to 3 percent slopes

This map unit occurs in areas as large as 500 acres on smooth upland areas. This map unit is similar to other Alliance series soils but may have lime present below a depth of 30 inches. Small areas of Rosebud, Dwyer, and Richfield series soils may be present. Soil blowing and water erosion are a moderate hazard if the soil surface is not protected. Runoff is slow. Most crops are dryfarmed, and wheat is the primary crop, with lesser amounts of oats and alfalfa. Corn is the main crop in irrigated areas. Approximately 242 acres of this soil unit are present in the MEA.

5106 – Alliance silt loam, 3 to 9 percent slopes

This map unit occurs in areas as large as 300 acres on uplands. The soil profile of this map unit is similar to other Alliance series soils, but has a slightly thinner surface layer. This soil is partially hydric. Water erosion and soil blowing are hazards in cultivated areas. Runoff is medium. This soil is used primarily for rangeland or native grass hay. It is suited for cultivation, but effective management practices and cropping systems are needed to help control erosion. Approximately 88 acres of this soil unit are present in the MEA.

5107 – Alliance silt loam, 3 to 9 percent slopes, eroded

This map unit is similar to unit 5106, but has a surface layer thinner than 7 inches which has been at least partially removed by erosion. Lime may be present at the surface, and the subsoil may be thinner than other Alliance series soils. Slope steepness limits irrigation development. Approximately 29 acres of this soil unit are present in the MEA.

Busher and Tassel Complex Soils

The Busher and Tassel soil complex consists of intricately adjoining areas of Busher series and Tassel series soils on uplands. Busher soils are found on the middle and lower portions of slopes, and Tassel soils are on ridgetops, knolls, and sides of small drainages. This soil unit is not hydric. Busher and Tassel soils are described more completely in this section. Busher and Tassel complex soils comprise approximately 4 percent of the MEA and include the following map unit:

5118 – Busher and Tassel loamy very fine sands, 6 to 20 percent slopes

This map unit occurs in areas as large as 100 acres on uplands. Slopes are mostly from 9 to 20 percent, but may be as low as 6 percent. Busher loamy very fine sand makes up about 60 percent of this unit, and Tassel loamy very fine sand makes up about 40 percent. Areas of shallower soils are present where bedrock is at a depth of 20 to 36 inches. Soil blowing and water erosion are serious hazards if the native grass cover is removed. Runoff is medium. Most of this soil unit is used for native grass rangeland. Approximately 185 acres of this soil unit are present in the MEA.

Busher Series Soils

The Busher series consists of deep, well drained to somewhat excessively drained soils that formed in material weathered from sandstone on uplands. Permeability is moderately rapid, and available water capacity is moderate. Natural fertility is medium to low, and organic matter content is moderate. Soil blowing and water erosion are serious hazards on all Busher series soils if the protective vegetation cover is removed. Where slopes are less than 9 percent, these soils are suited for cultivation and irrigation. Areas with slopes less than 6 percent (map units 5123 and 5124 below) are considered Farmland of Statewide Importance. No other Busher soils are considered prime farmland. Soil units 5123, 5124, and 5128 are partially hydric, but unit 5126 is not. Busher series soils comprise approximately 15 percent of

the MEA. Busher series soils are mapped as composite unit 5136 on **Figure 3.3-20** and include the following map units:

5123 – Busher loamy very fine sand, 1 to 6 percent slopes

This map unit occurs in areas as large as 100 acres on uplands. This unit is similar to other Busher series soils, but may have a surface layer consisting of very fine sandy loam or sandy loam, a transitional layer of loam or very fine sandy loam, or areas of shallower soil where bedrock is at a depth of 20 to 40 inches. Areas of Bridget, Jayem, Vetal, and Tassel soils may be present and make up as much as 15 percent of this unit. Management concerns include conserving soil moisture and maintaining soil fertility. This soil unit typically occurs in areas of native grass. Approximately 142 acres of this soil unit are present in the MEA.

5124 – Busher loamy very fine sand, 1 to 6 percent slopes, eroded

This map unit is similar to unit 5123, but occurs in areas as large as 200 acres and typically has a thinner (4 to 7 inches) surface layer due to erosion. This soil unit typically occurs in areas cultivated for dryfarmed wheat, alfalfa, and oats. Approximately 131 acres of this soil unit are present in the MEA.

5126 – Busher loamy very fine sand, 6 to 9 percent slopes

This map unit occurs in areas as large as 250 acres on uplands. This unit is similar to other Busher series soils, but may have a surface layer thinner than 7 inches and may have lime at a depth of 12 to 18 inches. Areas of Bridget, Jayem, Vetal, and Tassel soils are present and make up as much as 15 percent of this unit. This soil unit typically occurs in areas of native grass. Approximately 162 acres of this soil unit are present in the MEA.

5128 – Busher loamy very fine sand, 6 to 9 percent slopes, eroded

This map unit is similar to unit 5126, but occurs in areas as large as 100 acres and has a surface layer that is 4 to 7 inches thick. Bedrock may be present in areas of shallow soils at a depth of 20 to 36 inches. Small areas of rock outcrop may be present within this unit. This soil is somewhat droughty and typically occurs in areas cultivated for dryfarmed wheat, alfalfa, and oats. Approximately 135 acres of this soil unit are present in the MEA.

5129 – Busher loamy very fine sand, 9 to 20 percent slopes

This map unit occurs in areas as large as 200 acres on uplands. This unit is similar to other Busher series soils, but has a surface layer that is 4 to 7 inches thick and lime at a depth of 10 to 18 inches in places. Bedrock may be present in areas of shallow soils at a depth of 20 to 36 inches. Conserving soil moisture is a major management concern in this soil. Runoff is medium. This unit occurs primarily in areas of native grass. Areas with flatter slopes are cultivated, but the steepness of this unit makes most areas unsuitable. Approximately 141 acres of this soil unit are present in the MEA.

Canyon Series Soils

The Canyon series consists of shallow, well drained soils that formed in material weathered from sandstone on ridges, knolls, and the sides of upland drainages. These soils are found only in the northern half of the MEA. Canyon soils are typically loams that are at 15 inches or shallower. Permeability is moderate, and available water capacity is low. Natural fertility and organic matter content are also low. Because Canyon soils are steep and shallow, cultivation is limited to areas where they are adjacent to deeper, more suitable soils. These soils are not hydric. Canyon series soils comprise approximately 12

percent of the MEA. Canyon series soils are mapped as composite unit 5153 on **Figure 3.3-20** and include the following map units:

5152 – Canyon soils, 3 to 30 percent slopes

This map unit occurs in areas as large as 500 acres. This unit is similar to other Canyon series soils, but has a surface layer that may be silt loam or very fine sandy loam. Bedrock may be present at depths of less than 10 inches. Areas of Bridget, Rosebud, Oglala, and Tassel series soils make up less than 20 percent of this unit. Water erosion and soil blowing are very severe hazards if the soil surface is unprotected. These soils are droughty due to low available water capacity and shallow root zones. Conserving soil moisture is a management concern. Runoff is medium until soils are saturated, and then becomes rapid. This unit is typically found in areas of native grass used for grazing. Approximately 13 acres of this soil unit are present in the MEA.

5153 – Canyon soils, 30 to 50 percent slopes

This map unit occurs in areas as large as 500 acres on the sides of upland drainages. These soils are similar to map unit 5152, but occur in areas of steeper slopes that may also contain rock outcroppings. Very steep slopes, shallowness, and rock outcrops limit the use of these soils to range, woodland, and wildlife habitat. Runoff is very rapid. Approximately 537 acres of this soil unit are present in the MEA.

Oglala Series Soils

The Oglala series consists of deep, well drained soils that formed in material weathered from fine-grained sandstone on the middle and lower parts of side slopes in uplands. These soils are found only in the northern half of the MEA. Oglala soils typically have a loam surface layer overlying a silt loam subsoil. Permeability is moderate, and available water capacity is high. Natural fertility and organic matter content are moderate. In general, these soils are better suited to native grass than cultivation due to steep slopes. These soils are not hydric. Oglala series soils comprise less than 1 percent of the MEA and include the following map unit:

5200 – Oglala loam, 9 to 30 percent slopes

This map unit occurs in areas as large as 200 acres on hillsides. The surface horizon of this unit may be thinner (3 to 6 inches) in areas and lime may be present at depths of less than 20 inches. Areas of Bridget, Canyon, Rosebud, and Ulysses soils may be present and make up less than 15 percent of this unit. Water erosion and soil blowing are hazards if the soil surface is not protected. Runoff is medium to rapid, depending on slope steepness and type and amount of vegetative cover. Most of this unit is used for livestock grazing on native grass. Approximately 2 acres of this soil unit are present in the MEA.

Oglala-Canyon Complex Soils

The Oglala-Canyon soil complex consists of intricately adjoining areas of Oglala series and Canyon series soils on side slopes, ridges, and knolls in the northern portion of the MEA. Oglala soils are found on the middle and lower part of side slopes, and Canyon soils are on ridgetops and knolls. These soils are not hydric. The Oglala-Canyon complex comprises approximately 5 percent of the MEA and includes the following map unit:

5211 – Oglala-Canyon loams, 9 to 20 percent slopes

This map unit is found in areas as large as 1,000 acres. Oglala soils make up approximately 60 to 75 percent of this unit, and Canyon soils approximately 25 to 40 percent. Areas of Bridget, Duroc, Keith, Rosebud, and Ulysses soils may be present and make up 25 percent or less of this unit. Fragments of

sandstone may be present at the surface in some areas. Water erosion is a hazard if the soil surface is not protected. Runoff is medium to rapid, depending on slope steepness and the kind and amount of vegetative cover. This unit is not suited for cultivation and is typically found in areas of native grass. Approximately 236 acres of this soil unit are present in the MEA.

Schamber Series Soils

The Schamber series consists of shallow, somewhat excessively drained soils that occur on escarpments of stream terraces along tributaries of the Niobrara River in the southern portion of the MEA. Schamber series soils typically have a gravelly, very fine sandy loam surface layer and subsoil overlying coarse sandstone gravel at a depth of approximately 12 inches. Permeability is rapid to very rapid, and available water capacity is very low. Natural fertility and organic matter content are low. These soils are not well suited for cultivation and are not hydric. Schamber series soils comprise less than 1 percent of the MEA and include the following map unit:

5254 – Schamber soils, 3 to 30 percent slopes

This map unit is found in areas as large as 50 acres. The surface layer of this unit may be gravelly loam in areas. Areas of deeper soil exist where gravel is present at a depth of 20 to 40 inches. Areas of Keith, Mitchell, and Pierre series soils are present at lower elevations and may comprise up to 15 percent of this unit. Soil blowing and water erosion are hazards if the soil surface is not protected. Runoff is medium to rapid. These soils are typically found in areas of native grass used for grazing. The substrate of these soils may be a useful source of gravel for construction activities. Approximately 13 acres of this soil unit are present in the MEA.

Haverson Series Soils

The Haverson series consists of deep, well drained soils that formed in stratified silty and loamy alluvium on bottom lands and low stream terraces. Areas on very low bottom lands are subject to occasional to frequent flooding. Haverson soils are found only in the northern portion of the MEA. Permeability is moderate to moderately slow, and the available water capacity is high. Natural fertility is medium to low, and organic matter content is low. These soils are rich in lime, which typically occurs at the surface, and are suited for grass and irrigated crops. Haverson soils comprise approximately 1 percent of the MEA and include the following map unit:

5640 – Haverson loam, frequently flooded

This map unit is found in areas of irregular size and shape on low bottom lands and low stream terraces. Flooding frequently occurs due to their low position on the landscape. Areas of Glenberg soils may be included in higher elevation portions of this unit. Flooding is the main hazard and management concern in this unit. Soil blowing can also be a hazard if the soil surface is unprotected. Runoff is slow. Alfalfa is the main crop (where cultivated) and is suited for irrigation if flooding can be controlled. This soil unit is partially hydric. Approximately 50 acres of this soil unit are present in the MEA.

Tripp Series Soils

The Tripp series consists of deep, well drained soils that formed in silty and loamy alluvium on stream terraces along major drainages. Permeability is moderate in the upper part of the subsoil and decreases with depth where lime has accumulated. Available water capacity is high, natural fertility is medium, and organic matter content is moderate. These soils are suited for dryfarming and irrigation. Tripp soils comprise less than 1 percent of the MEA and include the following map unit:

5871 – Tripp silt loam, 1 to 3 percent slopes

This map unit occurs in areas as large as 200 acres on stream terraces in the north-central portion of the MEA. This unit is similar to other Tripp soils, but may be thinner and may have lime at shallower depths. This map unit may include areas of Bayard and Bridget soils at high elevations and Duroc and Halverson soils at low elevations. Soil blowing and water erosion are hazards if the soil surface is not protected. Runoff is slow. If irrigated, this soil is categorized as prime farmland; however, it is mostly used for dryfarming of alfalfa, wheat, and oats. This soil unit is partially hydric. Approximately 20 acres of this soil unit are present in the MEA.

Duroc Series Soils

The Duroc series consists of deep, well drained soils that formed in colluvium and alluvium derived from loess and weathered sandstone. Permeability is moderate, and available water capacity is high. Natural fertility and organic matter content are moderate. These soils are well suited to cultivation and irrigation. Duroc soils are primarily found as minor components of other soil map units within the MEA. Areas mapped as Duroc soils comprise less than 1 percent of the MEA and include the following map unit:

5947 – Duroc very fine sandy loam, 1 to 3 percent slopes

This map unit occurs on the northern boundary of the MEA on a stream terrace. It occurs in areas as large as 300 acres elsewhere in Dawes County. Alliance, Bridget, Keith, Richfield, and Rosebud soils may be associated with this unit at higher elevations. This soil is partially hydric. Runoff is slow. This unit is suited to irrigation but is mostly dryfarmed for wheat, oats, and alfalfa. This soil is prime farmland if irrigated. Less than 1 acre of this soil unit is present in the MEA.

Jayem Series Soils

The Jayem series consists of deep, well drained to somewhat excessively drained soils that formed in eolian sands on uplands. Permeability is moderately rapid, and available water capacity is moderate. Natural fertility and organic matter content are moderate. These soils are suited to both dryfarmed and irrigated crops. Jayem soils comprise less than 1 percent of the MEA and include the following map unit:

5978 – Jayem loamy very fine sand, 1 to 6 percent slopes

This map unit is found in areas as large as 200 acres on uplands. The surface horizon may consist of very fine sandy loam, and lime occurs at a depth of 10 to 26 inches. Areas of Keith, Sarben, and Vetal soils make up less than 15 percent of this unit. Soil blowing is a hazard if the soil surface is unprotected. Runoff is slow due to moderately rapid infiltration of rainfall. This unit is primarily found in areas of native grass used for grazing or hay, but is well suited for irrigation. This unit is considered to be Farmland of Statewide Importance. Wheat and alfalfa are the most commonly cultivated crops. This soil unit is partially hydric. Approximately 11 acres of this soil unit are present in the central portion of the MEA.

Tassel Series Soils

The Tassel series consists of shallow, well drained soils that formed in material weathered from fine grained sandstone on uplands. The surface horizon and subsoil of Tassel soils are typically composed of loamy very fine sand. Permeability is moderately rapid, and available water capacity is very low. Natural fertility and organic matter content are low. The shallow nature of these soils makes them poorly suited for commonly cultivated crops and better suited for range and wildlife habitat. Lime is typically present

at the surface of Tassel series soils. These soils are not hydric. Tassel soils comprise approximately 8 percent of the MEA and include the following map unit:

6028 – Tassel soils, 3 to 30 percent slopes

This map unit is found in areas as large as 500 acres on ridges, knolls, and the sides of upland drainages in the northern and central portions of the MEA. Areas of shallow soils where sandstone occurs at depths of 4 to 10 inches and areas of deeper soils where sandstone occurs at depths of 20 to 40 inches are present within this unit. Small outcrops of sandstone are also included in this unit. Areas of Bayard, Busher, Canyon, Jayem, and Sarben soil comprise up to 20 percent of this unit. Soil blowing is a hazard if the grass cover is removed or damaged. These soils are often droughty, and conserving moisture is a management concern. Runoff is slow to rapid, depending on the slope steepness and type and amount of vegetative cover. This unit is primarily found in areas of native grass used for grazing. Because shallowness and steep slopes make this unit unsuitable for cultivation, it is typically only cultivated where adjacent to deeper soils. Approximately 346 acres of this soil unit are present in the MEA.

Tassel-Ponderosa-Rock Outcrop Association

The Tassel-Ponderosa-Rock outcrop soil association consists of well drained soils mapped together in steep upland areas. Tassel series soils are described above and are found on ridges. Ponderosa series soils are deep, well drained, very fine sandy loams that formed from residuum weathered from fine grained sandstone on side slopes. Available water capacity of Ponderosa soils is moderate, and permeability is high (SSS 2011). Rock outcrops are very shallow, excessively drained weathered sandstone that occur on ridges. These soils are not hydric. This soil association comprises less than 1 percent of the project area and includes the following map unit:

6043 – Tassel-Ponderosa-Rock outcrop association, 9 to 70 percent slopes

This map unit occurs along the western margin of the MEA in areas smaller than 10 acres. These soils have a very high potential for wind and water erosion. Runoff is medium to rapid, depending on the slope steepness, type and amount of cover, and presence of rock outcrops. This association is unsuited for cultivation due to steep slopes and shallow soils. Approximately 1 acre of this soil unit is present in the MEA.

Sarben Series Soils

The Sarben series consists of deep, well drained soils that formed in eolian sands on uplands. Permeability is moderately rapid, and available water capacity is moderate. Natural fertility is medium to low, and organic matter content is low. Lime occurs at a depth of 24 inches. These soils are suited to dryfarming and irrigation and are considered prime farmland if irrigated. Sarben series soils present within the MEA are not hydric. Sarben soils comprise less than 1 percent of the MEA and include the following map unit:

6091 – Sarben fine sandy loam, 1 to 6 percent slopes

This map unit occurs in areas as large as 100 acres on gently rolling uplands in the south-central portion of the MEA. This unit is similar to other Sarben soils, but has lime deeper in the profile and may be deeper than other variations. Soil blowing and water erosion, to a lesser extent, are hazards if vegetative cover is removed. These soils are moderately droughty, and conserving moisture and improving fertility are management concerns. Runoff is slow. Dryfarmed wheat, alfalfa, and oats are the main uses of this unit, but grass for grazing and hay is also cultivated. Approximately 19 acres of this soil unit are present in the MEA.

3.4 Water Resources

3.4.1 Water Use

3.4.1.1 Dawes County

Every 5 years since 1950, the USGS is scheduled to assess U.S. water use (USGS 2005) and includes water use estimates for the State of Nebraska. The latest study examined usage in 2005. The USGS works in cooperation with local, state, and federal environmental agencies to collect and distribute water-use information. For Nebraska water use data, the USGS works in cooperation with the NDNR. The USGS's National Water-Use Information Program is responsible for compiling and disseminating the nation's water-use data (USGS 2013). Every 5 years, the USGS compiles these data at the county level to produce water-use information aggregated at the county, state, and national levels. The next report was scheduled to be issued in 2010, but due to delays, the next report completion and data availability is not expected until 2014 (USGS 2013). The State of Nebraska does not update the data in the above referenced USGS reports, so any more recent data listed in **Table 3.4-1** will not be available until the USGS issues its water-use report in 2014. **Table 3.4-2** was updated to reflected information on non-abandoned registered water wells for Dawes County as of April 8, 2013.

Estimated water use in 2005 for Dawes County, Nebraska is presented in **Table 3.4-1** (USGS 2005). The total 2005 population for Dawes County was 8,636 people, with public supply groundwater and surface water use totaling 2,590,000 gpd. Irrigation using groundwater and surface water accounted for a total of 24,550,000 gpd to irrigate an estimated 13,000 acres. Essentially all of the rural residents of Dawes County use groundwater for their domestic supply.

A summary of the number and types of registered non-abandoned water wells located in Dawes County as of April 8, 2013 is presented in **Table 3.4-2.** Note that this table refers to registered wells. Under current Nebraska law, water supply wells used solely for domestic purposes and completed prior to September 09, 1993 do not have to be registered (NRS 2008). Therefore, there are a number of domestic/agricultural and agricultural unregistered wells located in Dawes County. CBR identifies such wells through interviews with landowners and local drillers.

There are a total of 5,828 registered water wells in Dawes County used for a variety of purposes, as described in **Table 3.4-2**. According to the NDNR, there are a total of 251 domestic and 232 livestock wells located in Dawes County (NDNR 2013a). There are 36 public water supply wells located in Dawes County. Livestock water wells make up the majority of the wells identified in the MEA.

3.4.1.2 Marsland Expansion Area Project Area

The town nearest to the MEA project site is Marsland, Nebraska, which is located approximately 4.6 miles (7.4 km) southwest of the MEA site (centerpoint of Town of Marsland to centerpoint of MEA satellite building). There is no public water supply system for Marsland. The residential homes scattered throughout the MEA area are supplied with domestic water from private wells. Private well use is discussed in more detail below.

In general, groundwater supplies in the vicinity of the MEA are limited due to topography and shallow geology (University of Nebraska-Lincoln 1986). Groundwater quality in the vicinity near the MEA is generally poor (Engberg and Spalding 1978). Locally, groundwater is obtained from the Arikaree and Brule Formations. The primary groundwater supply is the Brule Formation, typically encountered at depths from approximately 50 to 350 feet bgs. In general, the static water level for Brule Formation wells

in the MEA ranges from 50 to 150 feet bgs, depending on local topography (**Figures 3.3-3a** through 3**.3-3n** and **1.4-1**).

Groundwater from the underlying basal sandstone of the Chadron Formation is not used as a domestic supply within the MEA because of the greater depth (800 to 1,150 feet bgs) and inferior water quality. Gosselin et al. (1996) state that: (1) "*the sands near the bottom of the Chadron Formation yield sodium-sulphate water with high total dissolved solids*," and (2) in proximity to "*uranium deposits in the Crawford area, groundwater from the Chadron Formation is not suitable for domestic or livestock purposes because of high radium concentrations*." In addition, it is economically impractical to install water supply wells into the deeper basal sandstone of the Chadron Formation in the vicinity of the MEA, in contrast to the vicinity of the NTEA, where most basal sandstone of the Chadron Formation wells either flow at the surface or have water levels very close to surface elevation because of artesian pressure.

Based on study funded by the American Water Works Association Research Foundation (AWWARF), the average household water use annually (including outdoor) is approximately 409 gpd (Mayer et al. 1999). The results of the study suggested a daily indoor per capita water use of 69.3 gallons. According to the U.S. EPA, the average family of four can use 400 gallons of water every day, and, on average, approximately 70 percent of that water is used indoors (USEPA 2013). Because there is only one occupied residence located within the proposed MEA (NW¼ SW¼ section 7, T29N R50W), total water use would be expected at an average of approximately 400 gpd, using the EPA water use value. Eight occupied residences have been identified within the 2.25-mile (3.62 km) AOR. Therefore, water use would be expected to average at about 3,200 gpd for the entire area. Another source of groundwater consumption in the AOR is private water well use for livestock watering. The Nebraska Resources Conservation Service (NRCS) located in Nebraska uses 0.45 animal unit (AU) per acre and estimate the water consumption to be 15 to 20 gallons per day per animal (Teahon 2013a). An AU is defined as an animal equivalent of 1,000 pounds live weight, with or without an unweaned calf. There is an estimated 27,572.4 acres of rangeland located with the MEA AOR. Based on the NRCS values for calculating livestock water consumption in Dawes County, livestock consumption within the MEA AOR (assuming full utilization), would be 186,114 to 248,152 gallons per day. There are approximately 3,694.6 acres located within the MEA license boundary, and based on the NRCS livestock consumption calculation values, livestock consumption (assuming full utilization of available rangeland acreage) would range from 24,938 to 33,251 gallons per day.

CBR conducted an updated water user survey in 2010 and 2011 to identify and locate all private water supply wells within the 2.25-mile (3.62 km) AOR of the proposed MEA. The water user survey targeted the location, depth, casing size, depth to water, and flowrate of all wells within the area that were (or potentially could be) used as domestic, agricultural, or livestock water supply. **Table 3.4.3** and **Appendix A** list the active and abandoned water supply wells within the MEA and AOR. The locations of all active and abandoned water supply wells are depicted on **Figure 3.4-6** and **6.1-5**. Available NDNR water well registrations within the AOR are presented in **Appendix E-1**, and available well abandonment records in the AOR are provided in **Appendix D-2**. The NDNR's water well retrieval database (NDNR 2013b) was reviewed on September 6, 2013 (Teahon 2013b), and no additional private water supply wells were identified to be installed or modified within the license boundary or AOR since the ER was submitted to the NRC by letter dated May 16, 2012.

There were a total of 134 active and inactive/unknown private water supply wells within the license boundary and associated AOR identified during the water user survey. There are a total of 97 active private water supply wells within the AOR and outside of the licensed boundary (**Table 3.4-3**). Within

this grouping of active private wells, 12 wells are classified as solely agricultural use, four wells are classified as solely domestic use, 13 wells – domestic/livestock, two wells – domestic/garden, one well – domestic/agricultural, and one well domestic/livestock/agricultural), and 63 wells classified as solely livestock use. One additional well has an unknown well use. It should be noted that 18 of these wells have multiple or mixed well use classifications. In terms of aquifer assignments, four wells are assigned to the Arikaree Formation, 35 wells are assigned to the Arikaree/Brule, 30 wells are assigned to the Brule Formation, and 28 wells are unassigned.

Within the MEA, there are a total of 11 active private water supply wells (**Table 3.4-3**). Within this grouping of active private wells, one well is classified as domestic use, ten wells are classified as livestock use, and two wells installed and used by CBR as driller water supply wells, have an “other” well use classification. In terms of aquifer assignments, three wells are assigned to the Arikaree Group, four wells are assigned to the Arikaree/Brule, four wells are assigned to the Brule Formation, and two wells are unassigned. Two wells within the MEA are designated as inactive. The NDNR water well retrieval database uses the code “other” for well uses defined as lake supply, fountain, geothermal, wildlife, wetlands, recreation, plant and lagoon, sprinkler, test, and other uses. (NDNR 2013b). For comparison, the following are water use designations used by the NDNR:

- A Aquaculture
- C Commercial/Industrial]
- D Domestic
- E Pit - Irrigation
- G Ground Heat Exchanger well - Closed Loop Heat Pump well
- H Heat Pump well - Open Loop Heat Pump Well
- I Irrigation
- J Injection
- L Observation (Groundwater Levels)

For well water uses that do not fall within these categories, the “other” well use code is used.

For all of the active private wells described above that remain unassigned to a formation, information provided by the well owner and from nearby wells was insufficient to accurately determine the well completion depth. However, based on discussions with landowners and known completion depths of private water supply wells in the area, these wells have suggested well completions within the Arikaree Group or Brule Formation (**Table 3.4-3**). Well construction and water quality information for these wells is not available in the NDNR water well data retrieval database (NDNR 2011) or known by the well owner. Based on available information, all water supply wells within the MEA and AOR are completed in the relatively shallow Arikaree Group and Brule Formation, with no domestic or agricultural use of groundwater from the basal sandstone of the Chadron Formation (**Figure 3.4-6** and **Table 3.4-3**). Sampling results of these wells by CBR indicate water quality of Arikaree Group and/or Brule Formation aquifers. Based on water quality and the depth of the Arikaree Group and Brule Formation in the MEA Project area, it can be assumed that wells less than 285 feet deep are located in the Arikaree Group and/or Brule Formation.

Two wells completed in the Brule Formation within the MEA are currently designated as inactive. Active private wells within the license boundary and 2 km radius of the license boundary have been sampled quarterly as part of the preoperational/preconstruction monitoring program (PPMP). There are currently 11 active private wells within the license boundary and an additional 41 active private wells within the 2 km radius of the license boundary (**Figures 3.4.-6**, **6.1-5** and **Table 3.4-3**). The preoperational baseline

groundwater sampling and analyses program for the private wells is discussed in Section 6.1.2.1. Sampling of wells is dependent upon landowner approval of access to the wells and condition of the wells.

Based on population projections, future water use within the MEA and AOR will be a continuation of present use (see Section 2.3). There is one irrigation crop circle with a center pivot that extends into the license boundary (SE ¼ section of section 18, T29N R50W; **Figure 3.1-2**). The nearest MUs to the crop circle are MU B and MU C, which are located (at the nearest points) 0.37 and 0.28 mile (0.59 and 0.45 km, respectively) from the crop circle, respectively. This crop circle located within the license boundary may continue to be operated by the landowner, but the pivot will not be operated inside any MEA monitor well ring. There are no other lands within the license boundary that are irrigated, and no additional irrigation within the license boundary will occur during MEA operations. Irrigation within the MEA AOR is anticipated to be consistent with the past. Any further development would be expected to be limited due to limited water supplies, topography, and climate. It is anticipated that the residents of Marsland and surrounding area will continue to use water supplied exclusively by private wells.

By operation of the leases, no new wells will be installed within the license area without CBR permission. The NDNR registered well database will be reviewed annually, and where appropriate, arrangements will be made to monitor any new wells.

In Nebraska, groundwater is subject to a combination of case law and statutory provisions administered by the Upper Niobrara White Natural Resource District and when necessary, the courts (Kelly 2010). Case law has adopted the "rule of reasonable use" in combination with a correlative rights doctrine for allocation among groundwater users in times of shortage. In essence, the owner of land is entitled to groundwater under his land, but the owner may not extract groundwater in excess of reasonable and beneficial use upon the land, especially if such use impacts others who use the same groundwater. If the supply is insufficient for all owners, each is entitled to a reasonable proportion. Because there are no nearby users of basal sandstone of the Chadron Formation groundwater, conflict is unlikely.

3.4.1.3 Wellhead Protection Area

The nearest town to the MEA project site is Marsland, Nebraska. It is located approximately 4.6 miles (7.4 km) southwest of the MEA site (centerpoint of Town of Marsland to centerpoint of MEA satellite building). Marsland is an unincorporated community, with the only business being a U.S. Post Office. There are scattered homesites in the area, with domestic water being supplied by private wells. Approximately eight households and ten people can be found in the immediate area of Marsland (Key to the City 2011). There is no public water supply system; therefore, there is no wellhead protection plan. The other nearest communities to the proposed MEA are the Town of Hemingford and City of Crawford, Nebraska, which are located, centerpoint to centerpoint, approximately 15.4 miles (24.8 km) to the southeast and 15.1 miles (24.3 km) to the northwest, respectively. The City of Crawford and Town of Hemingford have well protection plans in place (NE IDs NE3101303 and NE3104505, respectively). However, these communities are located at a distance from the MEA that precludes any potential impacts from the MEA operations. A horizontal distance of 1,000 feet is the minimum required separation of a city water supply well (used for domestic, irrigation, stock, or heat pump purposes) from potential sources of contamination (NDHHS 2010). The minimum horizontal distances required for additional potential sources of contamination range from 10 to 1,000 feet and are provided in **Table 3.4-4**.

3.4.2 Surface Water

3.4.2.1 Rivers, Creeks, and Drainages

The USGS maintains a hierarchical HUC system that divides the United States into 21 regions, 222 sub-regions, 352 accounting units, and 2,149 cataloging units based on surface hydrologic features or drainages (USGS 2011a). The smallest USGS unit, the 8-digit HUC (or 4th level HUC), averages about 448,000 acres, and is usually the level referred to as an HUC. The Hydrologic Unit system is a standardized watershed classification system. The State of Nebraska's major river basins are shown on **Figure 3.4-1**.

Below the cataloging units, the surface hydrologic features or drainages are further broken down into watersheds and subwatersheds. The MEA project site is located in the following HUC classification system (USGS 2011b):

Region:	Missouri (10)
Sub Region:	Niobrara River: The Niobrara River Basin and the Ponca Creek Basin [Nebraska South Dakota: Wyoming] (1015)
Accounting Unit:	Niobrara River [Nebraska: South Dakota: Wyoming] (101500)
Cataloging Unit:	Niobrara Headwaters [Nebraska: Wyoming] (10150002)
Basin:	Niobrara River (**Figure 3.4-2, Table 3.4-5** [NDEQ 2011a])
Subbasin:	Subbasin N14 (**Figure 3.4-3** [NDEQ 2011a])

The Niobrara Accounting Unit and Niobrara Headwaters Cataloging Unit occupy areas of 13,900 mi^2 (36,001 km^2) and 1,460 mi^2 (3,781.4 km^2), respectively (USGS 2011b). The Niobrara River Basin, with the majority located in Dawes County and the adjacent Sheridan County, is composed of a watershed area of approximately 11,870 mi^2 (30,743.3 km^2) (NDEQ 2005).

There are 25 segments within the Niobrara River Subbasin N14 (**Figure 3.4-3**). The MEA is located within the Niobrara River Subbasin N14, with the southernmost permit boundary being located approximately 0.24 mile (0.4 km) from the Niobrara River in Segment 4000 (**Figure 3.4-3**). The distance from the southern boundary of Mine Unit MU-F (southernmost mine unit in the MEA site) to the nearest point on the Niobrara River is approximately 0.42 mile (0.7 km).

The Niobrara River originates near Mansville, Niobrara County, eastern Wyoming and flows in an east-southeast direction into western Nebraska (**Figure 3.4-4**). The river flows across Sioux County in Nebraska, east through the Agate Fossil Beds National Monument, past Marsland to the south of the proposed MEA project site, and through Box Butte Reservoir. From the reservoir, the river flows east across northern Nebraska, and joins the Snake River approximately 13 miles (20.9 km) southwest of Valentine. The Niobrara River joins the Keya Paha River approximately 6 miles (9.7 km) west of Butte, Nebraska. The river eventually joins the Missouri River northwest of Niobrara, Nebraska in northern Knox County.

Water flow and water quality information on sampling points on the Upper Niobrara River are presented in Sections 6.1.3.1, 6.1.3.2, and 6.1.3.4.

3.4.2.2 Surface Impoundments

Based on available maps and site investigations conducted by CBR, no surface water impoundments, lakes, or surface ponds have been identified within the MEA. Rainfall runoff occasionally creates temporary small pools in a few places on the MEA site, but there is no evidence of persistent stream flow in recent times (HWA 2012).

Box Butte Reservoir is located approximately 3 miles (4.8 km) to the east of the southeast corner of the MEA permit boundary (**Figure 3.4-4**). Box Butte Reservoir Dam is located within Segment 4000 of Subbasin N14. The primary purpose of the reservoir is for irrigation with secondary benefits for recreation, fish, and wildlife (USBR 2008). The Box Butte Reservoir Dam has altered the hydrology of the Niobrara River by diverting water for irrigation (Alexander et al. 2010). The reservoir is part of the Mirage Flats Irrigation Project, which consists of the Box Butte Reservoir, the Dunlap Diversion Dam and associated canal, and laterals to irrigate 11,662 acres (**Figure 3.4-5;** USBR 2008). Dunlap Diversion Dam is located approximately 10 miles (16.1 km) downstream of the Box Butte Reservoir Dam. Average flows below the Box Butte Reservoir Dam are reduced by 90 percent relative to inflow to Box Butte Reservoir, but the river gains significant flow downstream from the Dunlap Diversion Dam, mainly due to groundwater seepage (Bentall and Shaffer 1979).

The Box Butte Reservoir was constructed between 1941 and 1946 and is under the control of the U.S. Bureau of Reclamation (USBR). The total storage capacity of the Box Butte Reservoir is 29,161 acre-feet (USBR 2008) and the pool elevation is 3,997.6 feet. The reservoir occupies approximately 1,600 surface acres with 14 miles (22.5 km) of shoreline. The reservoir has stabilized the agricultural economy of the area that has resulted in larger farm populations and increased employment in related industries. The lake is well suited for recreation activities (aquatic and outdoor sports). Recreation at the reservoir is managed for the USBR by the Nebraska Game and Parks Commission (NGPC).

There are no direct drainages from the MEA project site to the reservoir. Any discharges from the MEA site that could enter the Niobrara River could commingle with river water flowing into Box Butte Reservoir.

The storage capacity of the Box Butte Reservoir is discussed in Section 6.1.3.3.

3.4.3 **Groundwater**

This section describes the regional and local groundwater hydrology including local and regional hydraulic gradient and hydrostratigraphy, hydraulic parameters, baseline water quality conditions, and local groundwater use (including well locations related to the MEA). The discussion is based on information from investigations performed within the MEA, data presented in previous applications/reports for the current CPF where ISR mining is being conducted, the proposed NTEA and TCEA, and the geologic information presented in Section 3.3. In this regard, the hydrogeology of the MEA is expected to be similar in many respects to that encountered in the CPF, NTEA, and TCEA. Groundwater monitoring results and discussions are presented in Section 6.1.2.

The hydrostratigraphic section of interest for MEA includes the following (presented in descending order):

- Alluvium
- Arikaree Group

- Brule Formation (first overlying aquifer in the Orella Member)
- Chadron Formation (Upper Confining Unit including the combined upper and middle Chadron)
- Basal sandstone of the Chadron Formation (Mining Unit)
- Pierre Shale (Lower Confining Unit)

With regard to the CPF, NTEA, TCEA, and MEA in particular, two groundwater sources are of interest in the Crow Butte and surrounding area. These are the Brule Formation sand and the basal sandstone of the Chadron Formation. The basal sandstone of the Chadron Formation contains the uranium mineralization at the CPF, NTEA, TCEA, and MEA.

3.4.3.1 Groundwater Occurrence and Flow Direction

In the vicinity of the MEA, the alluvium, water has been observed in the alluvium, Arikaree Group, Brule Formation, and basal sandstone of the Chadron Formation. Alluvial deposits are discontinuous at MEA and have not been shown to contain usable amounts of water. Of the wells identified in **Table 3.4-3**, none are known to be completed within alluvial deposits, and those that are shallow enough (e.g., less than 50 feet) are understood to be completed within bedrock aquifers. Additionally, except during large storms that produce surface runoff, water within the alluvium is expected to recharge to underlying porous units of the Arikaree Group. Similarly, the Arikaree Group is not typically considered to be a reliable water source; however, the Arikaree Group is locally used for domestic and livestock purposes.

The Arikaree Group and Brule Formation within the MEA meet the NDEQ definition (Nebraska Administrative Code Title 122, Chapter 1, Part 006) of an aquifer: "a geological formation, group of formations, or part of a formation that is capable of yielding a useable amount of water to a well, spring, or other point of discharge." For the purposes of permitting at MEA, alluvium is not considered an aquifer. Likewise, although thin sandstones are present within the upper Chadron Formation, drill cuttings, cores, and geophysical logs have not indicated the presence of water within any portions of the upper Chadron or middle Chadron Formation. As described in Section 3.4.3.3 (confining layer), the upper Chadron and middle Chadron Formation constitute the confining unit between the basal sandstone of the Chadron Formation and overlying aquifers of the Brule Formation and Arikaree Group. Aquifer properties of the basal sandstone of the Chadron Formation are discussed in Section 3.4.3.2 in relation to aquifer pumping tests conducted in 2011.

Hydraulic conductivity for the Arikaree Group and Brule Formation was estimated using particle grain-size distribution data from core samples. Results of the particle size distribution analyses indicate sediments variably dominated by sands, silts, and clays. Hydraulic conductivity estimates were developed using the Kozeny-Carman equation, which is appropriate for sands and silts, but not for cohesive clayey soils with a high degree of plasticity. Published literature validates the use of the Kozeny-Carman equation for fine-grained non-plastic silts (Carrier 2003). For samples that have high plasticity, hydraulic conductivity values are likely overestimated. Therefore, the Kozeny-Carman equation provides a conservative estimate of hydraulic conductivity.

Arikaree Group

The Arikaree Group contains multiple sand-dominated units that may represent locally water-bearing units. In general, these deposits are most likely to occur as buff to gray fine sand without abundant silt and clay within the Upper Harrison Beds, massively bedded, and poorly consolidated fine-grained grey sandstones within the Harrison-Monroe Creek Formation, and coarse- to fine-grained sandstones of the

Gering Formation. Many of the potential water-bearing units have limited lateral extent and are interbedded with low-permeability mudstone units. The lateral and horizontal distribution of these sandy-dominated units are highly variable, as they may range between ten to several hundred feet wide and can be up to 50 feet thick.

In 2013, ten wells were installed across the MEA to acquire Arikaree Group water level (**Table 6.1-7**) and water quality data. Nine of the ten wells encountered measurable water (**Figures 6.1-3** and **6.1-6**). The greatest saturated thickness (78 feet) was observed on the north end of the MEA in well AOW-8 with considerably thinner saturated intervals (0 to 35 feet) observed near the central portion of the project. Saturated thickness increased from the central portion of the MEA southward toward the Niobrara River to approximately 30 to 35 feet. One well (AOW-7), located in the west-central portion of the MEA, did not contain measureable water during well development or monitoring even though a review of the well completion data indicated that the screened interval is below the observed potentiometric surface shown on **Figure 6.1-6**. This well demonstrates the potential for locally restricted groundwater flow and the overall unreliable nature of water within the Arikaree Group observed elsewhere in Dawes and Sioux Counties.

A total of ten core samples have been collected from the Arikaree Group for grain size analysis. Samples were collected from core intervals demonstrating visually observed textural compositions that ranged from siltstones to sandstones. Grain size analysis of core samples collected from the Arikaree Group indicates four samples dominated by sand-sized particles (M-533C Run 1 Sample 1; M-1912C Run 1 Sample 1; M-1912C Run 2 Sample 1; and M-1956C Run 1 Sample 1). Calculated hydraulic conductivity values for these samples range from 1.0×10^{-4} to 2.9×10^{-3} cm/sec. By contrast, the remaining core samples from the Arikaree Group are silt-dominated and have calculated hydraulic conductivity values ranging from 2.3×10^{-5} to 9.2×10^{-5} cm/sec. Based on grain size distributions, the average intrinsic permeability of sand-dominated units within the Arikaree Group is estimated to be approximately 1.5×10^{-6} cm^2.

Brule Formation

Within the Orella Member of the Brule Formation, sandy siltstones, overbank sheet sandstones, and occasional thick channelized sandstones may be locally water-bearing units. These sandstone and siltstone units can be difficult to correlate over any large distance and are often discontinuous lenses rather than laterally continuous strata. The Brule Formation produces widely variable amounts of water at MEA. CBR experience shows that in typical water wells, water flow in the Brule Formation can vary between 0.5 gpm to 50 gpm. At the upper end of the spectrum, agricultural well #732 produces in excess of 800 gpm. This variability in flow rate among wells within the same aquifer makes water production and aquifer thickness difficult to predict. Despite this characteristic, water supply wells are frequently completed in this unit.

At the base of the Orella Member is a channel sandstone that has incised into the underlying upper Chadron and constitutes the first overlying aquifer above the production zone. This 10- to 35-foot thick sandstone is present across the entire MEA, as observed in drill cuttings and geophysical logs. Other sand-rich horizons that may produce water within the Brule are also present above this lower sandstone, but are limited in lateral extent and do not extend across the entire MEA. **Figure 6.1-7b** shows the potentiometric surface as determined by groundwater level gauging of the 11 water wells completed in the Brule Formation. Because the Brule Formation potentiometric surface extends upward into the Arikaree Group, it can be assumed that the entire thickness of the Brule is saturated where local aquifer

properties permit the flow of groundwater. That said, not all stratigraphic horizons of the Brule Formation are capable of producing water in useable quantities.

A total of 12 core samples have been collected from the Brule Formation for grain size analysis, from units demonstrating a range in visually observed textural composition (mudstones to sandstones). However, grain size analysis of core samples collected from the Brule Formation indicate that all 12 samples are dominated by silt-sized particles. The two samples with the highest weight percent of sand (39.31 percent [M-1956C Run 4 Sample 1; 48.09 percent [M-1912C Run 3 Sample 1]) have calculated hydraulic conductivity values of 1.4×10^{-4} cm/sec and 2.3×10^{-4} cm/sec, respectively. By comparison, the geometric mean of all samples collected from the Brule Formation is 9.2×10^{-5} cm/sec. Based on grain size distributions, average intrinsic permeability of Brule Formation core samples is estimated to be approximately 4.2×10^{-7} cm^2.

The coefficient of variation (standard deviation divided by geometric mean) for all Brule Formation samples is an order of magnitude less than for all Arikaree Group samples. This may represent a higher level of lithologic heterogeneity within the Arikaree Group and higher potential for local barriers to groundwater flow to be present.

Baseline groundwater monitoring for private water supply wells and CBR monitor wells (water levels and water quality) is presented in Section 6.1.2.1.

Basal Sandstone of the Chadron Formation

Discussions of the groundwater conditions for the basal sandstone of the Chadron Formation are presented below in Sections 3.4.3.2, 3.4.3.3, 6.1.2.2, and 6.1.2.3.

3.4.3.2 Aquifer Testing and Hydraulic Parameter Identification Information

Prior to initiation of ISR mining activities, the NDEQ regulations require hydrologic testing and baseline water quality sampling. During the initial permitting and development activities within the MEA, an aquifer pumping test was performed between May 16 and May 20, 2011. The final report on pumping test activities in the MEA (Marsland Regional Hydrologic Testing Report – Test #8; Aqui-Ver 2011) is included in **Appendix F**. The pumping test was performed in accordance with the NDEQ approved Regional Pumping Test Plan dated September 27, 2010 (Worley Parsons 2010) and subsequent approved changes to the Regional Pumping Test Plan dated March 16, 2011 (Snowhite 2011). Testing activities and findings from pumping tests in the MEA are summarized below.

Prior to testing activities, CBR installed 14 monitoring wells in the basal sandstone of the Chadron Formation (CPW-2010-1, CPW-2010-1A, Monitor-1, Monitor-2, Monitor-3, Monitor-4, Monitor 4A, Monitor-5, Monitor-6, Monitor-7, Monitor-8, Monitor-9, Monitor-10, and Monitor-11) and nine wells in the Brule Formation (BOW-2010-1, BOW-2010-2, BOW-2010-3, BOW-2010-4, BOW-2010-4A, BOW-2010-5, BOW-2010-6, BOW-2010-7, and BOW-2010-8; **Figure 3.4-7**). Well information for wells used during the 2011 pumping test is summarized in **Table 3.4-7**. Monitor-4 and BOW-2010-4 were abandoned prior to pumping test activities. To assess pre-test baseline water level fluctuations, water level data and barometric pressure data were recorded prior to the pumping period starting on May 6, 2011 for 7 days before initiating the pumping test. The locations of wells used during pumping test #8 are shown on **Figure 3.4-7**. These data were interpreted as representative of static conditions within the aquifer. Based on these data, groundwater in the Brule Formation was interpreted to flow predominantly to the southeast toward the Niobrara River with a lateral hydraulic gradient of 0.011 ft/ft. (**Appendix F**).

To provide baseline groundwater elevation data for the pumping test, static water levels were collected from all 12 wells in the monitoring network on November 12, 2010 from the Brule Formation and the basal sandstone of the Chadron Formation. Water levels ranged from approximately 4,134 to 4,213 feet amsl in the Brule Formation and 3,709 to 3,714 feet amsl in the basal sandstone of the Chadron Formation (**Table 3.4-7**).

Static water levels of the Arikaree Group, Brule Formation, and Chadron Formation measured for existing and new CBR monitor wells in 2013 are discussed in Section 6.1.2.2.1.

As part of the NRC License Amendment Application to conduct ISR operations in the MEA, the 2011 regional groundwater pumping test was designed to accomplish the following:

- Evaluate the degree of hydraulic communication between the production zone pumping well and the surrounding production zone observation wells.
- Evaluate the presence or absence of the production zone aquifer within the test area.
- Assess the hydrologic characteristics of the production zone aquifer within the test area, including the presence or absence of hydraulic boundaries.
- Demonstrate sufficient confinement (hydraulic isolation) between the production zone and the overlying aquifer for the purpose of ISR mining.

The 2011 pumping test was conducted while pumping at CPW-2010-1A at an average discharge rate of 27.08 gpm for 103 hours (4.29 days). Based on the drawdown response observed at the most distant observation well locations (Monitor 2 and Monitor 8), the radius of influence (ROI) during the pumping test was estimated to be in excess of approximately 8,800 feet. More than 0.8 foot of drawdown was achieved during testing in all observation wells completed in the basal sandstone of the Chadron Formation in the observation well network, with a maximum drawdown of 23.40 feet observed in CPW-2010-1A (pumping well) during the test.

The drawdown response measured in all basal sandstone of the Chadron Formation observation wells monitored during the test confirm hydraulic communication between the production zone pumping well and the surrounding observation wells across the entire test area. During the test (pumping and recovery periods), no discernible drawdown or recovery responses attributed to the test were observed in overlying Brule Formation observation wells, which supports the conclusion that adequate confinement exists between the overlying Brule Formation and the basal sandstone of the Chadron Formation.

Drawdown and recovery data collected from observation wells were graphically analyzed to determine the aquifer properties, including transmissivity and storativity. The methods of analysis included the Theis (1935) drawdown and recovery methods and the Jacob Straight-Line Distance-Drawdown method (Cooper and Jacob 1946).

Estimated hydraulic parameters for individual well locations for the 2011 pumping test are summarized in **Table 3.4-7**. Results of the 2011 pumping test within the basal sandstone of the Chadron Formation indicate a mean hydraulic conductivity of 25 feet per day (ft/day) (ranging from 7 to 62 ft/day) or 8.82 x 10^{-3} centimeters per second (cm/sec) based on an average net sand thickness of 40 feet and a mean transmissivity of 1,012 square feet per day (ft^2/day; ranging from 230 to 2,469 ft^2/day). Based on both the drawdown and recovery analyses, hydraulic conductivities of the aquifer materials in the vicinity of the pumping well (CPW-2010-1A, CPW-2010-1, and Monitor-3) were approximately three to nine times greater than hydraulic conductivities estimated for other observation wells in the pumping test area.

An apparent higher conductivity boundary condition effect in these wells was indicated by a flattening of drawdown and recovery curves. Transmissivities for the recovery data were slightly higher than for the drawdown data and are considered more representative of the aquifer properties due to the slight variability in the discharge rate during the drawdown phase of the test. The mean storativity was 2.56 x 10^{-4} (ranging from 1.7 x 10^{-3} to 8.32 x 10^{-5}). Storativity units are a measure of the volumes of water that a permeable unit will absorb or expel from the storage unit per unit of surface area per unit of change in head. Storativity is a dimensionless quantity.

The hydrologic parameters observed at the MEA are consistent with, although slightly higher than, the aquifer properties determined for the areas of the CPF, TCEA, and NTEA (**Table 3.4-8**). No water level changes of concern were observed in any of the overlying wells during testing. The pumping test results demonstrate the following important conclusions:

- The pumping well and all observation wells completed in the basal sandstone of the Chadron Formation exhibited significant and predictable drawdown during the test, demonstrating that the production zone has hydraulic continuity throughout the MEA test area.
- The average transmissivity of the basal sandstone of the Chadron Formation within the portion of the MEA investigated during the test is significantly higher than the areas investigated within the TCEA, NTEA, and existing Crow Butte operations.
- A zone of relatively lower permeability is apparent in the vicinity of the pumping well (CPW-2010-1A) and observation wells CPW-2010-1 and Monitor-3, with significantly higher transmissivity noted elsewhere within the ROI of the test.
- Adequate confinement exists between the overlying Brule Formation and the basal sandstone of the Chadron Formation, as evidenced by no discernible drawdown in the Brule Formation observation wells.
- The hydrologic properties of the basal sandstone of the Chadron Formation have been adequately characterized within the majority of the proposed MEA to proceed with Class III UIC permitting and Nan NRC License Amendment Application for the MEA.

These conclusions indicate that, though variance in thickness and hydraulic conductivity may impact mining operations (e.g., well spacing, completion interval, and injection/production rates), it is not anticipated to impact regulatory issues.

3.4.3.3 Hydrologic Conceptual Model for the Marsland Expansion Area

Tables 3.3-1 and 3.3-2 present the regional and local stratigraphic columns in the vicinity of MEA. As discussed above in Section 3.4.3.1 aquifers within the stratigraphic section present at the MEA include permeable intervals of the Arikaree Group, permeable intervals in the Orella Member of the shallow Brule Formation, and the deeper confined basal sandstone of the Chadron Formation. The upper and lower confining units and the hydrologic conditions for the water-bearing intervals present at the MEA are discussed below.

<u>Confining Layers</u>

Upper confinement for the basal sandstone of the Chadron Formation within the MEA is represented by 650 to 710 feet of smectite-rich mudstone and siltstones of the upper Chadron and middle Chadron (**Figures 3.3-3a** through **3.3-3n, 3.3-8, and 3.3-9**). Particle grain size analyses of six core samples from the upper confining layer within the MEA indicate that all samples were clayey siltstone (**Appendix G-1**

and G-2). XRD analyses indicate that compositions of mudstone and claystone intervals of core samples from the middle Chadron are highly similar to the Pierre Shale (e.g., predominantly mixed-layered illite/smectite or montmorillonite with quartz), which would be expected if the Pierre Shale was a source of materials for the overlying middle Chadron (**Appendix G-2**). As a result, the Brule Formation is vertically and hydraulically isolated from the underlying aquifer proposed for exemption.

Lower confinement for the basal sandstone of the Chadron Formation in the vicinity of the MEA is represented by approximately 750 to more than 1,000 feet of black marine shale deposits of the Pierre Shale. Additional low permeability confining units are represented by the underlying Niobrara Formation, Carlile Shale, Greenhorn Limestone, and Graneros Shale. Together with the Pierre Shale, these underlying low permeability units hydraulically isolate the basal sandstone of the Chadron Formation from the underlying "D", "G", and "J" sandstones of the Dakota Group by more than 1,000 vertical feet (**Table 3.3-1**). The Pierre Shale is not a water-bearing unit, exhibits very low permeability, and is considered a regional aquiclude.

The Pierre Shale consists primarily of illite and smectite clays as indicated by x-ray diffraction of CBR core samples collected in 2011 and 2013 (**Appendix G-1** and **G-2**). The swelling nature of these clays in the presence of water makes it unlikely that any fractures or penetrations within the Pierre Shale would provide a pathway for loss of confinement through this thick unit. Regional estimates of hydraulic conductivity for the Pierre Shale range from 10^{-7} to 10^{-12} cm/sec (Neuzil and Bredehoeft 1980; Neuzil et al. 1982; Neuzil 1993). The Pierre Shale has a measured vertical hydraulic conductivity at the CPF of less than 1×10^{-10} cm/sec (WFC 1983), which is consistent with other studies in the region. Particle grain size analyses of two samples collected from the Pierre Shale within the MEA indicate low permeability silty clay compositions.

The upper surface of the Pierre Shale illustrated on **Figure 3.3-13** and cross-section A-A' (**Figure 3.3-3a**) is a gentle, southeasterly sloping surface consistent with that described by DeGraw (1971). This sloping surface rises northwesterly to the axial crest of the Cochran Arch north of the MEA. Cross-section A-A' does not show evidence of major folding across the axis of the Cochran Arch that could have created significant vertical fractures within the Pierre Shale. Regional studies also indicate that there is no observed transmissivity between vertical fractures in the Pierre Shale, which appear to be short and not interconnected (Neuzil et al. 1982). All oil and gas wells in the area of review that penetrate the Pierre Shale were abandoned in accordance with accepted regulatory practices at that time. Oil and gas well plugging records are provided as **Appendix D-1**.

As described in Section 3.4.31,. estimated hydraulic conductivities for the upper confining unit were developed using particle grain size distribution data from the six core samples collected from the upper Chadron and middle Chadron. Results of the particle size distribution analyses indicate sediments dominated by silts and clays. Estimated hydraulic conductivities of the four core samples collected from within the upper Chadron and middle Chadron ranged from1.7×10^{-5} to 5.9×10^{-5} cm/sec. Estimated hydraulic conductivities of the two core samples collected from within the middle Chadron ranged from 1.7×10^{-5} to 2.9×10^{-5} cm/sec. Hydraulic conductivities for the seven core samples collected from within the Pierre Shale were not estimated by the Kozeny-Carman method due to significant levels (up to 76 weight percent) of clay. The vertical hydraulic conductivity across the upper and lower confining layers is likely to be even lower due to vertical anisotropy. Additionally, hydraulic resistance to vertical flow is expected to be low due to the significant thickness of the upper confining zone within the MEA, which ranges between 650 and 710 ft.

Hydrologic Conditions

A potentiometric map and cross-sections of the basal sandstone of the Chadron Formation indicate confined groundwater flow (**Figures 3.3-3a** through **3.3-3n** and **6.1-8a** and **6.1-8b**). Elevations of the potentiometric surface of the basal sandstone of the Chadron Formation indicate that the recharge zone must be located above a minimum elevation of 3,715 feet amsl. Confined conditions exist at the MEA as a result of an elevated recharge zone most likely located west or southwest of the MEA. The top of the basal sandstone of the Chadron Formation occurs at much lower elevations within the MEA, ranging from approximately 3,210 to 3,290 feet amsl (**Figures 3.3-3a** through **3.3-3n**).

In the vicinity of the MEA, groundwater flow in the basal sandstone of the Chadron Formation is predominantly to the northwest toward the White River drainage at a lateral hydraulic gradient of 0.0004 ft/ft (Aqui-Ver 2011). Regional water level information for the basal sandstone of the Chadron Formation is currently only available in the vicinity of the current production facility and the NTEA, but suggest a discharge point at an elevation of at least 3,700 feet amsl (or below) located east of Crawford, presumably at a location where the basal sandstone of the Chadron Formation is exposed.

Regional water level information for the Brule Formation is currently only available in the vicinity of the current production facility. However, within the MEA, groundwater generally flows to the southeast across the entire MEA toward the Niobrara River at a lateral hydraulic gradient of 0.011 ft/ft (Aqui-Ver 2011). Though the Brule Formation is the primary groundwater supply in the vicinity of the MEA, low production rates indicate that the discontinuous sandstone lenses of the Orella Member may not be hydraulically well connected. Recharge to this unit likely occurs directly within the MEA, as the unit is unconformably overlain by 50 to 210 feet of overlying Arikaree Group and 0 to 30 feet of unconsolidated alluvial and colluvial deposits (depending on local topography). Alluvial deposits along the margins of the Niobrara River may offer limited groundwater storage depending on river levels.

At MEA, groundwater elevations for the Arikaree Group and the Brule Formation are distinctly different from those of the basal sandstone of the Chadron Formation.(**Figures 3.3-3a** through **3.3-3n** and **Table 6.1-7)**. See discussions of water level measurements for CBR monitor wells in Section 6.1.2.2. The available water level data suggest hydrologic isolation of the basal sandstone of the Chadron Formation with respect to the overlying water-bearing intervals in the MEA. This inference is further supported by the difference in geochemical groundwater characteristics between the basal sandstone of the Chadron Formation and the Brule Formation (see Section 6.1.2.3; **Tables 6.1-4**, **6.1-8**, **6.1-9**, **6.1-10** and **6.1-11**).

In summary, the following multiple lines of evidence indicate adequate hydrologic confinement of the basal sandstone of the Chadron Formation within the MEA.

- Results of the May 2011 aquifer pumping test demonstrate no discernible drawdown in the overlying Brule Formation observation wells screened throughout the MEA (see Section 3.4.3.2).
- Large differences in observed hydraulic head (330 to 500 feet) between the Brule Formation and the basal sandstone of the Chadron Formation indicate strong vertically downward gradients and minimal risk of naturally occurring impacts to the overlying Brule Formation (see Section 3.4.3.1).
- Significant historical differences exist in geochemical groundwater characteristics between the basal sandstone of the Chadron Formation and the Brule Formation (Section 6.1.2.3).
- Site-specific XRD analyses, particle grain size distribution analyses, and geophysical logging confirm the presence of a thick (between 650 and 710 feet), laterally continuous upper confining

layer consisting of low permeability mudstone and claystone, and a thick (more than 750 feet), regionally extensive lower confining layer composed of very low permeability black marine shale.

- Analyses of particle size distribution results suggest a maximum estimated hydraulic conductivity of 5.9 x 10^{-5} cm/sec for core samples from the upper confining layer.
- Hydraulic resistance to vertical flow is expected to be low due to the significant thickness of the upper confining zone within the MEA.
- The vertical hydraulic conductivity across the upper and lower confining layers is likely to be even lower than 10^{-5} cm/sec due to vertical anisotropy.

3.4.3.4 Description of the Proposed Mining Operation and Relationship to Site Geology and Hydrology

The basal sandstone of the Chadron Formation is currently mined using ISR techniques within the MUs of the current Crow Butte operations and represents the production zone and target of solution mining in the MEA. Ore-grade uranium deposits underlying the MEA are located in the basal sandstone of the Chadron Formation (**Figure 1.3-1**). The ore body located within the MEA is a stacked roll front system, which occurs at the boundary between the up-dip and oxidized part of a sandstone body and the reduced part of the sandstone body. Stratigraphic thickness of the unit within the MEA ranges from approximately 20 to 110 feet, with an average thickness of approximately 55 feet. The unit occurs at depths ranging from about 817 to 1,130 feet bgs within the MEA (**Figures 3.3-3a** through **3.3-3n**). The competent upper confining layer consists of the overlying middle Chadron and upper Chadron, which are composed of predominantly clay, claystone, and siltstone.

Based on extensive exploration hole data collected to date (more than 1,650 drill locations), the thickness of the upper confining layers in the MEA ranges from 650 to 710 feet (**Figures 3.3-3a** through **3.3-3n and 3.3-8**). Estimated hydraulic conductivities based on particle grain size distribution analyses for site-specific core samples collected within the upper confining layer are on the order of 10^{-5} cm/sec (see Confining Layers above). Geophysical logs from nearby oil and gas wells indicate that the thickness of the Pierre Shale lower confining layer ranges from approximately 750 to more than 1,000 feet (see White River Group in Section 3.3.1.1). The full thickness of the Pierre Shale is not depicted on **Figures 3.3-3a** through **3.3-3n**, as the required scale would obscure stratigraphic details of the overlying White River Group. The Pierre Shale exhibits very low permeabilities on the order of 0.01 millidarcies (md; less than 1 x 10^{-10} cm/sec; Wyoming Fuel Company 1983).

Based on similar regional deposition, the MEA ore body is expected to be similar mineralogically and geochemically to the CPF. The ore bodies in the two areas are within the same geologic unit (i.e., basal sandstone of the Chadron Formation) and have the same mineralization source (see Section 3.3.1.2). The sites are separated by only a few miles, and the cause of mineral deposition in the two areas appears to be similar (see Section 3.31.2). Neither site is anticipated to be affected by any recharge or other processes that would uniquely affect each area, so the groundwater characteristics of the current Crow Butte mineralized zone are presumed to be representative of the MEA. **Tables 3.4-9** through **3.4-11** are the Baseline and Restoration Values for MUs 1 through 3 in the current Crow Butte operations area. The values in these tables are expected to be representative of the geochemical characteristics of the MEA ore body. The MEA ore body, the outline of which is provided on **Figure 1.3-1,** is considered a zone of distinct water quality characteristics primarily due to the presence of relatively concentrated uranium and radium in the zone when compared to the concentrations of these parameters outside of the production zone (e.g., **Tables 6.1-4, 6.1-8** and **6.1-11**).

During the course of mining, the water quality is expected to change as outlined in **Table 3.4-12**. The chemicals used in the mining and recovery process will include $NaHCO_3$, an oxidizer such as O_2, and CO_2. As a result, the greatest changes in water quality are expected to be in alkalinity, bicarbonate, chloride, sodium, conductivity, and TDS. Significant increases are also likely to occur in calcium concentrations as a result of IX with clays. The oxidant will cause significant increases in uranium, vanadium, and radium and minor increases in trace metals such as copper, arsenic, molybdenum, and selenium. The genesis of the ore body and the facies of the host rock at the MEA are similar to that of the current Crow Butte site, so it is probable the change in water quality at the MEA will be similar to that experienced at the current Crow Butte site. Historical restoration activities at the current Crow Butte site have demonstrated the ability to successfully restore groundwater to established restoration standards. Groundwater restoration is discussed in detail in Sections 5.4.1.3 and 5.4.1.4.

The site-specific ISR mining process for the MEA is described in Section 1.3.2.

Net withdrawal within the wellfield must be maintained in order to capture injected mining solutions (see discussion below). Under NDEQ Title 122, Chapter 19, Section 002.02, injection of mining solutions shall not exceed the formation fracture pressure, but must be significant enough to overcome existing pressure heads within the confined aquifer while assuring that the pressure in the injection zone during injection does not cause migration of injection fluids into an underground source of drinking water. From an operations standpoint, procedures must be in place for responding to leaking well casings or well valves. Mechanical integrity testing is conducted following installation of all wells and subsequently every 5 years after a well begins operation. In addition, all wells that have had rig work completed with the drill string entering the well casing will be tested for mechanical integrity before being returned to service. Water quality is sampled bi-weekly at all monitoring well locations, which would detect an excursion (i.e., presence of mining solutions). Contingency plans in the event of well failure are discussed in Section 4.12.3, which may either include identifying and patching the leaking well casing or abandoning the well if the leak cannot be repaired. Well plugging and abandonment procedures are discussed in Section 5.1.3.1.

Maintenance of hydraulic control will be demonstrated by exterior monitoring wells surrounding each wellfield. Planned procedures for monitoring the capture of injected mining solutions are discussed in Sections 1.3.2.6 and 6.2.2.1. These procedures include routine water level measurements in the production zone and overlying water-bearing zones and water quality sampling at monitoring wells every 2 weeks. Any changes in water levels or water quality within the production zone will be evaluated after sample collection to ensure that the system is operating properly and successfully. The proposed procedures will also allow for flowrate adjustments to ensure capture of mining fluids. ISR mining at the MEA will be undertaken via a recirculation system with a close mass balance resulting from the over-production (or bleed) rates. Within the wellfield and its vicinity, there will be local changes in head and flow direction. However, beyond the MEA permit boundary, the magnitude of regional groundwater flow will not be meaningfully affected and will resume to regional flow conditions within a few hundred feet outside the permit boundary. The monitoring procedures proposed in Section 6.2.2.1 are considered an adequate trigger for hydraulic adjustments to the production system in response to increases in pumping by private wells screened in basal sandstone of the Chadron Formation.

The hydrologic properties of the basal sandstone of the Chadron Formation must be known to formulate the best injection/extraction well arrays and for appropriate containment. Based on the pumping rate, test duration, and formation characteristics, the ROI (i.e., the area over which drawdown occurs) can also be determined for a given test. **Tables 3.4-7** and **3.4-8** present relevant hydrologic information based on an

aquifer test performed in the MEA in May 2011, compared with the same properties in the CPF, NTEA, and TCEA. These data indicate that mean transmissivity and hydraulic conductivity at the MEA are more than adequate to successfully develop the MEA for ISR mining activities.

3.4.3.5 Lateral and Vertical Extent of the Proposed Exempt Aquifer

The lateral extent of the area requested being requested by CBR for an aquifer exemption under a separate application to the NDEQ, is shown on **Figure 1.3-1**. The lateral extent of the proposed aquifer exemption is equivalent to the proposed NDEQ Class III UIC Application permit boundary.

The vertical extent of the requested exemption is the full thickness of the basal sandstone of the Chadron Formation, which extends from the top of the Pierre Shale to the base of the middle Chadron (**Table 3.3-2; Figures 3.3-3a** through **3.3-3n**). This vertical extent is slightly different than the vertical extent requested and received in the 1983 Aquifer Exemption Petition for the current Crow Butte operations, which includes the middle Chadron and upper/middle Chadron, but it is similar to the vertical extent requested for the NTEA and TCEA.

3.5 **Ecological Resources**

This section describes the existing ecological resources within the MEA. The potential impacts associated with the proposed project and mitigation measures that would offset such impacts are discussed in Section 4. The analysis consisted of a review of documents, databases, and reports in conjunction with biological field surveys to determine the potential impacts, if any, to special-status plant and wildlife species and their habitats in the proposed expansion area. Pre-existing baseline ecological studies, including field observations, agency contacts, and literature searches, have been conducted for several other uranium ISR projects in the general area of the MEA, including CBR's main processing facility and for the proposed NTEA and TCEA uranium ISR satellite facilities. Baseline studies date from 1982 through 2008 for these project sites. These studies are discussed in more detail in this section. The purpose of the consultations and associated correspondence was to help identify biological issues and potential occurrences and distribution of special-status plants and wildlife and their habitats.

3.5.1 **Regional Setting**

The project area occurs within the Western High Plains Level III ecoregion and is characterized by a semiarid to arid climate, with annual precipitation ranging from 13 to 20 inches. Higher and drier than the Central Great Plains to the east, much of the Western High Plains comprises a smooth to slightly irregular plain having a high percentage of dryland agriculture. Potential natural vegetation in the Western High Plains ecoregion is dominated by drought-tolerant short-grass prairie and large areas of mixed-grass prairie in the northwest portion of the state. The northern portion of the project area occurs within the Pine Ridge Escarpment Level IV ecoregion, with Ponderosa pine (*Pinus ponderosa*) woodlands associated with mixed-grass prairie on ridge tops and north-facing and east-facing slopes. The southern portion of the project area, predominantly rangelands, is made up of mixed-grass prairie with areas of moderate relief and is characteristic of the Sandy and Silty Tablelands Level IV ecoregion (Chapman et al. 2001).

3.5.2 **Local Setting - Marsland Expansion Area**

The proposed MEA is located in southwest Dawes County, Nebraska within sections 26, 35, 36 T30N:R51W; sections 1, 2, 11, 12, 13 T29N:R51W; and sections 7, 18, 19, 20, 29, 30, T29:R50W. The

project area occupies 4,622.3 acres approximately 4.6 miles (7.4 km) northeast of Marsland, Nebraska (centerpoint of MEA satellite building to centerpoint of Town of Marsland; **Figures 1.1-2 and 1.1-3)**. Land ownership is primarily private within the project area and the 2.5-mile (4.0 km) radius area referred to as the Ecological Study Area (ESA). There is a total of one section of State Trust Land located in the AOR, with a ¼ of this section located in the MEA license boundary. The northern portion of the buffer intersects with the administrative boundary of the Nebraska National Forest-Pine Ridge Ranger District. However, the administrative boundary was proclaimed by Congress mainly for the purposes of limiting the area in which land swaps and acquisitions could be undertaken, and the boundary itself provides no jurisdiction on nonfederal parcels.

3.5.3 **Climate**

The proposed MEA is located in a semiarid or steppe climate. The area is characterized by abundant sunshine, low relative humidity, and sustained winds which lead to high evaporative demand. There are also large diurnal and annual variations in temperature. The region has cold, harsh winters; hot, dry summers; and relatively warm, moist springs and autumns. Temperature extremes range from roughly -25° F in the winter to 100° F in the summer. The "last freeze" occurs during late May and the "first freeze" in mid to late September. The area has a growing season of approximately 120 days (NOAA and University of Nebraska-Lincoln 2011).

Historical average minimum and maximum meteorological data (i.e., temperature, precipitation, and snowfall) typical of the Scottsbluff area are presented in **Table 3.5-1** (NOAA and University of Nebraska-Lincoln 2011). Scottsbluff is located approximately 45 miles (72.4 km) to the southwest of the MEA. A detailed discussion of more recent and expanded meteorological data (2010 through 2011) considered representative of the MEA project site is provided in Section 3.6.

3.5.4 **Pre-existing Baseline Data**

Ecological studies have been conducted for several other mines in the general area of the MEA, including the CBR Crow Butte Uranium Project (Radioactive Source Materials License SUA-1534) and the TCEA. The first baseline study was conducted for the Crow Butte Mine in 1982 (Wyoming Fuel Company 1983), and additional baseline data were collected in 1987, 1995, 1996, 1997, and 2004 (CBR 2007). Baseline data, including field observations, agency contacts, and literature searches, were conducted for the TCEA in 2005 and 2008 (CBR 2010).

3.5.5 **Terrestrial Ecology**

The information presented in this report summarizes the baseline data collected for the Crow Butte Mine and TCEA between 1982 and 2008, and from field observations, surveys, and mapping conducted for the MEA in 2011.

3.5.5.1 Methods

Baseline studies were performed during 2011 to determine presence or absence of federally or state-listed species of plants and animals as well as regional species of concern deemed by the state. Surveys were conducted in accordance with approved protocols established by state and federal agencies for: (1) winter bald eagle (*Haliaeetus leucocephalus*) roosts, (2) raptor nests, (3) burrowing owl (*Athene cunicularia*) nests, (4) black-tailed prairie dog (*Cynomys ludovicianus*) colonies, (5) swift fox (*Vulpes velox*), (6) threatened and endangered fish species, and (7) wetland habitat. In addition, amphibian breeding habitat

was opportunistically documented, as well as all other wildlife species observed within or near the project area.

The goal was to document and summarize the ecological resources not only within the project area, but also the surrounding ESA. The 2.5-mile (4.0 km) ESA area overlaps the 2.25-mile (3.62 km) AOR buffer. Aerial surveys conducted included the entire ESA area, but groundwork was almost entirely restricted to the project area due to limited access to private lands. Thus, certain ecological resources within the ESA were identified using aerial surveys, documented from public roads, and/or mapped using National Agriculture Imagery Program (NAIP) imagery (e.g., prairie dog colonies). When possible, these resources were later verified and mapped from the ground if landowner permission was granted.

Information was also gleaned from recent field surveys conducted for the TCEA in 2005 and 2008, and from the baseline surveys conducted for the Crow Butte Mine in 1982. In 2005, primary floral and faunal species were identified through observation to determine the distribution and composition of vegetation communities that occurred within the project area. Raptor surveys were also conducted and compiled with past ecological data collected during 2008.

3.5.5.2 Existing Disturbance

Human expansion into the region was prompted by the development of the transcontinental railroad by the Union Pacific Railroad during the late 1800s. As a result of this expansion, the region became a regional railroad trade hub and eventually a source for agriculture, intensive rangeland, mining, and human development. Disturbance within the project area is limited to one small residence (i.e., farmhouse), farming and ranching activity, watering sites for cattle (e.g., windmills, water tanks), improved gravel and unimproved two-track roads, and one small gravel pit.

3.5.5.3 Vegetation and Land Cover Types

Vegetation classifications were applied to the MEA through heads-up digitizing of NAIP imagery and categorized into eight vegetation communities similar to the definitions in the TCEA Technical Report (**Figure 3.5-1**). These communities include mixed-grass prairie, degraded rangeland, mixed conifer, cultivated, drainage, structure biotope, range-rehabilitation, and deciduous streambank forest. The mixed-conifer vegetation type was not defined in the TCEA Technical Report, but was present in the MEA. The degraded rangeland class was added following field observations. Vegetation types were ground-truthed, and species composition of each type was recorded. Vegetation types represent a variety of species compositions and relative abundances. **Table 3.5-2** summarizes the abundance of vegetation types within the MEA.

The Chadron State College herbarium contains 468 plant species from Dawes County (Wyoming Fuel Company 1983). In addition, the Institute of Agriculture and Natural Resources lists 603 native and 123 introduced plant species that occur in Dawes County. During the 1982 baseline study (Wyoming Fuel Company 1983), more than 400 species of plants were collected (**Appendix H-1**).

<u>Mixed-Grass Prairie</u>

The most common vegetation type present in the MEA is mixed-grass prairie, comprising 65 percent of the area (**Table 3.5-2**). Common species observed in this vegetation type include the following grasses: needle-and-thread grass (*Hesperostipa comata*), junegrass (*Koeleria macrantha*), Sandberg bluegrass (*Poa secunda*), and threadleaf sedge (*Carex filifolia*). The non-native species cheatgrass (*Bromus tectorum*) and Kentucky bluegrass (*Poa pratensis*) were also abundant in this vegetation type. Common

forbs observed included white sagebrush (*Artemisia ludoviciana*), fringed sagebrush (*A. frigida*), phlox (*Phlox sp.*), locoweed (*Oxytropis sp.*), lupine (*Lupinus sp.*), pussytoes (*Antennaria sp.*), and yucca (*Yucca glauca*). This vegetation type is the most common in the northern portion of the project area, and is quite variable in composition (**Figure 3.5-1**).

Degraded Rangeland

Areas where non-native species, predominantly cheatgrass, have overtaken the landscape are classified as degraded rangeland. Considerable portions of the southern half of the project area were observed to have larges patches dominated by cheatgrass and Kentucky bluegrass. The southernmost portion of the project area has large patches dominated by smooth brome (*Bromus inermus)*. Overall biodiversity in these areas is lower than in areas of mixed-grass prairie. While non-native grasses are common throughout the project area, sections of the southern portion of the project area were particularly dominated by these species. The degraded rangeland vegetation type comprises 13.7 percent of the project area (**Table 3.5-2**; **Figure 3.5-1**).

Mixed Conifer

Mixed-conifer forests are concentrated along drainages in the northern third of the project area, often expanding out onto nearby hills and plains (**Figure 3.5-1**). This vegetation type is dominated by Ponderosa pine, with chokecherry (*Prunus virginiana*), skunkbush sumac (*Rhus trilobata*), and snowberry (*Symphoricarpus albus*) common in the understory. A combination of native and non-native grasses were common, with smooth brome being particularly abundant in low-lying areas. Pussytoes was a commonly observed forb. Mixed-conifer forests comprise 8.3 percent of the project area, making this the most common of the forested vegetation types (**Table 3.5-2**).

Cultivated

Cultivated fields make up approximately 6.3 percent of the project area and include crops such as alfalfa (*Medicago sativa*), wheat (*Triticum* spp.), oats (*Avena* spp.), corn (*Zea mays*), barley (*Hordeum* spp.), and rye (*Secale cereale*). In an environment not altered by humans, areas occupied by this vegetation type would most likely be occupied by mixed-grass prairie.

Drainages

Drainages in the south end of the project area are well drained and usually dry, covering 2.9 percent of the project area (**Table 3.5-2**; **Figure 3.5-1**). The vegetation composition in these intermittent tributaries to the Niobrara River is similar to that of surrounding grassland, though the vegetation is generally more robust. Meadow death camas *(Zigadenus venenosus)*, wild onion (*Allium sp.)*, and monkeyflower (*Mimulus sp.)* were observed in these areas. In the north side of the project area, conifers dominate the overstory of drainages with smooth brome in the understory. Standing water was only observed in the northern portion of the survey area, mostly in the area mapped as deciduous streambank forest. The weed houndstongue (*Cynoglossum officinale*) was observed in low densities.

Deciduous Streambank Forest

Deciduous stands found along ephemeral streams make up a very small portion of the project area, totaling less than 1 percent (**Table 3.5-2**; **Figure 3.5-1**). The most common overstory species observed within this habitat type include eastern cottonwood (*Populus deltoides*), boxelder (*Acer negundo*), and willow (*Salix sp.*). Snowberry was the dominant shrub, with Kentucky bluegrass, smallwing sedge (*Carex microptera*), *Rumex sp.*, and annual mustards (*Brassicaceae sp.*) common in the understory.

Structure Biotopes

The term "structure biotopes" refers to man-made features, with the exception of cultivated land. Common examples include roads, highways, buildings, farmlands, cities, and industry infrastructure. This cover type comprises 1.4 percent of the project area (**Table 3.5-2**; **Figure 3.5-1**). Dominant plant species in these areas are often non-native weedy species, including smooth brome, cheatgrass, white sweetclover (*Melilotus alba*), yellow sweetclover (*Melilotus officinalis*), and mustard species.

Range Rehabilitation

Previously cultivated fields are defined as range rehabilitation areas and are generally heavily grazed. Seasonal haying is also an important component of these areas. Vegetation of this habitat type is variable, with weedy species being more prevalent in areas with greater disturbance from cattle. Crested wheatgrass (*Agropyron cristatum*) was the dominant grass species observed, while fringed sagebrush was also common. This habitat type comprises less than 1.4 percent of the project area (**Table 3.5-2**; **Figure 3.5-1**).

3.5.6 **Mammals**

Information concerning current and historical mammal observations and distribution within and near the MEA were obtained from a variety of sources including the NGPC and the Nebraska Natural Heritage Program (NNHP). The NNHP is a primary repository for wildlife information in the State of Nebraska and contains records of wildlife observations for birds, mammals, herptiles, fish, and species at risk in the state. Wildlife information for the MEA was supplemented with survey data collected by Hayden-Wing Associates during spring/summer 2011 as part of the baseline and monitoring data requirements. A list of known and expected mammal species for Dawes County is provided in **Appendix H-2**.

3.5.6.1 Big Game

Six big game species occur or potentially occur in the vicinity of the MEA, including pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), elk (*Cervus elaphus*), bighorn sheep (*Ovis canadensis*), and bison (*Bison bison*). Big game populations are managed by the NGPC. Population objectives are set annually based on multiple factors including, but not limited to, the carrying capacity of the habitat, herd production and health, and weather (e.g., drought).

Pronghorn

Pronghorn typically inhabit grasslands and semi-desert shrublands of the western and southwestern United States. This species is most abundant in short- and mixed-grass habitats and is less abundant in more xeric habitats. Home ranges for pronghorn can vary between 400 and 5,600 acres, according to several factors including season, habitat quality, population characteristics, and local livestock occurrence. Typically, daily movement does not exceed 6 miles (9.7 km). Some pronghorn make seasonal migrations between summer and winter habitats, but these migrations are often triggered by availability of succulent plants and not local weather conditions (Fitzgerald et al. 1994). Pronghorn occur mainly in the western half of Nebraska, with the highest densities occurring in Sioux and Dawes Counties. In Nebraska, this species primarily inhabits short-grass prairies and badlands (NGPC 2011a).

The project area is located in the Box Butte Antelope Hunt Unit, which extends from the Wyoming/Nebraska border, north from the North Platte River, east to Nebraska Highway 250, and south from the Pine Ridge Escarpment. In 2007 and 2008, 34 and 32 pronghorn, respectively, were harvested

within this hunt unit (NGPC 2008a). In 2009, 36 pronghorn were harvested (NGPC 2010); and in 2010, 48 pronghorn were harvested (NGPC 2011b). Pronghorn populations in Nebraska are increasing, and harvest is at a 25-year high (NGPC 2011b). Pronghorn were observed regularly throughout the project area in 2011, and they appear to be relatively common year-round.

Mule Deer

Mule deer occur throughout western North America from central Mexico to northern Canada. Mule deer are found throughout Nebraska, but are more common in the western half of the state (NGPC 2011a). They inhabit a wide variety of habitats (e.g., sagebrush-steppe, grasslands, foothills) and feed on succulent grasses, forbs, shrubs, and agricultural crops. Mule deer tend to follow elevational migrations, moving from uplands during the warmer months to lowlands in the winter where denser, taller vegetation cover allows for manageable snow levels for foraging (Fitzgerald et al. 1994). Mule deer fawn mortality is typically due to predation or starvation. Adult mortality often occurs from hunting, winter starvation, and automobile collisions. Typical mule deer predators may include coyotes, bobcats, golden eagles, mountain lions, bears, and domestic dogs (Fitzgerald et al. 1994).

The MEA is located within the Pine Ridge Mule Deer Hunt Unit, which occupies areas of Box Butte, Dawes, Sheridan and Sioux Counties north of the Niobrara River and west of Nebraska Highway 27. Due to concerns with harvest of buck deer, the NGPC conducted a study (based on aged sample projected by total kill) of adult bucks 2.5 years or older during the 1987, 1992, and 1997 regular firearm hunting seasons. Adult mule deer buck harvests in the Pine Ridge unit for 1987, 1992, and 1997 were 202, 446, and 385, respectively (NGPC 2011c). The adult mule deer buck harvest for the Pine Ridge unit was 735 in 2008 (NGPC 2008a) and 922 in 2009 (NGPC 2010). In 2010, 10,709 mule deer were harvested in Nebraska; 957 of these were adult bucks harvested in the Pine Ridge Unit (NGPC 2011b). Mule deer were seen within the project area during field work in 2011 but not in high numbers, though higher numbers are likely during winter.

White-tailed Deer

White-tailed deer occur throughout North America from the southern United States to Hudson Bay in Canada. Across much of its range, this species inhabits forests, swamps, brushy areas, and nearby open fields. In Nebraska, white-tailed deer are found throughout the state, but have higher densities in the eastern half. They are typically concentrated in riparian woodlands, mixed-shrub riparian areas, and irrigated agricultural lands, and are generally absent from dry grasslands and coniferous forests (NGPC 2011a). White-tailed deer have a diverse diet, capitalizing on the most nutritious plant matter available at any time. In addition to native browse, grass, and forbs, this species often relies on agricultural crops, fruits, acorns, and other nuts. Mortality of white-tailed deer is typically related to hunting, winter starvation, collisions with automobiles, and predation. Predators may include coyotes; mountain lions; wolves; and occasionally bears, bobcats, and eagles (Fitzgerald et al. 1994).

White-tailed deer hunting in the region occupies the same unit as previously described for mule deer. Results of the white-tailed deer buck harvest for the Pine Ridge area were 186, 318, and 363 in 1987, 1992, and 1997, respectively (NGPC 2011c). In 2008 and 2009, the white-tailed deer adult buck harvests for the Pine Ridge unit were 824 (NGPC 2008a) and 1,053 (NGPC 2010), respectively. In 2010, the white tailed deer adult buck harvest for the Pine Ridge Unit was 1,252 (NGPC 2011b). According to the NGPC (2011a), the fall white-tailed deer population in Nebraska is estimated to be between 150,000 and 180,000 animals. Currently, the NGPC has a goal of reducing white-tailed deer populations in eastern

Nebraska by increasing harvest numbers. In 2010, a record 77,028 white-tailed deer were harvested in the state (NGPC 2011d).

Within the MEA, white-tailed deer were commonly seen during the 2011 survey around the agricultural and riparian habitats, but they were also seen in the higher elevations and in the forested areas.

Elk

Elk formerly ranged over much of central and western North America from the southern Canadian Provinces and Alaska south to the southern United States, and eastward into the deciduous forests. In Nebraska, this species occurs primarily in the northwestern region in a variety of habitats, including coniferous forests, meadows, short- and mixed-grass prairies, and sagebrush and other shrub lands. Similar to other members of the deer family, this species relies on a combination of browse, grasses, and forbs, depending on their availability throughout the seasons. Elk tend to be migratory, moving between summer and winter ranges. Typically, mortality is a result of predation on calves, hunting, and winter starvation. Predators may include coyotes, mountain lions, bobcats, bears, and golden eagles (Fitzgerald et al. 1994).

NGPC estimates the state elk population at approximately 2,300 individuals, and most of the population inhabits the Pine Ridge area (NGPC 2011e). The MEA Project Area is located in the Pine Ridge area, within the Ash Creek Elk Unit, specifically located east of Nebraska Highway 2, north of Spur L7E and west of U.S. Highway 385. The 2008 elk harvest was 73 individuals in the Pine Ridge area, and 10 individuals in the Ash Creek Elk Unit (NGPC 2008a). The 2009 elk harvest was 85 individuals in the Pine Ridge area, and 17 individuals in the Ash Creek Elk Unit (NGPC 2010). In 2010, elk harvest in the Pine Ridge included 114 individuals (17 in the Ash Creek Elk Unit) with an estimated 1,000 to 1,200 individuals comprising the population (NGPC 2011b).

Relatively large numbers of elk are known to occur year-round within the project area. During the fall and winter, the elk occupy many of the agricultural fields and lower elevation upland habitat. Although still found in the lower elevations during the spring and summer, the majority of the herd appears to move north to higher elevations in the forested portions of the Pine Ridge during the warmer portions of the year.

Bighorn Sheep

Prior to the 1900s, the Audubon bighorn sheep (*O. canadensis auduboni*) inhabited parts of western Nebraska including the Wildcat Hills, the Pine Ridge, along the North Platte River to eastern Lincoln County, and along the Niobrara River. It is thought that the Audubon bighorn probably became extinct in the early 1900s, with its last stronghold being the South Dakota badlands (NGPC 2011a).

Bighorn sheep were reintroduced into Nebraska in the early 1980s; the current population is estimated at 300 sheep, divided between two populations in the Pine Ridge and Wildcat Hills (NGPC 2011b). The reintroduction project began in 1981, when 12 bighorn sheep were first released in Fort Robinson State Park. Between 1988 and 1993, a total of 44 sheep were released in the state park. Twenty-two sheep were released in the Wildcat Hills south of Gering, Nebraska in 2001, and in 2005, an additional 49 were released into the Pine Ridge area. The most recent reintroduction occurred in 2007, with 51 bighorn sheep from Montana released in the Wildcat Hills south of McGrew, Nebraska (NGPC 2011f). As a result of disease, herd growth is limited; consequently, only a single lottery and a single auction permit were authorized for bighorn sheep hunting in 2011 (NGPC 2011b). Appropriate escape terrain habitat is

not present within the MEA, and it is therefore extremely unlikely that bighorn sheep would occur within the project area.

Bison

Fort Robinson State Park currently manages a herd of 200 bison. These bison are contained in a compound and do not occur within the project area boundary.

3.5.6.2 Carnivores

The following species of carnivores have been documented or are expected to be present within the MEA: coyotes (*Canis latrans*) and red foxes (*Vulpes vulpes*) typically occupy grassland, shrub-steppe, and agricultural habitats; long-tailed weasels (*Mustela frenata*) are habitat generalists and can be found in a wide variety of habitats; bobcats (*Lynx rufus*) tend to occupy woodland and shrubland habitat; badgers (*Taxidea taxus*) inhabit areas with loose soils that are suitable for digging burrows which frequently includes roadsides, prairie dog colonies, and areas near surface disturbance; and mountain lions (*Puma concolor*) prey upon mule and white-tailed deer and tend to occupy wooded habitats. Coyotes are considered non-game species, and residents do not need a permit to harvest this species. Mountain lion permits are not available, and lions cannot be trapped or hunted in Nebraska. Badger, bobcat, long-tailed weasel, raccoon (*Procyon lotor*), red fox, and striped skunk (*Mephitis mephitis*) are open to hunting and trapping with appropriate permits.

Using infrared-triggered remote trail cameras, which were deployed for documenting the presence/absence of swift fox (see Section 3.5.11), Hayden-Wing Associates documented the presence of coyotes and badgers within the project area (HWA 2011). Several other carnivore species are expected to be present, such as red fox, bobcat, raccoon, striped skunk, and long-tailed weasel, even though they were not detected by the cameras.

3.5.6.3 Small Mammals

Small mammals occupy a wide variety of habitats within the region, but most are considered common and widespread. Species known to occur or that are potentially present in the MEA include the deer mouse (*Peromyscus maniculatus*), white-footed mouse (*Peromyscus leucopus*), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), meadow jumping mouse (*Zapus hudsonius*), plains pocket gopher (*Geomys bursarius*), least chipmunk (*Tamias minimus*), and meadow vole (*Microtus pennsylvanicus*). Muskrat (*Ondatra zibethicus*) and beaver (*Castor canadensis*) are known to occur in or near the project area, especially near the Niobrara River along the southern edge of the project area. Porcupine (*Erethizon dorsatum*) occurs in the wooded areas of the project area, as does the eastern fox squirrel (*Sciurus niger*). Four rabbit species are known or suspected to occur within the project area, including the white-tailed jackrabbit (*Lepus townsendii*), black-tailed jackrabbit (*Lepus californicus*), eastern cottontail (*Sylvilagus floridanus*), and desert cottontail (*Sylvilagus auduboni*) (HWA 2011).

Two bat species have been recorded within a few miles of the MEA: the fringe-tailed myotis (*Myotis thysanodes pahasapensis*) and the long-legged myotis (*Myotis volans*). Both bat species are listed at Tier I At-Risk species by Nebraska Natural Legacy Project (NNLP), and the fringe-tailed myotis is listed as Sensitive in the nearby Pine Ridge Ranger District by the U.S. Forest Service (USFS) Nebraska National Forest. According to the USFS (Abegglen, pers. comm. 2011), the fringe-tailed myotis is known to occur in the Ponderosa pine habitat near the MEA. Both species may be present in the project area if suitable hibernacula exist (e.g., caves, mines, buildings, cliff crevices, hollows in snags, or hollow areas under the

bark of trees). Also, it is likely that these and other bat species use the project area for foraging, but no formal bat surveys were conducted by Hayden-Wing Associates in 2011.

Black-tailed prairie dogs, which are listed as Sensitive in the Pine Ridge Ranger District by the USFS, are known to occur in the vicinity of the project area. Four colonies were found during aerial surveys: two are situated along the project area border, and two are located within the 2.5-mile (4.0 km) ESA (HWA 2011). All four are occupied with prairie dogs. The smallest is only 0.63 acre in size, which is located just east of the project boundary in section 7, T29N:R50W. The other colony that borders the project area is approximately 20 acres in size and is located in section 30, T29N:R50W. The current boundaries of both of these colonies were mapped on foot in 2011.

The two colonies in the ESA were much larger: one south of the project area measured 47 acres and one east of the project area measured 151 acres in size. The southernmost colony (section 36, T29N:R51W and sections 2 and 3, T28N:R51W) was mapped entirely using NAIP 2010 imagery due to a lack of access, but the colony to the east (sections 16 and 21, T29N:R50W) was partly mapped from the ground (i.e., portion in section 21), and the remaining portion was mapped using NAIP imagery due to a lack of landowner access permission. Prairie dogs, groundhogs (*Marmota monax*), and porcupine are considered non-game species in Nebraska, and residents do not need a permit to harvest these species. Prairie dog colonies, however, provide habitat for several other at-risk or sensitive species, such as swift foxes, long-billed curlews (*Numenius americanus*), ferruginous hawks (*Buteo regalis*), and burrowing owls. Therefore, avoidance of prairie dog colonies is recommended by the U.S. Fish Wildlife Service (USFWS) and NGPC for projects involving ground disturbance activity.

3.5.7 Birds

The Nebraska Ornithologists Union lists 291 bird species occurring in Dawes County (**Appendix H-3**) and 455 species recorded in the state (NOU 2011). Of the 455 species in the state, 329 occur regularly (reported 9 out of the past 10 years); 78 are accidental (occurring less than two times in the past 10 years); 42 are casual (occurring between four and seven times in the past 10 years); four are extirpated, and two are extinct (NOU 2011). During a survey conducted in 1982, 201 bird species were documented in an area just north of the MEA (CBR 2010). Although formal point count bird surveys were not performed for the project area, a total of 73 bird species were documented in and around the project area in 2011, the majority of which are believed to breed locally (HWA 2011). Of the 73 species, 68 were documented during the 1982 baseline survey, four were listed as "reported by knowledgeable individual" in previous ecological surveys (blue jay [*Cyanocitta cristata*], eastern bluebird [*Sialia sialis*], northern mockingbird [*Mimus polyglottos*], and peregrine falcon [*Falco peregrinus*]), and one was new for the list of species (Eurasian collared-dove [*Streptopelia decaocto*]).

3.5.7.1 Passerines

Many species of passerines (perching birds, including songbirds) use the MEA for breeding, feeding, migration, wintering, and as year-round habitats. All habitats throughout the project area are likely used to some degree by various species. The Migratory Bird Treaty Act (MBTA; 16 USC, §703 *et seq.)* protects 836 migratory bird species (to date) and their eggs, feathers, and nests from disturbances (USFWS 2011a). See **Appendix H-3** for a list of known or expected bird species for the project area and surrounding ESA.

The Crawford Breeding Bird Survey (BBS) route passes within 4 miles (6.4 km) of the MEA to the north. In an analysis of data collected along this BBS route from 1966 to 2007, the five most abundant species

were western meadowlark (*Sturnella neglecta*; 181.1 birds per route), mourning dove (*Zenaida macroura*; 56.1 birds per route); American robin (*Turdus migratorius*; 18.1 birds per route); American crow (*Corvus brachyrhynchos*; 16.4 birds per route); and lark sparrow (*Chondestes grammacus*; 16.3 birds per route) (Sauer et al. 2011).

3.5.7.2 Upland Game Birds

Wild turkey (*Meleagris gallopavo*), ring-necked pheasant (*Phasianus colchicus*), gray partridge (*Perdix perdix*), and sharp-tailed grouse (*Tympanuchus phasianellus*) occur in the MEA. The site is located in the Panhandle hunting region for upland game birds and is managed by the NGPC. Wild turkeys in the Pine Ridge area use habitats in the foothills, plateaus, forest habitats, and riparian draws and are likely to be distributed throughout the project area. Ring-necked pheasants often use open grasslands and agricultural areas and are fairly common. Gray partridge, which are introduced and uncommon, are often located in areas near dense shrub cover. Sharp-tailed grouse inhabit open grassland and steppe habitats with scattered trees and shrubs. The scattering of trees and shrubs plays an important role in their life cycle for food and cover, and this species is known to occur in the project area in low numbers. Upland game birds designated as migratory that are confirmed or potentially present in the project area include mourning dove, Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), and Wilson's snipe (*Gallinago delicata*). Mourning doves occupy a wide variety of habitats including sagebrush, grasslands, shrubland, and riparian areas. Sora and Virginia rail typically occupy areas near wetlands, and snipe are frequently found in flooded fields and ditches (HWA 2011).

3.5.7.3 Raptors

Several raptor species are known or expected to occur in or around the MEA. Grasslands, shrublands, and scattered trees provide suitable nest substrates for a variety of species for breeding, hunting, and wintering. The Niobrara River drainage immediately south of the site provides habitat for tree-nesting species and provides potential roosting sites for wintering raptors (e.g., bald eagle, rough-legged hawk [*Buteo lagopus*]). All raptors and their nests are protected from "take" or disturbance under the MBTA (16 USC, §703 *et seq.*; USFWS 2011a). Golden eagles and bald eagles also are afforded additional protection under the Bald and Golden Eagle Protection Act, amended in 1973 (16 USC, §669 *et seq.*). In addition, several raptor species are considered at-risk or sensitive by NNLP and/or Nebraska National Forest-Pine Ridge Ranger District.

Aerial surveys were conducted for documenting raptor nests throughout the MEA and the ESA on April 28 and May 13, 2011. A ground survey for confirming nest locations, determining nest status, and searching for new nests was conducted from May 10 to 12, 2011. The ground survey was limited to the project area and areas adjacent to public roads in the ESA due to minimal access to private lands. Additional ground surveys for determining productivity of known nests, including nests in the ESA found during the aerial surveys, were conducted from June 7 to 8 and July 7 to 8, 2011 (HWA 2011).

A total of seven raptor nests were documented within the MEA during 2011, including two active red-tailed hawk (*Buteo jamaicensis*) nests, two active burrowing owl nests, one active great horned owl (*Bubo virginianus*) nest, and two inactive stick nests of unknown species (**Figure 3.5-2**). An additional 19 nests were documented within the ESA, including five active red-tailed hawk nests, two active great horned owl nests, nine active burrowing owl nests, one active Swainson's hawk (*Buteo swainsoni*) nest, one active ferruginous hawk nest, and one inactive stick nest of an unknown species. One additional active great horned owl nest was located just outside the ESA (HWA 2011). Of the five species documented nesting in and around the MEA, two (ferruginous hawk and burrowing owl) are designated by the NNLP

as Tier I At-Risk species. All but one of the burrowing owl nests were found in active prairie dog colonies.

Of the five active nests in the MEA, only one great horned owl nest (nest #13) and one red-tailed hawk nest (nest #20) were confirmed to be productive (i.e., at least one fledged chick) at the time of the last survey. Both great horned owl nests in the ESA had large chicks during the first ground survey and both likely fledged young, and red-tailed hawk nest #12 in the ESA was confirmed productive during the last survey. The remaining active nests still had young to medium-aged nestlings when surveyed last or, in the case of the burrowing owl nests, production could not be determined due to chicks remaining underground or the burrow entrances being too obscured by vegetation to observe chicks during the final ground survey (HWA 2011).

Several additional raptor species were observed in and around the project area during the spring surveys, including Cooper's hawk (*Accipiter cooperii*), northern harrier (*Circus cyaneus*), golden eagle (*Aquila chrysaetos*), American kestrel (*Falco sparverius*), and peregrine falcon (HWA 2011).

With the exception of peregrine falcons, for which little nesting habitat exists within the project area, all the other species are possible breeders in and around the project area. Other species documented within 10 miles (16.1 km) of the MEA and that have the potential to occur and breed within the MEA include bald eagle, osprey (*Pandion haliaetus*), merlin (*Falco columbarius*), prairie falcon (*Falco mexicanus*), sharp-shinned hawk (*Accipiter striatus*), northern goshawk (*Accipiter gentilis*), short-eared owl (*Asio flammeus*), long-eared owl (*Asio otus*), barn owl (*Tyto alba*), northern saw-whet owl (*Aegolius acadicus*), and eastern screech owl (*Megascops asio*). Rough-legged hawks are common within the MEA during the winter, and other species that have the potential to occur during migration or winter include broad-winged hawk (*Buteo platypterus*), red-shouldered hawk (*Buteo lineatus*), gyrfalcon (*Falco rusticolus*), and snowy owl (*Bubo scandiacus*).

Northern goshawk, Cooper's hawk, and sharp-shinned hawk are typically forest-nesting raptors. Potential nesting habitat includes scattered, mixed-conifer forests located in the northern portion of the project area and in the ESA. These forests may also provide nesting habitat for red-tailed hawks, osprey, merlins, American kestrels, and long-eared owls. Owls and falcons with only a few exceptions are dependent on other species for the availability of nests. Long-eared owls and merlins are secondary stick nesters (they use stick nests of other species, such as magpies and crows), and the smaller owls and kestrels are secondary cavity nesters (they use tree cavities established by other species, such as woodpeckers). Ferruginous hawks are found primarily in mixed-grass prairie and sagebrush steppe habitats during the spring, summer, and fall. They generally build nests on the ground, rock outcrops, cliff ledges, or small isolated trees. The one ferruginous hawk nest documented in the ESA is in a small isolated tree. Swainson's hawks typically nest in small trees or large shrubs along water features (e.g., irrigation ditches, streams), frequently near agricultural areas. Within the project area, the majority of *Buteo* nests are located in the deciduous trees along the Niobrara River, shelterbelts, trees around farmhouses and old homesteads, and the Ponderosa pine trees in the northern portion of the project area. Golden eagles commonly nest on cliffs and in large trees. Although cliff habitat is limited within the project area, golden eagle nests are known to occur just north of the project area, and suitable nesting habitat (i.e., large trees) occurs within the MEA and the ESA. Prairie falcons and peregrine falcons are strictly cliff-nesting species, and although they have been documented near the project area, cliff habitat within the project area is limited and nests are unlikely (HWA 2011).

Wintering Bald Eagles

All potential bald eagle roosting habitat within the ESA was surveyed on three separate occasions during the 2010/2011 winter (HWA 2011). Potential roosting habitat was defined as any medium or large deciduous or coniferous tree or group of trees. All potential habitat was identified and delineated using NAIP imagery from 2010. Aerial surveys were conducted using a Cessna 172 fixed-winged aircraft. Survey dates included December 14, 2010, January 12 and February 8, 2011, and all surveys were conducted between 30 minutes pre-sunrise to 1 hour post-sunrise or between 1 hour pre-sunset to 30 minutes post-sunset. Large blocks of potential habitat (i.e., conifer forest) were flown using north-south transects spaced by 0.5 mile (0.8 km). Linear habitat (i.e., riparian habitat) was flown by flying parallel to the habitat type. Information recorded for each eagle sighting included number of adults, number of subadults, behavior, and perch type.

During the winter surveys, no bald eagles were seen within the MEA, and one adult bald eagle was seen on one occasion (Dec. 14, 2010) in the ESA. The results suggest that bald eagles are present in the vicinity of the MEA during the winter and likely use the surrounding habitat for feeding and roosting, but apparently, regularly attended roost locations are not present even though suitable roosting habitat exists in the area (HWA 2011).

3.5.7.4 Waterfowl

During spring and fall migration, some waterfowl species may use the area for feeding, nesting, or resting, specifically those areas along the Niobrara River which occur within the ESA of the MEA, but little open water exists within the project area. Box Butte Reservoir is likely used heavily during migration; however, this waterway is just outside the ESA. The baseline study in 1982 documented 24 species of waterfowl (CBR 2010). A complete list of waterfowl species that may potentially occur in the project area is included in **Appendix H-3**.

3.5.8 Reptiles and Amphibians

The baseline study in 1982 documented 13 species of reptiles and amphibians (CBR 2010). Though formal surveys were not conducted for the MEA, several species of herptiles were documented opportunistically, including: plains spadefoot toad (larval stage) (*Spea bombifrons*), northern leopard frog (*Rana pipiens*), and common snapping turtle (*Chelydra serpentina*). Only the spadefoot toads were found within the project area; the other two species were found along the Niobrara River corridor near the project area. The spadefoot toad tadpoles were found in a small ephemeral wetland in NW section 13, T29N:R51W. Identification of the tadpoles to species was aided by D. Ferraro, Extension Associate Professor and Herpetologist, School of Natural Resources, University of Nebraska-Lincoln (Ferraro, pers. comm. 2011). A complete list of known or expected herptiles for Dawes and Box Butte Counties is provided in **Appendix H-4** (Fogell 2010).

3.5.9 Threatened, Endangered, or Candidate Species

Under the Federal Endangered Species Act (FESA) of 1973 and the Nongame and Endangered Species Conservation Act (Neb. Rev. Stat. §37-430 *et seq*.) several species receive unique protections due largely to their rarity, population declines, and/or habitat loss. A summary of potentially occurring threatened and endangered species within the MEA is presented in **Table 3.5-3** (also see **Appendix H-7** for range maps in Nebraska). Consultations were held between Hayden-Wing Associates and the NGPC, which consisted of emails and phone conversations (NGPC 2011). The NGPC provided a written response to Hayden-Wing Associates (NGPC 2011; **Appendix V**).

Black-footed Ferret

The black-footed ferret (*Mustela nigripes*) is listed by the USFWS as endangered and is considered the most endangered mammal species in the United States. Several factors have contributed to declines in ferret populations, including eradication of prairie dogs by humans and disease outbreaks (i.e., sylvatic plague and canine distemper). Distributions of black-footed ferrets closely correspond to those of prairie dogs. Black-footed ferrets depend heavily on prairie dogs for food and they also use prairie dog burrows for shelter, parturition, and raising young. Black-tailed prairie dog colonies occur in the project area. However, no known ferret populations occur in Nebraska (NGPC 2011a); therefore, the likelihood of black-footed ferrets occurring within the project area is minimal.

Whooping Crane

The whooping crane (*Grus americana*) is North America's tallest bird, with males close to 5 feet tall. The species is listed as endangered by USFWS and NGPC, and according to USFWS they have the potential to occur in Dawes County (USFWS 2011b). Whooping cranes migrate through central Nebraska during spring and fall, and primarily stop over along the Platte River Valley (NGPC 2011a). Whooping cranes use a variety of habitats during the non-breeding season, including wetland mosaics, cropland, and riverine habitat in Nebraska. They depend on seasonally and semi-permanently flooded wetlands for roosting. Such habitat is limited or absent in the MEA. The USFWS maintains a database of confirmed whooping crane sightings within the known migration corridor for this species. According to this database, there has been one confirmed whooping crane sighting in Dawes County in the last 50 years: a sighting of one individual adult whooping crane in 1991, approximately 17 miles (27.4 km) north of the MEA (USFWS 2011c). It is unlikely that whooping cranes would occur within or near the project area due to the lack of suitable habitat.

Gray Wolf

Gray wolves were first listed as endangered in the lower 48 states in 1967. After decades of intensive management, including reintroductions in Idaho and Wyoming, the species was delisted in the Northern Rocky Mountain Distinct Population Segment (DPS) except Wyoming on May 5, 2011 (USFWS 2011d). There are no known populations of wolves in Nebraska. However, dispersing individuals from either Montana or Wyoming into the state would be afforded full protection under the FESA as an endangered species. Wolves are capable of dispersing significant distances, but it is extremely unlikely that wolves would occur in or near the project area.

Swift Fox

The swift fox is a state-listed endangered species that inhabits short-grass and mixed-grass prairies over most of the Great Plains. It appears to prefer flat to gently rolling terrain. Swift foxes feed primarily on lagomorphs, but arthropods and birds are also included in their diets. They mate between late December and February. A mating pair can bear two to five pups in late March to early May, and pups emerge from the den in June. Dens are generally located along slopes or ridges that offer good views of the surrounding area (Fitzgerald et al. 1994). In a study completed in southeastern Colorado, the home range size of an adult swift fox was approximately 3.6 mi^2 (9.4 square km^2) at night, and their day ranges are typically much smaller (Schauster et al. 2002).

The swift fox is found in native short-grass prairies in northwestern Nebraska. Unlike coyotes or red fox, the swift fox uses dens in the ground year-round. Some characteristics of swift fox dens differentiate them from other dens. Swift fox den entrances measure about 8 inches in diameter, similar to the size of a

badger den. However, swift fox usually have more than one entrance, whereas badgers and most other animals have only one. Swift fox tend to spread excavated soil over a larger area than most other animals, resulting in a less prominent mound near the burrow's entrance. Dens are located on relatively flat ground away from human activity. Where coyotes are abundant, predation by coyotes is a significant cause of mortality for swift fox, and den availability is an important aspect of swift fox survival (Schauster et al. 2002).

Numerous natural and anthropocentric factors influence swift fox populations. Natural factors include fluctuating prey availability, interspecies competition, disease, and landscape physiography. Anthropogenic factors include habitat loss from agricultural, industrial, and urban conversion; land uses on remaining habitat, including hydrocarbon production, military training, and grazing; and pesticide use. Competition with coyotes and red foxes may currently be the most significant threat to swift fox populations, though habitat loss is also a major threat (Stephens and Anderson 2005).

Presence of swift foxes has been confirmed by NGPC in Dawes, Box Butte, and Sioux Counties (NGPC 2009), and potentially suitable habitat occurs in and around the project area; thus, the presence of swift fox within the MEA is possible. However, much of the habitat within the project area appears to be marginal, and previous site-specific surveys in the area have failed to detect the species. Grass height in particular appears to create unsuitable conditions throughout the majority of the project area, where dense fields of cheatgrass exceed 14 inches in many areas during summer (HWA 2011).

As general surveillance for carnivore species in the project area, and with a focus on sampling areas most suitable for swift fox, Hayden-Wing Associates deployed remote infrared trail cameras throughout mixed-grassland portions of the project area in 2011. Cameras were used instead of the conventional track station methods because of time and budget constraints. Hayden-Wing Associates used Reconyx© HyperFire™ HC600 passive infrared (no glow illuminator) remote trail cameras for the monitoring. Four cameras were deployed simultaneously among eight locations throughout the southern half of the project area. Cameras were deployed continuously from June 6 to July 7, 2011. The number of sampling days per location was largely determined by the timing of other field surveys, but cameras were deployed for 9 to 22 days per location. Cameras were positioned along fencelines and other likely travel corridors and baited with a combination of skunk scent (to act as a long-distance lure) and fish oil. Camera locations were deliberately selected based on quality of habitat, proximity to prairie dog colonies, and presence of cattle (to protect cameras).

No swift fox were detected using the remote cameras during 2011. Only two species of carnivores were detected: coyote and badger. Other species detected by the cameras included pronghorn, white-tailed deer, elk, cottontail *sp*., jackrabbit *sp.*, cattle, and a lark bunting (*Calamospiza melanocorys*) (HWA 2011).

Fish

Three species of state-listed fish are found in the Niobrara River system and may potentially be impacted by a reduction in river flow or impairment of stream quality (**Table 3.5-3**).

The blacknose shiner (*Notropis heterolepis*), a state-listed endangered species that was once commonly distributed throughout the state, is now restricted to three main areas along the Niobrara and Snake Rivers (NGPC 2009). This species typically inhabits cool weedy creeks, rivers, and lakes, usually with a sand substrate (NatureServe 2010). Reductions in stream flows and/or quality are important considerations for this species, as it resides downstream from the project area.

The northern redbelly dace (*Phoxinus eos*) and finescale dace (*Phoxinus neogaeus*) are state-listed threatened species. These species are both found in pools and beaver ponds in the headwaters of creeks and small rivers, usually in areas with a silty substrate (NatureServe 2010). Both of these species are downstream residents from the project area and could be impacted by reductions in water quantity and/or quality.

3.5.10 **Aquatic Ecology**

The MEA is located within the Niobrara River Basin. Annual flows within the Niobrara River basin are regulated mainly by snowmelt, precipitation, and groundwater discharge. No perennial streams occur within the MEA. The Niobrara River, located just south of the project area, is the prominent drainage in the vicinity of the MEA and flows into Box Butte Reservoir. Other small drainages include Dooley Spring, Willow Creek, and other small unnamed drainages, but all are dry and re-vegetated. All lack distinct stream channels and banks. Occasional runoff may create small pools in a few places, but there is no evidence of persistent stream flows in recent times (HWA 2011). Based on existing land uses, intensive grazing and agricultural practices are likely the largest factors influencing water quality in the area.

3.5.10.1 Fish

The 1982 and 1996 studies for the Crow Butte Mine recorded 21 species of fish throughout various streams and the White River (CBR 2010; **Appendix H-5**). Game fish collected included rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and white sucker (*Catostomus commersonii*). Minnow species included longnose dace (*Rhinichthys cataractae*), common shiner (*Luxilus cornutus*), fathead minnow (*Pimephales promelas*), and creek chub (*Semotilus atromaculatus*). Many of the same species are thought to occur, or to have formerly occurred, in the Niobrara River. According to a local landowner (Troester, pers. comm. 2011), trout previously occurred in the Niobrara River just south of the MEA. However, a combination of drought and northern pike (*Esox lucius*) becoming more numerous upstream from Box Butte Reservoir during the past 10 years may have altered the fish community dramatically because pike are major predators of minnows and small trout (NPS 2002).

The local fish population was sampled at three sites along the Niobrara River during early June and mid-September, 2011 (HWA 2011). The goal was to collect baseline information on the species composition and general abundance upstream and downstream of the proposed project for comparison with future monitoring efforts. The sampling was intended also as surveillance for the state-listed species (black-nose shiner, northern redbelly dace, and finescale dace) known to occur in the Niobrara River. Sampling methods involved mainly electroshocking techniques, but seine nets were also used. Methods complied with the U.S. Environmental Protection Agency's Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (Barbour et al. 1999).

During the June sampling effort, only two species were detected: northern pike and white sucker. Green sunfish (*Lepomis cyanellus*) and red shiner (*Cyprinella lutrensis*) were also detected during the training period. None of the state-listed species were detected (HWA 2011).

During the September sampling effort, eight species were detected: northern pike, white sucker, common carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavescens*), bluegill (*Lepomis macrochirus*), pumpkinseed sunfish (*Lepomis gibbosus*), and central stoneroller (*Campostoma anomalum*). Again, no state-listed species were detected (HWA 2011).

3.5.10.2 Macroinvertebrates

Macroinvertebrates were also sampled during the baseline study in 1982, and results suggested that streams in the Crow Butte area were stressed, with low water quality and degraded stream habitats (CBR 2010; **Appendix H-6**). Aquatic conditions within the MEA may be similar, but macroinvertebrates were not sampled directly, although crayfish (unknown species) were commonly found during the fish sampling in the Niobrara River (HWA 2011).

3.5.10.3 Wetlands

The MEA was surveyed for areas that qualify as wetlands as defined by the U.S. Army Corps of Engineers (USACE 2008). All locations within the MEA identified in the National Wetlands Inventory (NWI) as wetlands or potential mesic sites were assessed as well (USFWS 2011e). Because ground-disturbing activity is not planned for wetland areas, only wetland habitat was surveyed and delineated. All drainages and low-lying areas were surveyed by all-terrain vehicle (ATV) or on foot. Three types of indicators were used for assessing whether a site qualified as a wetland, including hydric soil, hydrophytic vegetation, and hydrology. Sites containing all three indicators of hydric conditions were classified and delineated as wetlands.

A total of four sites were evaluated as potential wetlands within the MEA (**Figure 3.5-1**):

- Site #1 – location identified in the NWI as “freshwater emergent wetland.” Low-lying depression in a grassy field with ephemeral open water created by runoff and rainwater. Tadpoles were present. Location had appropriate hydric soil, vegetation, and hydrology. Qualifies as wetland.
- Site #2 – representative location in bottom of dry drainage. Wetland-like conditions not present, but location assessed in order to compare dry drainages to mesic locations. Does not qualify as wetland or mesic.
- Site #3 – location identified in the NWI as “freshwater emergent wetland.” Site satisfied the vegetation and hydrology indicators for a wetland, but hydric soils were absent. Does not qualify as wetland, but mesic conditions exist.
- Site #4 – location not identified in the NWI, but found during ground surveys. Site satisfied the vegetation and hydrology indicators for a wetland, but hydric soils were absent. Does not qualify as wetland, but mesic conditions exist.

3.6 Climate, Meteorology, and Air Quality

3.6.1 Introduction

The proposed MEA is located in a semiarid or steppe climate. The area is characterized by abundant sunshine, low relative humidity, and sustained winds which lead to high evaporative demand. There are also large diurnal and annual variations in temperature. The region has cold, harsh winters; hot, dry summers; and relatively warm, moist springs and autumns. Temperature extremes range from roughly -25° F in the winter to 100° F in the summer. The “last freeze” occurs during late May and the “first freeze” in mid to late September. The area has a growing season of approximately 120 days (NOAA and University of Nebraska-Lincoln 2010).

Yearly precipitation totals typically range from 13 to 16 inches. Migratory storm systems that originate in the Pacific Ocean release a majority of their moisture over the Rocky or Cascade Mountains. Major precipitation events can occur when these systems regain moisture already present in the area or moisture

advected from the Gulf of Mexico. The region is prone to severe thunderstorm events throughout the spring and early summer months and much of the precipitation is attributed to these events. In a typical year, the area will experience four or five severe thunderstorm events (as defined by NWS criteria) and 40 to 50 thunderstorm days. Autumn stratiform rain events also contribute to precipitation totals, but to a lesser degree. Snow frequents the region throughout winter months (30 to 50 inches per year), but generally provides less moisture than rain events.

Windy conditions are fairly common to the area. Roughly 3 percent of the time, hourly wind speed averages exceed 25 miles per hour (mph) (40.2 km). The predominant wind directions are north-northwesterly and northwesterly, with the wind blowing from those directions roughly 25 percent of the time. Surface wind speeds are relatively moderate at a year-round, hourly average of 10 to 11 mph. Higher average wind speeds are encountered during the winter months, while summer months experience lower average wind speeds.

For the regional analysis, meteorological data have been compiled for 21 sites surrounding the MEA. Data were acquired for these sites through the Western Regional Climate Center (NOAA and Desert Research Institute 2011) for Cooperative Observer Program (COOP) and Automated Surface Observation Stations (ASOS) operated by the NWS. Among these regional sites, the Scottsbluff Airport was selected as most representative of the MEA meteorology. Scottsbluff is less than 50 miles (80 km) south of the project site, with an elevation roughly 300 ft lower than the project area. It is also the closest NWS station to the project site that collects hourly wind and relative humidity data. Hourly data from Scottsbluff are available from the last 15 years.

Hourly data for the Scottsbluff weather station were only available from NCDC in electronic form for years 1996 and later. In order to corroborate the conclusions drawn in the TR regarding temporal representativeness, hourly data from the Chadron airport have been compiled and analyzed. Only 12 years of NCDC hourly data were available for Chadron in electronic form, spanning the period from January 1, 2001 through December 31, 2012. The results of the Chadron data analysis are attached to this report as **Appendix S**. In addition, **Appendix S** presents the regression analyses for both Scottsbluff and Chadron with associated p-values. For both sites, the conclusion reached is that the consistently low p-values render the high coefficients of determination (near 1.0) statistically significant. The strong correlation implied between wind characteristics during the baseline monitoring year and wind characteristics over a longer period is real at both the Scottsbluff and the Chadron sites. One may infer a similar relationship at the project site, some 30 miles southwest of Chadron and 48 miles north of Scottsbluff. This justifies the conclusion that the baseline year's wind data represent the long term.

For the site-specific analysis, meteorological data from the MEA meteorological station were used. These data were collected during the 1-year baseline monitoring period extending from August 24, 2010 through August 29, 2011. **Table 3.6-1** provides the station ID, coordinates, and periods of operation for the regional and site-specific meteorological stations. The locations of the regional and MEA meteorological station are shown on **Figure 3.6-1**.

These sites have been analyzed collectively to evaluate regional climatic temperature and precipitation in the proposed project area. The NWS sites have also been incorporated into the snowfall discussion. The nearest available long-term monitoring site that continuously records all weather parameters is the Scottsbluff Airport. This site was analyzed for the regional wind summaries. At the project site, hourly average meteorological data include wind speed, wind direction, sigma theta, temperature, relative humidity, precipitation, and solar radiation. Evapotranspiration (ET) rates were calculated for both the

Scottsbluff site and project site by applying Penman's equation to available solar radiation, wind speed, temperature, and relative humidity data. As solar radiation data were not available from the Scottsbluff data set, estimated monthly averages for solar radiation were obtained for the Scottsbluff area from the U.S. Department of Energy's National Renewable Energy Laboratory (NREL 1990).

In the information that follows, a regional overview is presented first. This section includes a discussion of the maximum and minimum temperatures and relative humidities, annual precipitation including snowfall estimates, a brief wind speed and direction summary, and a discussion of ET rates. A combination of monitoring stations is analyzed for the regional overview of temperature, snowfall, and total precipitation.

A site-specific analysis follows the regional overview. Most of this analysis is based on the onsite monitoring. An in-depth wind analysis summarizes average wind speeds and directions, wind roses, wind speed frequency distributions, and a joint (wind speed and direction) frequency distribution to characterize the wind data for the MEA by atmospheric stability class. A discussion of monthly and seasonal data is included for the temperature, precipitation, ET, and wind parameters. General upper atmosphere data from the NWS station at Rapid City, South Dakota represent the project site.

The site-specific analysis includes a justification for using wind data from the baseline monitoring year to predict meteorological conditions over the long term. This is necessary to validate air sampling locations and MILDOS dispersion modeling inputs. The short-and long-term wind data from the Scottsbluff site are correlated for this purpose.

3.6.2 **Regional**

3.6.2.1 Temperature

The annual average temperature for the region is approximately 48° F (8.9º C). Temperatures at the Scottsbluff Airport meteorological station are considered to be representative of the region.

Figure 3.6-2 shows monthly average temperatures for the Scottsbluff Airport site, along with the monthly maximum and minimum temperatures over the last 15 years. July has the highest average monthly temperature (74.5° F), followed by August. December records the lowest average temperatures for the year (26.0° F), followed by January. **Table 3.6-2** shows average, minimum, and maximum monthly temperatures for the Scottsbluff Airport site. Low temperatures in the region can drop to nearly -30º F, while high temperatures can reach 107° F.

Large diurnal temperature variations occur in the region due in large part to its high altitude and low humidity. **Figure 3.6-3** depicts the monthly diurnal temperature variation for the Scottsbluff Airport site from 1996 through August 2011. Spring and summer daily variations of 30° F are common with maximum temperature variations exceeding 40° F during extremely dry periods. Less daily variation is observed during the cooler portions of the year, as fall and winter have average variations of roughly 20° F. This can be attributed to the more stable atmospheric conditions in the region during the fall and winter months. Stable periods have much lower mixing heights and accompanying lapse rates, allowing for less temperature variation.

On a year-round basis, daily maximum temperatures in the project region average approximately 60° F, and daily minimum temperatures average approximately 33° F. July has the highest maximum temperatures, with averages near 90° F, while the lowest minimum temperatures are observed in January

with averages near 10° F (NCDC 2011). Annual average minimum and maximum temperatures are shown on **Figures 3.6-4** and **3.6-5**, respectively.

3.6.2.2 Relative Humidity

The Scottsbluff Airport site records relative humidity (dew point) data. The graph on **Figure 3.6-6** charts monthly average relative humidity values for this site. The Scottsbluff Airport data are from 1996 through August 2011. These data indicate that July has the driest air, with relative humidity averaging around 58 percent. The winter months of December, January, and February make up the most humid part of the year, with average relative humidity approaching 70 percent. The overall average relative humidity is 63 percent at Scottsbluff Airport.

Relative humidity is a temperature-based calculation which reflects the fraction of moisture present relative to the amount of moisture for saturated air at that temperature. Warmer air holds more moisture at saturation than colder air. Therefore, for a given amount of moisture in the air, relative humidity maximum values occur more frequently in the early mornings, while minimum values typically occur during the mid-afternoon hours. The summer months exhibit a much greater variation in relative humidity between morning and afternoon values due to greater temperature variations (**Figure 3.6-7**).

3.6.2.3 Precipitation

The region is characterized by moderately dry conditions. The Scottsbluff Airport received measurable (>0.01 in) precipitation on an average of 82 days per year between 1996 and 2011. Average annual precipitation during that period was 15.2 inches per year. In general, the project region has an annual average from 14 to 23 inches (**Figure 3.6-12).** Spring showers and thunderstorms produce nearly half of the precipitation at Scottsbluff Airport (**Figure 3.6-8**). May and June are typically the wettest months of the year; with most of the region receiving an average greater than 2 inches for each of those months (**Figure 3.6-9**). The region receives less precipitation in January than in any other month, averaging generally 0.5 inch or less. The winter months (December through February) typically account for less than 10 percent of the yearly precipitation totals. Only moderate precipitation occurs in late summer, when atmospheric conditions are more stable and the absence of convective activity limits storm development.

Severe weather does arise throughout the region, but is limited on average to five or six severe events per year. These severe events are generally split between hail and damaging wind events. Tornadoes can occur but are rare in western Nebraska.

Average annual snowfall varies throughout the region. Major snowstorms (more than 5 in/day) are relatively infrequent in the region. The region experiences fewer than three major snowstorms per year. Hay Springs, Nebraska has the highest annual snowfall of the sites closest to the project, with an average of 52 inches, while Sidney, Nebraska has the lowest averages at 30.7 inches per year. The interpolated values **(Figure 3.6-13**) show average snowfall of 30 to 60 inches per year in the project region.

Snowfall at the Scottsbluff Airport site averaged 38.2 inches per year over the last 15 years. Monthly average snow amounts are depicted in **Figure 3.6-10**, which shows the highest amount of snowfall in March. Monthly snowfall amounts in the overall region follow a similar pattern (**Figure 3.6-11**).

3.6.2.4 Wind Patterns

Year-round wind speeds in the area average between 8 and 11 mph. **Table 3.6-3** shows monthly average wind speeds for the Scottsbluff Airport site. The overall average wind speed at this site was 8.9 mph for the 1996 to 2011 period analyzed in this study. Mean monthly average wind speeds are lowest in the summer months and highest in April at nearly 11 mph.

Table 3.6-3 also shows monthly maximum hourly wind speeds for the Scottsbluff Airport. High wind events are fairly common in this region; wind data from this site show every month recording peak hourly wind speeds greater than 30 mph during the 15-year period analyzed.

Figure 3.6-14 graphs the Scottsbluff Airport 15-year monthly average and monthly maximum wind speeds listed in **Table 3.6-3.**

Figure 3.6-15 shows the 15-year wind rose for the Scottsbluff Airport site. Predominant winds are generally from the west-northwesterly or northwesterly directions. These winds, often associated with storm fronts, dominate the late fall, winter, and early spring seasons. A secondary mode occurs from the east-southeasterly or easterly directions. These winds are generally associated with the summer season when regional high pressure dominates. The highest wind speeds tend to occur from the northwesterly direction. **Table 3.6-4** provides the same information as the wind rose, but in tabular form.

Winds at the Scottsbluff Airport site and throughout the region exhibit a diurnal pattern. **Figure 3.6-16** shows the pattern at Scottsbluff for each season of the year. Wind speeds peak during the early afternoon for the winter and fall seasons. During spring and summer, wind speeds peak in late afternoon largely due to longer daylight hours and the predominant effect of solar heating on wind patterns. **Figure 3.6-16** also shows that the highest average wind speeds occur during the spring season, when the atmosphere tends to be least stable and storm systems are the strongest. The lowest wind speeds occur during summer, when the atmosphere is generally stable and storm systems are weak.

3.6.2.5 Heating, Cooling, and Growing Degree Days

Figure 3.6-17 summarizes the monthly cooling, heating, and growing degree days for Scottsbluff, Nebraska (NWS meteorological monitoring site 257665). The data are assumed to be indicative of the project area due to its proximity and comparable elevation.

The heating and cooling degree days are included to show deviation of the average daily temperature from a predefined base temperature. In this case, 50° F has been selected as the base temperature for computation of growing degree days. The base temperature for computing heating and cooling degree days is 65° F. The number of heating degree days is computed by taking the average of the high and low temperatures occurring that day and subtracting it from the base temperature. The calculation for growing and cooling degree days is the same, except that the base temperature is subtracted from the average of the high and low temperatures for the day. Negative values are disregarded for both calculations.

As expected, the graphs of heating degree days and cooling degree days are inversely related, and the growing and cooling degree days are directly related. The maximum number of heating degree days occurs in December and January, at roughly 1,200 degree days. This coincides with the months having the lowest minimum average temperatures. Conversely, July registers the most growing degree days with nearly 700, and the most cooling degree days at fewer than 300. This also corresponds to July having the highest average temperature.

3.6.2.6 Evapotranspiration

The project region is characterized by high evaporative demand during much of the year. This demand is related to dry air (low dew points), high daytime temperatures, and moderate wind speeds. **Figure 3.6-18** graphs monthly potential ET rates, in inches of water per month, at the Scottsbluff Airport site. Potential ET is an estimate only, calculated using the Penman Equation (Jensen et al. 1990). Meteorological inputs to this equation include wind speed, barometric pressure, solar radiation, and temperature and humidity extremes.

For the Scottsbluff site, barometric pressure was estimated based on the elevation. Because solar radiation data were not available at this site, estimated monthly averages for solar radiation were obtained for the Scottsbluff area from the NREL. A flat-plate collector at zero degrees incline from horizontal represents the global solar radiation available at a given location. Wind speed, temperature, and humidity data for the ET calculation were obtained from the Scottsbluff Airport hourly database.

Potential ET values are highest in July, at 10 inches, and lowest in December and January, at 2 inches. Annual ET for this area is projected at 68.6 inches per year.

3.6.3 Site-Specific Analysis

3.6.3.1 Introduction

The site-specific discussion of climate, meteorology, and air quality is limited to on-site meteorological data collected for the baseline monitoring period of August 2010 through August 2011. These on-site data are supplemented by meteorological data from the nearby Scottsbluff Airport site, collected during the 15-year period from 1996 through August 2011. The Scottsbluff site is included to incorporate wind monitoring results from a longer period of record and to demonstrate that, for this region, winds during the baseline monitoring period are representative of the longer term. The Scottsbluff site is located 48 miles (77.2 km) south of the MEA, with elevation and topographic features comparable to the project area. In both cases, the surrounding area is characterized by rolling hills and flat plains bordered by small ridges and breaks with ephemeral drainages. With the exception of cultivated land, the vegetation types are mainly confined to native grasses with some sage brush and wooded areas.

3.6.3.2 Temperature

The annual average project site temperature is similar to the regional average temperature at approximately 46° F. The maximum temperature for the baseline monitoring year was 99° F, and the minimum temperature was -28° F.

Figure 3.6-19 shows the monthly average, minimum, and maximum temperatures for the project site. **Table 3.6-5** provides the same data in tabular form. Daily average temperatures range from near 20° F in the winter months to above 70° in the summer months.

Table 3.6-6 provides a meteorological summary for the MEA site for the baseline monitoring year. The averages, maximums, and minimums are specified for each parameter recorded at the site along with the data recovery rate for each. The recovery rates are greater than 97 percent for all parameters.

3.6.3.3 Wind Patterns

Figure 3.6-20 presents a wind rose for the project site during the 12-month baseline monitoring period. **Table 3.6-7** presents the same information in tabular form. The predominant wind direction is north-

northwesterly and northwesterly, with the highest wind speeds also coming from those directions. During periods of fair weather, particularly in late spring and summer, high pressure located over the northern plains produces moderate southeasterly winds in the project area. Synoptic weather systems generally interrupt this pattern, producing high north-northwesterly winds. **Figure 3.6-21** shows seasonal wind roses for the project area. Spring experiences the greatest variability in wind direction with secondary modes as a result of the synoptic scale transition period that occurs during this time. Low pressure regions develop on the lee side of the Rocky Mountain, bringing southeasterly winds during storm development. As the low pressure systems form and move off with the general atmospheric flow, winds switch to a north-northwesterly direction.

Figure 3.6-22 presents a diurnal graph of wind speeds at the project site by season. For all seasons, wind speeds peak during the afternoon. Winds during the summer plateau at less than 12 mph, while the rest of the year experiences peak afternoon wind speeds averaging roughly 15 mph. Nighttime winds average 8 to 10 mph throughout the year.

Figure 3.6-23 shows the time distribution of wind speeds at the project site. Half of the time, wind speeds are less than 8 mph, while winds exceed 18 mph 10 percent of the time.

The average wind speed for the project site was 10.6 mph over the 12 months of monitoring, slightly higher than the 8.9 mph long-term average at Scottsbluff. The monthly average and maximum hourly wind speeds at the project site are summarized on **Figure 3.6-24.** The graph shows higher wind speeds in the winter and spring, peaking in April.

Table 3.6-8 provides a breakdown of wind speeds by wind direction. Wind speeds average near or above 12 mph when the wind blows from the northwest quadrant. A secondary maximum occurs for southerly winds, averaging more than 10 mph. For all other directions, wind speeds average less than 10 mph.

The Joint Frequency Distribution (JFD) provides more detail on wind speed distribution by wind direction and atmospheric stability class. The distribution shows the frequencies of hourly average wind speed for each direction based on stability class. **Table 3.6-9** lists the annual JFD for the MEA. **Tables 3.6-10** through **3.6-13** list the seasonal JFDs. A majority of the winds at the project site fall into stability class D, which represents near neutral to slightly unstable conditions. The light winds which accompany stable environments are reflected in the stability class F summary.

3.6.3.4 Precipitation

Figure 3.6-25 shows monthly precipitation at the project site during the baseline monitoring year. Total precipitation was 17 inches, although 10 inches fell during the abnormally wet month of May. Very little precipitation fell during the fall and winter months. Based on long-term records at other weather stations in the region, precipitation recorded during the baseline monitoring year at Marsland is probably not representative of the long term. An annual average precipitation of 15 inches is considered more likely.

3.6.3.5 Evapotranspiration

Daily ET rates were calculated for the project site by applying Penman's equation to recorded solar radiation, wind speed, temperature, and relative humidity data. These calculations were then summed for each month. **Figure 3.6-26** shows projected monthly ET at the project site during the baseline monitoring period. From these calculations, annual ET is computed at approximately 60 inches. This compares favorably to the long-term, calculated average of 68 inches at the Scottsbluff Airport site.

3.6.3.6 Justification of Baseline Year as Representative of Long Term

The proposed project is situated in northwest Nebraska (Scottsbluff 15-year vs baseline year wind roses). The baseline meteorological monitoring period extended approximately 1 year, from August 24, 2010 through August 29, 2011. To demonstrate that this baseline year is representative of the longer-term wind conditions, the Scottsbluff Airport site was analyzed. Among the weather stations in this region, the Scottsbluff Airport was selected as most representative of the MEA meteorology. Scottsbluff is less than 50 miles (80 km) south of the project site, with an elevation roughly 300 ft lower than the project area. It is also the closest NWS station to the project site that logs hourly wind data. Available hourly data from Scottsbluff span from January 1, 1996 to the present and therefore represent the last 15 years.

Figure 3.6-27 shows wind roses for Scottsbluff (Scottsbluff 15-year vs baseline year wind roses). The wind rose on the left reflects 15 years of monitoring (1996 through August, 2011), while the one on the right reflects the MEA baseline monitoring period only. Wind speeds and directions are demonstrated to be very similar between the 15-year and 1-year monitoring periods.

Figure 3.6-28 compares the wind direction frequency distributions between the 15-year and baseline periods at Scottsbluff. The percent of the time the wind blows from each of the 16 cardinal directions shown is quite similar for the two monitoring periods.

Figure 3.6-29 compares the wind speed frequency distributions of the 15-year and baseline periods at Scottsbluff. The percent of the time the wind speed falls within each of the six wind speed classes shown is quite similar for the two monitoring periods.

In order to quantify this similarity, it is useful to isolate wind speed and wind direction variables in order to correlate short-term and long-term frequency distributions. IML Air Science has developed a statistical methodology for assessing the degree to which the distributions of wind speed class and wind direction frequencies from 1 year of monitoring at a particular location represent the long-term distributions at that same location.

For the joint frequency wind distribution used in the MILDOS-AREA model (NRC 1981), wind speeds are divided into six classifications ranging from mild (0 to 3 mph) to strong (> 24 mph), as illustrated in **Table 3.6-9** and on **Figure 3.6-29.** Likewise, wind directions are divided into 16 categories corresponding to the compass directions illustrated in the wind roses and on **Figure 3.6-28**.

The percent of the time that winds occur in each of the six wind speed categories can be calculated to produce a wind speed frequency distribution. The percent of the time that winds blow from each of the 16 directions can be calculated to produce a wind direction frequency distribution. For each parameter, the 1-year and 15-year distributions can then be compared. Linear regression analysis provides a useful tool to assess the degree of correlation between short- and long-term distributions.

Figure 3.6-30 presents this correlation for the wind speed distributions at Scottsbluff. Each point represents one of the six wind speed classes. The x coordinate corresponds to the percent of the 1-year period during which the wind speed fell in a given class, while the y coordinate corresponds to the percent of the 15-year period during which the wind speed fell in that same class.

The regression line (red) on **Figure 3.6-30** represents the least-squares fit to the six data points. The corresponding R^2 value of 94.5 percent implies very strong linear correlation. The linear slope of 0.98

further implies that short- and long-term wind speed frequencies not only correlate, but are substantially equivalent in magnitude.

A similar analysis can be performed for wind direction frequencies. **Figure 3.6-31** presents this correlation, again for the Scottsbluff Airport site. Each point represents one of the 16 wind direction categories. The x coordinate corresponds to the percent of the 1-year period during which the wind blew from a given direction, while the y coordinate corresponds to the percent of the 15-year period during which the wind blew from that same direction.

The regression line (red) on **Figure 3.6-31** represents the least-squares fit to the 16 data points. The corresponding R^2 value of 97.2 percent implies very strong linear correlation. The linear slope of 1.02 further implies that short- and long-term wind speed frequencies not only correlate, but are substantially equivalent in magnitude.

Figures 3.6-30 and **3.6-31** offer conclusive evidence that the 2010-2011 baseline monitoring year adequately represents the last 15 years at Scottsbluff Airport. Because the 1-year wind data serve as reliable predictors of the long-term wind conditions at Scottsbluff, and because the MEA site experiences similar regional weather patterns, it is proposed here that the 1-year baseline monitoring represents long-term meteorological conditions at the MEA site.

3.6.3.7 On-Site Meteorological Instrument Specifications

Table 3.6-14 lists the meteorological instruments employed at the MEA meteorological monitoring station. The table shows instrument models, accuracy specifications, and instrument heights above the ground. An example of a calibration report for the meteorological instruments is contained in **Appendix B** to this document.

Meteorological data collection, management, and reporting methods at the project site conform to NRC atmospheric dispersion modeling requirements for uranium milling operations, and meet the acceptance criteria established in the NRC's RG-1569. The onsite monitoring program was developed according to RG 3.63, "Onsite Meteorological Measurement Program for Uranium Recovery Facilities – Data Acquisition and Reporting." Hourly average values for wind speed, wind direction, sigma theta, temperature, relative humidity, precipitation, and solar radiation are generated by field instruments and recorded by continuous data loggers. Data recovery exceeded 97 percent for the 12-month monitoring period. All hourly data have been downloaded to a relational database for quality assurance, statistical analysis, and reporting purposes.

The meteorological instruments are located in the MEA in an area that represents as closely as possible the long-term meteorological characteristics of the area for which the measurements are being made. NRC RG 3.63 provides guidance acceptable to the NRC regarding the siting of meteorological instruments. The siting of the MEA meteorological instruments followed this NRC guidance and is discussed in **Appendix R** of this document. This appendix addresses the NRC's siting conditions identified as being necessary to achieve meteorological data representative of the proposed project site.

3.6.3.8 Upper Atmosphere Characterization

Mixing height is the height of the atmosphere above the ground that is well mixed due either to mechanical turbulence or convective turbulence. The air layer above this height is stable. Higher mixing heights are associated with greater dispersion, all other parameters being the same. Stable periods have

much lower mixing heights and accompanying lapse rates, allowing for less temperature variation. The MILDOS-AREA model uses mixing height, along with other wind parameters, to predict pollutant dispersion. Unstable air leads to more dispersion, which leads to lower predicted impacts on ambient air quality. The default mixing height used by MILDOS-AREA is 100 meters, a very conservative value given that typical mixing heights exceed 1,000 meters.

The nearest upper-air data available from the NWS are from Rapid City, South Dakota, approximately 108 miles (173.8 km) north of the project area. Average mixing heights were derived from the American Meteorological Society (AMS)/EPA Regulatory Model (AERMOD) calculations used for dispersion modeling, based on hourly data obtained from the NWS stations in Rapid City (upper air). The AERMOD calculation is based on a combination of mechanically and convectively driven boundary layer processes. The results of these calculations are provided for morning and afternoon in **Table 3.6-15**. The annual average mixing height is 1,110 meters.

The mixing or inversion heights are entered as inputs to the MILDOS-AREA model for pollutant dispersion modeling. For the MEA project, the MILDOS default value of 100 meters was used for both morning and afternoon mixing heights. Argonne National Laboratory has used a default value of 100 meters for the annual average morning and afternoon atmospheric mixing heights (ANL 1998). Page 12 of the Guide states “Mixing Heights: annual average Morning and Afternoon atmospheric mixing height in meters. The default value is 100 m for both.” Therefore, this default value was used for MILDOS modeling of the MEA site.

Because this mixing height of 100 m is lower than the calculated mixing heights in **Table 3.6-15**, and lower mixing heights lead to less pollutant dispersion, the dosage concentrations calculated by the MILDOS model are conservatively high.

3.6.3.9 Bodies of Water and Special Terrain Features

The only significant body of water near the proposed MEA is the Niobrara River, which flows easterly to the south of the project site. The southernmost MEA license boundary is located approximately 0.24 mile (0.4 km) from the Niobrara River (**Figure 3.4-4)**. The distance of the southern boundary of Mine Unit MU-F (southernmost mine unit in the MEA site) to the nearest point on the Niobrara River is approximately 0.42 mile. The average flowrate at this location, however, is only 29 cubic ft/sec (USGS 2009). It is unlikely that the influence of such a small stream could be measured 4 miles (6.4 km) away with a standard humidity probe.

The nearest mountain ranges to the project site are:

- The Laramie Mountains, approximately 100 miles (160.9 km) to the west
- The Black Hills, approximately 65 miles (104.6 km) to the north

It is believed that, at these distances, the mountain ranges have minimal impact on meteorology in the project area. As discussed above, storms moving eastward from the Rocky Mountains generally relinquish moisture on the windward side of the mountains, creating a drier climate on the leeward side. This is mitigated, however, by occasional moist air masses moving into Nebraska and Wyoming from the Gulf of Mexico.

3.6.4 Conclusion of Site Specific Analysis

The proposed MEA near Crawford, Nebraska is located in a semiarid or steppe climate. The area is characterized by abundant sunshine, low relative humidity, and sustained winds which lead to high evaporative demand.

Thirteen NWS meteorological stations were used to characterize regional weather patterns. The region experiences average daily maximum temperatures near 90° F in July, and average daily minimum temperatures around 15° F in January. There are large diurnal and annual variations in temperature. The region has cold, harsh winters; hot, dry summers; and relatively warm, moist springs and autumns. Temperature extremes range from roughly -25° F in the winter to 100° F in the summer. The site average temperature is expected to be 46° F with extremes of -30° to + 105° F. The region generally receives little precipitation, with annual averages between 13 and 16 inches. Spring and early summer precipitation events are responsible for the majority of the yearly average.

The region is characterized by annual average wind speeds of 9 to 12 mph. Winds at the project site are expected to average 10 to 11 mph annually, with summer averages dipping below 8 mph and winter averages exceeding 12 mph. The predominant wind directions are from the north-northwest and northwest.

The MEA meteorological station and the Scottsbluff Airport meteorological station were both analyzed in the site-specific analysis. The Scottsbluff site is included to validate the temporal representativeness of on-site wind data by incorporating wind monitoring results from a longer period of record. The Scottsbluff site is located 48 miles (77.2 km) south of the MEA, with elevation and topographic features comparable to the project area. The distribution of wind speeds and directions at Scottsbluff during the baseline monitoring period have been shown to closely represent long-term wind speeds and directions.

3.6.5 Air Quality

3.6.5.1 National Ambient Air Quality Standards

The NDEQ air quality regulations are based on federal and/or state law, with the primary source of the authority for air quality regulations being the Federal Clean Air Act (NDEQ 2003). The NDEQ adopts the majority of these federal regulations into Title 129 (Nebraska Air Quality of the Nebraska Administrative Code). The basic foundation of the NDEQ air program is the National Ambient Air Quality Standards (NAAQS), which are concentrations of pollutants the EPA has established (and adopted by the NDEQ) as being protective of human health and the environment. The standards are established for six "criteria" pollutants: particulate matter, sulfur dioxide (SO_2), nitrogen oxides, carbon monoxide, ozone, and lead (**Table 3.6-16,** EPA 2013). The State of Nebraska is required to keep areas in compliance with the standards and restore compliance in any areas out of compliance. The NDEQ has several ambient air monitors located throughout the state to measure the concentrations of pollutants in the ambient air (NDEQ 2011). An area may be classified as nonattainment if the concentration of one or more criteria pollutants in an area is found to exceed the regulated or "threshold" level for one or more of the NAAQS. Those areas with concentrations of criteria pollutants below the levels established by the NAAQS are considered in attainment or unclassifiable.

The overall air quality in the State of Nebraska is considered to be good. Nebraska is located in a part of U.S. that is largely in attainment with NAAQS, thereby minimizing the impact of pollutant transport from other states on Nebraska air quality (NDEQ 2011). All areas within the state are in attainment with

NAAQS (NDEQ 2011). The City of Omaha previously had a nonattainment designation for lead, but due to actions by Omaha Air Quality Control, NDEQ, EPA, and local industries, the area is now classified as attainment. The City of Omaha is located more than 375 miles (603.5 km) from the MEA area.

On February 14, 2012, the EPA proposed thresholds for classifying nonattainment areas for the 2008 ozone NAAQS promulgated by the EPA on March 12, 2008 (EPA 2012). This proposal also addresses the timing of attainment dates for each classification and revokes the 1997 ozone NAAQS 1 year after the effective date of designations for the 2008 ozone NAAQS for transportation conformity purposes only. The February 14, 2012 proposal establishes a necessary step to implement the 2008 NAAQS for ground-level ozone. The EPA set those standards at 0.075 parts per million (ppm) on March 12, 2008.

There are no ambient air quality monitoring data for criteria pollutants in the proposed MEA license boundary or AOR. However, there are a limited number of state and federal monitoring sites in the region of the MEA that can be used as levels representative of the region for the monitored parameters. These monitoring sites are maintained for a variety of purposes, including for regional background purposes by the NDEQ, per Appendix D of 40 CFR Part 58. However, the parameters measured are limited to particulate and ozone monitoring.

Regional monitoring sites and parameters measured are presented in **Table 3.6-17**. The locations of the monitor sites in western Nebraska are shown on **Figure 3.6-32**. The data available at the time of preparation of this section are summarized in **Tables 3.6-18** through **3.6-25**. The results of this monitoring indicate that the regions being monitored, including the MEA area, are well within compliance of NAAQS standards.

3.6.5.2 Prevention of Significant Deterioration

In addition to the ambient air quality standards, there are national standards for the Prevention of Significant Deterioration (PSD) of air quality (40 CFR 51.166). The PSD program is administered by the States of Nebraska and South Dakota, with their programs designed to protect the air quality in area that are in attainment with the NAAQS and to prevent degradation of air quality in areas below the standard (designated as clean air areas). PSD differs from the NAAQS in that the NAAQS provides for maximum allowable concentrations of pollutants, while PSD requirements provide maximum allowable increases in concentrations of pollutants for areas already in compliance with the NAAQS. The PSD requirements establish allowable pollution "increments" that may be added to the air in each area while still protecting air quality. The increment is the maximum allowable deterioration of air quality. The maximum allowable increments applicable to Nebraska and South Dakota are shown in **Table 3.6-26.**

The allowable increments vary by location across the states. Those areas characterized as Class I (i.e., National Parks and Wilderness Areas) allow for less incremental pollution increase. Class III areas are planning areas set aside for industrial growth. The areas classified as Class II are essentially all other areas of the state not designated as Class I or Class III. There are no Class I National Park and Wilderness Areas in Nebraska. The Soldier Creek Wilderness Area, located north of Fort Robinson, is not designated as Class I. The State of South Dakota has two Class I Areas: Badlands and Wind Cave National Parks. The Wind Cave National Park is closer to the MEA, at a distance of approximately 75 miles (120.7 km).

No potential impacts to NAAQS parameters or PSD Class I, II, or III areas are expected to occur as the result of the MEA operations. The primary emissions from the proposed MEA will be tailpipe emissions of nitrogen oxides (NO_x), carbon monoxide (CO), SO_2, non-methane-ethane volatile organic compounds (VOCs), and particulate matter with a diameter less than ten microns (PM_{10}) resulting from vehicle traffic

within the MEA. The majority of the emissions generated during construction will be fugitive dust and vehicle combustion emissions. Effects of air emissions and impacts associated with construction and operations are discussed in Section 4.6

3.7 Noise

The MEA site and immediate area is predominantly rural and undeveloped, with a minimal number of residences (**Figure 3.1-2).** Such rural areas tend to be relatively quiet. Primary man-made noises that contribute to the background noise levels at the MEA would include the following:

- Farm and ranching activities in the area

  The MEA is in an area of ranching and farming, so noise associated with farm and ranch equipment would contribute to seasonal background noise levels at the MEA.

- US/State Highways and county roads vehicle traffic

  Highway 20, SH 2/71, and various county roads are located nearby, and vehicle traffic would contribute to the background noise levels.

- Train traffic

  The Burlington Northern Santa Fe (BNSF) Railroad tracks are located just to the west of the MEA, with numerous trains passing daily. This train traffic is one of the main sources of noise in the area of the MEA.

Noise impacts associated with construction of the satellite facilities would be of short duration compared to the operations period. Noise levels during site construction are expected to increase due to increased vehicle traffic in support of construction on SH 2/71. Additionally, heavy equipment use during construction may include bulldozers, scrapers, graders, front-end loaders, cranes, and various trucks used for conveying personnel. Train usage would not increase as a result of construction. Noise from construction would not be generated during nighttime hours, and increases in noise levels would be intermittent and temporary.

Noise sources during operation are expected to increase due to increased vehicle traffic as increased numbers of employees traveling to and from the City of Crawford and area for work, and from resin transfer to the CPF. Processing equipment at the satellite facility would be minimal and is not expected to significantly add to existing noise sources. Increases due to operations are expected to be less than noise levels generated during construction. Therefore, it is expected that noise levels during operations would be barely perceptible over the existing ambient noise that is dominated by vehicle and BNSF railroad noise.

Noise impacts are discussed in Section 4.7.

3.8 Regional Historic, Archeological, Architectural, Scenic, and Natural Landmarks

3.8.1 Historic, Archeological, and Cultural Resources

There have been few cultural resources investigations on private land in southern Dawes County. Cultural resources investigations have been more numerous around the White River and the Cities of Chadron and Crawford about 10 miles (16.1 km) to 15 miles (24.1 km) to the north, and the results of those surveys can provide a cultural context for comparison to the MEA. Known resources in that area include

indigenous people, artifact scatters, faunal kill and processing sites, and camps; fur trade and other contact period sites; the Sidney-Deadwood Trail; historic railroads; historic farming sites; Fort Robinson; and the Cities of Chadron and Crawford. In the mid-1800s, this region was occupied predominantly by bands of Lakota Sioux and Cheyenne. In the 1870s, the Red Cloud Indian Agency was located at Fort Robinson west of Crawford. By 1878, the tribes had officially been relocated to reservations, but sporadic Lakota and Cheyenne resistance continued through the 1880s. The MEA is south of the Pine Ridge Escarpment near the Niobrara River, and the nearby Town of Marsland is small in comparison to the Cities of Chadron and Crawford. The Town of Marsland is located along the Sidney-Deadwood Trail, along one of the historic railroad corridors that also passed through Crawford, and along a major river that would have attracted fur trappers. The fur trade in northwest Nebraska was centered along the White and Niobrara Rivers.

The proposed MEA is located on private lands east of SH 2/71 and north of the Niobrara River. An archaeological files search through the Archaeology Division of the Nebraska State Historical Society (NSHS) indicated that there have been no previous archaeological investigations within 1 mile (1.6 km) of the MEA, and that no archaeological sites have been previously reported. An architectural and structural properties search through the Nebraska State Historic Preservation Office (SHPO) indicated that four historic structures (DWOO-240, DWOO-241, DWOO-242, and DWOO-243) have been reported in the study area. Two of these structures are within the MEA, and the other two are close to the MEA.

A search of the BLM Public Land Patent Records indicates that nine patents were granted for lands in the MEA from 1891 to 1917. This is consistent with the completion of the Chicago, Burlington, and Quincy Railroad through Crawford in 1889, which made the land more accessible to homesteaders, and with a brief moist period in the region between 1910 and 1920. A search of the National Register of Historic Places (NRHP) online database for Dawes County yielded 11 sites in the northern portions of the county. None of these NRHP-listed sites is within 10 miles (16.1 km) of the MEA. Fort Robinson and the Red Cloud Indian Agency, about 15 miles (24.1 km) north-northwest of the MEA, are also listed as a National Historic Landmark.

ARCADIS completed an intensive pedestrian block cultural resources inventory of approximately 4,500 acres for the MEA during the period from November 2010 to February 2011 (Graves et al. 2011). The MEA was inventoried for the presence of euroamerican and indigenous peoples' properties (cultural resources that are listed or eligible for listing on the NRHP) and may be impacted by proposed mine development. Graves et al. (2011) recorded 15 newly discovered euroamerican historic sites and five euroamerican historic isolated finds, and updated the documentation on two of the previously recorded historic farmstead sites (DWOO-242 and DWOO-243).

ARCADIS submitted the "Cameco Resources Marsland Expansion Area Uranium Project Cultural Resource Inventory" report and associated Nebraska Archeological Site Survey Forms to the NHPS/SHPO on April 28, 2011 (Graves 2011), and SHPO concurrence was granted by the Deputy State Historic Preservation Officer on May 19, 2011. The SHPO approval was issued via a stamped concurrence on the April 28, 2011 submittal letter.

CBR requested that ARCADIS complete a field survey of an additional 160 acres in section 36 T30N R51W surveyed during the original field investigation but not documented in the original report. The 160 acres was field investigated by ARCADIS on February 19, 2011, and no new cultural resources were discovered. One historic bridge (25DW362) was identified in section 36 T30N R51W and reported within the original cultural resource inventory report. An addendum to the original cultural resources

report was prepared to address the additional 160 acres (Graves and Graves 2012). Historic site 25DW362 was recommended not eligible for listing on the NRHP with SHPO concurrence.

The Nebraska SHPO concurred with the findings of the addendum to the cultural resources report that no archaeological, architectural, or historic context property resources will be affected by the proposed project (NSHS 2012). As stated in the SHPO concurrence letter, the SHPO's review does not constitute the opinions of any Native American Tribes that may have an interest in Traditional Cultural Properties potentially affected by this project.

No indigenous people sites or artifacts were found in the project area. Regardless, a process for tribal identification of Traditional Cultural Properties is being developed and will be implemented during review of the MEA Environmental Report to satisfy NEPA.

The newly recorded historic sites included six farmsteads (25DW359, 25DW360, 25DW361, 25DW365, 25DW366, and 25DW370), three artifact scatters (25DW357, 25DW363, and 25DW369), two cisterns (25DW358 and 25DW364), one corral and windmill (25DW367), one bridge (25DW362), one dugout depression and berm (25DW368), and one stone quarry (25DW371). All of these sites were recommended not eligible for the NRHP.

The previously recorded farmstead sites were recorded jointly by SHPO and NSHS as part of a historic building survey of Dawes County in 2005 as the B. Chapman House (DWOO-242; built about 1910); and an abandoned farmhouse (DWOO-243; built about 1890). Updated documentation was prepared for the two buildings in the survey area. This documentation included the completion of NSHS archaeological site survey forms that included documentation of associated artifacts and features in addition to the buildings. Updated documentation of the DWOO-242 included a concrete cistern, a storage shed, two modern propane tanks, and historic and modern artifacts. The house is well maintained and appears to be occupied. Site DWOO-243 is more extensive. This site includes two abandoned 1.5-story farmhouses; a smaller 1-story house; two storage sheds; one stock shelter; one foundation with a chicken coop gate; two metal grain bins; abandoned vehicles, wagons, and farm implements; a network of fenced enclosures; and a large pile of historic debris.

All of the newly recorded historic sites were recommended not eligible for the NRHP and do not qualify as historic properties. Isolated finds are by definition not eligible for the NRHP. Historic farmstead DWOO-242 is recommended not eligible for the NRHP, but appears to be currently or recently occupied. Site DWOO-243 may have the potential to yield information important in history and may be potentially eligible for the NRHP. Avoidance of these two sites by project actions is recommended. If these recommendations are followed, the proposed project will have no adverse effect on historic properties, and no further cultural resource investigations are recommended.

Specific information included in cultural resources investigations falls under the confidentiality requirement for archaeological resources under Section 304 of the National Historic Preservation Act (NHPA; 16 U.S.C. 470w-3(a)). In addition, disclosure of such information is protected under Nebraska State Statute Section 84-712.05 (13 and 14). The cultural resources inventory report and Attachment A of that report have been marked "FOR OFFICIAL USE ONLY: DISCLOSURE OF SITE LOCATIONS IS PROHIBITED (43CFR 7.18). In compliance with Nebraska SHPO, NRC RG-1569 Section 24, and NDEQ Title 122 Ch. 11 Sections 006.07. These materials should be treated as confidential information for the purpose of public disclosure of this NRC license amendment. The cultural resources report will be submitted to the NRC and State of Nebraska SHPO under separate cover.

The NRC is responsible for the government-to-government NHPA Section 106 consultation for the Crow Butte project areas near Crawford, Nebraska. These project areas include the CBR current operation ISR facility license renewal and the proposed NTEA, TCEA, and MEA. As part of the NRC's ongoing efforts to identify historic properties of religious and cultural significance to Native American Tribes that could be affected by CBR's proposed projects, the NRC sent a letter, dated October 31, 2012, offering each consulting Tribe an opportunity to participate in a field study to identify potential places of religious and cultural significance at these sites (NRC 2013). In support of the NRC's offering, CBR offered to open each of the four project areas for field inspection during the period of November 14 through December 7, 2012.

Two consulting Tribes accepted CBR's offer to open the CBR project areas during the November 14 through December 7, 2012 timeframe (NRC 2013). Tribal field crews inspected the current CPF site, MEA, and TCEA project areas for zones thought to potentially contain places of Tribal religious and cultural significance. The Santee Sioux Nation submitted a Traditional Cultural Properties Survey report on the behalf of the Crow Tribe of Montana and the Santee Sioux Nation for the Crow Butte operations (Santee Sioux Nation 2013; **Appendix U**). A report for this survey was submitted to the NRC; the survey did not result in the recognition of any historic property of potential significance for NRHP listing.

3.9 Scenic Resources

3.9.1 Introduction

The MEA is on private land that is not managed to protect scenic quality by any public agency. The MEA is located on generally level ground south of the Pine Ridge area of northwestern Nebraska, and may be visible from some public roads in the areas. The existing landscape and the visual effect of the proposed facilities have been inventoried and assessed for the proposed project using the BLM Visual Resource Management (VRM) system.

3.9.2 Methods

The VRM system is the basic tool used by the BLM to inventory and manage visual resources on public lands. The VRM inventory process involves rating the visual appeal of a tract of land, measuring public concern for scenic quality, and determining whether the tract of land is visible from travel routes or observation points.

The scenic quality inventory was based on methods provided in BLM Manual 8410 – Visual Resource Inventory (BLM 1986a). The key factors of landform, vegetation, water, color, influence of adjacent scenery, scarcity, and cultural modifications were evaluated according to the rating criteria, and provided with a score for each key factor (BLM 1986b). The criteria for each key factor ranged from high to low quality based on the variety of line, form, color, texture, and scale of the factor within the landscape. A score was associated with each rating criterion, with a higher score applied to greater complexity and variety for each factor in the landscape. The results of the inventory and the associated score for each key factor are summarized in **Table 3.9-1**. According to RG-1569; 2.4.3(7), if the visual resource evaluation rating is 19 or lower, no further evaluation is required. The total score of the scenic quality inventory is 13; however, an analysis was prepared to reflect the growing concern some residents may have for scenic resource, as Dawes County is expected to continue to develop tourism in the region.

3.9.2.1 VRM Classes

The elements used to determine the visual resource inventory class are the scenic quality, sensitivity levels, variety classes, and distance zones. Each of the elements used to identify the VRM Class is defined below:

Scenic Quality – Scenic quality is a measure of the visual appeal of a tract of land. In the visual resource inventory process, public lands are assigned an A, B, or C rating based on the apparent scenic quality, which is determined using seven key factors: landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications. During the rating process, each of these factors is ranked comparatively against similar features within the physiographic province.

Sensitivity Level – A degree or measure of viewer interest in the scenic qualities of the landscape. Factors to consider include 1) type of users, 2) amount of use, 3) public interest, 4) adjacent land uses, and 5) special areas. Three levels of sensitivity have been defined:

- Sensitivity Level 1 – The highest sensitivity level, referring to areas seen from travel routes and use areas with moderate to high use.
- Sensitivity Level 2 – An average sensitivity level, referring to areas seen from travel routes and use areas with low to moderate use.
- Sensitivity Level 3 – The lowest sensitivity level, referring to areas seen from travel routes and use areas with low use.

Distance Zones – Areas of landscapes denoted by specified distances from the observer, particularly on roads, trails, concentrated-use areas, rivers, and other locations. The three categories are foreground-middleground, background, and seldom seen.

- Foreground-Middleground – The area visible from a travel route, use area, or other observer position to a distance of 3 miles (4.8 km) to 5 miles (8.0 km). The outer boundary of this zone is defined as the point where the texture and form of individual plants are no longer apparent in the landscape, and vegetation is apparent only in pattern or outline.
- Background - The viewing area of a distance zone that lies beyond the foreground and middleground. This area usually measures from a minimum of 3 miles (4.8 km) to 5 miles (8.0 km) to a maximum of about 15 miles (24.1 km) from a travel route, use area, or other observer position. Atmospheric conditions in some areas may limit the maximum to about 8 miles (12.9 km) or increase it beyond 15 miles (24.1 km).
- Seldom Seen – The area is screened from view by landforms, buildings, other landscape elements, or distance.

The visual resource inventory classes are used to develop VRM classes, which are generally assigned by the BLM through the resource management plan process. VRM objectives are developed to protect scenic public lands, especially those that receive the greatest amount of public viewing. The following VRM classes are objectives that outline the amount of disturbance an area can tolerate before it no longer meets the visual quality of that class.

- Class I Objective: To preserve the existing character of the landscape. The level of change to the characteristic landscape should be very low and must not attract attention.

- Class II Objective: To retain the existing character of the landscape. The level of change to the characteristic landscape should be low.
- Class III Objective: To partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate.
- Class IV Objective: To provide for management activities which require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high.

The Scenic Quality, Sensitivity Level, and Distance Zone inventory levels are combined to assign a VRM Class to inventoried lands as shown in **Table 3.9-2**.

3.9.2.2 Affected Environment

The MEA lies mostly in the Sandy and Silty Tableland ecoregion, with the northern portion of the MEA lying in the Pine Ridge Escarpment; both are sub-regions of the Western High Plains ecoregion. The physiography of the Pine Ridge Escarpment is characterized by alternating ridges and valleys with entrenched channels and rock outcrops, with elevations increasing from the northeast to the southeast. Vegetation includes ponderosa pine woodlands with Rocky Mountain juniper, western snowberry, skunkbush sumac, choke cherry, and Arkansas rose. Mixed-grass prairie is also found, containing little bluestem, western wheatgrass, prairie sandreed, needle-and-thread, blue grama, and threadleaf sedge. The physiography of the Sandy and Silty Table is characterized by tablelands with areas of moderate relief, with some areas of isolated sand dunes, and canyons along stream valleys. Vegetation includes mixed-grass prairie containing blue grama, little bluestem, threadleaf sedge, and needle-and-thread, and some scattered Sand Hills prairie with sand reed and little bluestem (EPA 2000).

The MEA landscape is rural and agricultural in character, and is composed primarily of scenery that is common for the ecoregion. Vegetation cover consists of grassy meadows and croplands interspersed with shrubby riparian growth along drainages. The landscape colors are dominated by tan, gold, and green vegetation. The colors and values (degrees of lightness and darkness) of soils and vegetation are similar, exhibiting little contrast during most of the year, although the dark greens of Ponderosa pine visible in the background from the MEA exhibit striking color contrasts throughout the year. The scenic quality of the MEA is enhanced by the backdrop of the slopes covered with Ponderosa pine in the Nebraska National Forest to the south.

The characteristic landscape of the MEA consists of flat to rolling hills dissected by tributaries of the Niobrara River, which is located south of the MEA. The terrain becomes progressively higher in elevation to the north. The MEA is blocked from view along the entirety of SH 2/71 by low ridges located close to the highway. Portions of the MEA are visible from E. Belmont Road, Squaw Mound Road, Hollibaugh Road, and River Road.

The visual character of the landscape includes human modification from a variety of land uses, including open lands, cropland, roadways, rural residences, and utility corridors. Open land used for grazing activities is the dominant land use in the MEA. The northern portion of the MEA is accessible from E. Belmont Road, and the southern portion from River Road. Both are gravel-surfaced county roads, which in turn connects to SH 2/71, one of the primary north-south roadways through Dawes County. Human modifications to the natural landscape evident in the MEA include private roads, rural residences, agricultural implements, and electric distribution lines.

3.9.2.3 MEA Visual Inventory

Most of the MEA is characterized by the low, rolling plains and agricultural land uses characteristic of the area in northwestern Nebraska. The scenic quality of the MEA landscape is typical of the ecoregion, and is rated as Class B. There are no Class A landscapes visible from the MEA.

Sensitive Viewing Areas

Sensitive viewing areas in the MEA include E. Belmont Road, River Road, Squaw Mound Road, and Hollibaugh Road (the primary transportation routes through and adjacent to the MEA) and rural residences. In general, residents and other users of the region are accustomed to viewing human modification in the rural landscape, but could be sensitive to increased levels of development.

The characteristic landscape of the MEA as viewed from any of the roads and the residences consists of a broad expanse of mixed-grass prairie and cropland with scenic backdrops to the north. The MEA is located more than 3.5 miles (5.6 km) east of SH 2/71 at its nearest point, and is not visible from the highway. Public use of county and private roads within the MEA is relatively low, with motorists falling into the categories of local ranchers and residents.

The greatest number of viewers of the proposed facilities would be traveling on E. Belmont Road, River Road, Squaw Mound Road, or Hollibaugh Road. The majority of motorists on the road would be residents within and outside of the MEA. There is one occupied residence within the MEA. The MEA landscape is also within the view of five residences within the 2.25-mile (3.62 km) AOR.

The level of use on E. Belmont Road, River Road, Squaw Mound Road, or Hollibaugh Road and residences within or near to the MEA is low to moderate (Sensitivity Level 2) due to the fact that River Road is one of only three routes into Box Butte Reservoir State Recreation Area. Viewers at isolated rural residences with views of the project area are few.

A potential sensitive viewing area is the Nebraska National Forest located north of the north boundary of the MEA. However, there are no developed campgrounds or other facilities within the National Forest that could view the MEA due to the topography of the area. Individuals hiking through the National Forest could view the MEA in the background. While the level of concern for scenic landscapes would be high for many park visitors, the MEA would not be visible from most of the National Forest.

VRM Class

Based on the project area Class B scenic quality, the Sensitivity Level 2 (Medium) as viewed from E. Belmont Road, River Road, Squaw Mound Road, Hollibaugh Road, and residences; and the location of the project area in the background distance zone as seen from the Nebraska National Forest, the MEA has been assigned Class III for both the visual resource inventory and the VRM objective.

3.10 Population Distribution

Information presented in this section concerns those demographic and social characteristics of the environment that may be affected by the proposed expansion of the Crow Butte Uranium Project to include operations in the MEA. Data were obtained through the 1980, 1990, and 2000 Decennial Census, with updates from the 2010 census; various State of Nebraska government agencies; and other publicity available sources.

3.10.1 **Demography**

3.10.1.1 Regional Population

The area within a 50-mile (80 km) radius of the project site includes portions of six counties in northwestern Nebraska, two counties in southwestern South Dakota, and two counties in eastern Wyoming. Because the 50-mile (80 km) radius extends only slightly into two very rural portions of Garden County, Nebraska and Niobrara and Goshen Counties in Wyoming, these areas are not discussed in detail beyond data summarized in **Tables 3.10-1** through **3.10-3**. **Figure 3.10-1** depicts significant population centers within a 50-mile (80 km) radius of the proposed MEA.

Historical and current population trends in the project area counties and communities are summarized in **Table 3.10-1**. Most counties have experienced a decline in population since either the 1970 or 1980 Decennial Census; the exceptions are Shannon County, South Dakota and Goshen County, Wyoming, which have both seen population increases. All of the Nebraska counties comprising the project area experienced slight growth or actual population decline between 1960 and 1980 and population decline between 1980 and 2010. The state experienced its fastest growth since the 1920s between 1990 and 2000. The total state population in 2010 was 1,826,000, which was a 6.7-percent increase over the 2000 population of 1,711,000. The Nebraska counties in the project area experienced little of the 15.7 percent growth spurt seen state-wide in the 1990 to 2010 period; only Scotts Bluff and Dawes Counties registered positive population growth in this time period, and that growth was less than 3 percent. In general, population trends for the past two decades show that the population in urban areas is increasing, while population in rural areas is declining. Areas within 50 miles (80 km) of the project site that are defined as urban (all territory, population, and housing units in urbanized areas and in places of more than 2,500 persons outside of urbanized areas) by the U.S. Census 2000 are the Cities of Chadron and Alliance, Nebraska (USCB 2003a).

Dawes County grew slightly between 1990 and 2000, gaining 1.8 percent in population; this is attributed to growth in the City of Chadron, which more than offset the population declines in other communities in the county. This population growth has not offset the large loss of population that occurred in the 1980 to1990 time period; the population today remains below its 1980 level. The City of Chadron and the City of Crawford are the nearest large communities in Dawes County close to the project site. The City of Chadron is located approximately 25 miles (40 km) northeast of the project site; its 2010 population was recorded at 5,851; an increase of 3.9 percent from 2000 (USCB 2011). The City of Crawford, which is located within 15.1 miles (24.3 km) of the MEA satellite building (centerpoint to centerpoint), had a 2010 population of 1997; an almost 10 percent decrease from 2000 (USCB 2011). The population declines in the City of Crawford were greater than the losses in most other communities and the county as a whole.

Sioux County has been losing population since the 1970 Decennial Census; the pace of these losses has fluctuated over the last 40 years, but has averaged approximately 10 percent per decade. The population decline was slowest in the 1990 to 2000 period due to a population increase of nearly 16 percent in the City of Harrison.

Box Butte County experienced a significant gain in population in the 1970 to 1980 timeframe, but has been losing population ever since. The population decline has averaged approximately 6 percent per decade since the 1980 Census, with the county losing 7 percent of its population since the 2000 Census. The Town of Hemingford, the nearest significant community in Box Butte County to the project site, has seen fluctuating population levels since the 1970 Census, although the town lost approximately 19 percent of its population in the past decade.

Similarly, Sheridan County saw a gain in population in the 1970 to 1980 timeframe, but has been steadily losing population at an average rate of approximately 10 percent per decade since. This decline in population has been seen in the county's larger communities of Hay Springs and Rushville, both of which have similar rates of decline in their populations since 1980.

Scotts Bluff and Morrill Counties have experienced less severe population losses over the 1980 to 2010 timeframe, with losses of 6 and 1.1 percent per decade, respectively. The communities of Scottsbluff and Minatare in Scotts Bluff County have experienced population growth of 0.7 and 2.1 percent, respectively, since the 2000 Census.

Within South Dakota, portions of Fall River and Shannon Counties fall inside the 50-mile (80 km) study area. Fall River County experienced population growth in the 1970 to 1980 period, but has lost more than 16 percent of its population in the last 30 years despite a small positive growth rate in the 1990 to 2000 period. The county-wide trends in population growth and loss are mirrored in the community of Oelrichs, which has lost more than 21 percent of its population since 1980. Shannon County, on the other hand, has grown by an average of better than 15 percent per decade since 1970; this growth has been realized in significant swings, with 38 percent growth in the 1970 to 1980 period followed by a 12.5 percent decline in population over the 1980 to 1990 period, which was then followed by a decade of nearly 26 percent growth from 1990 to 2000 and then 9 percent growth from 2000 to 2010. Much of the growth occurred in the Pine Ridge and Oglala Census Designated Places, which are urban areas as defined by the U.S. Census but are not incorporated municipalities.

The population declines in the counties within the 50-mile (80 km) radius reflect trends in the overall region, where population declines have been attributed to the declines in the rural farming-based economy and limited economic opportunities for youth. Persistent drought conditions have also contributed to the shrinking of the agriculture-based economy. Rural residents have been migrating to larger cities, depopulating the largely rural Great Plains states. Many of the people migrating out of the state are young adults and families, which results in fewer people of childbearing age, and therefore, fewer children. This trend also contributes to the increasing proportion of the elderly population in the state (UNRI 2008).

3.10.1.2 Population Characteristics

2010 population by age and sex for counties within 50 miles (80 km) of the MEA is shown in **Table 3.10-2**. Overall, 74.5 percent of the population in the region is more than 18 years old. Fewer than 20 percent of the populations of Garden, Fall River, and Niobrara Counties are under the age of 18; Shannon County has the youngest population, with nearly 40 percent of its population under the age of 18. Females slightly outnumbered males in all but four counties, with an overall population of 50.6 percent female to 49.4 percent male (USCB 2011).

In 2010, 81.5 percent of the population of the 11 counties was classified as white. American Indians comprised the largest non-white classification. The largest American Indian population is found in Shannon County, South Dakota, where American Indians comprise 96 percent of the 13,586 people in the county (USCB 2011).

3.10.1.3 Population Projections

The projected population for selected years by county within the 50-mile (80 km) radius of the proposed MEA Project is shown in **Table 3.10-3**. The population is expected to decrease or hold steady in all 11

counties surrounding the project area. These counties are primarily rural, with agriculture-based economies. It is anticipated that the declining population trends of the last two decades will continue into the foreseeable future for these counties as populations shift to more urban counties (e.g., Douglas, Lancaster, Sarpy). The largest declines are projected for Dawes and Garden Counties, which are each expected to lose more than 20 percent of their current populations by the year 2030.

3.10.1.4 Seasonal Population and Visitors

According to the Final Environmental Impact Statement for the Northern Great Plains Management Plans Revision (May 2001), the various state parks in northwest Nebraska, the Pine Ridge Ranger District, and the Oglala National Grassland are increasingly becoming regional tourist destinations.

Approximately 345,923 people visited Fort Robinson State Park in 2010. This number represents a 25 percent decrease from 460,154 in 2007 and a 2 percent decrease from 356,352 in 1993 (NDED 2011). Approximately 50 percent of the visitors in 2002 were from other states, which is an increase in the number of out-of-state visitors from 1981, as the majority of 1981 visitors were Nebraskan families. It is likely that the decline of visitors from Nebraska has resulted from the overall decline of population in rural counties within a few hours commuting distance of the park.

There were 55,000 visitors to the Pine Ridge District of the Nebraska National Forest in 2001. Camping and motorized travel/sightseeing are the two most popular recreation categories within the Pine Ridge Ranger District and the Oglala National Grassland.

The forest provides a wide range of other undeveloped backcountry recreation opportunities such as hunting, hiking, backpacking, fishing, and wildlife observation. The district provides the greatest number of miles of mountain biking trails in the state. District trails also attract horseback riders and off-highway motorized vehicle use. The Pine Ridge is an important destination for deer hunting, and provides the most popular turkey hunting area in Nebraska.

One source of seasonal population in this region is Chadron State College, located approximately 21.6 miles (35 km) from the site. During the fall seasons of 2005, 2006, 2007, 2008, 2009, 2010, and 2011, the enrollment was 2,601, 2,767, 2,726, 2,769, 2,744, 2,759, and 2,609, respectively (CSC 2010a, 2010b, Haag 2012, and Universities.com 2010). The average enrollment from 1994 through 1999 was 2,944, with a range of 2,768 to 3,189 (NCCPE 2005). Enrollment from 2011 (2,609) versus this later average of 2,944 is a 0.11 percent reduction in student enrollment. A rising enrollment trend has been observed at the college since 2006, with the overall increase near 30 percent during the period (Haag 2012). Actual enrollment values presented in this paragraph may vary depending on the time of the year of the enrollment count.

3.10.1.5 Schools

The City of Crawford is served by the City of Crawford Public School District. The Crawford High School and grade school are presently under capacity (Vogl, pers. comm. 2010). Enrollment for the 2010-2011 school year was 123 in the grade school and 115 in the high school; this represents a decline of about 9.5 percent in total enrollment for both schools from the 2007-2008 school year (NDE 2011a).

The Town of Hemingford is served by the Hemingford Public Schools. Enrollment for the 2010-2011 school year was 232 in the grade school and 169 in the high school, an increase of more than 9 percent in

total enrollment for both schools from the 2007-2008 school year (NDE 2011b). This enrollment level is lower than in past years, reflecting continuing pressures on population levels in the area.

Families moving into the Crawford or Hemingford School Districts as a result of the proposed MEA operations would not stress the current school system.

3.10.1.6 Sectorial Population

Existing population, as determined for the original analysis in the CBR commercial license application prepared in 1987 for the 50-mile (80 km) radius was estimated for 16 compass sectors by concentric circles of 0.6, 1.2, 1.9, 2.5, 3.1, 6.2, 12.4, 18.6, 24.9, 31, 37.3, 43.5, and 50 miles (1, 2, 3, 4, 5, 10, 20, 30, 40, 50, 60, 70, and 80 km) from the site (a total of 208 sectors). 2010 US Census data were used; subtotals by sector and compass points as well as the total population are shown in **Table 3.10-4**.

Population within the 50-mile (80 km) radius was estimated using the following techniques:

- U.S. Census 2010 data were used to estimate the total population within a 50-mile (80 km) radius, measured from the center of the proposed MEA site. The data were created by Geographic Data Technology, Inc., a division of Earth Sciences and Research Institute (ESRI), from Census 2000 boundary and demographic information for block groups within the United States.
- ArcInfo GIS was used to extract data from U.S. Census 2000 population estimates for 40 Census Tract Block Groups located wholly or partially within the 50-mile (80 km) radius from the approximate center of the MEA site. Urban areas within each county were generally assigned their own block group.
- To assign a population to each sector, a percentage area of each sector within one or more block groups was calculated for all of the block groups.
- 2010 U.S. Census of population estimates for cities and counties in Nebraska, South Dakota, and Wyoming were used to determine total urban population.

3.10.2 **Local Socioeconomic Characteristics**

3.10.2.1 Major Economic Sectors

In 2009, average annual unemployment rates in Dawes and Box Butte Counties decreased from the 2008 rates. **Table 3.10-5** summarizes unemployment rates and employment in the Nebraska project area counties, as well as the overall change in employment in economic sectors between 1994 and 2009. Dawes and Box Butte Counties exhibited unemployment rates at 4.4 percent in Dawes County and 6.8 percent in Box Butte County in 2009. The Dawes County unemployment rate was slightly lower than the statewide rate of 4.7 percent, whereas the Box Butte County rate was significantly higher (NDOL 2010).

The major economic sectors in the project area have changed little in recent years, although individual sectors have shifted in their relative proportion in the overall economy. The area continues to depend on trades, government, and services. Economic sectors in the City of Crawford area include farming, ranching, cattle feed lots, tourism, and retail sales.

Agriculture accounted for a significant portion (19.2 percent) of the total employed labor force in Dawes County in 2009. During the same time period, farm employment was 2.0 percent of total employment in Box Butte County. Retail trade accounted for 14.7 percent of total employment in Dawes County, followed by local government employment (12.6 percent), leisure and hospitality (11.1 percent),

education and health services (9.8 percent), and state government (6.5 percent). Mining and construction accounted for 5.0 percent. In Box Butte County, the largest four non-farm employment sectors are local transportation, communication, and utility services (20.2 percent); local government (17.7 percent); production (8.6 percent); and leisure and hospitality (8.0 percent) (NDOL 2010).

While agriculture employment is not dominant, agriculture provides the economic base for the counties, as other economic sectors support the agricultural industry. Events that affect agriculture are generally felt throughout rural economies. According to the Nebraska Department of Economic Development (NDED 2010), farm employment in Nebraska is expected to decline by nearly 14,000 jobs (20 percent) between 2000 and 2045, while overall non-farm employment will increase by nearly 26 percent. The decrease in jobs in the agricultural sector could continue to fuel migration from rural counties to urban areas, resulting in overall declines in other sectors of the local economy as dollars spent from personal income and agricultural business expenditures move out of the counties.

Per capita personal income is the income that is received by persons from all sources, including wages and other income, over the course of 1 year. In 2010, personal income in Dawes County was $28,981, which was 74 percent of the state average of $39,332. The county ranks 87th out of 93 counties in the state (BEA 2011). In 2010, personal income in Box Butte County was $35,225, which was 89 percent of the state average of $39,332. Box Butte County ranks 58th out of 93 counties in the state.

3.10.2.2 Housing

Between 1970 and 1980, total housing units increased by 17 percent in Dawes County from 3,388 to 3,965 units (USCB 1990a). After a decline in total units during the 1980s, growth increased by 2.4 percent from 3,909 units in 1990 to 4,004 units in 2000, and then increased again by 6.2 percent to 4,252 units in 2010. The City of Chadron, the largest community in Dawes County and within 25 miles (40 km) of the project site, experienced a negligible increase (0.3 percent) in housing stock between 1980 and 1990, a 5 percent increase between 1990 and 2000, and a 4.4 percent increase to 2,559 units between 2000 and 2010. Between 1980 and 1990, the City of Crawford housing stock decreased by nearly 7 percent to 576 (USCB 2003a). The number of housing units continued to decline through 2010, when 567 units were reported.

Box Butte County, which borders Dawes County to the south, exhibited a 1 percent loss in total housing units between 1990 and 2000, when 5,488 units were counted in the 2000 Census; a similarly small loss of 10 units was reported in the following decade, with a total of 5,478 units reported in 2010. In the Town of Hemingford, 418 housing units were reported in 2010; this represents a slight decrease from the 438 units reported in 2000.

In 2000, Dawes and Box Butte Counties had homeowner vacancy rates of 1.7 and 1.4 percent, respectively. In 2010, these rates were 2.3 and 2.4 percent, respectively. As of June 2011, there were six single-family housing units for sale in the City of Crawford. Five of the units were listed at prices below $100,000. One unit was listed at a price higher than $250,000. Three new single-family housing units were constructed between 2006 and 2008 in the City of Crawford, and average new home construction costs were $70,000 (NPPD 2011); one permit was issued in 2009 for a home with a construction cost of $60,000. In Hemingford, one permit was issued in 2006 for a residence with a construction cost of $25,100. The median gross rent for the City of Crawford in 2009 was $440 per month; in the Town of Hemingford, the median gross rent was $344 (Advameg 2010).

The demand for rental housing did not change significantly between 1990 and 2000, as rental vacancy rates were 11.8 percent in Dawes County and 15.4 percent in Box Butte County in 2000 (USCB 2003c) compared with 1990 rental vacancy rates of 12.6 percent and 14.9 percent, respectively (USCB 1990b). Similar rates continue to be seen: the rental vacancy rate in Dawes County is currently 10.2 percent, and 17.7 percent in Box Butte County (USCB 2011).

High interest rates and tax rates were the major deterrents for potential homebuyers in the project area in the past. Current deterrents are economic uncertainty and unemployment, as home mortgage interest rates have recently been at historic lows.

The majority of housing demand expected over the next two decades in Dawes County is most likely to occur in the City of Chadron, reflecting a continued shift from rural to more urbanized environments.

The purchase of homes by Crow Butte employees provides the City of Crawford with ad valorem property taxes. The City of Crawford levies taxes at a dollar per hundred of valuation. In 2010, the total levy was 0.424539, which would result in taxes on a $50,000 property of approximately $212 per year. The Town of Hemingford levies taxes at a dollar per hundred of valuation. In 2010, the total levy was 0.98062, which would result in taxes on a $50,000 property of approximately $490 per year (NE Revenue 2010).

3.10.3 **Environmental Justice**

The 2010 Census provides population characteristics for Census Tracts, which contain Block Groups that are further divided into Blocks. The Blocks are the smallest Census areas that contain the race characteristics of the population in the MEA region. The MEA contains all or a portion of, or is adjacent to, 23 Blocks within Census Tract 9506 in Dawes County. Census Bureau-generated 2009 data on the poverty status of school district populations were used as a proxy.

The affected area selected for the Environmental Justice analysis includes the racial characteristics of the population within Census Tract Blocks within the MEA, and the poverty status of students enrolled in local school districts.

The State of Nebraska was selected to be the geographic area with which to compare the demographic data for the population in the affected Blocks. This determination was based on the need for a larger geographic area encompassing affected area Block Groups in which equivalent quantitative resource information is provided. The population characteristics of the MEA are compared with Nebraska population characteristics to determine whether there are concentrations of minority or low-income populations in the MEA relative to the state.

According to the 2010 Census, and summarized in **Table 3.10-6**, the combined population of the Census Block Groups within or adjacent to the MEA was 32. The entire population was white; with one individual identified as Hispanic. The next nearest minority populations reside within the City of Crawford, located approximately 15.1 miles (24.3 km) north-northwest of the MEA satellite building (centerpoint to centerpoint), and the Town of Hemingford, located approximately 15.4 miles (24.8 km) south-southeast (centerpoint to centerpoint). Races in the City of Crawford consist of white non-Hispanic (95.6%), American Indian (0.9%), Hispanic (1.0%), persons reporting two or more races (2.3%), and smaller percentages of other races. Races in the Town of Hemingford consist of white non-Hispanic (96.1%), American Indian (1.2%), Hispanic (4.6%), persons reporting two or more races (2.1%), and

smaller percentages of other races. The total percentage is greater than 100 percent because Hispanics could be counted in other races.

No concentrations of minority populations were identified as residing in rural areas near the proposed MEA. There would be no disproportionate impact to any minority population from the construction and implementation of the MEA.

The schools located nearest the MEA are those in the City of Crawford (operated by Crawford Public Schools), the Town of Hemingford (operated by Hemingford Public Schools), and in the community of Marsland (the Pink Public School operated by the Sioux County Public Schools). 12.9 percent of all students aged 5 to 17 in the State of Nebraska are identified as living in families in poverty. This compares to 22.8 percent of students in the Crawford Public Schools, 13.8 percent in the Hemingford Public Schools, and 19.8 percent in the Sioux County Public Schools. These data indicate that more students in the vicinity of the MEA live in families in poverty than are found in the state as a whole. Lower income levels are characteristic of predominantly rural populations and small communities that serve as a local center of agricultural activity. No adverse environmental impacts would occur to the population within the MEA from proposed project activities; therefore, there would be no disproportionate adverse impact to populations living below the poverty level in these Block Groups.

3.11 Public and Occupational Health

3.11.1 Non-Radiological Impacts of the Current Operation

3.11.1.1 Chemical Impacts of the Current Operation

The current operation at the CPF involves the use of hazardous chemicals in the process in quantities that could present a hazard to workers and the environment. Specifically, CBR stores and uses hydrochloric acid, sodium hydroxide, H_2O_2, liquid O_2, and CO_2. The design of facilities and the storage and handling of these chemicals at CBR is performed in accordance with accepted codes and standards as recommended in RG/CR-6733. CBR is also subject to the requirements of the Occupational Safety and Health Administration (OSHA) set forth in the Process Safety Management Standard contained in 29 CFR §1910.119. As a result of these requirements and the management and administrative controls implemented by CBR, there has never been a serious incident involving hazardous chemicals at the CPF.

As part of CBR's SHEQMS Program, a risk assessment was completed to recognize potential hazards and risks associated with chemical storage facilities (and other processes), and to mitigate those risks to acceptable levels. The risk assessment process identified hydrochloric acid as the most hazardous chemical with the greatest potential for impacts to chemical and radiological safety. The hydrochloric acid storage and distribution system is located only at the CPF and will not be used at the satellite facility.

None of the hazardous chemicals used at the CPF are covered under the EPA's RMP regulations. The RMP regulations require certain actions by covered facilities to prevent accidental releases of hazardous chemicals and minimize potential impacts to the public and environment. These actions include measures such as accidental release modeling, documentation of safety information, hazard reviews, operating procedures, safety training, and emergency response preparedness.

3.11.1.2 Potential Declines in Groundwater Quality

Excursions at the current operation represent a potential effect on the adjacent groundwater. During production, injection of the lixiviant into the wellfield results in a temporary degradation of water quality

in the exempted aquifer, compared to pre-mining conditions. Movement of this water out of the wellfield results in an excursion. Excursions of contaminated groundwater in a wellfield can result from: an improper balance between injection and recovery rates; undetected high permeability strata or geologic faults; improperly abandoned exploration drill holes; discontinuity and unsuitability of the confining units which allow movement of the lixiviant out of the ore zone; and poor well integrity. Hydrofracturing has not, and will not, be utilized at the CBR operations in Dawes County. To date, there have been several confirmed horizontal excursions in the Chadron sandstone in the CPF license area. These excursions were quickly detected and recovered through overproduction in the immediate vicinity of the excursion. In the majority of cases, the reported vertical excursions were actually due to natural seasonal fluctuations in Brule groundwater quality and very stringent upper control limits (UCLs). In no case did the excursions threaten the water quality of an underground source of drinking water (USDW) because the monitor wells are located well within the aquifer exemption area approved by the EPA and the NDEQ. **Table 3.11-1** provides a summary of excursions reported for the CPF license area.

3.11.2 Radiological Impacts of the Current Licensed Operation

CBR is currently licensed to operate the CPF at a maximum production flowrate of 9,000 gpm and a maximum annual production of 2,000,000 pounds U_3O_8. Because the project is an in-situ operation, the particulate emission sources normally associated with the ore crushing and grinding and tailings disposal at a conventional uranium mill are not present. A vacuum dryer is in use at the commercial operation. The vacuum dryer works on the principle that gases or particulates released into the system are collected in a liquid condenser and there is no release of particulates. The effluent collection efficiency for this dryer system is, therefore, 100 percent. The only routine radioactive emission is radon-222 gas.

Radon is present in the ore body and is formed from the decay of radium-226. The radon dissolves in the lixiviant as it travels through the ore body to a production well, when the solution is brought to the surface, the radon is released.

In order to assess the radiological effect of radon on the environment, an estimate of the quantity released during the operation was made in the CPF License Renewal Application submitted to NRC in 2007. Meteorological data and MILDOS-AREA (June 1989) were used to predict the ground level air concentration at various points in the environment. The ingrowth of radon daughters is important, and their concentration in the soil, vegetation, and animals was calculated. Finally, the impact on humans from these concentrations of radionuclides in the environment was determined.

Based on the MILDOS-AREA results for the current operation, the anticipated effects were not significantly above naturally occurring background levels. This background radiation, arising from cosmic and terrestrial sources, as well as naturally occurring radon, comprises the primary radiological impact to the environment in the region surrounding the project.

3.11.2.1 Exposures from Water Pathways

The solutions in the mining zone are controlled and adequately monitored to ensure that migration does not occur. The overlying aquifers will also be monitored.

Three commercial evaporation ponds located approximately 2,000 feet from the current CPF building have been constructed for commercial operation. There are also two R&D evaporation ponds located approximately 1,000 feet from the CPF building. The R&D evaporation ponds have a 34-mil Hypalon liner and a leak detection system. The commercial evaporation ponds are lined with double impermeable

synthetic liners. The ponds, therefore, are not considered a source of liquid radioactive effluents. There is a leak detection system installed to provide a warning if the liner develops a leak.

The CPF is located on a curbed concrete pad to prevent any liquids from entering the environment. Solutions used to wash down equipment drain to a sump and are pumped to the ponds. The pad is of sufficient size to contain the contents of the largest tank in the event of its rupture.

Because there are no routine liquid discharges of process water from the CPF, there are no definable water-related pathways.

3.11.2.2 Exposures from Air Pathways

The only source of radioactive emissions from the current operation is radon released into the atmosphere through the plant ventilation systems or from the wellfield. This radon release results in radiation exposure via the inhalation, ingestion, and external exposure pathways. The TEDE to nearby residents in the region around the Crow Butte project was estimated in the 2007 License Renewal Application by using the computer simulation MILDOS-AREA. The joint frequency data compiled from a site-specific meteorological station were used to define the atmospheric conditions in the project area.

Based on the site-specific data and method of estimation of the source term, the emission rate of radon-222 from the Crow Butte project was estimated at 5,937 Curies/yr for a flow of 5,000 gpm in the upflow IX columns in the existing CPF. In order to show compliance with the annual dose limit found in 10 CFR §20.1301, CBR demonstrated by calculation that the TEDE to the individual most likely to receive the highest dose from the current licensed operation was less than 100 mRem per year. The dose to the most effected resident was 23.2 mRem/yr (0.232 mSv/yr) or 23.2 percent of 100 mRem/yr dose constraint.

3.11.2.3 Exposure to Flora and Fauna

The exposure to flora and fauna was evaluated in the Environmental Report submitted in September of 1987, and the doses were found to be negligible.

The long-term impacts on groundwater quality should also be minimal, as restoration activities have been shown to be successful in returning the groundwater quality to background or class of use standards. Additionally, there is no mechanism in EPA or NDEQ regulations to “unexempt” an aquifer. Therefore, the groundwater in the immediate mining area will never be used as a USDW. The primary purpose for restoration is to ensure that post-mining conditions do not affect adjacent USDWs.

3.11.2.4 Occupational Safety

CBR has an exemplary safety record at the Crow Butte project. The company has been recognized on several occasions for this safety record including being named the recipient of the Governor’s Safety Award and the Star Award, awarded by the Nebraska Safety Council. The Health and Safety Management System (HSMS) implemented at the project is designed to meet the Occupational Health and Safety Management System (OHSAS):18001 international HSMS standard.

3.12 Waste Management

The effluents of concern at the proposed satellite facility will include the release or potential release of radon-222, radionuclides in liquid process streams, and dried yellowcake. Yellowcake processing and drying operations are conducted nearby at the CPF. Loaded IX resin from the satellite facility will be

transported to the CPF for elution, precipitation, drying, and packaging. Effluent control systems will be used at the satellite facility to control the release of radioactive materials to the atmosphere.

The yellowcake drying facilities at the CPF are composed of one vacuum dryer. The current license allows for the addition of a second dryer. By design, vacuum dryers do not discharge any uranium when operating. Effluent controls for yellowcake drying at the CBR CPF have been reviewed by NRC and approved in the current license.

3.12.1 **Gaseous and Airborne Particulates**

The principal radioactive airborne gaseous radiological effluent at the MEA will be radon-222 gas. Processing at the satellite facility will produce water-based solutions and loaded resins (no yellowcake processing or drying); therefore, airborne uranium concentrations are expected to be at or near local background levels. Airborne releases from uranium ISR facilities normally are radon-222 and its daughters from process fluids and particulates from yellowcake drying and packaging operations (NRC 2001). One process area at the proposed MEA where small quantities of airborne uranium particulates have the potential for occurring is the resin transfer station, where minor spills may occur. The loaded IX resin is transferred to a truck for transport to the CPF for completion of uranium recovery. Spills can occur during resin transfer, and this is where exposure to uranium particulates is possible. All spills will be cleaned up as soon as possible to prevent the wet materials from drying and creating the potential for airborne particulates. Spills associated with resin transfer would involve the impregnated resin itself. The uranium is still bound to the resin at this stage, reducing the potential of employee exposure.

Maintenance activities on piping containing pregnant lixiviant could also result in the release of radon and uranium. Any spills or releases during maintenance of these potential sources would be cleaned up promptly to prevent drying of the material and creation of particulates subject to dispersion.

Radon-222 is found in the pregnant lixiviant that comes from the wellfield into the satellite facility. The uranium is then separated from the lixiviant by passing the solution through fixed- bed IX units operated in a pressurized downflow mode. Vessel vents from the individual IX vessels will be directed to a manifold that is exhausted to atmosphere outside the satellite building. Venting any released radon-222 gas to the atmosphere outside the satellite facility via high-volume exhaust fans minimizes employee exposure. Small amounts of radon-222 may be released via solution sampling and spills, filter changes, IX resin transfer, RO system operation during groundwater restoration, and maintenance activities. These are minimal, infrequent radon gas releases. The general building ventilation system in the satellite facility will further reduce employee exposure. The air in the satellite facility is sampled for radon daughters to ensure that concentration levels of radon and radon daughters are maintained as low as reasonably achievable (ALARA).

Injection wells are generally closed and pressurized, but are periodically vented, releasing radon to the atmosphere. Production wells will be continually vented to the surface, but water levels will typically be low, and radon venting will be minimal. All of the well releases will be outside of buildings and directly vented to the atmosphere.

Some venting would also occur from the wellhouses to remove any radon releases from the building to the surrounding atmosphere. The exhaust fans are located in the wall directly opposite the entryway. Releases to the atmosphere from wells and wellhouses would result in radon emissions dispersing rapidly. Wellfield offgassing is not considered a significant source of radon or a safety issue. This statement is supported by MILDOS-AREA calculations (Section 4.12.2.3) and by monitoring at the current CPF.

Employee radon daughter monitoring results and work area ventilation systems at the CPF are also discussed in Section 5.7 of the MEA Technical Report.

3.12.2 **Liquid Wastes**

ISR mining will produce several sources of liquid waste. The potential wastewater sources that exist at the satellite facility include the following:

3.12.2.1 Liquid Waste Generated

Water and Drill Cuttings Generated during Well Drilling and Development

Well drilling and development will result in the generation of the following wastewaters:

- "well drilling fluid" - fluids used while drilling in order to lubricate and cool the drill bit, remove drill cuttings from the borehole, and to seal the borehole walls to minimize fluid loss into the surrounding formation
- "well development water" - generated during the under-reaming, air-lifting, and well rehabilitation phases of well installation

Well Drilling Fluid

Well drilling fluid is drilling fluid and recovered groundwater that has not been exposed to any mining process or chemicals. However, the fluid may contain elevated concentrations of naturally occurring radioactive material from the mineralized zone. Well drilling fluid is discharged to the drilling pit, where it is allowed to evaporate.

Drill cuttings will be captured within earthen drill pits during drilling. Upon completion of the hole, and once the drilling fluid has evaporated, the pits will be filled in and the dirt mounded to allow for subsidence. Later, topsoil will be applied, and the site and any surface disturbance will be leveled to conform with the surrounding area. Disposal of drilling cuttings in an approved disposal pit is allowed by Nebraska Administrative Code (NAC) Title 135, Chapter 5, paragraph 002.02E.

Well Development Water

Once a well has been cased, any water generated during under-reaming, air-lifting, or other subsequent rig work that results in removing water from the cased well will be captured in water trucks specifically labeled for such purpose and equipped with signage indicating that these trucks may only discharge their contents to the MEA wastewater disposal system. The development waters collected in water trucks will be discharged into a cone-bottom tank (well work-over fluid tank) at the satellite plant. That tank will feed a belt filter or other separation equipment to separate solids from water. Filtered water will be discharged to the DDW water supply tank for disposal in the onsite DDWs. Solids will be bagged for 11e.(2) disposal. This will allow treatment and disposal of the fluids without the accumulation of waste solids.

As a backup to this system, the well fluids would be transported to the existing evaporation ponds at the CPF. This option would only be exercised if there were equipment issues with the separation system.

Purge Water from Baseline Monitor Well Sampling

Except where a baseline well is on excursion, purge water is released onto the ground surface, but is not discharged directly into a stream. When a baseline well is on excursion, the purge water is collected and

disposed in the wastewater disposal system or taken to the evaporation ponds at the CPF. This is allowed by the NDEQ because the monitor wells are hydrologically separated from the confined basal sandstone of the Chadron Formation.

Liquid Process Waste

The operation of the satellite facility results in one primary source of liquid waste, a production bleed, as previously discussed in Section 1.3.2.6. This bleed will be routed to wastewater tanks housed in the satellite building and then pumped from the tanks to the DDWs.

Waste Petroleum Products and Chemicals

Small quantities of waste petroleum products and chemicals typical of ISR facilities will be generated and will include items such as waste oil and out-of-date or partially used reagents/chemicals. All such wastes that are non-hazardous will be temporarily stored in appropriate sealed containers above ground prior to disposal by a contracted waste disposal entity at an approved waste disposal or recycling facility. Such wastes are not considered to be affiliated with the processing or generation of 11e.(2) byproduct material and will not be classified as Atomic Energy Act (AEA)-regulated waste. It is estimated that less than 50 gallons of waste petroleum products and chemicals will be disposed of annually. Any used oil that may be generated will be recycled by an approved commercial recycler, and such materials are not classified as a hazardous waste. Hazardous waste generation is discussed in Section 3.1.3.4.

Aquifer Restoration Waste

Following mining operations, restoration of the affected aquifer results in the production of wastewater. The current groundwater restoration plan consists of four activities:

1. Groundwater transfer
2. Groundwater sweep
3. Groundwater treatment
4. Wellfield circulation

Only the groundwater sweep and groundwater treatment activities will generate wastewater.

During groundwater sweep, water would be extracted from the mining zone without injection, causing an influx of baseline quality water to sweep the affected mining area. The extracted water must be sent to the wastewater disposal system during this activity, being disposed of by deep well disposal. As has been the case with past operations at CBR, it is anticipated that, during restoration, groundwater at the MEA will be treated using IX and RO. Using this method, there would be no water consumption, and only the bleed has to be disposed, with the rest of the treated water being reinjected.

Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected mining area. An RO unit will be used to reduce the TDS in the groundwater. The RO unit produces clean water (permeate) and brine. The permeate is either injected into the formation or disposed of in the wastewater disposal system. The brine is sent to the wastewater disposal system.

Stormwater Runoff

Stormwater may be contaminated by contact with industrial materials. Stormwater management is controlled under permits issued by the NDEQ. CBR is subject to stormwater NPDES permitting requirements for industrial facilities and construction activities. The NDEQ NPDES regulatory program contained in Title 119 (NDEQ 2010a) requires that procedural and engineering controls be implemented so that runoff will not pose a potential source of pollution. The design and engineering controls for the proposed MEA facilities will be such that any potentially contaminated stormwater runoff or snowmelt (e.g., any tankage diking or curbing outside of the satellite building) will be collected and disposed of in ~~the~~a DDW. Engineering and procedural controls contained in a SWPPP, in combination with the design of the project facilities, will ensure that stormwater runoff is not a potential source of pollution.

Domestic Liquid Waste

Domestic liquid wastes from the restroom toilets and lavatories and sink in the lunchroom/break area will be disposed of in an approved septic system that meets the requirements of the State of Nebraska. The septic system will be designed with a capacity sufficient to handle the projected number of employees, contractors, and visitors. CBR currently maintains a Class V UIC Permit issued by the NDEQ for operation of the septic system at the CPF. A similar permit will be required for the satellite facility.

CBR will employ an estimated 10 to 12 employees at the proposed MEA satellite facility. Assuming 13 gpd for each employee (based on the estimate for industrial employees by EPA), a total of approximately 130 to 160 gpd of sanitary waste would be generated (EPA 2002). An assumed additional 50 gpd of miscellaneous sanitary wastewater (e.g., lavatories and sink in lunchroom/break area) would result in approximately 180 to 210 gpd of sanitary wastewater being discharged to the septic system.

The number of temporary construction employees for the proposed satellite facility is estimated at 10 to 15 personnel. An assumed an average of five to 10 full-time employees during construction would result in a total of 15 to 25 employees on site for some periods. This would result in approximately 200 to 325 gpd of sanitary waste generation. During initial construction, portable sanitary units will be used, which will be provided and serviced by a third-party contractor.

The septic system will be designed, constructed, operated, and permitted as per applicable NDEQ Title 124 regulations.

Laboratory Waste

There will be no laboratory located in the satellite building.

Liquid Waste Disposal

Liquid waste disposal is discussed in Section 4.13.2.2.

CBR plans to use DDWs as the primary liquid waste disposal system at the MEA site. The DDWs will be operated without the need for surge tanks or surge/evaporation ponds.

The proposed DDWs at Marsland is the third project to be developed by CBR in Nebraska that uses underground injection wells to dispose of a non-hazardous waste stream associated with ISR Uranium mining operations from the basal sandstone of the Chadron Formation.

CBR currently operates two non-hazardous Class I injection wells in the CPF license area for disposal of wastewater under Permits #NE0206369 and #NE0210825 (DDW-1 and DDW-2, respectively). The wells are permitted under NDEQ regulations in Title 122 (NDEQ 2010b) and operated under a Class I UIC Permit. The permits for both wells allow unlimited flow and maximum operating pressure of 650 psi. To preserve optimum performance, ~~Well #1~~DDW-1 has typically been operated at up to 40 psi with a 200 gpm flow.

CBR has operated DDW-1 at the CPF license area for more than 10 years with excellent results and no serious compliance issues. DDW-2 was incorporated into the license by action of the CBR Safety and Environmental Review Panel on November 18, 2011, with the well started up on November 30, 2011. CBR expects that the liquid waste stream at the satellite facility will be chemically and radiologically similar to the waste disposed of in the current DDWs. Radiological data for the years 2008 through 2012 for DDW-1 injection stream are shown in **Table 3.12-1**, and radiological data for DDW-2 for the year 2012 in **Table 3.12-2** The non-radiological data for DDW-1 and DDW-2 injection streams for 2012 are presented in **Table 3.12-3**.

CBR has submitted an application to the NDEQ for an Area Permit to install and operate Class I Non-hazardous Waste Injection Wells on private lands within the MEA license boundary. The purpose of establishing an Area Permit is to allow for multiple injection wells to be installed at the MEA site over the expected multi-year life of the project. This permit application is for the initial two Class I Non-hazardous Waste Injection Wells to be installed under the Area Permit. Cameco is aware that a permit modification would be required for any additional wells added to the Area Permit at a later date. The permit application was prepared in accordance with regulatory requirements presented in the NDEQ Assessment Section, Title 122 Rules and Regulations for Underground Injection and Mineral Production Wells (Effective April 2, 2002). The formation receiving the injected waste fluids shall be restricted to the Lower Dakota, Morrison, and Sundance Formations, which have been demonstrated to be located below the lowermost underground source of drinking water. In addition, the Lower Dakota, Morrison, and Sundance Formations exhibit water quality that is not considered under state and federal regulations to be underground sources of drinking water due to measured TDS concentrations.

CBR has found that permanent deep disposal is preferable to evaporation in ponds. The basic reasons for this position are as follows:

- The potential for human contact while using a DDW is lower because the waste is handled in enclosed systems.
- The potential for emissions from the pond surface is higher than the enclosed DDW disposal system.
- Evaporation ponds carry the potential for leaks.

Use of evaporation ponds creates a larger amount of 11.e(2) byproduct waste. The DDWs at Marsland will be located as shown in ~~near the satellite building (~~**Figure 1.1-7**, and will always be placed within the perimeter monitor well ring~~)~~. All tankage, filtration, and process equipment will be located at the main operating satellite facility. Feed from the satellite facility will pass through a set of bag filters and will be pumped to the DDWs located in ~~a~~ DDW wellhouses. At ~~the~~each DDW wellhead, there will be a set of filters, flowmeters, check valve, and annulus fluid tank. Per NDEQ permitting requirements, CBR will be required to continually monitor and record the injection pressure, injection flowrate and volume, and annual pressure. Any failure of the monitoring system requires that the DDW be shut down immediately until the potential for a release has been investigated.

Two dedicated storage tanks located in the satellite building will supply feed to the DDWs. One tank will serve as the primary DDW supply tank, with all makeup water to the DDW flowing to this tank (e.g., RO brine, wellfield bleed, plant sump, and filtered well workover fluid). At the CPF, a DDW water supply tank is operated using similar makeup water, and the primary DDW supply tank at the MEA site is expected to be operated in a similar fashion at the MEA. All flow to the DDWs will pass through a set of bag filters at the satellite building and the DDWs wellhouses.

Current plans are to use the second tank for managing special wastewaters that are periodically generated, such as collecting filtered water from the well workover fluid tank, which is then sent to the primary DDW tank for disposal. This second tank would also be used for surge capacity for the DDW well system when needed (very infrequent based on CPF operations). Under normal operations, this tank will be operated with water levels sufficient to allow use for surge capacity. The surge capacity will be designed to only handle short-term flows and not for long-term periods when additional capacity is needed and/or the DDWs may not be available. In the event that capacity of the DDW tanks is insufficient to receive additional flows, such as during upset conditions, the commercial process will be immediately curtailed to reduce the wastewater generated until tank levels can return to normal. See Section 3.12.2.2 (MEA water balance) for discussions of actions that be taken to address long-term shutdown periods of the DDWs.

The size and detailed operations of the wastewater tanks will be defined in the detailed engineering phase of the project.

The DDWs will be installed in sufficient time to be used for wastewater disposal allowed by the permit. Details of the DDWs operations, controls, monitoring, waste management, and spill issues will be addressed in a future NDEQ permit application. No wastewaters will be discharged to the land surface or surface water of the State of Nebraska.

Radioactive liquids not referenced above will be disposed of as per NRC License SUA-1534.

In addition to the use of DDWs as a disposal method, the NDEQ has issued CBR an NPDES permit for the CPF license area that allows land application of treated wastewater. CBR has not used this waste disposal method at the current operation. At this time, CBR does not intend to apply for an NPDES permit to allow land application at the satellite facility. It is expected that liquid waste generated in the MEA can be satisfactorily managed with deep disposal. If needed in an emergency situation, contaminated wastewater can be collected and trucked to the evaporation ponds at the CPF site or to an approved commercial disposal facility for disposal.

Evaporation Ponds

No evaporation ponds will be used at the proposed MEA site. The alternate approach is the use of storage tanks located in the satellite building that will discharge to a DDW.

3.12.2.2 Water Balance

From 2015 to 2022, the majority of the wastewater produced at the MEA satellite facility during production will be the production bleed. Starting in 2022, the wastewater flows will rise sharply as the bleed from the RO process and must be addressed.

Other liquid wastewater that will be generated will consist of process liquids (e.g., affected well development water, laundry water, and plant washdown water). These waste streams will account for an

intermittent discharge with an maximum average of 1 to 2 gpm. The disposal water balance discussed below is of such a magnitude that these small quantities of wastewaters will be easily managed in the proposed disposal system. The well development water will be collected using a vacuum truck and delivered to the well workover fluid tank located in the satellite building (**Figure 1.1-8**). The other liquid wastes (i.e., laundry and plant washwater originating in restricted areas) described above will flow to plant sumps and transfer to a wastewater tank located within the satellite building. All of the above waste streams will be disposed of through the DDWs.

Liquid waste will be generated from process bleed and groundwater restoration water (approximately 96 percent), plant cleanup water (miscellaneous non-hazardous water; approximately 2 percent), and water originating from fresh water well(s) (approximately 2 percent). The detailed MEA water balance for production and restoration for the life of the project is shown in **Appendix T**. The project required disposal water balance is depicted in **Table 3.12-4,** and the process flow diagram is shown as a flow chart in **Figure 3.12-1**. These water balances illustrate the anticipated water management and disposal capacity needed for production bleed and restoration activities. These schedules are based on installation of two wells prior to commencing operation, with the assumption that each well will have an injection capacity of 45 gpm. The 45 gpm minimum injection capacity assumption is based upon the Crow Butte well with lower flow. Both of the DDWs at the existing plant are drilled into the same formations proposed for the MEA.

Two DDWs will accommodate all wastewater generated from startup in 2015 through the end of 2020. In 2021, groundwater restoration will result in increased wastewater volumes, which may require additional disposal capacity. Considering the capacity of the two DDWs, the need to install additional deep disposal well(s) and/or new surge/evaporation ponds will be evaluated to supply long-term wastewater disposal. At the current time, it is estimated that an additional four DDWs (for a total of six DDWs) will be needed to address wastewater generation over the life of the project. The easting/northing and longitude/latitude for the proposed six DDWs are listed in **Table 1.3-7** and locations are shown in **Figure 1.1-7**. CBR has submitted an area permit application for multiple Class I non-hazardous waste injection wells at the MEA site.

Operating procedures at the MEA site that will minimize the amount of water requiring disposal via DDW include: design wellfields to maximize the ability to continuously minimize the amount of production bleed through continuous and effective wellfield balancing; minimize the consumptive use of process water by injecting all of the ISR fluids except for the small production and restoration bleed streams that are necessary to maintain an inward hydraulic gradient in each wellfield configuration; and if necessary, two stages of RO may be used to treat restoration fluids and reduce the total required wastewater disposal capacity.

As shown in **Appendix T**, only five MUs will be in production mode at any one given time. Total production flow over the life of the project will be variable, ranging from approximately 1,100 to 5,400 gpm. The production bleed (1.2 percent) and the RO bleed, over the life of operations, will vary from approximately 25 to 65 gpm and 80 to 250 gpm, respectively. Permeate flows will vary from 500 to 750 gpm, with 750 gpm being the estimated average flow from 2022 to 2037. The amount of brine sent to DDWs will range from approximately 167 to 250 gpm beginning in year 2022 and continuing until 2037.

Figure 3.12-2 depicts the water balance at MEA during the third quarter of 2024 when maximum production and restoration flows will occur (5,400 gpm and 1,800 gpm, respectively). As illustrated in **Figure 3.12-2**, process bleed during maximum production and operation will be approximately 65 gpm,

with up to an additional 250 gpm RO bleed of disposal capacity is needed to accommodate groundwater restoration. DDWs are expected to provide the majority of the disposal capacity needed at each expansion area. As has been demonstrated at the CPF, DDW injection rates may be greater than the assumed 45 gpm per well at the MEA site.

Until the capacity of the first two DDWs is known, the exact needs for additional water disposal wells beyond 2020 is not understood. Additional disposal options required for use during production and restoration activities will be dependent on both the volume of wastewater generated, the efficiency of production and restoration activities including the RO process, and the actual injection capacity of DDWs (e.g., surge/evaporation ponds and/or land application).

For the years 2015 through 2020, two DDWs will be used. Each DDW can act as a backup for the other if maintenance is required. At the same time, plant operations can be curtailed as needed to ensure that an inward hydraulic gradient is maintained. A third option would be trucking water to the CPF evaporation ponds.

In the event of an extended total facility shutdown (e.g., lengthy power failures), the ability to maintain hydraulic containment of the wellfields has be assessed. This analysis demonstrated that hydraulic containment of the ISR wellfields could be provided using one or two wells (powered by portable generator) located near the downgradient edge of the MU wellfield, operating at a total pumping rate of 30 gpm. Groundwater extracted from the ISR wellfields would be either disposed of in an onsite DDW equipped with a portable generator, or trucked to the main CPF facility for disposal in the evaporation ponds.

In order to accomplish this analysis of being able to maintain hydraulic containment during an extended total facility shutdown, the following basic analyses were performed (Aqui-Ver 2013b):

- The maximum velocity of groundwater under non-pumping conditions was calculated for the MEA ISR wellfields.
- A hypothetical pumping well was placed within an ISR wellfield and the zone of hydraulic containment (capture zone) was computed using an analytical groundwater flow model and particle tracking techniques. The well location and pumping rate were adjusted until an optimal capture zone was achieved.

Groundwater Velocity of the Basal Sandstone of the Chadron Formation

Under non-pumping conditions (e.g., facility shutdown, pre-development), the velocity of groundwater within the basal sandstone of the Chadron Formation (production aquifer) can be computed from Darcy's Law and a knowledge of aquifer properties and hydrologic data collected as part of the regional aquifer pumping test conducted at the MEA in May 2011 (Aqui-Ver 2011), as follows:

$$V = KI/ne$$ (Aqui-Ver 2011)

where V is the groundwater velocity, K is the hydraulic conductivity of the production aquifer, I is the baseline or pre-development hydraulic gradient, and ne is the aquifer effective porosity.

As a conservative measure, the maximum groundwater velocity was computed by using the maximum observed values for hydraulic conductivity (61.7 ft/day) and hydraulic gradient (0.00048) identified from baseline sampling and aquifer testing at the MEA. Using these aquifer properties and an estimated

effective aquifer porosity of 0.2, the resulting maximum groundwater velocity of the production aquifer is approximately 0.15 ft/day (55 ft/year). It was concluded from this calculation that mining solutions from ISR operations would only migrate a very small distance over any reasonable period of time representing temporary facility shutdown.

<u>ISR Wellfield Hydraulic Containment Analysis</u>

Additional analyses were performed to demonstrate hydraulic containment can be maintained in the event of an extended facility shutdown. Because groundwater velocity is a maximum of 0.15 ft/day as previously described, hydraulic containment would essentially be provided without active remediation unless monitor wells were already on excursion status. Therefore, for purposes of this analysis, we have assumed a worst-case scenario in which downgradient monitor wells are on excursion status when the facility experiences a hypothetical temporary shutdown.

To accomplish this task, an analytical groundwater flow model (ESI 1999) was used to simulate groundwater flow in the production aquifer at the MEA. Particle-tracking techniques were used to illustrate the zone of hydraulic containment (capture zone) produced by a hypothetical pumping well(s) placed within an ISR wellfield. MU 5 at the MEA was used for illustrative purposes in this analysis.

The monitor well ring is assumed to be located 300 feet from the edge of the ISR wellfield pattern area (production zone), identical to the design used at the main Crow Butte ISR facility. Input parameters for the groundwater flow model were assigned in order to produce a conservatively small capture zone and provide a margin of safety, as follows:

Aquifer Transmissivity (T) – 2,469 ft^2/day (maximum observed from aquifer pumping test) (Aqui-Ver 2011)

Regional Hydraulic Gradient (I) – 0.00048 (maximum observed from baseline monitoring) (Aqui-Ver 2011)

Effective Porosity – 0.2

Pumping Rate – 30 gpm

The zone of hydraulic containment was computed using reverse particle-tracking techniques after 30 days of pumping (zone will expand over time). **Figure 3.12-3** illustrates the zone of hydraulic containment produced by a single well placed near the downgradient edge of the MU 5 wellfield. The zone of hydraulic containment includes the entire ISR wellfield plus an adequate buffer zone. Although an adequate zone of containment is provided using a single well operating with a sufficiently large pump at 30 gpm, a similar zone of containment can be provided using two wells operating at 15 gpm each (30 gpm total) in the same general location and separated by approximately 300 feet (east-west) along the downgradient edge of the mine unit.

The 30 gpm pumping rate is conservatively estimated based on maximum values of aquifer transmissivity and hydraulic gradient observed at the site. Under more realistic conditions (e.g. using average values for aquifer properties), the pumping rate needed to maintain hydraulic containment is significantly lower (10 gpm).

These results are generally applicable to all MEA mine units. If multiple mine units are in operation at the time of the hypothetical shutdown, additional wells would be needed (e.g., one or two wells at a total rate of 30 gpm per mine unit) to maintain complete containment of multiple mine units.

Historically, power outages at the CPF site last less than 24 hours. The longest time without power at the CPF was approximately 40 hours due to a winter storm. Potential adverse impacts associated with power outages are not anticipated.

CBR will ensure adequate DDW disposal capacity is available at each mine unit under normal operating conditions during production, production and restoration, and restoration phases described in this document. Such capacity demonstration will be phased, initially to address years 2015 through 2020 (with two DDWs), with additional demonstrations as needed in order to address future increases in production and restoration flows. Capacity demonstrations will be addressed in written procedures for NRC written verification prior to preoperational inspection (for years 2015 through 2020) and prior to construction of future mine unit expansions beginning in 2021.

Cumulative impacts associated with the potential impacts on groundwater due to the concurrent operations of the CPF, MEA, NTEA, and TCEA projects are discussed in Section 4.14.

3.12.2.3 Inspections

CBR will maintain an inspection program to routinely monitor the wastewater and other waste management systems, including containment berms, the DDWs, and associated structures and other assets used to manage wastes. Inspections will support the MEA operational procedures, including the SPCC Plan requirements. Monitoring will include daily, weekly, monthly, quarterly, and annual inspections. The inspection monitoring program will be a component of operating manuals of CBR's SHEQMS. The inspection procedures will be developed once final engineering design and construction drawings have been completed and approved by management.

3.12.2.4 Potential Pollution Events Involving Liquid Waste

Although there are a number of potential sources of pollution present at the CPF, existing regulatory requirements from the NRC and NDEQ and provisions of the SHEQMS have established a framework that significantly reduces the possibility of a pollution incident. Extensive training of all personnel is standard policy at the existing CBR facility and will be implemented at the satellite facility. As discussed above, waste management facilities and systems will be inspected frequently. Detailed procedures are included in the SHEQMS, which will be adapted for use at the satellite facility.

Corrective action procedures needed to support existing procedures in the CBR's SHEQMS will be developed to address the most probable causes of potential releases/spills. The objective is to respond to such events as quickly as possible to minimize potential environmental damage or exposure to employees and the public. Some of the potential sources of liquid spills/releases that will be addressed include the following:

- Satellite processing facilities
- Wastewater tanks and associated piping
- DDWs and associated piping and equipment
- Trunklines to and from the wellfields to the satellite facility

- Wellhouse piping
- Wellfield piping and pumps
- Tanker trucks hauling process and waste liquids
- Trucks hauling loaded and eluted resin to and from the CPF

3.12.2.5 Wellfield Buildings and Piping

Wellfield buildings are not considered to be a potential source of pollutants during normal operations, as there will be no process chemicals or effluents stored within. The only instance in which a wellfield building could contribute to pollution would be in the event of a release of injection or recovery solutions due to pipe failure. The possibility of such an occurrence is considered to be minimal, as the piping will be leak-checked before initial placement into service. Piping from the wellfields will generally be buried, minimizing the possibility of an accident. In addition, the flows through the wellfield piping and manifold pressure gauges in the wellhouses are monitored 24 hours per day, 7 days per week by control room operators using visual and audible alarms. Flow monitoring systems will alarm in the event of a significant piping failure, which will allow flow to stop, preventing any significant migration of process fluids. Wellfield buildings will also be equipped with wet alarms for early detection of leaks.

Satellite Facility

The satellite facility will serve as a central hub for the mining operations in the MEA. Therefore, the satellite facility carries the greatest potential for spills or accidents resulting in the release of potential pollutants. Spills could result from a release of solutions due to a piping failure or a process storage tank failure.

The satellite facility building will be designed so that any release of liquid waste would be contained within the structure. A concrete curb will be built around the entire process building. This pad will be designed with a capacity equal to that of the largest tank within the building in the event of a rupture. In the event of a piping failure, the pump system will immediately shut down, limiting any release. Liquid inside the building, either from a spill or from washdown water, will be drained through a sump and sent to the liquid waste disposal system.

Deep Well Pumphouse and Wellhead

The deep well pumphouse and wellhead will be designed so that any release of liquids will be contained within the building or in a bermed containment area surrounding the facilities. Liquid inside the building will be contained and managed as appropriate.

Transportation Vehicles

The release of pollutants to the environment could occur due to accidents involving transportation vehicles. This could involve vehicles transporting IX resin to and from the satellite facility or the CPF or transporting radioactive contaminated waste from the satellite facility to an approved disposal site.

All chemicals and products delivered to or transported from the satellite facility will be carried in DOT-approved packaging. In the event of an accident, procedures are currently in place in the SHEQMS Volume VIII, Emergency Manual, to ensure a rapid response.

The uranium-loaded resin will be transported from the satellite facility to the CPF processing building in a specially designed, low-profile, 4,000-gallon capacity tanker trailer. The primary access route is approximately 30 miles (48.3 km) long, of which approximately 11.6 miles (18.7 km) are on county or private roads. The Alternate A access route is approximately 14 miles (22.5 km) long, with all of the roads being unpaved county and private roads. In the event of an accident, each resin transport vehicle will be equipped with an emergency contingency package whereby the driver could initiate the containment of any spilled material. Because the uranium adheres to the resin and the resin is wet when transferred, the radiological and environmental impacts of a spill due to an accident would be minimal. Finally, each resin transfer vehicle will be equipped with a radio for communications with the CPF. This allows quick response and implementation of the emergency response plan for transportation accidents.

Spills and Contingency Plans

Spills can take two forms within an ISR facility. These are surface spills (e.g., tankage leaks, piping ruptures) and subsurface releases (e.g., well casing failure) resulting in a release of waste solutions.

Engineering and administrative controls are in place at the CPF and will be implemented at the satellite facility to prevent both surface and subsurface releases to the environment, and to mitigate the effects should an accident occur. The most common form of surface release from in-situ mining operations occurs from breaks, leaks, or separations within the piping that transfers mining fluids from the satellite processing building to the wellfield and back. With the current CBR monitoring system, these releases are generally small, quickly discovered, and promptly mitigated.

In general, piping from the satellite facility to and within the wellfield will be constructed of HDPE with butt-welded joints or equivalent. All pipelines will be pressure-tested before final operation. A break in a buried section of line would be unlikely because no additional stress is placed on the pipes. In addition, underground pipelines will be protected from vehicles driving over the lines, which is the major cause of failure. Typically, the only exposed pipes will be at the satellite facility, at the wellheads, and in the wellhouses in the wellfield. Trunkline flows and manifold pressures will be monitored for spill detection and process control.

3.12.3 **Solid Waste**

Any facility or process with the potential to generate industrial waste should practice good housekeeping. This activity generally consists of keeping facilities, equipment, and process areas clean and free of industrial waste or other debris. Good housekeeping includes promptly cleaning any spillage or process residues on floors or other areas that could be spread and collecting solid wastes in designated containers or area until proper disposal.

Solid waste generated at the satellite facility is expected to include spent resin, resin fines, empty reagent containers, miscellaneous pipe and fittings, waste oil, out-of-date reagents, well drilling wastes, and domestic trash. Solid wastes will be classified as contaminated or non-contaminated waste according to survey results. The solid waste will be segregated based on whether it is clean or carries the potential for contamination with 11(e).2 byproduct materials. These non-hazardous wastes will be stored in appropriate containers prior to disposal by an approved off-site waste disposal facility.

All exploration and development holes drilled in the MEA will be abandoned in accordance with the requirements of State of Nebraska Title 135, Chapter 5.002 and the Mineral Exploration Permit as

approved by NDEQ. The Hole Plugging Plan is outlined in Attachment 2 of the approved Application for Mineral Exploration Holes for Mineral Exploration Permit NE#0210824 (NDEQ 2009).

Drill cuttings will be captured within earthen drill pits. Upon completion of the hole, the pits will be filled in and the dirt mounded to allow for subsidence. Later, topsoil will be applied and the site and any surface disturbance will be leveled to conform with the surrounding area.

The largest volume of solid wastes requiring disposal at the MEA site will be produced during facility decommissioning. Soils would be included in decommissioning surveys, and any soils exceeding NRC release limits at 10 CFR Part 40, Appendix A, Criterion 6 would be removed and disposed of as 11e.(2) byproduct waste. Proposed decommissioning and reclamation activities are discussed in Section 5.

3.12.3.1 Non-contaminated Solid Waste

Non-contaminated solid waste is waste which is not contaminated with 11(e).2 byproduct material or which can be decontaminated and re-classified as non-contaminated waste. This type of waste may include trash, piping, valves, instrumentation, equipment, and any other items that are not contaminated or that may be successfully decontaminated. Release of contaminated equipment and materials is discussed further in Section 5.

CBR has recently estimated that the CPF produces approximately 1,055 cubic yards (yd^3) of non-contaminated solid waste per year. This estimate is based on the number of collection containers on site and the experience of the contract waste hauler. CBR estimates that the proposed satellite facility would produce approximately 700 yd^3 of non-contaminated solid waste per year. Non-contaminated solid waste will be collected on the site in designated areas and disposed of in the nearest permitted sanitary landfill.

3.12.3.2 11(e).2 Byproduct Material

Solid 11e.(2) byproduct wastes consists of solid waste contaminated with 11e.(2) byproduct material that cannot be decontaminated.

11(e).2 byproduct material generated at ISR facilities consists of filters, PPE, spent resin, piping, and other materials. CBR has recently estimated that the CPF produces approximately 60 to 90 yd^3 of 11(e).2 byproduct material waste per year. This estimate is based on the historical number of shipments to the licensed disposal facilities. CBR estimates that the proposed satellite facility would produce approximately 60 yd^3 of 11(e).2 byproduct materials per year. These materials will be stored on site until a full shipment can be shipped to a licensed waste disposal site or licensed mill tailings facility.

CBR currently has a contractual agreement with Dension Mines (USA) Corp. (DUSA) for the disposal of 11e.(2) byproduct materials at DUSA's White Mesa Mill site located near Blanding, Utah (CBR and DUSA 2010). CBR is required to notify NRC in writing within 7 days if the disposal agreement expires or is terminated, and to submit a new agreement for NRC approval within 90 days of the expiration or termination. See additional discussions of this contractual agreement in Section 5.1.4.3.

Additional discussions of solid wastes are presented in Section 4.13.2.3.

If decontamination is possible, surveys for residual surface contamination will be made prior to releasing the material. Decontaminated materials carry activity levels lower than those specified in NRC guidance

(NRC 1987). An area will be maintained inside the restricted area boundary for storage of contaminated materials prior to their disposal.

3.12.3.3 Septic System Solid Waste

Domestic liquid wastes from the restroom toilets, lavatories, and a sink in the lunchroom/break area will be disposed of in an approved septic system that meets the requirements of the State of Nebraska. The satellite building will not have a laboratory. Solid materials collected in septic systems must be disposed of by companies or individuals licensed by the State of Nebraska. NDEQ regulations for control of these systems are contained in Title 124 (NDEQ 2010c).

3.12.3.4 Hazardous Waste

The potential exists for any industrial facility to generate hazardous waste as defined by the RCRA. In the State of Nebraska, hazardous waste is governed by the regulations contained in Title 128 (NDEQ 2010d). Based on waste determinations conducted by CBR as required in Title 128, CBR is a CESQG. To date, CBR only generates universal hazardous wastes such as fluorescent light tubes, used waste oil, and batteries. CBR recently estimated that the current operation generates approximately 1,325 liters of waste oil per year. CBR estimates that the proposed satellite facility would produce approximately 800 liters of waste oil per year. Waste oil is disposed of by a licensed waste oil recycler. CBR has management procedures in place in the SHEQMS Volume VI, Environmental Manual, to control and manage these types of wastes.

Table 3.1-1 Major Land Use Definitions

Table 3.1-1 Major Land Use Definitions

Croplands (C)	Harvested cropland, including grasslands cut for hay, cultivated summer-fallow, and idle cropland.
Commercial and Services (C/S)	Those areas are used predominantly for the sale of products and services. Institutional land uses, such as various educational, religious, health, and military facilities are also components of this category.
Forested Land (F)	Areas with a tree-crown density of 10 percent or more are stocked with trees capable of producing timber or other wood products and exert an influence on the climate or water regime. This category does not indicate economic use.
Habitat (H)	Land dedicated wholly or partially to the production, protection or management of species of fish or wildlife.
Industrial (I)	Areas such as rail yards, warehouses, and other facilities used for industrial manufacturing or other industrial purposes.
Mines, Quarries, or Gravel Pits (M)	Those extractive mining activities that have significant surface expression.
Pastureland (P)	Land used primarily for the long-term production of adapted, domesticated forage plants to be grazed by livestock or occasionally cut and cured for livestock feed.
Rangeland (R)	Land, roughly west of the 100th meridian, where the natural vegetation is predominantly grasses, grass like plants, forbs, or shrubs; which is used wholly or partially for the grazing of livestock. This category includes wooded areas where grasses are established in clearings and beneath the over-story.
Urban Residential (UR)	Residential land uses range from high-density, represented by multi-family units, to low-density, where houses are on lots of more than 1 acre. These areas are found in and around Crawford and Ft. Robinson. Areas of sparse residential land use, such as farmsteads, will be included in categories to which they are related.
Water (W)	Areas of land mass that are persistently water-covered.
Recreational (RC)	Land used for public or private leisure, including developed recreational facilities such as parks, camps, and amusement areas, as well as areas for less intensive use such as hiking, canoeing, and other undeveloped recreational uses.

Table 3.1-2 Present Major Land Use Within a 2.25-Mile (3.6-Km) Radius of the Proposed Marsland Expansion Area License Boundary

Table 3.1-2 Present Major Land Use Within a 2.25-Mile (3.6-Km) Radius of the Proposed Marsland Expansion Area License Boundary

COMPASS SECTOR[1]	LAND USE[2,3] (ACRES)					TOTAL ACRES
	Cropland	Drainage/Potential Wetland	Forest Land	Rangeland	Recreational Land	
E	9.0	38.5	-	1,580.7	-	1,628.2
ENE	42.8	37.4	414.5	859.8	-	1,354.5
ESE	764.1	66.0	-	1,793.2	-	2,623.4
N	59.2	77.4	653.0	2,537.3	244.8	3,571.8
NE	177.4	35.8	535.4	772.7	-	1,521.4
NNE	108.0	49.6	636.4	1,679.7	-	2,473.7
NNW	1.0	71.8	613.8	2,464.3	802.9	3,953.8
NW	47.2	63.3	1,024.8	1,769.7	187.3	3,092.3
S	379.5	138.3	-	2,393.8	-	2,911.6
SE	314.3	200.0	-	3,352.9	-	3,867.2
SSE	169.3	81.2	-	3,694.3	-	3,944.8
SSW	585.6	64.2	-	884.2	-	1,534.1
SW	34.6	25.0	0.1	981.2	-	1,040.9
W	70.8	45.8	489.0	782.1	-	1,387.6
WNW	121.1	63.2	679.6	1,102.8	-	1,966.8
WSW	40.5	17.7	25.0	923.7	-	1,006.8
TOTAL	2,924.4	1,075.3	5,071.6	27,572.4	1,235.0	37,878.6

1 22 1/2° sectors centered on each of the 16 compass points

2 See Table 3.1-1 for an explanation of major land use types: C = cropland; F = forested land; R = rangeland; RR = rangeland rehabilitation; SB = structural biotope; RC = recreational. Land uses not identified: mines, quarries or gravel pits; pastureland; water; habitat; commercial/services; urban residential; industrial

3 Values are inclusive of MEA

Table 3.1-3 Present Land Use Within the Proposed Marsland Expansion Area License Boundary

Table 3.1-3 Present Land Use Within the Proposed Marsland Expansion Area License Boundary

COMPASS SECTOR[1]	LAND USE (ACRES)				
	Cropland	Drainage/Potential Wetland	Forest Land	Rangeland	TOTAL ACRES
E	4.9	3.8	-	121.6	130.4
ENE	40.5	4.0	-	61.9	106.4
ESE	44.4	8.1	-	174.3	226.7
N	59.2	21.1	127.5	395.1	602.9
NE	46.6	4.5	-	44.0	95.1
NNE	55.7	5.4	11.1	73.8	146.1
NNW	1.0	26.0	164.3	1,009.5	1,200.7
NW	0.4	10.6	57.1	300.8	368.8
S	4.6	0.9	-	42.0	47.5
SE	144.8	17.2	-	552.5	714.5
SSE	37.5	19.1	-	778.1	834.7
SSW	3.1	0.7	-	17.6	21.4
SW	0.6	0.4	-	34.2	35.3
W	0.2	0.4	-	25.8	26.5
WNW	0.2	1.0	-	31.5	32.7
WSW	0.3	0.3	-	32.0	32.7
TOTAL	443.9	123.7	360.1	3,694.6	4,622.3

Table 3.1-4 Agricultural Yields for Croplands in Dawes County 2010

Table 3.1-4 Agricultural Yields for Croplands in Dawes County 2010

Crop	Harvested		Yield		Production
	Acres[a]	km^2	Per acre	Per km^2	
Corn (bu)	1,900	7.7	121.6 bu	30,049.17 bu	231,000 bu
Oats (bu)	400	1.6	38 bu	9391.99 bu	15,200 bu
Wheat (bu)	35,200	142.4	33.9 bu	8390.72 bu	1,195,000 bu
Forage (tons)	52,700	213.2	1.8 tons	453.04 tons	96,600 tons

Source: NASS 2011

Notes: bu = bushels

[a] 1 acre = 0.0040469 km^2

Table 3.1-5 Livestock Inventory for Dawes County 2007

Table 3.1-5 Livestock Inventory for Dawes County 2007

Livestock	Number	Percent of Total	Animal Units [a]	
			Pounds (000s)	Percent
All Cattle, except dairy	69,405	96.2	69,405	99.5
Dairy cattle	24	0.03	24	0.03
Hogs and pigs	321	0.4	71	0.1
Sheep and lambs	1,294	1.8	259	0.4
Chickens	1,092	1.5	5	0.008
Total animals	72,136	100.0	69,763.9	100.0

Source: NASS 2009a

Notes: [a] Animal unit conversions:

1 cow = 1,000 lb.
1 hog = 220 lb.
1 sheep = 200 lb.
1 chicken = 5 lb.
1 animal unit = 1,000 lb.

Table 3.1-6 Recreational Facilities Within 50 Miles (80 km) of the Proposed Marsland Expansion Area

Table 3.1-6 Recreational Facilities Within 50 Miles (80 km) of the Proposed Marsland Expansion Area

Name of Recreational Facility	Distance From MEA Boundary (miles)
Box Butte Reservoir and Wildlife Area	~3
Ponderosa Wildlife Management Area	~5
Fort Robinson State Park	~9
Legend Buttes Golf Course	~11
Roberts Trailhead and Campground	~11
Crawford City Park	~12
Peterson Wildlife Management Area	~14
Chadron State Park	~16
Red Cloud Campground	~16
Soldier Creek Wilderness	~16
Whitney Lake	~16
Ridgeview Country Club Golf Course	~21
Agate Fossil Beds National Monument	~22
Hudson-Meng Bison Bonebed	~22
Toadstool Geologic Park	~24
Museum of the Fur Trade	~26
Walgren Lake State Recreation Area	~32
Gilbert-Baker Wildlife Area	~34
Warbonnet Battlefield	~35

Source: DeLorme Maps, 2005

Table 3.1-7 Uranium Recovery Activities in Region of Proposed Marsland Expansion Area

Table 3.1-8 Uranium Recovery Activities in Region of Proposed Marsland Expansion Area

Company	Site	Design	Location (County)	Status
Eastern Wyoming				
Uranium One	Willow Creek	ISR-Restart	Johnson & Campbell	License approved
Uranerz Energy Corp.	Nichols Ranch	ISR-New	Johnson & Campbell	License approved
Uranium One	Moore Ranch	ISR-New	Converse	License approved
Uranium One	Allemand-Ross	ISR-Expansion	Converse	Application pending
Uranium One	Ludeman	ISR-New	Converse	Reapplication Pending
Strategy Energy, Inc.	Ross	ISR-New	Oshoto, Cook	Technical Review
Power Resources, Inc.	Smith Ranch Highland CPP	ISR-Expansion	Converse	Renewal
AUC LLC	Reno Creek	ISR-New	Campbell	Pre-submittal audit
Power Resources, Inc.	Ruby Ranch	ISR-Expansion	Campbell	Application pending
Power Resources, Inc.	Ruth	ISR-Expansion (for Smith Ranch Highland CPP)	Campbell	Pending operations plan approval (satellite facility)
Power Resources, inc.	North Butte	ISR-Operations Plan	Campbell	Pending operations plan approval
The Bootheel Project, LLC	Bootheel	ISR-New	Albany	Application pending
Western Nebraska				
Crow Butte resources, Inc.	Crow Butte Production Facilities	ISR-License Renewal	Dawes	License renewal (draft license issued)
Crow Butte Resources, Inc.	North Trend	ISR-Expansion	Dawes	License approval pending
Crow Butte Resources, Inc.	Three Crow	ISR-Expansion	Dawes	Review deferred
Crow Butte Resources, Inc.	Marsland	ISR-Expansion	Dawes	Application pending
Western South Dakota				
Powertech Uranium Corp.	Dewey Burdock	ISR-New	Custer & Fall River Cos.	Technical review

ISR – *In situ* Recovery

Table 3.3-1 General Stratigraphic Chart for Northwest Nebraska

Table 3.3-1 General Stratigraphic Chart for Northwest Nebraska

Geologic Period	Series	Formation or Group	Rock Types[1]	Thickness (ft)
Tertiary	Miocene	Ogallala	SS, Slt	1560*
	Oligocene/Eocene	Arikaree White River	SS, Slt SS, Slt, Cly	1070* 1450*
Cretaceous	Upper	Pierre	Sh	1500
		Niobrara	Chalk, Ls, Sh	300
		Carlile	Sh	200-250
		Greenhorn	Ls	30
		Graneros	Sh	250-280
		D Sand	SS	5-30
		D Shale	Sh	60
		G Sand	SS	10-45
		Huntsman	Sh	60-80
	Lower	J Sand	SS	10-30
		Skull Creek	Sh	220
		Dakota	SS, Sh	180
Jurassic	Upper	Morrison	Sh, SS	300
		Sundance	SS, Sh, Ls	300
Permian	Guadalupe	Satanka	Ls, Sh, Anhy	450
	Leonard	Upper	Ls, Anhy	150
		Lower	Sh	150
	Wolfcamp	Chase	Anhy	80
		Council Grove	Anhy, Sh	300
		Admire	Dolo, Ls	70
Pennsylvanian	Virgil	Shawnee	Ls	80
	Missouri	Kansas City	Ls, Sh	80
	Des Moines	Marmaton/	Ls, Sh	130
		Cherokee		
	Atoka	Upper/Lower	Ls, Sh	200
Mississippian	Lower	Lower	Ls, Sh	30
Pre-Cambrian			Granite	

[1]Rock Type Abbreviations: Anhy: Anhydrate; Cly: claystone; Dolo: Dolomite; Ls: limestone; Sh: shale; Slt: siltstone; SS: sandstone.

* Maximum thickness based on Swinehart, et. al. 1985.

Table 3.3-2 Representative Stratigraphic Section – Marsland Expansion Area

Table 3.3-2 Representative Stratigraphic Section – Marsland Expansion Area

Elevation (ft amsl)	Average Depth (ft bgs)	Group	Formation & Member (Schultz and Stout 1955)			Formation and Member (Revised)		References (Revised)	Formation & Member (USGS)	
Varying 4150 -4,380	15 - 135	Arikaree Group	Monroe Creek Formation			Upper Harrison Beds		Swinehart et al. (1985)	Arikaree Group	Harrison Sandstone
						Monroe Creek-Harrison Formation				Monroe Creek Sandstone
			Gering Formation			Gering Formation				Gering Formation
Varying 4,140 -4.020	135 - 285	White River Group	Brule Formation	Whitney Member		Brule Formation	"Brown Siltstones"	LaGarry (1998)	Brule Formation	Whitney Member
							Whitney Member			
				Orella Member	Orella D		Orella Member			Orella Member
					Orella C					
					Orella B					
					Orella A		Big Cottonwood Creek Member	Terry (1998) Terry and LaGarry (1998)		
4,020 – 3,890	285 – 650		Chadron Formation	Upper Chadron	Chadron C	Chadron Formation			Chadron Formation	
				Upper/Middle Chadron	Chadron B					
3,890 – 3,380	650 -925			Middle Chadron			Peanut Creek Member	Terry (1998) Terry and LaGarry (1998)		
3,380 -3,180	925 – 1,025			Upper Interior Paleosol	Chadron A	Chamberlain Pass Formation	Upper Interior Paleosol	Terry (1998)		
				basal sandstone of the Chadron Formation			Channel Sandstone	Terry (1998) Terry and LaGarry (1998)		
3,180 – 3,130	1,025 - ? (Bottom not seen in logs)	Montana Group	Pierre Shale	Interior Paleosol		Pierre Shale	Yellow Mounds Paleosol	Retallack (1983) Terry (1998)	Pierre Shale	
				Pierre Shale			Pierre Shale	Terry (1998) Terry and LaGarry (1998)		

Notes:

1) The Shultz and Stout conventions for Formation & Member are utilized throughout this document for consistency with historical permitting, with the exception of the Red Clay Horizon, which is referred to as the Upper Interior Paleosol.

2) Topsoil, colluvial and alluvial deposits are not shown, but are Quaternary in age and range in thickness from 0 to 30 ft-bgs.

3) The terms "Arikaree Group", "Arikaree Formation", and "Arikaree Sandstone" are accepted usages by USGS in Nebraska.

4) The terms "Gering Formation" and "Gering Sandstone" are both accepted usages by USGS in Nebraska.

5) Subdivisions of the Chadron Formation are not formally recognized by USGS in Nebraska.

6) ft amsl = feet above mean sea level; ft bgs = feet below ground surface.

7) Elevations are representative averages for MEA only, and based on Log M-1252.

Table 3.3-3 Marsland Expansion Area Coring Summary

Table 3.3-3 Marsland Expansion Area Coring Summary

Boring ID Date Completed	Latitude Longitude (deg min sec)	Core Interval (feet bgs)	Core Barrel Type	Geologic Unit	Dominant Observed Lithologies	Core Runs Collected
Borings Completed in 2011						
M-1454C 3/23/2011	42 30 45.96736 -103 15 39.46470	600-605	Randolf	Upper Chadron	Siltstone	Run 1
		910-915	Randolf	Middle Chadron	Siltstone	Run 2
		1051-1056	Randolf	Basal Sandstone[1]	Sandstone	Run 3
		1056-1061	Randolf	Pierre Shale	Shale	Run 4
M-1624C 3/28/2011	42 30 02.24164 -103 14 49.32652	580-585	Randolf	Upper Chadron	Siltstone	Run 1
		860-865	Randolf	Middle Chadron	Siltstone	Run 2
		1020-1025	Randolf	Basal Sandstone[1]	Sandstone	Run 3
		1025-1030	Randolf	Basal Sandstone[1]	Sandstone	Run 4
		1035-1040	Randolf	Pierre Shale	Shale	Run 5
Borings Completed in 2013						
M-2169C 8/12/2013	42 32 11.26329 -103 15 53.03808	110-115	Randolf	Arikaree	Silt	Run 1
		155-160	Randolf	Arikaree	Sandstone	Run 2
		355-360	Randolf	Brule	Sandstone	Run 3
		370-380	Christensen	Brule	Siltstone/Mudstone	Run 4
		600-610	Christensen	Upper Chadron	Mudstone	Run 5
		1103-1113	Christensen	Basal Sandstone[1]	Sandstone	Run 6
		1130-1140	Christensen	Pierre Shale	Shale	Run 7
M-533C 8/12/2013	42 30 44.61003 -103 15 38.52320	60-70	Christensen	Arikaree	Sandstone/Siltstone	Run 1
		297-307	Christensen	Brule	Sandstone/Siltstone/Mudstone	Run 3
		1038-1043	Randolf	Basal Sandstone[1]	Sandstone	Run
		1043-1053	Christensen	Basal Sandstone[1] / Pierre Shale	Sandstone/Shale	Run 5
M-1956C 8/20/2013	42 29 39.82221 -103 14 27.90156	42-52	Christensen	Arikaree	Sandstone	Run 1
		72-82	Christensen	Arikaree	Siltstone	Run 3
		193-203	Christensen	Brule	Sandstone/Siltstone/Mudstone	Run 4
		425-435	Christensen	Brule	Mudstone/Siltstone	Run 5
		1004-1014	Christensen	Basal Sandstone[1] / Pierre Shale	Sandstone/Shale	Run 6

Table 3.3-3 Marsland Expansion Area Coring Summary

Boring ID Date Completed	Latitude Longitude (deg min sec)	Core Interval (feet bgs)	Core Barrel Type	Geologic Unit	Dominant Observed Lithologies	Core Runs Collected
Borings Completed in 2013 (continued)						
M-1912C 8/15/2013	42 29 07.30429 -103 14 02.26635	63-73	Christensen	Arikaree	Sandstone	Run 1
		128-138	Christensen	Arikaree	Siltstone	Run 2
		255-265	Christensen	Brule	Sandstone/Siltstone/Mudstone	Run 3
		965-975	Christensen	Basal Sandstone[1] / Pierre Shale	Sandstone/Shale	Run 4
M-1635C 8/23/2013	42 28 23.73852 -103 13 32.61933	70-80	Christensen	Arikaree	Sandstone/Siltstone	Run 1
		197-207	Christensen	Brule	Sandstone/Siltstone/Mudstone	Run 2
		530-540	Christensen	Upper Chadron	Siltstone/Mudstone	Run 3
		960-965	Randolf	Basal Sandstone[1]	Sandstone	Run 4
		965-975	Christensen	Basal Sandstone[1]	Sandstone	Run 5
		985-995	Christensen	Pierre Shale	Shale	Run 6

Notes:

[1] Basal Sandstone of the Chadron Formation

Table 3.3-4 USGS Abbreviated Modified Mercalli (MM) Intensity Scale

Table 3.3-3 **USGS Abbreviated Modified Mercalli (MM) Intensity Scale**

Richter Magnitude	Modified Mercalli Scale	Description of MM Scale
1.0 – 3.0	I	Not felt except by a very few under especially favorable conditions.
3.0 – 3.9	II	Felt only by a few persons at rest, especially on upper floors of buildings.
	III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
4.0 – 4.9	IV	Felt indoors by many, outdoors by a few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
	V	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
5.0 – 5.9	VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
	VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
6.0 – 6.9	VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
	IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
7.0 and higher	X	Some well-built wooded structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
	XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
	XII	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Source: FOO 2002

Table 3.3-5 Historical Earthquakes in Northwestern Nebraska in Close Proximity to the Chadron and Cambridge Arches (1884 – 2009)

Table 3.3-4 **Historical Earthquakes in Northwestern Nebraska in Close Proximity to the Chadron and Cambridge Arches (1884 – 2009)**

Date	Location	Latitude	Longitude	Depth (km)[a]	Richter Magnitude[b]	Modified Mercalli Intensity [b]	Source
3/17/1884	North Platte, NE	41.133	100.75			IV	D
				--	--		
12/16/1916	Stapleton, NE	41.55	100.467	--	--	II-III	D
9/24/1924	Gothenberg, NE	40.95	100.133	--	--	IV	D
8/08/1933	Scottsbluff, NE	41.867	103.667	--	--	IV-V	D
7/30/1934	Chadron, NE	42.85	103	==	==	VI	D
3/24/1938	Fort Robinson, NE	42.683	103.417	--	--	IV	D
3/09/1963	Chadron, NE	42.85	103	--	--	II-III	D
3/28/1964	Merriman, NE	42.8	101.667	--	--	VII	D
5/7/1978	SW Cherry County, NE	42.26	101.95	--	--	V	E
3/06/1983	NE Sheridan, NE	42.96	102.2	--	--	III	E
1/01/1987	Crawford, NE	42.79	103.48	--	--	III	E
2/08/1989	Merriman, NE	42.8	101.6	--	--	IV	E
2/09/1989	39 Miles SE of White Clay, NE	42 41 21 38	101 54 00 32	5 (3.21 miles)	3.8	III	A
7/18/1990	7 miles SSE of Ord, NE	41 30 16 72 N	98 57 39 74 W	5 (3.21 miles)	3.0	II	A
9/30/1990	18 miles SE of Hyannis, NE	41 48 52 97 N	101 30 12 67 W	5 (3.21 miles)	3.0	II	A
8/26/1991	10 miles SE of Brownlee, NE	42 09 46 40 N	100 32 03 25 W	5 (3.21 miles)	3.4	II	A
2/20/1993	14 miles SE of Merriman, NE	42 49 48 00 N	101 27 44 36 W	5 (3.21 miles)	3.5	II - III	A
1/25/1994	5 miles ESE of Wood Lake, NE	42 37 36 39 N	100 08 25 90 W	5 (3.21 miles)	3.3	II	A

Table 3.3-4 Historical Earthquakes in Northwestern Nebraska in Close Proximity to the Chadron and Cambridge Arches (1884 – 2009)

Date	Location	Latitude	Longitude	Depth (km)[a]	Richter Magnitude[b]	Modified Mercalli Intensity [b]	Source
2/06/1996	1 mile N of Wausa, NE	42 30 47 42 N	97 32 35 99 W	5 (3.21 miles)	3.6	III	A
8/09/1997	5.5 miles NW of Chadron, NE	41 47 43 66 N	98 11 08 76 W	5 (3.21 miles)	3.4	II	A
6/18/1998	21 miles SE of Crawford, NE	42 37 23 70 N	103 00 16 58 W	5 (3.21 miles)	3.4	II	A
6/20/2002	5 miles NE of Scotia, NE	41 30 35 65 N	98 37 15 12 W	5 (3.21 miles)	3.5	II - III	A
11/03/2002	4 miles NW of Bassett, NE	42 46 02 38 N	98 54 10 63 W	5 (3.21 miles)	4.0	IV	A
2/14/2003	8 miles SE of Cambridge, NE	40 14 39 46 N	100 01 14 97 W	5 (3.21 miles)	2.9	I	A
2/01/2006	4 miles NE of Bassett, NE	42 36 55 52 N	99 28 23 72 W	5 (3.21 miles)	2.9	I	A
9/07/2006	16 miles SE of Whiteclay, NE	42 58 32 63 N	102 14 15 90 W	5 (3.21 miles)	3.1	II	A
4/16/2007	61 miles SE of Ogallala	40 36 40 42 N	100 44 50 99 W	5 (3.21 miles)	3.0	II	A
4/24/2007	25 miles SE of Crawford, NE	40 35 04 82 N	102 56 13 78 W	5 (3.21 miles)	2.7	I	A
12/16/2009	7 miles E of Johnson, NE	40 24 N	95.857 W	5 (3.21 Miles)	3.5	II - III	B

Source: A USGS 2009f [Note: Locations (lat and long) based on using USGS Google Earth Files for USGS/NEIC Catalog, so locations are approximate].
Source: B USGS 2009c
[a] Depth where the earthquake begins to rupture (Default values used).
[b] Ratings as per Table 3.3-3

Table 3.3-6 Earthquakes in Wyoming and South Dakota Within 125 miles of City of Crawford, NE (1992 – 2009)

Table 3.3-5 **Earthquakes in Wyoming and South Dakota Within 125 miles of City of Crawford, NE (1992 – 2009)**

Date	Location	Latitude	Longitude	Depth (km)[a]	Richter Magnitude[b]	Modified Mercalli Intensity[b]	Source
WYOMING							
8/29/2004	10 miles NW of Douglas, WY	42 54 05 38 N	105 30 33 39 W	5 (3.1 miles)	3.8	III	A
2/15/2004	12 miles N of Douglas, WY	42 56 27 51 N	105 24 12 32 W	10 (6.2 miles)	3.5	II - III	A
4/09/1996	5 miles SE of Redbird, WY	43 03 43 28 N	104 05 54 17 W	5 (3.1 miles)	3.7	III	A
12/13/1993	9 miles SW of Esterbrook, WY	42 20 11 47 N	105 30 04 15 W	5 (3.1 miles)	3.5	II - III	A
10/10/1993	26 miles W of Esterbrook, WY	42 25 25 99 N	105 52 21 90 W	5 (3.1 miles)	3.7	III	A
7/23/1993	18 miles WNW of Esterbrook, WY	42 28 34 03 N	105 42 18 29 W	5 (3.1 miles)	3.7	III	A
6/30/1993	15 miles N of Douglas, WY	42 59 02 58 N	105 22 48 50 W	5 (3.1 miles)	3.0	II	A
2/24/1993	11 miles SE of Wright, WY	43 42 46 50	105 17 20 18 W	0	3.6	III	A
11/02/1992	3 miles SE of Lusk, WY	42 44 49 37 N	104 53 22 98 W	5 (3.1 miles)	3.0	II	A
SOUTH DAKOTA							
2/07/2007	1 mile SW of Owanka, SD	44 01 56 13 N	102 34 47 35 W	5 (3.1 miles)	3.1	II	A
5/25/2003	35 miles E of Pine Ridge, SD	43.08 N	101.84 W	5 (3.1 miles)	4.0	IV	B
5/03/1996	18 miles NW of Ardmore, SD	43 02 32 88 N	104 01 11 30 W	5 (3.1 miles)	3.1	II	A
2/06/1996	8.3 miles NW of Hill City, SD	43 58 52 67 N	103 43 41 52 W	5 (3.1 miles)	3.7	III	A
3/20/1994	3 miles SW of Hot Springs, SD	43 23 51 02 N	103 29 57 16 W	5 (3.1 miles)	2.3	I	A

Table 3.3-5 Earthquakes in Wyoming and South Dakota Within 125 miles of City of Crawford, NE (1992 – 2009)

Date	Location	Latitude	Longitude	Depth (km)[a]	Richter Magnitude[b]	Modified Mercalli Intensity[b]	Source
3/18/1994	3 miles SW of Hot Springs, SD	43 23 51 02 N	103 29 57 16 W	5 (3.1 miles)	2.8	I	A
9/05/1993	2.5 miles NW of Central City, SD	44 24 11 63 N	103 48 07 76 W	5 (3.1 miles)	2.7	I	A
11/05/1991	1.5 miles SE of Central City, SD	44 21 10 54 N	103 45 01 27 W	0	2.5	I	A
3/02/1990	13 miles NW of Wounded Knee, SD	43 19 00 23 N	102 30 04 97 W	5 (3.1 miles)	3.2	II	A
1/28/1990	13 miles NW of Wounded Knee, SD	43 19 00 23 N	102 30 04 97 W	5 (3.1 miles)	4.0	IV	A

Source: A USGS 2009f [Note: Locations (lat and long) based on using USGS Google Earth Files for USGS/NEIC Catalog, so locations are approximate].
Source: B USGS 2009c
[a] Depth where the earthquake begins to rupture (Default values used).
[b] Rating as per Table 3.3-3

Table 3.3-7 Summary of Soil Resources Within the MEA

Table 3.3-6 **Summary of MEA Soil Resources**

Map Unit	Map Unit Name	Acres	Percent of Project Area
1013	Bankard loamy coarse sand, frequently flooded	127.2	2.8
1014	Bankard loamy fine sand, frequently flooded	188.5	4.2
1036	Glenberg loamy very fine sand, 0 to 3 percent slopes	8.5	0.2
1356	Bridget silt loam, 1 to 3 percent slopes	269.0	6.0
1357	Bridget silt loam, 3 to 6 percent slopes	102.8	2.3
1620	Keith silt loam, 1 to 3 percent slopes	53.2	1.2
1742	Rosebud-Canyon loams, 3 to 9 percent slopes	174.0	3.9
1881	Valent and Dwyer loamy fine sands, 0 to 3 percent slopes	283.5	6.3
1882	Valent and Dwyer loamy fine sands, 3 to 20 percent slopes	786.0	17.5
5070	Vetal and Bayard soils, 1 to 6 percent slopes	110.6	2.5
5105	Alliance silt loam, 1 to 3 percent slopes	241.9	5.4
5106	Alliance silt loam, 3 to 9 percent slopes	87.5	2.0
5107	Alliance silt loam, 3 to 9 percent slopes, eroded	29.3	0.7
5118	Busher and tassel loamy very fine sands, 6 to 20 percent slopes	185.1	4.1
5123	Busher loamy very fine sand, 1 to 6 percent slopes	142.2	3.2
5124	Busher loamy very fine sand, 1 to 6 percent slopes, eroded	131.2	2.9
5126	Busher loamy very fine sand, 6 to 9 percent slopes	162.3	3.6
5128	Busher loamy very fine sand, 6 to 9 percent slopes, eroded	134.5	3.0
5129	Busher loamy very fine sand, 9 to 20 percent slopes	116.3	2.6
5152	Canyon soils, 3 to 30 percent slopes	13.3	0.3
5153	Canyon soils, 30 to 50 percent slopes	452.6	10.1
5200	Oglala loam, 9 to 30 percent slopes	2.0	0.0
5211	Oglala-Canyon loams, 9 to 20 percent slopes	225.4	5.0
5254	Schamber soils, 3 to 30 percent slopes	12.7	0.3
5640	Haverson loam, frequently flooded	49.7	1.1
5871	Tripp silt loam, 1 to 3 percent slopes	19.4	0.4
5947	Duroc very fine sandy loam, 1 to 3 percent slopes	0.1	0.0
5978	Jayem loamy very fine sand, 1 to 6 percent slopes	10.9	0.2
6028	Tassel soils, 3 to 30 percent slopes	339.3	7.6
6043	Tassel-Ponderosa-Rock outcrop association, 9 to 70 percent slopes	1.0	0.0
6091	Sarben fine sandy loam, 1 to 6 percent slopes	19.4	0.4
TOTAL		**4479.1**	**100.0**

Table 3.4-1 USGS Estimated Water Use in Dawes County 2005

Table 3.4-1 USGS Estimated Water Use in Dawes County 2005

Total Population Served	Public Supply - Million Gallons Per Day				Irrigation (Mgal/da)			1000s
	Ground-water Withdrawals	Surface Water Withdrawals	Total Withdrawals	Domestic Deliveries	Groundwater Withdrawals	Surface Water Withdrawals	Total Withdrawals	Acres Irrigated Total
8,636	1.47	1.12	2.59	1.77	14.24	10.31	24.55	13

Source: USGS 2005

Table 3.4-2 Summary of Non-Abandoned Registered Water Wells for Dawes County, Ne on File as of April 08, 2013

Table 3.4-2 Summary of Non-Abandoned Registered Water Wells for Dawes County, Ne on File as of April 08, 2013

Number of Registered Wells					
Commercial	**Domestic**	**Irrigation**	**Monitoring [a]**	**Other Wells [b]**	**Total**
497	251	85	607	4,388	**5,828**

Other Wells (Registered)

Ground Heat Exchange	Injection	Observation [d]	Other [e]	Recovery	Livestock	Public Water Supply [f]	Public Water Supply [g]	Total Other Wells
7	916	7	16	3,174	232	16	20	**4,388**

Source: NDNR 2013a

[a] Monitoring (Ground Water Quality)

[b] Listed below [Other Wells (Registered)]

[c] The same acres may be reported under more than one well registration.

[d] Observation (Ground Water Levels)

[e] Other (Lake Supply, Fountain, Geothermal, Wildlife, Wetlands, Recreation, Plant & Lagoon, Sprinkler, Test, Vapor Monitoring)

[f] With spacing protection (A well owned and operated by a city, village, municipal corporation, metropolitan utilities district, reclamation district, or sanitary improvement district that provides water to the public fit for human consumption through at least 15 service connections, or regularly serve at least 5 individuals.

[g] Without spacing protection (A well *not* owned or operated by a city, village, municipal corporation, metropolitan utilities district, reclamation district, or sanitary improvement district that provides the public water fit for human consumption through at least 15 service connections or regularly serves at least 25 individuals.

Table 3.4-3 Active, Inactive and Abandoned Water Supply Wells in the MEA and 2.25-Mile Area of Review

Table 3.4-3 Active, Inactive and Abandoned Water Supply Wells in the Marsland Expansion Area and 2.25-Mile Area of Review

Well No.	Estimated Depth (ft)	Formation	Well Use	Well Status
ACTIVE AND INACTIVE WELLS				
Wells Located Within License Boundary (13 active and 2 inactive)				
700	180 - 200	Brule	Livestock	Active
701	180 - 200	Brule	Livestock	Inactive
705	Unknown	Arikaree	Livestock	Active
720	240	Arikaree/Brule	Other [c]	Active
721	360	Arikaree/Brule	Other [c]	Active
722	160	Brule	Livestock	Active
727	180	Arikaree/Brule	Livestock	Active
728	260	Brule	Livestock	Active
730	Unknown	Unknown[a]	Domestic	Active
731	180	Brule	Livestock	Active
733	Unknown	Unknown[a]	Livestock	Active
744	80	Arikaree	Livestock	Active
747	225	Arikaree/Brule	Livestock	Active
787	130	Brule	Livestock	Inactive
788	130 - 140	Arikaree	Livestock	Active
Wells Located Within 1 Km Radius of License Boundary (25 active and 7 inactive)				
702	180 - 200	Brule	Livestock	Active
703	280	Brule	Domestic/Livestock	Active
704	Unknown	Unknown[a]	Livestock	Active
707	Unknown	Unknown[a]	Livestock	Active
719	160	Brule	Livestock	Active
723	220	Brule	Domestic/Livestock	Active
724	Unknown	Unknown[a]	Domestic/Livestock	Inactive
725	240	Brule	Livestock	Active
729	Unknown	Unknown[a]	Livestock	Inactive
732	280	Brule	Agricultural	Active
735	375	Brule[b]	Livestock	Active
736	200	Brule[b]	Agricultural	Active
739	60	Arikaree	Livestock/Garden	Active
740	110	Brule	Agricultural	Active
741	190	Brule	Agricultural	Active
743	140	Brule[b]	Livestock	Active
745	140[c]	Brule	Livestock	Active
746	Unknown	Unknown[a]	Livestock	Active
748	Unknown	Unknown[a]	Livestock	Active
749	Unknown	Unknown[a]	Livestock	Inactive
750	Unknown	Unknown[a]	Livestock	Active
752	200 - 300	Brule	Domestic/Livestock	Active
753	200 - 300	Brule	Domestic/Livestock	Active
754	200 - 300	Brule	Livestock	Active
755	200 - 300	Brule	Livestock	Active

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Table 3.4-3 Active, Inactive and Abandoned Water Supply Wells in the Marsland Expansion Area and 2.25-Mile Area of Review

Well No.	Estimated Depth (ft)	Formation	Well Use	Well Status
756	200 - 300	Brule	Livestock	Inactive
759	200 - 300	Brule	Livestock	Active
777	60	Arikaree	Domestic/Garden	Active
778	60	Arikaree	Livestock	Inactive
802	180 - 200	Brule	Livestock	Active
834	300	Brule	Domestic/Livestock	Inactive
843	300	Brule[b]	Livestock	Inactive
Wells Located Between 1 and 2 Km Radius (18 active and 6 inactive)				
706	Unknown	Unknown[a]	Livestock	Active
714	135	Brule[b]	Domestic/Livestock	Active
715	135	Arikaree	Agricultural	Active
716	135	Brule	Agricultural	Inactive
734	300	Brule[b]	Livestock	Active
737	340	Brule[b]	Agricultural	Active
742	60	Arikaree[b]	Livestock	Active
760	Unknown	Unknown[a]	Agricultural	Active
790	Unknown	Unknown[a]	Livestock	Inactive
794	300	Arikaree/Brule[b]	Domestic/Livestock	Active
795	350	Arikaree/Brule[b]	Domestic/Livestock	Active
796	350	Arikaree/Brule[b]	Domestic/Livestock	Inactive
799	250	Brule	Livestock	Active
809	300	Brule	Livestock	Active
810	>300	Unknown[a]	Domestic/Livestock	Active
811	>300	Unknown[a]	Domestic/Livestock	Active
815	140	Brule	Domestic	Active
816	140	Brule	Livestock	Inctive
817	160	Brule	Livestock	Inctive
821	160	Brule[b]	Livestock	Active
835	300	Brule	Livestock	Inactive
836	220	Brule	Livestock	Active
841	220	Brule[b]	Livestock	Active
845	Unknown	Unknown[a]	Domestic/Livestock	Active
Wells Located Between 2 Km Radius and AOR Boundary (54 active, 8 inactive and 1 unknown)				
708	Unknown	Unknown[a]	Livestock	Active
709	Unknown	Unknown[a]	Livestock	Active
710	Unknown	Unknown[a]	Livestock	Active
711	Unknown	Unknown[a]	Livestock	Active
712	Unknown	Unknown[a]	Livestock	Active
713	Unknown	Unknown[a]	Livestock	Active
717	160	Arikaree/Brule	Livestock	Active
738	260	Arikaree/Brule[b]	Livestock	Active

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Deleted: 761
Deleted: Unknown
Deleted: Unknown[a]
Deleted: Livestock
Deleted: Active
Deleted: 774
Deleted: 200 - 300
Deleted: Arikaree/Brule[b]
Deleted: Domestic/Livestock
Deleted: Active
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Table 3.4-3 Active, Inactive and Abandoned Water Supply Wells in the Marsland Expansion Area and 2.25-Mile Area of Review

Well No.	Estimated Depth (ft)	Formation	Well Use	Well Status
751	Unknown	Unknown[a]	Livestock	Active
762	200 - 300	Arikaree/Brule[b]	Livestock	Active
763	200 - 300	Arikaree/Brule[b]	Livestock	Active
764	200 - 300	Arikaree/Brule[b]	Livestock	Active
765	200 - 300	Arikaree/Brule[b]	Livestock	Active
767	200 - 300	Arikaree/Brule[b]	Livestock	Active
768	200 - 300	Arikaree/Brule[b]	Domestic	Active
769	200 - 300	Arikaree/Brule[b]	Livestock	Active
771	200 - 300	Arikaree/Brule[b]	Livestock	Active
772	200 - 300	Arikaree/Brule[b]	Livestock	Active
773	200 - 300	Arikaree/Brule[b]	Livestock	Active
775	220	Arikaree/Brule[b]	Livestock	Active
776	200 - 300	Arikaree/Brule[b]	Livestock	Active
781	60	Arikaree/Brule	Livestock	Active
782	100	Brule[b]	Agricultural	Active
783	70	Arikaree/Brule[b]	Domestic	Active
784	40 - 60	Arikaree/Brule[b]	Livestock	Inactive
785	140	Arikaree/Brule[b]	Livestock	Inactive
786	140	Arikaree/Brule[b]	Livestock	Inactive
791	Unknown	Unknown[a]	Livestock	Active
792	Unknown	Unknown[a]	Livestock	Active
793	300	Arikaree/Brule[b]	Livestock	Active
798	200	Brule	Livestock	Active
800	Unknown	Unknown[a]	Livestock	Active
801	220	Arikaree/Brule[b]	Domestic/Garden	Active
803	Unknown	Unknown[a]	Livestock	Active
804	Deep	Unknown[a]	Domestic/Livestock	Active
805	Shallow	Unknown[a]	Livestock	Inactive
806	Unknown	Unknown[a]	Livestock	Inactive
808	160	Arikaree/Brule[b]	Domestic/Livestock	Active
812	260	Unknown[a]	Domestic/Livestock	Active
813	280	Unknown[a]	Livestock	Active
814	Unknown	Unknown[a]	CBR Exploration	Inactive
818	140	Arikaree/Brule[b]	Livestock	Active
819	140	Arikaree/Brule[b]	Livestock	Active
822	140	Brule[b]	Livestock	Active
823	100	Arikaree/Brule[b]	Livestock	Active
827	Unknown	Unknown[a]	Livestock	Active
828	160	Arikaree/Brule[b]	Domestic	Active
837	300	Brule[b]	Livestock	Active
838	300	Arikaree/Brule[b]	Livestock	Active
839	300	Arikaree/Brule[b]	Livestock	Active
840	300	Arikaree/Brule[b]	Livestock	Active
842	300	Arikaree/Brule[b]	Livestock	Active

Table 3.4-3 Active, Inactive and Abandoned Water Supply Wells in the Marsland Expansion Area and 2.25-Mile Area of Review

Well No.	Estimated Depth (ft)	Formation	Well Use	Well Status
846	Unknown	Unknown[a]	Livestock	Active
849	Unknown	Unknown[a]	Livestock	Active
850	200	Arikaree/Brule[b]	Agricultural	Active
851	140	Arikaree/Brule[b]	Agricultural	Active
853	150	Arikaree/Brule[b]	Agricultural	Active
856	Unknown	Unknown[a]	Unknown	Unknown
857	40 - 50	Arikaree/Brule[b]	Domestic/Agricultural	Inactive
858	200	Arikaree/Brule[b]	Agricultural	Active
859	120	Arikaree/Brule[b]	Domestic	Inactive
861	40	Arikaree/Brule[b]	Domestic/Livestock/ Agricultural	Active
862	155	Arikaree/Brule[b]	Domestic/Agricultural	Active
ABANDONED WELLS				
Wells Located Within License Boundary				
726A	300	Brule	Unknown	Abandoned
Wells Located Within 1 Km Radius of License Boundary				
868A	Unknown	Unknown[a]	Unknown	Abandoned
869A	Unknown	Unknown[a]	Unknown	Abandoned
Wells Located Between 1 and 2 Km Radius				
867A	Unknown	Unknown[a]	Unknown	Abandoned

[a] Information provided by well owner and information from nearby wells are insufficient to make a definitive determination of aquifer utilized. However, discussions with land owners and known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation.

[b] Information provided by well owner and information from nearby wells indicate that one or more aquifer is utilized, but cannot be specifically determined. Assigned formation based on available information.

[c] CBR driller water supply.

Table 3.4-4 Minimal Horizontal Distance Separating a Municipal Water Well from Potential Sources of Contamination

Table 3.4-4 Minimal Horizontal Distance Separating a Municipal Water Well from Potential Sources of Contamination

Potential Source of Contamination	Distance	
	Feet	Meters
Water well	1,000	305
Sewage Lagoon	1,000	305
Land Application of municipal/industrial waste material	1,000	305
Feedlot or feedlot runoff	1,000	305
Underground disposal system (septic system, cesspool, etc.)	500	153
Corral	500	153
Pit Toilet/Vault Toilet	500	153
Wastewater holding tanks	500	153
Sanitary landfill/dump	500	153
Chemical or petroleum product storage	500	153
Sanitary treatment plant	500	153
Sewage wet well	500	153
Sanitary sewer connection	100	153
Sanitary sewer manhole	100	153
Sanitary sewer line	50	15

Source: Nebraska Department of Health and Human Services (NDHHS). 2010. Title 179. Public Water Systems, Chapter 7, 7-007 Design Standards, 7-007.03 Wells/Groundwater Source(s). April 4.

Table 3.4-5 Stream Classification of Niobrara River Subbasin N14

Table 3.4-5 Stream Classification of Niobrara River Subbasin N14

Stream Segment [a]	Segment Number	Recreation	Aquatic Life		Water Supply	Aesthetics	Key Species	Comments
			Cold Water	Warm Water	Agricultural			
Niobrara R. - NE-WY border to Whistle Creek (Sioux Co.)	50000	·	B		A	·	5	Threatened Species
Whistle Creek (Sioux Co.)	40100		B		A	·		
Niobrara R. to Box Butte Reservoir Dam (Dawes Co.)	40000	a	B		A	·	5	Threatened Species
Niobrara R. – Box Butte Reservoir Dam to Mirage Flats Canal Diversion (Dawes Co.)	30000	a	B		A	·	d, e	
Cottonwood Creek (Dawes Co.)	20200		B		A	·		
Pepper Creek (Dawes Co.)	20100		B		A	·		
Lake Name								
Box Butte Reservoir (Dawes Co.)	N14-L0080	·		A	A	·		Northern Pike [b]

Source: NAC 2011a and NAC 2011b. Stream segments as occurring in vicinity of Marsland Expansion Area: from Wyoming/Nebraska state line (Sioux County) to the Dawes/Sheridan County line (Dawes County) (**Figure F.1-3**). Marsland south permit boundary located approximately 1/4 mile north of Niobrara River in Subbasin N14.

a = Impaired for beneficial use: Total Maximum Daily Load (TMDL) for *E coli* approved 1/06/2010) (NDEQ 2010).

b = Fish consumption advisory for mercury in Northern Pike tissue. (NDEQ 2011).

Species codes used in basin tables: to identify key species which typically occur in a stream segment:
5 = Finescale Dace; d = Brown Trout; e = Rainbow Trout

Coldwater Class A: These waters provide a habitat which supports natural reproduction of a salmonid (trout) population. These waters also are capable of maintaining year-round populations of a variety of other coldwater fish and associated vertebrate and invertebrate organisms and plants.

Coldwater Class B: These are waters which provide, or could provide, a habitat capable of maintaining year-round populations of a variety of coldwater fish and associated vertebrate and invertebrate organisms and plants or which support the seasonal migration of salmonids. These waters do not support natural reproduction of salmonid populations due to limitations of flow, substrate composition, or other habitat conditions, but salmonid populations may be maintained year-round if periodically stocked.

Warmwater Class A: These waters provide, or could provide, a habitat suitable for maintaining one or more identified key species on a year-round basis. These waters also are capable of maintaining year-round populations of a variety of other warmwater fish and associated vertebrate and invertebrate organisms and plants.

Agricultural Class A: These are waters used for general agricultural purposes (e.g., irrigation and livestock watering) without treatment.

Aesthetics: This use applies to all surface waters of the state. To be aesthetically acceptable, waters shall be free from human-induced pollution which causes: 1) noxious odors; 2) floating, suspended, colloidal, or settleable materials that produce objectionable films, colors, turbidity, or deposits; and 3) the occurrence of undesirable or nuisance aquatic life (e.g., algal blooms). Surface waters shall also be free of junk, refuse, and discarded dead animals.

Primary Contact Recreation: This use applies to surface waters which are used, or have a high potential to be used, for primary contact recreational activities. Primary contact recreation includes activities where the body may come into prolonged or intimate contact with the water, such that water may be accidentally ingested and sensitive body organs (e.g., eyes, ears, nose, etc.) may be exposed. Although the water may be accidentally ingested, it is not intended to be used as a potable water supply unless acceptable treatment is applied. These waters may be used for swimming, water skiing, canoeing, and similar activities. These criteria apply during the recreational period of May 1 through September 30.

Table 3.4-6 Water Levels - Arikaree Group, Brule Formation and Basal Sandstone of Chadron Formation

Table 3.4-7 Summary of 2011 Marsland Pumping Test #8 Well Information

Table 3.4-6 **Summary of 2011 Marsland Pumping Test #8 Well Information**

Well	Distance to Pumping Well	Northing (ft)	Easting (ft)	Township & Range	Section	TOC Elev. (ft-amsl)	Surface Elevation (ft-amsl)	Casing Stickup (ft)	Depth Drilled (ft bgs)	Casing Depth (ft bgs)	Top Screen (ft bgs)	Bottom Screen (ft bgs)	Screen Length (ft)	Casing O.D. (in.)	11/12/10 Static Water Elevation (ft AMSL)
Basal Chadron Sandstone Pumping Well															
CPW-1A	0.00	446,202.00	1,121,450.00	1	T29N R51W	4,262.70	4,261.10	1.60	1,055	1019	1022	1052	30	4.95	NM
Basal Chadron Sandstone Observation Wells															
CPW-1	67	446,225.00	1,121,528.00	1	T29N R51W	4,261.85	4,259.80	2.10	1070	1009	1015	1048	33	4.95	3710.75
Monitor-2	8,800	439,439.00	1,126,362.00	18	T29N R50W	4,198.40	4,197.20	1.20	1027	974	970	1010	40	4.95	3713.83
Monitor-3	100	446,288.00	1,121,519.00	1	T29N R51W	4,261.30	4,260.20	1.10	1069	1008	1016	1043	27	4.95	3710.27
Monitor-4A	4,067	450,084.00	1,121,344.00	1	T29N R51W	4,327.49	4,326.30	1.60	1134	1079	1088	1110	22	4.95	3709.69
Monitor-5	2,800	447,734.00	1,119,236.00	1	T29N R51W	4,339.50	4,337.40	2.10	1120	1069	1070	1120	50	4.95	3711.05
Monitor-6	4,667	442,856.00	1,124,385.00	12	T29N R51W	4,215.00	4,213.80	1.20	1050	989	990	1023	33	4.95	3712.83
Monitor-7	6,200	440,358.00	1,120,757.00	12	T29N R51W	4,244.38	4,243.20	1.20	1050	999	1000-1013	1023-1043	33	4.95	3713.39
Monitor-8	6,800	450,974.00	1,117,005.00	2	T29N R51W	4,353.70	4,352.40	1.30	1180	1079	1085	1125	40	4.95	3709.23
Brule Formation Observation Wells															
BOW-2010-1	133	446,250.00	1,121,572.00	1	T29N R51W	4,260.10	4,259.20	0.90	370	279	285-305	325-365	60	4.95	4133.97
BOW-2010-2	4,167.00	450,154.00	1,121,367.00	1	T29N R51W	4,323.40	4,322.30	1.10	400	339	339-369	389-399	40	4.95	4173.04
BOW-2010-3	6,867	450,974.00	1,117,056.00	2	T29N R51W	4,350.30	4,349.80	0.50	415	339	345-365	385-415	50	4.95	4212.81

Note:

1. NM = not measured
2. TOC = top of casing
3. ft = feet
4. AMSL = above mean sea level
5. ft bgs - feet below ground surface
6. ft-amsl = feet above mean sea level

Table 3.4-8 Summary of 2011 Marsland Pumping Test Results

Table 3.4-7 Summary of 2011 Marsland Pumping Test Results

Well	Distance from Pumping Well (feet)	Analytical Results	Theis Drawdown	Theis Recovery	Averages
CPW-1A**	Pumping Well	Transmissivity (ft^2/day)	--	573	573
		Hyd. Cond. (ft/day)	--	14	14
		Storativity	--	--	--
CPW-1**	67	Transmissivity (ft^2/day)	430	523	477
		Hyd. Cond. (ft/day)	11	13	12
		Storativity	8.32E-05	--	8.32E-05
Monitor 2*	8,800	Transmissivity (ft^2/day)	1781	2469	2125
		Hyd. Cond. (ft/day)	45	62	54
		Storativity	4.72E-05	--	4.72E-05
Monitor 3	100	Transmissivity (ft^2/day)	230	299	265
		Hyd. Cond. (ft/day)	6	7	7
		Storativity	1.70E-03	--	1.70E-03
Monitor 4A	4,067	Transmissivity (ft^2/day)	903	1377	1140
		Hyd. Cond. (ft/day)	23	34	29
		Storativity	5.41E-05	--	5.41E-05
Monitor 5	2,800	Transmissivity (ft^2/day)	915	971	943
		Hyd. Cond. (ft/day)	23	24	24
		Storativity	5.50E-05	--	5.50E-05
Monitor 6	4,667	Transmissivity (ft^2/day)	901	1063	982
		Hyd. Cond. (ft/day)	23	27	25
		Storativity	3.44E-05	--	3.44E-05
Monitor 7	6,200	Transmissivity (ft^2/day)	983	1315	1149
		Hyd. Cond. (ft/day)	25	33	29
		Storativity	3.57E-05	--	3.57E-05
Monitor 8*	6,800	Transmissivity (ft^2/day)	989	1596	1293
		Hyd. Cond. (ft/day)	25	40	33
		Storativity	3.95E-05	--	3.95E-05
Discharge Rate: 27.08 [U.S. gallons/min]				Avg. Transmissivity (ft^2/day)	1012
Aquifer Thickness: 40 [feet]				Avg. Hyd. Cond. (ft/day)	25
				Avg. Storativity	7.46E-05

Note:

1. * = Monitor 2 and Monitor 8 were monitored and analyzed as described in the origional pumping test plan, but are not part of the formal monitoring network used to establish the radius of influence.

2. ** = Water level data for CPW-1A and CPW-1 were not corrected for barometric variations due to the logging interval of the pressure transducers.
3. Pumping started at 5:03am on 5/16/2011 and ended at 12:00 pm on 5/20/11.
4. Hydraulic conductivity calculatee based on a typical net sand thickness of 40 feet.
5. ft^2/day = square feet per day
6. ft/day = feet per day

Table 3.4-9 Summary of Marsland Pumping Test Results Compared to Previous Testing

Table 3.4-8 Summary of Marsland Pumping Test Results Compared to Previous Testing

	Tests #1-#3 Existing Class III Permit Area (mean)	Test #4 Existing Class III Permit Area (mean)	Test #6 North Trend 2006 (mean)	Test #7 Three Crow 2008 (mean)	Test #8 Marsland 2011 (mean)
Transmissivity (ft^2/day)	363	826	60	477	1,012
Formation Thickness (feet)	39.0	39.0	26	64	40
Hyd. Cond. (ft/day)	9.3	20.6	2.3	7.5	25
Storativity	9.7E-05	6.2×10^{-5}	5.3E-05	8.8E-04	2.56×10^{-4}

Note:

1. ft^2/day = square feet per day

2. ft/day = feet per day

Table 3.4-10 Baseline and Restoration Values for Current Crow Butte Production Area Mine Unit 1

Table 3.4-9 Baseline and Restoration Values for Current Crow Butte Production Area Mine Unit 1

Baseline and Restoration Values for CPF Mine Unit 1	Groundwater Standard	MU-1 Baseline (Primary Standard)	MU-1 Standard Deviation	MU-1 NDEQ Restoration Value
Ammonium (mg/l)	10	<0.372		10
Arsenic (mg/l)	0.010	<0.00214		0.05
Barium (mg/l)	2.0	<0.1		1
Cadmium (mg/l)	0.005	<0.00644		0.005
Chloride (mg/l)	250	203.9	38	250
Copper (mg/l)	1.3	<0.017		1
Fluoride (mg/l)	4.0	0.686	0.04	4
Iron (mg/l)	0.3	<0.0441		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.011		0.05
Molybdenum (mg/l)	Reserved	<0.0689		1
Nickel (mg/l)	Reserved	<0.0340		0.15
Nitrate (mg/l)	10	<0.050		10
Lead (mg/l)	0.015	0.0315		0.05
Radium (pCi/L)	5.0	229.7	177.1	584
Selenium (mg/l)	0.05	<0.00323		0.05
Sodium (mg/l)	Reserved	412	19.2	4120
Sulfate (mg/l)	250	356.2	9.4	375
Uranium (mg/l)	0.030	0.0922	0.089	5
Vanadium (mg/l)	Reserved	<0.0663		0.2
Zinc (mg/l)	5.0	<0.036		5
pH (Std. Units)	6.5 - 8.5	8.46	0.2	6.5 – 8.5
Calcium (mg/l)	N/A	12.5	3.2	125
Total Carbonate (mg/l)	N/A	351	31.1	585
Potassium (mg/l)	N/A	12.5	1.5	125
Magnesium (mg/l)	N/A	3.2	0.8	32
TDS (mg/l)	500	1170.2	47.6	1170.2

[1] Standard for Cadmium lowered in modification to UIC permit dated March 9, 2001 following NDEQ approval of Mine Unit 1 restoration.

[2] Title 118 numerical standards in effect at the time the Notice of Intent was filed with the NDEQ.

[3] Restoration values based on Title 118 numerical standards and well field averages at the time the Notice of Intent was submitted to the NDEQ.

N/A = Not Applicable

CPF = Crow Butte Production Facility

Table 3.4-11 Baseline and Restoration Values for Current Crow Butte Production Mine Unit 2

Table 3.4-10 Baseline and Restoration Values for Current Crow Butte Production Mine Unit 2

Baseline and Restoration Values for CPF Mine Unit 2	Groundwater Standard	MU-2 Baseline (Primary Standard)	MU-2 Standard Deviation	MU-2 NDEQ Restoration Value
Ammonium (mg/l)	10	0.37	0.07	10
Arsenic (mg/l)	0.010	<0.001		0.05
Barium (mg/l)	2.0	<0.1		1
Cadmium (mg/l)	0.005	<0.007		0.005
Chloride (mg/l)	250	208.6	30.8	250
Copper (mg/l)	1.3	<0.013		1
Fluoride (mg/l)	4.0	0.67	0.04	4
Iron (mg/l)	0.3	<0.045		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.01		0.05
Molybdenum (mg/l)	Reserved	<0.073		1
Nickel (mg/l)	Reserved	<0.037		0.15
Nitrate (mg/l)	10	<0.039		10
Lead (mg/l)	0.015	<0.035		0.05
Radium (pCi/L)	5.0	234.5	411.8	1058
Selenium (mg/l)	0.05	<0.001		0.05
Sodium (mg/l)	Reserved	410.8	18.2	4108
Sulfate (mg/l)	250	348.2	10.3	369
Uranium (mg/l)	0.030	0.046	0.037	5
Vanadium (mg/l)	Reserved	<0.07		0.2
Zinc (mg/l)	5.0	<0.026		5
pH (Std. Units)	6.5 - 8.5	8.32	0.2	6.5 – 8.5
Calcium (mg/l)	N/A	13.4	2.4	134
Total Carbonate (mg/l)	N/A	366.9	13.3	585
Potassium (mg/l)	N/A	12.6	2.5	126
Magnesium (mg/l)	N/A	3.5	0.4	35
TDS (mg/l)	500	1170.4	41	1170.4

[1] Standard for Cadmium lowered in modification to UIC permit dated March 9, 2001 following NDEQ approval of Mine Unit 1 restoration.

[2] Title 118 numerical standards in effect at the time the Notice of Intent was filed with the NDEQ.

[3] Restoration values based on Title 118 numerical standards and well field averages at the time the Notice of Intent was submitted to the NDEQ.

N/A = Not Applicable

CPF = Crow Butte Production Facility

Table 3.4-12 Baseline And Restoration Values For Current Crow Butte Production Mine Unit 3

Table 3.4-11 Baseline And Restoration Values For Current Crow Butte Production Mine Unit 3

Baseline and Restoration Values for CPF Mine Unit 3	Groundwater Standard	MU-3 Baseline (Primary Standard)	MU-3 Standard Deviation	MU-3 NDEQ Restoration Value
Ammonium (mg/l)	10	<0.329		10
Arsenic (mg/l)	0.010	<0.001		0.05
Barium (mg/l)	2.0	<0.1		1
Cadmium (mg/l)	0.005	<0.01		0.005
Chloride (mg/l)	250	197.6	16.7	250
Copper (mg/l)	1.3	<0.0108		1
Fluoride (mg/l)	4.0	0.719	0.05	4
Iron (mg/l)	0.3	<0.05		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.01		0.05
Molybdenum (mg/l)	Reserved	<0.1		1
Nickel (mg/l)	Reserved	<0.05		0.15
Nitrate (mg/l)	10	<0.0728		10
Lead (mg/l)	0.015	<0.05		0.05
Radium (pCi/L)	5.0	165	222.5	611
Selenium (mg/l)	0.05	<0.00115		0.05
Sodium (mg/l)	Reserved	428	27.6	4280
Sulfate (mg/l)	250	377	13.4	404
Uranium (mg/l)	0.030	0.115	0.158	5
Vanadium (mg/l)	Reserved	<0.1		0.2
Zinc (mg/l)	5.0	<0.0131		5
pH (Std. Units)	6.5 - 8.5	8.37	0.3	6.5 – 8.5
Calcium (mg/l)	N/A	13.3	3.1	133
Total Carbonate (mg/l)	N/A	358.7	24.8	592
Potassium (mg/l)	N/A	13.9	4	139
Magnesium (mg/l)	N/A	3.5	0.9	35
TDS (mg/l)	500	1183	47.4	1183

[1] Standard for Cadmium lowered in modification to UIC permit dated March 9, 2001 following NDEQ approval of Mine Unit 1 restoration.

[2] Title 118 numerical standards in effect at the time the Notice of Intent was filed with the NDEQ.

[3] Restoration values based on Title 118 numerical standards and well field averages at the time the Notice of Intent was submitted to the NDEQ.

N/A = Not Applicable

CPF = Crow Butte Production Facility

Table 3.4-13 Anticipated Changes in Water Quality During Mining

Table 3.4-12 Anticipated Changes in Water Quality During Mining

Analyte	Average Ore Zone Water Quality		
	Units	Pre-Mining (Well W-007)	Typical Water Quality During Mining at CPF
Alkalinity, Total as CaCO3	mg/L	328	1,600
	mg/L	0	<1.0
Bicarbonate as HCO3	mg/L	401	2,050
Calcium	mg/L	29.6	77
Chloride	mg/L	202	600
Fluoride	mg/L	1.23	0.6
Magnesium	mg/L	5.3	23
Ammonia as N	mg/L	0.74	<0.05
Nitrate+Nitrite as N	mg/L		0.46
Potassium	mg/L	15.0	35
Silica	mg/L	11.3	21
Sodium	mg/L	567	1,310
Sulfate	mg/L	737	900
Conductivity	umhos/cm	2,723	6,000
pH	s.u.	8.1	7.8
TDS	mg/L	1,804	4,080
Aluminum	mg/L	<0.10	<0.1
Arsenic	mg/L	<0.002	0.06
Barium	mg/L	<0.10	<0.1
Boron	mg/L	1.61	1.1
Cadmium	mg/L	<0.01	<0.005
Chromium	mg/L	<0.05	<0.05
Copper	mg/L	<0.01	0.04
Iron	mg/L	<0.05	<0.030
Lead	mg/L	<0.05	<0.05
Manganese	mg/L	0.01	0.05
Mercury	mg/L	<0.001	<0.001
Molybdenum	mg/L	<0.10	0.5
Nickel	mg/L	<0.05	<0.05
Selenium	mg/L	<0.175	0.07
Uranium	mg/L	<0.0032	44
Vanadium	mg/L	<0.10	2.5
Zinc	mg/L	<0.02	0.02
Radium 226	pCi/L	11.9	1,090

Nebraska Title 118, Chapter 4, Section 002

CPF = Crow Butte Production Facility

Table 3.5-1 Monthly Climate Summary for Scottsbluff WSO Airport, NE (257665)

Table 3.5-1 Monthly Climate Summary for Scottsbluff WSO Airport, NE (257665)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Average Maximum Temperature (°F)	39.4	43.2	50.9	61.5	71.3	82.0	89.4	87.5	78.2	65.9	51.2	40.8	63.4
Average Minimum Temperature (°F)	12.3	15.4	22.5	32.1	42.4	52.1	58.0	55.7	45.2	33.2	21.9	13.9	33.8
Average Total Precipitation (Inches)	0.39	0.50	0.92	1.76	2.61	2.72	1.84	1.24	1.25	0.93	0.55	0.50	15.23
Average Total Snowfall (Inches)	5.3	5.6	7.6	5.1	0.9	0.0	0.0	0.0	0.3	2.5	4.8	6.1	38.3
Average Snow Depth (Inches)	1	1	1	0	0	0	0	0	0	0	1	1	0

Source: HPRCC. 2011. Period of Record: 1/ 1/1893 to 12/31/2010

Table 3.5-2 Marsland Expansion Area Vegetation and Land Cover Types

Table 3.5-2 Marsland Expansion Area Vegetation and Land Cover Types

Habitat	Acres	Percent
Mixed-grass prairie	2978.2	64.4
Degraded rangeland	645.9	14.0
Mixed conifer	418.4	9.1
Cultivated	299.7	6.5
Drainage	132.5	2.9
Range rehabilitation	69.7	1.5
Structure biotope	67.9	1.5
Deciduous streambank forest	10.0	0.2
Total	**4622.3**	**100.0**

Source: HWA 2011

Table 3.5-3 Federal and State Threatened, Endangered, and Candidate Species with the Potential to Occur Within the Vicinity of the Marsland Expansion Area

Table 3.5-3 Federal and State Threatened, Endangered, and Candidate Species with the Potential to Occur Within the Vicinity of the Marsland Expansion Area

Species	Scientific Name	Potential Occurrence[2]	Status
Mammals			
Black-footed ferret	*Mustela nigripes*	U	Endangered – Federally
Gray wolf	*Canis lupus*	U	Threatened – Federally
Swift fox	*Vulpes velox*	L	Endangered – State
Birds			
Whooping crane	*Grus americana*	U	Endangered – Federally
Fish			
Blacknose shiner[1]	*Notropis heterolepis*	P, PAD	Endangered – State
Finescale dace[1]	*Phoxinus neogaeus*	P, PAD	Threatened – State
Northern redbelly dace[1]	*Phoxinus eos*	P, PAD	Threatened – State

[1]*Presence in the Niobrara River system downstream of the project area.*
[2]*Potential Occurrence: likely (L), possible (P), unlikely (U), and potentially affected downstream (PAD)*
Source: USFWS 2011b; NGPC 2008b

Table 3.6-1 Meteorological Stations Included in Climate Analysis

Table 3.6-1 Meteorological Stations Included in Climate Analysis

Name	Agency	X	Y	Z (ft)	Years Operation
Alliance	NWS	-102° 54'	42° 6'	3990	1894 - 2010
Atkinson	NWS	-98° 58'	42° 33'	2130	1906 - 2010
North Platte	NWS	-100° 41'	41° 8'	2780	1948 - 2010
Gregory	NWS	-99°26'	43° 14'	2160	1906 - 2010
Rapid City	NWS	-103° 4'	44° 3'	3160	1948 - 2009
Long Valley	NWS	-101° 30'	43° 28'	2470	1927 - 2010
Lusk	NWS	-104° 29'	42° 45'	5090	1893 - 2007
Springview	NWS	-99° 45'	42° 49'	2450	1893 - 2010
Ainsworth	NWS	-99° 52'	42° 33'	2510	1905 - 2010
Mullen	NWS	-101° 3'	42° 3'	3250	1893 - 2010
Kimball	NWS	-103° 40'	41° 14'	4710	1893 - 2010
Newcastle	NWS	-104° 13'	43° 51'	4410	1906 - 2010
Chugwater	NWS	-104° 49'	41° 45'	5300	1900 - 2010
Cheyenne	NWS	-104° 49'	41° 09'	6120	1915 - 2010
Sidney	NWS	-103°	41° 14'	4320	1908 - 2010
Scottsbluff	NWS	-103° 36'	41° 52'	3950	1893 - 2010
Valentine	NWS	-100° 33'	42° 52'	2590	1948 - 2010
Rushville	NWS	-102° 26'	42° 43'	3760	1941 - 2010
Hay Springs	NWS	-102° 42'	42° 30'	3810	1951 - 2010
Oelrichs	NWS	-103° 14'	43° 11'	3350	1893 - 2010
Mt Rushmore	NWS	-103° 27'	43° 53'	5170	1962 - 2010
MEA (on-site)	Cameco	-103° 15'	42° 30'	4,200	2010 - 2011

Source: National Climate Data Center 2011; Cameco Resources, Inc. 2011.
NWS = National Weather Service
MEA = Marsland Expansion Area

Table 3.6-2 Annual and Monthly Temperature Statistics for Scottsbluff Airport, NE

Table 3.6-2 Annual and Monthly Temperature Statistics for Scottsbluff Airport, NE

Month	Temperature Statistics (º F)				
	Monthly Average	Monthly Maximum	Monthly Minimum	Average Daily High	Average Daily Low
Jan	26.8	69	-28	39.4	12.3
Feb	29.2	74	-22	43.2	15.4
Mar	37.5	81	-7	50.9	22.5
Apr	45.6	86	1	61.5	32.1
May	56.2	99	18	71.3	42.4
Jun	66.6	104	32	82.0	52.1
Jul	74.5	107	32	89.4	58.0
Aug	71.0	103	32	87.5	55.7
Sep	60.8	102	25	78.2	45.2
Oct	46.9	90	1	65.9	33.2
Nov	35.5	79	-13	51.2	21.9
Dec	26.0	72	-26	40.8	13.9

Source: National Climate Data Center, 2011, hourly data from 1961 through 2011

Table 3.6-3 Scottsbluff Airport Monthly Wind Parameters Summary

Table 3.6-3 Scottsbluff Airport Monthly Wind Parameters Summary

Month	Hourly Average Wind Speeds (mph)		
	Monthly Average	Monthly Maximum	Monthly Minimum
Jan	8.9	39	0
Feb	9.5	44	0
Mar	10.1	43	0
Apr	10.7	43	0
May	10.4	49	0
Jun	9.1	48	0
Jul	7.7	49	0
Aug	7.3	32	0
Sep	7.4	56	0
Oct	8.3	39	0
Nov	8.5	45	0
Dec	8.6	40	0

Source: National Climate Data Center, 2011, hourly data from 1996 through 2011

Table 3.6-4 Scottsbluff Airport 15-Year Wind Frequency Distribution

Table 3.6-4 Scottsbluff Airport 15-Year Wind Frequency Distribution

Relative Frequency (% of Recorded Winds) for Wind Rose at Scottsbluff Airport, NE							
11/01/1996 Hr. 1 to 8/31/2011 Hr. 23							
Wind Direction (degrees)	**0.0 – 4.0**	**4.0 – 7.4**	**7.4 – 12.1**	**12.1 – 19.0**	**19.0 – 25.8**	**25.8 – 100.0**	**Row Total**
	mph						
0.0	1.1	1.8	1.4	1.1	0.3	0.1	5.8
22.5	0.6	1.0	1.0	0.6	0.2	0.0	3.4
45.0	0.6	0.9	0.9	0.6	0.1	0.0	3.1
67.5	0.7	1.3	1.0	0.5	0.1	0.0	3.5
90.0	1.5	4.8	3.5	0.7	0.0	0.0	10.5
112.5	0.9	3.2	5.0	2.2	0.2	0.0	11.5
135.0	0.6	1.6	2.5	1.5	0.2	0.0	6.4
157.5	0.4	1.0	1.1	0.9	0.2	0.0	3.6
180.0	0.5	0.8	0.8	0.5	0.1	0.0	2.7
202.5	0.2	0.4	0.3	0.2	0.0	0.0	1.1
225.0	0.2	0.2	0.2	0.1	0.0	0.0	0.8
247.5	0.2	0.3	0.2	0.1	0.0	0.0	0.9
270.0	0.7	1.6	2.0	1.5	0.6	0.2	6.6
292.5	0.9	3.1	4.3	2.8	0.8	0.3	12.2
315.0	1.2	3.8	3.5	2.0	0.8	0.6	11.9
337.5	1.1	2.2	1.5	1.5	0.7	0.3	7.3
TOTAL	**11.3**	**28.0**	**29.3**	**16.7**	**4.3**	**1.6**	**91.2**
0 mph (8.8%) Invalid Readings 4,453 Number of possible readings: 149,723 Valid Readings: 146,270 Data capture: 97.03%							

Source: National Climate Data Center, 2011, hourly data from 1996 through 2011

Table 3.6-5 Marsland Expansion Area Maximum, Minimum and Average Monthly Temperatures

Table 3.6-5 Marsland Expansion Area Maximum, Minimum and Average Monthly Temperatures

Month	Temperature Statistics (º F)		
	Monthly Average	Monthly Minimum	Monthly Maximum
Jan	23.4	-14.4	55.6
Feb	21.9	-27.9	63.4
Mar	35.4	3.1	69.2
Apr	41.9	22.5	78.9
May	49.0	22.1	82.9
Jun	62.7	41.3	92.1
Jul	73.7	50.3	98.6
Aug	72.1	39.7	99.0
Sep	59.7	30.3	90.1
Oct	49.9	18.5	82.7
Nov	33.1	-4.7	72.3
Dec	27.1	-3.3	55.6

Source: Crow Butte Resources, Inc., 2011 data from 8/24/2010 to 8/29/2011

Table 3.6-6 Marsland Meteorological Summary

Table 3.6-6 Marsland Meteorological Summary

Meteorological Data Summary 8/24/2010 – 8/29/2011			
Hourly Data			
Parameter	**Average/Total**	**Maximum**	**Minimum**
Wind Speed (mph)	10.6	40.5	0.0
Sigma-Theta (^{o})	21.6	99.9	0.0
Temperature (^{o}F)	46.3	99.0	-27.9
10m Temperature (^{o}F)	47.1	97.2	-22.3
Relative Humidity (%)	64.5	163.6	6.5
Precipitation (inches)	16.90	0.59	--
Solar Radiation (w/m^{-2})	173.1	939.0	--
Data Recovery			
Parameter	**Possible (Hours)**	**Reported (Hours)**	**Recovery (Percent)**
Wind Speed	8893	8708	97.92
Wind Direction	8893	8708	97.92
Sigma-Theta	8893	8708	97.92
Temperature	8893	8884	99.90
10m Temperature	8893	8884	99.90
Relative Humidity	8893	8884	99.90
Precipitation	8893	8884	99.90
Solar Radiation	8893	8884	99.90

Source: Crow Butte Resources, Inc., 2011, data from 8/24/2010 to 8/29/2011

Note: Predominant wind direction was from the NNW sector, accounting for 13.0% of the possible winds.

Table 3.6-7 Marsland Expansion Area Meteorological Station

Table 3.6-7 Marsland Expansion Area Meteorological Station

Relative Frequency (% of Recorded Winds) for Wind Rose at 8/24/2010 Hr. 2 to 8/29/2011 Hr. 15							
Wind Direction (degrees)	**0.0 – 4.0**	**4.0 – 7.4**	**7.4 – 12.1**	**12.1 – 19.0**	**19.0 – 25.8**	**25.8 – 100.0**	**Row Total**
	mph						
0.0	1.3	1.6	2.4	2.5	0.7	0.2	8.8
22.5	0.8	0.8	1.5	1.2	0.3	0.1	4.8
45.0	0.7	0.7	0.9	0.8	0.0	0.0	3.3
67.5	0.6	0.9	1.0	0.6	0.0	0.0	3.2
90.0	0.6	1.2	1.4	0.7	0.0	--	3.9
112.5	0.8	1.6	1.8	0.6	0.1	0.0	4.9
135.0	1.0	1.7	1.9	0.7	0.1	--	5.4
157.5	1.0	1.6	1.9	1.6	0.4	0.1	6.6
180.0	1.1	1.3	1.7	1.8	0.5	0.0	6.4
202.5	1.2	1.4	1.4	1.0	0.2	0.0	5.3
225.0	0.8	1.3	1.6	0.7	0.2	0.0	4.7
247.5	0.9	1.5	2.0	1.3	0.4	0.0	6.2
270.0	0.7	0.9	1.5	1.6	0.5	0.3	5.4
292.5	0.7	1.0	1.4	2.4	1.0	0.4	7.0
315.0	0.8	1.5	2.2	3.2	2.3	0.9	10.9
337.5	1.6	2.9	3.0	3.2	1.5	0.7	13.0
TOTAL	**14.8**	**22.1**	**27.6**	**24.1**	**8.3**	**2.8**	**99.7**
0 mph (1.0%) Invalid Readings 185 Number of possible readings: 8.894 Valid Readings: 8,708 Data capture: 97.92%							

Source: Cameco Resources, Inc. 2011. Meteorological data from 8/24/2010 to 8/29/2011.

Table 3.6-8 Marsland Expansion Area Wind Summary

Table 3.6-8 Marsland Expansion Annual Wind Summary

8/24/2010 2:00:00 AM – 8/29/2011 3:00:00 PM			
Hourly Data			
Parameter	**Average**	**Maximum**	**Minimum**
Wind Speed (mph)	10.59	40.51	--
Sigma Theta (º)	21.61	99.90	--
Wind Speed by Direction (mph)			
N	10.82	32.70	0.16
NNE	10.13	39.89	0.27
NE	8.64	26.80	1.07
ENE	8.16	27.72	0.79
E	8.27	22.53	--
ESE	7.79	29.17	--
SE	7.93	22.80	--
SSE	9.81	28.86	--
S	10.28	29.51	--
SSW	8.41	26.62	0.00
SW	8.52	26.31	0.58
WSW	9.80	32.57	0.87
W	12.01	36.62	0.76
WNW	13.24	40.51	1.04
NW	14.46	39.91	--
NNW	11.89	40.22	--
Data Recovery			
	Possible (Hours)	Reported (Hours)	Recovery (%)
Wind Speed	8917	8708	97.66
Sigma Theta	8917	8708	97.66
Wind Direction	8917	8708	97.66

Source: Cameco Resources, Inc, 2011, data from 8/24/2010 to 8/29/2011

Note: Predominant wind direction was from the NNW sector, accounting for 13% of the winds; the average wind direction was 307º.

Table 3.6-9 Marsland Annual Joint Frequency Distribution

Table 3.6-9 Marsland Annual Joint Frequency Distribution

Stability Class	Wind Direction	Wind Speed (mph) - One Year (Calm = 1.0%)					
		0 - 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24
A	N	0.001414	0.002357				
	NNE	0.000236	0.001532				
	NE	0.000707	0.001886				
	ENE	0.000825	0.001768				
	E	0.000943	0.001768				
	ESE	0.001296	0.002593				
	SE	0.001061	0.002004				
	SSE	0.002121	0.002121				
	S	0.001768	0.002121				
	SSW	0.003536	0.002593				
	SW	0.001414	0.002239				
	WSW	0.000943	0.004007				
	W	0.001179	0.001179				
	WNW	0.000825	0.001179				
	NW	0.000589	0.002004				
	NNW	0.000589	0.002121				
B	N		0.002004	0.000236			
	NNE		0.002239				
	NE		0.002475	0.000118			
	ENE		0.001768				
	E		0.001768	0.000118			
	ESE	0.000354	0.002475	0.000354			
	SE	0.000118	0.003418	0.000354			
	SSE	0.000471	0.002475	0.000236			
	S	0.000471	0.002357	0.000707			
	SSW	0.000943	0.003182	0.000589			
	SW	0.000118	0.003064				
	WSW		0.002593	0.000471			
	W	0.000118	0.001296	0.000236			
	WNW	0.000118	0.001650	0.000118			
	NW		0.002357	0.000707			
	NNW		0.002121	0.000471			
C	N	0.000118	0.000589	0.010253			
	NNE		0.000589	0.004714			
	NE		0.000589	0.002946			
	ENE		0.000825	0.003418			
	E		0.001179	0.003300			
	ESE		0.001768	0.005539			
	SE	0.000354	0.001886	0.004125			
	SSE	0.000118	0.001532	0.004361			
	S	0.000354	0.001532	0.004950			
	SSW	0.000236	0.001414	0.004361			
	SW	0.000118	0.001886	0.005657			
	WSW		0.000825	0.006600			
	W		0.000707	0.004361			
	WNW		0.000471	0.004714			
	NW		0.000589	0.008132			
	NNW		0.000943	0.007778			

Table 3.6-9 Marsland Annual Joint Frequency Distribution

Stability Class	Wind Direction	Wind Speed (mph) - One Year (Calm = 1.0%)					
		0 - 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24
D	N	0.000236	0.007307	0.019093	0.017796	0.004125	0.001414
	NNE	0.000236	0.004714	0.010725	0.008603	0.002239	0.000118
	NE		0.001886	0.009193	0.003064	0.000118	
	ENE		0.003064	0.007307	0.002004		0.000118
	E	0.000118	0.005775	0.010371	0.003182	0.000118	
	ESE	0.000471	0.008839	0.009193	0.003064	0.000236	0.000118
	SE	0.000236	0.010489	0.012139	0.003889	0.000354	
	SSE	0.000118	0.007543	0.016500	0.009546	0.003418	0.000118
	S	0.000118	0.005186	0.013082	0.013789	0.002829	0.000118
	SSW	0.000118	0.003889	0.008957	0.006718	0.001179	
	SW	0.000236	0.004832	0.007896	0.003654	0.001414	
	WSW	0.000118	0.005068	0.014614	0.008721	0.002475	0.000236
	W		0.004125	0.012728	0.012610	0.002946	0.002357
	WNW	0.000118	0.003771	0.014850	0.019564	0.007189	0.002946
	NW	0.000118	0.006836	0.019093	0.030053	0.016971	0.005893
	NNW	0.000707	0.013553	0.023689	0.028167	0.012375	0.004478
E	N	0.001532	0.002357	0.000471			
	NNE	0.000707	0.001296	0.000354			
	NE		0.001650	0.000236			
	ENE		0.002004	0.000471			
	E	0.000589	0.001532	0.000589			
	ESE	0.000354	0.003064	0.000236			
	SE	0.000825	0.002004	0.000236			
	SSE	0.000707	0.002475	0.000471			
	S	0.000354	0.002711	0.000236			
	SSW		0.002004	0.000236			
	SW	0.000354	0.002946	0.000589			
	WSW	0.000354	0.002829	0.001061			
	W	0.000118	0.002004	0.000943			
	WNW	0.000707	0.001296	0.000825			
	NW	0.000589	0.003536	0.001414			
	NNW	0.000943	0.009664	0.001886			
F	N	0.009782	0.007071				
	NNE	0.006953	0.002829				
	NE	0.006364	0.001179				
	ENE	0.005421	0.002593				
	E	0.004478	0.003536				
	ESE	0.005186	0.003182				
	SE	0.006718	0.003418				
	SSE	0.006128	0.004832				
	S	0.007543	0.003418				
	SSW	0.006600	0.004950				
	SW	0.005775	0.004361				
	WSW	0.007307	0.004714				
	W	0.005657	0.002946				
	WNW	0.005775	0.005539				
	NW	0.006718	0.004596				
	NNW	0.013318	0.008368				

Source: Crow Butte Resources, Inc., 2011, data from 8/24/2010 to 8/29/20

Table 3.6-10 Marsland Winter Joint Frequency Distribution

Table 3.6-10 Marsland Winter Joint Frequency Distribution

Stability Class	Wind Direction	Wind Speed (mph) - Winter (Calm = 1.7%)						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
A	N	0.000512	0.000463					0.000975
	NNE		0.000463					0.000463
	NE	0.001025	0.000463					0.001488
	ENE							
	E	0.001025	0.000926					0.001951
	ESE	0.000512	0.001389					0.001901
	SE	0.001537	0.001389					0.002926
	SSE	0.001025	0.000463					0.001488
	S	0.000512	0.001389					0.001901
	SSW	0.002562	0.001389					0.003951
	SW	0.002050	0.001852					0.003902
	WSW	0.001025	0.001389					0.002414
	W	0.000512	0.001389					0.001901
	WNW	0.000512	0.000926					0.001438
	NW	0.000512	0.002778					0.003290
	NNW	0.000512	0.001852					0.002364
B	N		0.000463					0.000463
	NNE		0.000926					0.000926
	NE		0.001852					0.001852
	ENE		0.000463					0.000463
	E		0.000463	0.000463				0.000926
	ESE	0.001025	0.000926					0.001951
	SE		0.000463					0.000463
	SSE	0.000512	0.001389					0.001901
	S		0.000463					0.000463
	SSW		0.001852	0.000463				0.002315
	SW		0.002315					0.002315
	WSW		0.000463					0.000463
	W		0.001389					0.001389
	WNW		0.002778					0.002778
	NW		0.001852					0.001852
	NNW		0.000926	0.000463				0.001389
C	N		0.000463	0.005093				0.005556
	NNE			0.003704				0.003704
	NE		0.000463	0.001852				0.002315
	ENE			0.000463				0.000463
	E		0.000463	0.000463				0.000926
	ESE		0.001389					0.001389
	SE	0.000512	0.003241	0.001389				0.005142
	SSE		0.000926	0.001852				0.002778
	S	0.000512	0.000926	0.001389				0.002827
	SSW	0.000512	0.000463	0.000926				0.001901
	SW	0.000512	0.001852	0.002315				0.004679
	WSW			0.004630				0.004630
	W		0.000926	0.001389				0.002315
	WNW			0.003704				0.003704
	NW		0.000463	0.005556				0.006019
	NNW		0.000463	0.005556				0.006019

Table 3.6-10 Marsland Winter Joint Frequency Distribution (continued)

Stability Class	Wind Direction	Wind Speed (mph) - Winter (Calm = 1.7%)						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
D	N	0.000512	0.008333	0.026852	0.014815	0.003241	0.001389	0.055142
	NNE	0.000512	0.005556	0.013426	0.003704			0.023198
	NE		0.001389	0.009259	0.001389	0.000463		0.012500
	ENE		0.003704	0.009259	0.000463		0.000463	0.013889
	E	0.000512	0.005556	0.005556	0.000463			0.012086
	ESE	0.001537	0.009259	0.009259	0.000926			0.020982
	SE		0.007407	0.010648	0.004167	0.000926		0.023148
	SSE		0.004167	0.013889	0.005093	0.002315		0.025463
	S		0.004630	0.011574	0.011111	0.001389		0.028704
	SSW		0.002778	0.007407	0.003704	0.000463		0.014352
	SW		0.003241	0.006944	0.002315	0.000463		0.012963
	WSW	0.000512	0.006944	0.021296	0.012037	0.005093		0.045883
	W		0.008333	0.023148	0.021296	0.006019	0.002778	0.061574
	WNW	0.000512	0.004167	0.025000	0.033796	0.012500	0.002778	0.078753
	NW	0.000512	0.007407	0.023148	0.047222	0.025926	0.003241	0.107457
	NNW	0.000512	0.009259	0.029167	0.036111	0.011111	0.006481	0.092642
E	N	0.000512	0.002315	0.000926				0.003753
	NNE	0.001537	0.000463					0.002000
	NE		0.000926	0.000463				0.001389
	ENE		0.001852					0.001852
	E	0.000512	0.000926	0.000463				0.001901
	ESE		0.000926	0.000463				0.001389
	SE	0.000512	0.001389					0.001901
	SSE	0.000512	0.000926					0.001438
	S	0.000512	0.002778					0.003290
	SSW		0.001389	0.000926				0.002315
	SW	0.000512	0.003241	0.000463				0.004216
	WSW	0.001025	0.004630	0.001389				0.007043
	W		0.002778	0.003241				0.006019
	WNW	0.001537	0.000926	0.001389				0.003852
	NW	0.000512	0.004630	0.001852				0.006994
	NNW	0.001537	0.006019	0.000926				0.008482
F	N	0.013323	0.005556					0.018878
	NNE	0.008199	0.001852					0.010051
	NE	0.006149						0.006149
	ENE	0.005124	0.003241					0.008365
	E	0.004612	0.003241					0.007853
	ESE	0.008199	0.002315					0.010514
	SE	0.007686	0.003241					0.010927
	SSE	0.010248	0.003704					0.013952
	S	0.010761	0.002778					0.013539
	SSW	0.012298	0.004630					0.016928
	SW	0.009736	0.005556					0.015292
	WSW	0.010761	0.005093					0.015853
	W	0.009736	0.005093					0.014829
	WNW	0.005124	0.006944					0.012069
	NW	0.006149	0.005556					0.011705
	NNW	0.012810	0.005093					0.017903

Source: Crow Butte Resources, Inc., 2011, data from 8/24/2010 to 8/29/2011

Table 3.6-11 Marsland Spring Joint Frequency Distribution

Table 3.6-11 Marsland Spring Joint Frequency Distribution

Stability Class	Wind Direction	Wind Speed (mph) - Spring (Calm = 0.6%) < 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	Row Total
A	N	0.001473	0.001836					0.003309
	NNE		0.001836					0.001836
	NE	0.000491	0.001377					0.001868
	ENE	0.000982	0.000918					0.001900
	E	0.000982	0.002295					0.003277
	ESE	0.000491	0.002295					0.002786
	SE		0.002295					0.002295
	SSE	0.001473	0.000918					0.002391
	S	0.001473	0.002754					0.004226
	SSW	0.001473	0.002295					0.003767
	SW	0.000491	0.002295					0.002786
	WSW	0.000491	0.005507					0.005998
	W	0.000982	0.001377					0.002359
	WNW	0.001964	0.002295					0.004258
	NW	0.000491	0.000918					0.001409
	NNW	0.000491	0.002295					0.002786
B	N		0.001836					0.001836
	NNE		0.001836					0.001836
	NE		0.002295					0.002295
	ENE		0.000918					0.000918
	E		0.001836					0.001836
	ESE		0.001377	0.001377				0.002754
	SE		0.003212					0.003212
	SSE	0.000491	0.002295					0.002786
	S	0.000491	0.003671	0.000918				0.005080
	SSW		0.002754	0.000459				0.003212
	SW		0.002754					0.002754
	WSW		0.003212	0.000918				0.004130
	W		0.002295	0.000459				0.002754
	WNW		0.001836					0.001836
	NW		0.002754	0.000459				0.003212
	NNW		0.001836					0.001836
C	N			0.015603				0.015603
	NNE		0.000459	0.007802				0.008261
	NE		0.000459	0.005048				0.005507
	ENE		0.000918	0.006425				0.007343
	E		0.000918	0.003212				0.004130
	ESE		0.001836	0.006884				0.008720
	SE		0.001377	0.005048				0.006425
	SSE		0.001377	0.005507				0.006884
	S		0.002295	0.007343				0.009637
	SSW		0.000459	0.004589				0.005048
	SW		0.001377	0.007802				0.009179
	WSW		0.000459	0.009179				0.009637
	W		0.000459	0.005966				0.006425
	WNW			0.005048				0.005048
	NW		0.000459	0.009637				0.010096
	NNW		0.000918	0.009637				0.010555

Table 3.6-11 Marsland Spring Joint Frequency Distribution

Stability Class	Wind Direction	Wind Speed (mph) - Spring (Calm = 0.6%)						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
D	N		0.005048	0.020193	0.033043	0.005048		0.063332
	NNE		0.005507	0.013768	0.012391	0.004130		0.035796
	NE		0.002754	0.012850	0.006884			0.022487
	ENE		0.002754	0.006884	0.004130			0.013768
	E		0.005048	0.015603	0.009179	0.000459		0.030289
	ESE		0.008720	0.010096	0.006425	0.000459		0.025700
	SE	0.000491	0.011014	0.011473	0.006425			0.029403
	SSE		0.006884	0.019734	0.010555	0.009637	0.000459	0.047269
	S		0.003671	0.010096	0.012850	0.007343	0.000459	0.034419
	SSW		0.005507	0.010096	0.010555	0.003212		0.029371
	SW	0.000491	0.004130	0.007343	0.001377	0.000918		0.014259
	WSW		0.001377	0.013768	0.008261	0.001836	0.000918	0.026159
	W		0.001836	0.010096	0.015603	0.003212	0.006425	0.037173
	WNW		0.002295	0.018816	0.014227	0.008720	0.003671	0.047728
	NW		0.006884	0.019275	0.033961	0.013309	0.008261	0.081689
	NNW		0.007343	0.024782	0.032584	0.015603	0.003212	0.083525
E	N	0.000491	0.001377	0.000459				0.002327
	NNE	0.000491	0.000918	0.000459				0.001868
	NE		0.002754					0.002754
	ENE		0.001836					0.001836
	E	0.000491	0.002754	0.001377				0.004621
	ESE		0.003671	0.000459				0.004130
	SE	0.000982	0.002295					0.003277
	SSE	0.000491	0.002754					0.003245
	S	0.000491	0.002295					0.002786
	SSW		0.000459					0.000459
	SW	0.000491	0.002295	0.000459				0.003245
	WSW		0.001377					0.001377
	W		0.000459					0.000459
	WNW	0.000982	0.002295					0.003277
	NW	0.000491	0.001377	0.000918				0.002786
	NNW	0.000491	0.005048	0.001377				0.006916
F	N	0.004418	0.005507					0.009926
	NNE	0.004909	0.001836					0.006745
	NE	0.003928	0.000918					0.004845
	ENE	0.001473	0.002295					0.003767
	E	0.003437	0.003671					0.007108
	ESE	0.003437	0.004589					0.008026
	SE	0.004418	0.002295					0.006713
	SSE	0.004909	0.004130					0.009040
	S	0.004909	0.002754					0.007663
	SSW	0.000982	0.005048					0.006030
	SW	0.002946	0.002295					0.005240
	WSW	0.002455	0.002754					0.005208
	W	0.001964	0.002754					0.004717
	WNW	0.004418	0.002754					0.007172
	NW	0.006873	0.003671					0.010545
	NNW	0.007364	0.004130					0.011494

Source: Crow Butte Resources, Inc., 2011, data from 8/24/2010 to 8/29/2011

Table 3.6-12 Marsland Summer Joint Frequency Distribution

Table 3.6-12 Marsland Summer Joint Frequency Distribution

Stability Class	Wind Direction	Wind Speed (mph) - Summer (Calm = 0.2%) < 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	Row Total
A	N	0.002875	0.004710					0.007585
	NNE	0.000958	0.003297					0.004256
	NE		0.004710					0.004710
	ENE	0.001438	0.005181					0.006619
	E	0.001438	0.002826					0.004264
	ESE	0.001438	0.005181					0.006619
	SE	0.000958	0.003768					0.004727
	SSE	0.002875	0.005652					0.008527
	S	0.003833	0.003297					0.007131
	SSW	0.005750	0.005652					0.011403
	SW	0.001917	0.002355					0.004272
	WSW	0.000958	0.005652					0.006611
	W	0.001917	0.001413					0.003330
	WNW		0.000942					0.000942
	NW	0.000958	0.002355					0.003314
	NNW		0.003297					0.003297
B	N		0.004239	0.000942				0.005181
	NNE		0.005181					0.005181
	NE		0.005652	0.000471				0.006123
	ENE		0.005652					0.005652
	E		0.003768					0.003768
	ESE	0.000479	0.007537					0.008016
	SE		0.008008	0.000942				0.008950
	SSE	0.000479	0.005652	0.000942				0.007074
	S	0.000479	0.005181	0.001413				0.007074
	SSW	0.000479	0.003768	0.000942				0.005189
	SW		0.003768					0.003768
	WSW		0.003768	0.000942				0.004710
	W	0.000479	0.001413	0.000471				0.002363
	WNW	0.000479	0.001413	0.000471				0.002363
	NW		0.002826	0.001884				0.004710
	NNW		0.003768	0.001413				0.005181
C	N	0.000479	0.000471	0.013660				0.014610
	NNE		0.000471	0.006123				0.006594
	NE		0.000471	0.003768				0.004239
	ENE		0.001884	0.005652				0.007537
	E		0.002355	0.008008				0.010363
	ESE		0.003297	0.015073				0.018370
	SE		0.002355	0.009421				0.011776
	SSE		0.003297	0.007537				0.010834
	S		0.000942	0.009421				0.010363
	SSW		0.002826	0.007537				0.010363
	SW		0.002355	0.008008				0.010363
	WSW		0.002355	0.010363				0.012718
	W		0.000471	0.007537				0.008008
	WNW		0.001884	0.007065				0.008950
	NW		0.001413	0.007065				0.008479
	NNW		0.000471	0.008479				0.008950

Table 3.6-12 Marsland Summer Joint Frequency Distribution

Stability Class	Wind Direction	Wind Speed (mph) - Summer (Calm = 0.2%)						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
D	N		0.005652	0.014131	0.009892	0.002826	0.000942	0.033443
	NNE	0.000479	0.005181	0.009421	0.010834	0.002355	0.000471	0.028741
	NE		0.001413	0.012718	0.002355			0.016486
	ENE		0.005181	0.009421	0.003297			0.017899
	E		0.008950	0.013660	0.002826			0.025436
	ESE	0.000479	0.009421	0.013660	0.003768			0.027328
	SE	0.000479	0.015073	0.016957	0.003297			0.035807
	SSE		0.008950	0.014131	0.009892	0.001413		0.034385
	S		0.007065	0.015544	0.021196	0.000942		0.044748
	SSW		0.005652	0.012247	0.009421	0.000942		0.028262
	SW		0.004239	0.010834	0.005181	0.001413		0.021667
	WSW		0.005181	0.007537	0.005181	0.001413		0.019312
	W		0.001413	0.006594	0.001884	0.000471		0.010363
	WNW		0.001884	0.000471	0.002826			0.005181
	NW		0.002826	0.003297	0.013189	0.003768		0.023081
	NNW	0.000958	0.009892	0.016486	0.016015	0.004239	0.000942	0.048533
E	N	0.000958	0.003297	0.000471				0.004727
	NNE		0.001884					0.001884
	NE		0.000942					0.000942
	ENE		0.002826	0.000942				0.003768
	E		0.001884					0.001884
	ESE		0.002826					0.002826
	SE	0.000479	0.003297					0.003776
	SSE	0.000958	0.004239	0.000942				0.006140
	S		0.003768	0.000942				0.004710
	SSW		0.004239					0.004239
	SW		0.003768					0.003768
	WSW	0.000479	0.002826	0.000471				0.003776
	W		0.002355					0.002355
	WNW		0.000471					0.000471
	NW	0.000479	0.003297	0.000471				0.004247
	NNW		0.010363	0.002826				0.013189
F	N	0.008625	0.011305					0.019930
	NNE	0.006229	0.002826					0.009056
	NE	0.007667	0.001884					0.009551
	ENE	0.005750	0.002355					0.008105
	E	0.003833	0.006123					0.009957
	ESE	0.004792	0.003768					0.008560
	SE	0.008146	0.005181					0.013327
	SSE	0.003354	0.008008					0.011362
	S	0.007188	0.004710					0.011898
	SSW	0.007667	0.005181					0.012848
	SW	0.003833	0.003297					0.007131
	WSW	0.005750	0.004710					0.010460
	W	0.005271	0.001884					0.007155
	WNW	0.004792	0.005652					0.010444
	NW	0.006229	0.003297					0.009527
	NNW	0.012938	0.008950					0.021887

Source: Crow Butte Resources, Inc., 2011, data from 8/24/2010 to 8/29/2011

Table 3.6-13 Marsland Fall Joint Frequency Distribution

Table 3.6-13 Marsland Fall Joint Frequency Distribution

Stability Class	Wind Direction	Wind Speed (mph) - Fall (Calm = 1.7%)						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
A	N	0.001028	0.002364					0.003392
	NNE		0.000473					0.000473
	NE	0.001541	0.000946					0.002487
	ENE	0.001028	0.000946					0.001973
	E	0.000514	0.000946					0.001459
	ESE	0.003083	0.001418					0.004501
	SE	0.002055	0.000473					0.002528
	SSE	0.003596	0.001418					0.005015
	S	0.001541	0.000946					0.002487
	SSW	0.005138	0.000946					0.006083
	SW	0.001541	0.002364					0.003905
	WSW	0.001541	0.003310					0.004851
	W	0.001541	0.000473					0.002014
	WNW	0.001028	0.000473					0.001500
	NW	0.000514	0.001891					0.002405
	NNW	0.001541	0.000946					0.002487
B	N		0.001418					0.001418
	NNE		0.000946					0.000946
	NE							
	ENE							
	E		0.000946					0.000946
	ESE							
	SE	0.000514	0.001891	0.000473				0.002878
	SSE	0.000514	0.000473					0.000987
	S	0.001028		0.000473				0.001500
	SSW	0.003596	0.004255	0.000473				0.008325
	SW	0.000514	0.003310					0.003823
	WSW		0.002837					0.002837
	W							
	WNW		0.000473					0.000473
	NW		0.001891	0.000473				0.002364
	NNW		0.001891					0.001891
C	N		0.001418	0.006147				0.007565
	NNE		0.001418	0.000946				0.002364
	NE		0.000946	0.000946				0.001891
	ENE		0.000473	0.000946				0.001418
	E		0.000946	0.001418				0.002364
	ESE		0.000473					0.000473
	SE	0.001028	0.000473	0.000473				0.001973
	SSE	0.000514	0.000473	0.002364				0.003351
	S	0.001028	0.001891	0.001418				0.004337
	SSW	0.000514	0.001891	0.004255				0.006660
	SW		0.001891	0.004255				0.006147
	WSW		0.000473	0.001891				0.002364
	W		0.000946	0.002364				0.003310
	WNW			0.002837				0.002837
	NW			0.009929				0.009929
	NNW		0.001891	0.007092				0.008983

Table 3.6-13 Marsland Fall Joint Frequency Distribution

Stability Class	Wind Direction	Wind Speed (mph) - Fall (Calm = 1.7%)						Row Total
		< 3	4 - 7	8 - 12	13 - 18	19 - 24	> 24	
D	N	0.000514	0.009929	0.014184	0.012293	0.005201	0.003310	0.045431
	NNE		0.002364	0.005674	0.007092	0.002364		0.017494
	NE		0.001891	0.001418	0.001418			0.004728
	ENE		0.000473	0.003310				0.003783
	E		0.003310	0.006147				0.009456
	ESE		0.007565	0.003310	0.000946	0.000473	0.000473	0.012766
	SE		0.008038	0.008983	0.001418	0.000473		0.018913
	SSE	0.000514	0.009929	0.017494	0.012293			0.040230
	S	0.000514	0.005674	0.014657	0.009456	0.001418		0.031719
	SSW	0.000514	0.001418	0.005674	0.002837			0.010443
	SW	0.000514	0.007565	0.006147	0.005674	0.002837		0.022736
	WSW		0.006619	0.015130	0.008983	0.001418		0.032151
	W		0.004728	0.010402	0.010875	0.001891		0.027896
	WNW		0.006619	0.014184	0.026478	0.007092	0.005201	0.059574
	NW		0.009929	0.029787	0.024113	0.024113	0.011820	0.099764
	NNW	0.001541	0.027423	0.023168	0.026478	0.017967	0.007092	0.103669
E	N	0.004624	0.002364					0.006988
	NNE	0.001028	0.001891	0.000946				0.003864
	NE		0.001891	0.000473				0.002364
	ENE		0.001418	0.000946				0.002364
	E	0.001541	0.000473	0.000473				0.002487
	ESE	0.001541	0.004728					0.006269
	SE	0.001541	0.000946	0.000946				0.003433
	SSE	0.001028	0.001891	0.000946				0.003864
	S	0.000514	0.001891					0.002405
	SSW		0.001891					0.001891
	SW	0.000514	0.002364	0.001418				0.004296
	WSW		0.002364	0.002364				0.004728
	W	0.000514	0.002364	0.000473				0.003351
	WNW	0.000514	0.001418	0.001891				0.003823
	NW	0.001028	0.004728	0.002364				0.008120
	NNW	0.002055	0.017021	0.002364				0.021440
F	N	0.015413	0.005674					0.036053
	NNE	0.010276	0.004728					0.030110
	NE	0.009248	0.001891					0.019538
	ENE	0.010789	0.002364					0.009591
	E	0.007193	0.000946					0.011140
	ESE	0.005652	0.001891					0.011165
	SE	0.008221	0.002837					0.009100
	SSE	0.007707	0.003310					0.017032
	S	0.009248	0.003310					0.014060
	SSW	0.007193	0.004728					0.011682
	SW	0.008221	0.006147					0.012097
	WSW	0.012331	0.006147					0.011656
	W	0.007707	0.001891					0.013519
	WNW	0.010276	0.006619					0.018945
	NW	0.009248	0.005674					0.021865
	NNW	0.023634	0.015130					0.041199

Source: Crow Butte Resources, Inc., 2011, data from 8/24/2010 to 8/29/2011

Table 3.6-14 Marsland Onsite Meteorological Station Description

Table 3.6-14 Marsland Onsite Meteorological Station Description

Equipment	Description
10 meter town	Free standing 10-meter (or 33 feet) aluminum town which is self supporting with typical sets of instruments at wind levels up to 110 mph.
Wind Sensor Model 034B	Model 034B wind sensor combines wind speed and direction measurements into a single sensing unit. The sensor is constructed of aluminum and stainless steel. Specifications: 1. Wind Speed · Range: 0 to 167 miles per hour (mph) (0 – 75 ms (meter/second)) · Starting Threshold: 0.9 mph (0.4 m/s) · Accuracy : <22.7 mph (0.25 mph [0.1 m/s]) · Accuracy: >22.7 mph (+ 1.1 percent of true) 2. Wind Direction · Range: Mechanical: 0 - 360° Electrical: 0 - 356° · Starting Threshold: 0.9 mph (0.4 m/s) · Accuracy: 0.4° · Damping ratio: 0.25 standard (0.4 to 0.6 optional) · Resolution: <0.5° 3. Temperature Range · -30° C to +70° C (Minimal icing conditions) 4. Output Signal · Wind Speed: Pulsed contact closure · Wind Direction: Potentiometer output (0 – 10 kohms)
Air temperature Sensor	Met One Model 062 MP Specifications: 1. General · Sensing Element: Multi-stage state thermistor, highly linearized · Time Constant: Less than 10 seconds in still air · Self-Heating: None 2. Housing: 3/8 in (9.5 mm) x 6 in (152.4 mm) 3. Range: -50 °C to +50 °C 4. Accuracy: + 0.05° C, PSD compliant 5. For a system range of: / Maximum Error/degree of Differential temperature: / Maximum Error over range: -5 °F to + 5 °F / 0.02 °F / 0.05 °F -5 °C to + 5 °C / 0.02 °C / 0.05 °C -5 °F to + 10 °F / 0.02 °F / 0.1 °F -5 °C to + 10 °C / 0.02 °C / 0.1 °C -10 °F to 20 °F / 0.02 °F / 0.2 °F
Relative Humidity & Temperature Probes; Solar Radiation Shield	Model HMP45AC Specifications: 1. Operating temperature range: -40..+60 °C (-40…+140 °F) 2. Storage temperature range: -40…+80 °C (-40…+176 °F) 3. Supply voltage: 7…35 VDC 4. Settling Time: 500 ms 5. Power consumption: <4 mA 6. Relative Humidity: · Measuring Range: 0.8 to 100 %RH · Output scale: 0…100 %RH equals 0.1…VDC · Accuracy at + 20 °C (+68 °F) (including nonlinearity & hysteresis) against calibration against references: +1 %RH field calibration against references: +2 %RH (0…90 %RH)

Table 3.6-14 Marsland Onsite Meteorological Station Description

Equipment	Description
	$\underline{+}$3 %RH (90…100 5RH) · Typical long-term stability: <1 %RH/year · Temperature dependence: $\underline{+}$0.05 %RH/^{o}C ($\underline{+}$0.03 %RH/^{o}F) · Response time (90% at +20 ^{o}C) 10 s with membrane filter · Humidity sensor: HUMICAP 180 7.Temperature · Measurement range: -39.2…+ 60 ^{o}C (-32…+ 140 ^{o}F) · Output Scale: -40…+60 ^{o}C (-40…+ 140 ^{o}F) equals 0…1 VDC · Accuracy at +20 ^{o}C (+68 ^{o}F)
Solar Radiation	LiCor 200 Pyranometer Designed for field measurement if global solar radiation. Specifications: 1. Sensitivity: Typically 90 µA per 1000 W m-^{2} 2. Linearity: maximum deviation of 1% up to 3000 W m^{-2} 3. Stability: <$\underline{+}$ 2% change over a 1-year period 4. Response time: 10 µs 5. Temperature dependence: 0.15% per ^{o}C maximum 6. Cosine correction: cosine corrected up to 80^o angle of incidence 7. Azimuth: <$\underline{+}$ 1% error over 360o at 45^o elevation 8. Operating temperature: -40 to 65 ^{o}C 9. Relative Humidity: 0 to 100%
Datalogger	Campbell Scientific CR 1000 Programmable control and data acquisition system Provides direct communications and telecommunications, reduce data, controls external devices, and stores data and programs in on-board, non-volatile storage. Sensor data can be directly downloaded from the datalogger. Specifications: 1.Analog inputs: 16 single-ended or 8 differential, individually configured 2.Pulse counters: 2 3.Switched voltage excitations: 3 4.Control/digital ports: 8 5.RS-232 port: 1 6.CS I/O port: 1 7.Scan rate: 100 Hz 8.Burst mode: 1500 HZ 9.Programming: CR Basic 10.Data storage: Table
Tipping Bucket Rain Gage	Texas Electronics TE525WS Tipping Bucket Rain Gage Specifications: 1. Orifice diameter: 8-inch 20.3 cm) 2. Rainfall per tip: 0.01" (0.254 mm) 3. Accuracy: · Up to 1 inch/hr: $\underline{+}$ 1% · 1 to 2 inch/hr: +0, -2.5% · 2 to 3 inch/hr: +0, -3.5% 4.Temperature: 0^o C to +50 ^{o}C 5.Resolution: 1 tip 6.Magnetic reed switch

Source: Cameco Resources, Inc.

Table 3.6-15 Rapid City Mixing Heights

Table 3.6-15 Rapid City Mixing Heights

Time Period (Filtered)	Average Mixing / Inversion Height
Morning (2 am – 6 am)	333 meters
Afternoon (12 pm – 4 pm)	1,547 meters

Table 3.6-16 EPA National Ambient Air Standards (NAAQS)

Table 3.6-16 EPA National Ambient Air Quality Standards (NAAQS)

Pollutant [final rule cite]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide [76 FR 54294, Aug 31, 2011]		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead [73 FR 66964, Nov 12, 2008]		primary and secondary	Rolling 3-month average	0.15 μg/m^3 [(1)]	Not to be exceeded
Nitrogen Dioxide [75 FR 6474, Feb 9, 2010] [61 FR 52852, Oct 8, 1996]		primary	1-hour	100 ppb	98th percentile, averaged over 3 years
		primary and secondary	Annual	53 ppb [(2)]	Annual mean
Ozone [73 FR 16436, Mar 27, 2008]		primary and secondary	8-hour	0.075 ppm [(3)]	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution Dec. 14, 2012	$PM_{2.5}$	primary	Annual	12 μg/m^3	Annual mean, averaged over 3 years
		secondary	Annual	15 μg/m^3	Annual mean, averaged over 3 years
		primary & secondary	24-Hour	35 μg/m^3	98th percentile, averaged over 3 years
	$PM_{2.5}$	primary & secondary	24-Hour	150 μg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide [75 FR 35520, Jun 22, 2010] [38 FR 25678, Sept 14, 1973]		primary	1-hour	75 ppb [(4)]	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

Source: EPA 2013.

[(1)] Final rule signed October 15, 2008. The 1978 lead standard (1.5 μg/m^3 as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978 standard, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

[(2)] The official level of the annual NO2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard.

[(3)] Final rule signed March 12, 2008. The 1997 ozone standard (0.08 ppm, annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years) and related implementation rules remain in place. In 1997, EPA revoked the 1-hour ozone standard (0.12 ppm, not to be exceeded more than once per year) in all areas, although some areas have continued obligations under that standard ("anti-backsliding"). The 1-hour ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is less than or equal to 1.

[(4)] Final rule signed June 2, 2010. The 1971 annual and 24-hour SO2 standards were revoked in that same rulemaking. However, these standards remain in effect until one year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, for which the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.

Table 3.6-17 Nebraska and South Dakota Ambient Air Monitoring Network in Region of Marsland Expansion Area

Table 3.6-17 Nebraska and South Dakota Ambient Air Monitoring Network Near Marsland Expansion Area

Site	Operating Agency	Location			Parameters Monitored	Monitoring Objective	Distance from MEA
		State	County	Coordinates [o]			
Wind Cave National Park	SD DENR	SD	Custer	UTM Zone 13, NAD 83 E 622,471.56 N 4,823,856.93	PM_{10} $PM_{2.5}$ SO_2 NO_2 Ozone	Background (Regional) Pollutant Transport	70 miles
Badlands National Park	SD DENR	SD	Jackson	UTM Zone 13, NAD 83 E 263,173,81 N 4,847,799.95	PM_{10} $PM_{2.5}$ SO_2 NO_2 Ozone	PM2.5: Regional Others: Background (Regional) & Pollutant Transport	107 miles
Black Hawk	SDDENR	D	Meade	UTM Zone 13, NAD 83 E 634,683.07 N4,890,309.65	PM_{10} Ozone	PM10: Population & Urban Background Ozone: Population & High Concentration	110 miles
Agate Fossil Beds [a]	National Park Service	NE	Sioux	42.429300 -103.729400	Ozone	Background (regional)	23 miles
Scottsbluff (Library) [b]	NDEQ	NE	Scotts Bluff	41.865000 -103.664444	$PM_{2.5}$	Background (Regional) Population (Closed)	45 miles
Scottsbluff (Senior High School)	NDEQ	NE	Scotts Bluff	40.942099 -98.364967	$PM_{2.5}$	Background (Regional) Population	45 miles
Rapid City National Guard	SD DENR	SD	Pennington	UTM Zone 13,NAD 83 E 638,543.08 N4,882,373.72	PM_{10}	Population High Concentration	105 miles
Rapid City Credit Union	SD DENR	SD	Pennington	UTM Zone 13,NAD 83 E 638,199.75 N4,882,811.92	$PM_{2.5}$ PM_{10}	Background (Regional) Population	105 miles

Sources: NDEQ 2009; SD DENR 2011
[a] data not suitable for NAAQS compliance determination – only for general trend information.
[b] closed May 11, 2009; replaced by monitors at Scottsbluff Senior High school)

Note: Clarification of mining objectives:

- **Background Level** monitoring is used to determine general background levels of air pollutants. This can be applied to areas such as regions, neighborhoods, and urban areas.
- **High Concentration** monitoring is conducted at sites to find the highest concentration of an air pollutant in an area within a given monitoring network. A monitoring network may have multiple high concentration sites as a result of varying meteorology, source area variability, etc.
- **Population Exposure** monitoring is conducted to represent the air pollutant concentrations to which a populated area is exposed.
- **Pollutant Transport** is the movement of pollutant(s) between air basins or areas within an air basin. Pollutant transport monitoring is used to assess and address sources from upwind areas when those transported pollutant(s) affect neighboring downwind areas. Transport monitoring can also be used to determine the extent of regional pollutant transport.

Table 3.6-18 Comparison of Ambient Particulate Matter (PM_{10}) Monitoring Data for Regional Monitoring Sites

Table 3.6-18 Comparison of Ambient Particulate Matter (PM_{10}) Monitoring Data for Regional Monitoring Sites

Site	2006	2007	2008	2009	2010	3-Year Average	Attainment with NAAQS[b]
PM_{10} Annual Averages for Monitoring Sites							
Wind Cave, SD	7	7	10	9	8	9	[a]
Bad Lands, SD	9	9	12	7	8	11	[a]
Black Hawk	15	16	18	16	14	16	[a]
Rapid City, SD. (Natl. Guard)	27	29	32	26	30	28	[a]
Second Highest 24-Hour Concentration							
Wind Cave, SD	26	43	47	141	67	80	Yes
Bad Lands, SD	30	40	56	32	31	40	Yes
Black Hawk	47	42	36	34	29	33	Yes
Rapid City, SD. (Natl. Guard)	91	89	84	65	73	74	Yes

[a] Annual PM_{10} standard was revoked by the USEPA in 2006 and later removed by the states of Nebraska and South Dakota.
[b] Standard of 150 ug/m^3 is not to be exceeded more than once per year on average over 3 years.
Source: SD DENR 2011.

Table 3.6-19 PM_{10} Annual Average Monitoring Data for South Dakota Monitoring Sites

Table 3.6-19 PM_{10} Annual Average Monitoring Data for South Dakota Monitoring Sites

Year	Wind Cave		Badlands		Black Hawk		Rapid City (Natl. Guard)	
	Annual Average	Maximum 24-Hr Average	Annual Average	Maximum 24-Hr Average	Annual Average	Maximum 24-Hr Average	Annual Average	Maximum 24-Hr Average
	ug/m^3							
1992	--	--	--	--	--	--	37	No Data
1993	--	--	--	--	--	--	34	No Data
1994	--	--	--	--	--	--	39	No Data
1995	--	--	--	--	--	--	33	No Data
1996	--	--	--	--	--	--	35	No Data
1997	--	--	--	--	--	--	41	No Date
1998	--	--	--	--	--	--	31	87
1999	--	--	--	--	--	--	28	117
2000	--	--	12	39	--	--	32	97
2001	--	--	12	48	21	70	35	82
2002	--	--	10	26	19	77	34	105
2003	--	--	16	74	21	77	36	92
2004	--	--	10	24	20	42	35	72
2005	7	32	9	40	15	52	27	94
2006	7	28	9	30	16	50	29	124
2007	10	44	12	50	18	42	32	93
2008	9	47	11	56	16	36	26	124
2009	9	141	7	32	16	34	26	124
2010	8	67	8	31	14	29	30	97

Standard of 150 ug/m^3 is not to be exceeded more than once per year on average over 3 years.
Source: USEPA 2011; SD DENR 2011.

Table 3.6-20 $PM_{2.5}$ Annual Average Monitoring Data for Regional Monitoring Sites

Table 3.6-20 $PM_{2.5}$ Annual Average Monitoring Data for Regional Monitoring Sites

Year	Wind Cave		Badlands		Black Hawk		Rapid City (Natl. Guard)		Scottsbluff	
	Annual Average	Maximum 24-Hr Average	Annual Average	Maximum 24-Hr Average	Annual Average	Maximum 24-Hr Average	Annual Average	Maximum 24-Hr Average	Annual Average	Maximum 24-Hr Average
	ug/m^3									
1998	--	--	--	--	--	--	--	--	--	--
1999	--	--	--	--	--	--	--	--	8.17	32.0
2000	--	--	5.38	13.9	--	--	7.94	29.5	6.31	21.8
2001	--	--	5.60	12.7	6.09	23.2	8.44	24.5	6.21	16.9
2002	--	--	5.15	15.1	6.29	35.5	7.73	26.7	5.69	19.8
2003	--	--	5.77	24.0	6.38	26.6	7.71	21.2	6.10	23.0
2004	--	--	5.25	13.5	6.29	24.4	8.09	13.6	5.69	15.4
2005	5.4	16.2	5.35	15.4	--	--	8.6 [b]	--	5.28	20.1
2006	5.3	16.5	5.38	15.7	--	--	9.3 [b]	--	5.76	27.3
2007	6.2	22.4	5.49	18.7	--	--	8.3 [b]	--	7.10	19.8
2008	4.9	41.6	5.2	51.2	--	--	7.7 [b]	--	6.77	31.1
2009	4.7	--	4.0	--	--	--	6.7 [b]	--	5.13	--
2010	4.7	--	3.9	--	--	--	6.6 [b]	--	5.27 [a]	--

Source: NDEQ 2011; SD DENR 2011; USEPA 2011 and 2013

[a] Scottsbluff site was relocated from 1809 3rd St. (shut-down on 5/11/2009) to the Scottsbluff High School at Hwy 26 and 5th St (start-up 5/13/2010). Combined data for both sites is presented here.

[b] New monitor location for determination of $PM_{2.5}$ compliance at Rapid City, SD (Rapid City Credit Union).

-- data not available.

Table 3.6-21 Comparison of Ambient Particulate Matter ($PM_{2.5}$) Monitoring Data for Regional Monitoring Sites

Table 3.6-21 Comparison of Ambient Particulate Matter ($PM_{2.5}$) Monitoring Data for Regional Monitoring Sites

Site	2006	2007	2008	2009	2010	3-Year Average	Attainment with NAAQS
	ug/m³						
Comparison of 98th Percentile, 24-Hour Concentrations for $PM_{2.5}$ to NAAQS [a]							
Wind Cave, SD	12.2	17.5	10.8	9.6	12.4	14.0	Yes
Bad Lands, SD	12.2	12.4	12.8	10.4	13.6	13.0	Yes
Scottsbluff, NE	19.0	17.7	19.3	12.0	14.0	15.1	Yes
Rapid City, SD. (Credit Union)	--	--	18.7	14.3	14.0	15.7	Yes
Comparison of 3-Year Annual Averages for $PM_{2.5}$ to NAAQS [b]							
Wind Cave, SD	5.3	6.2	4.9	4.7	4.7	5.5	Yes
Bad Lands, SD	5.3	5.5	5.2	4.0	3.9	5.3	Yes
Scottsbluff, NE [c]	5.76	7.10	6.77	5.13	5.27	6.68	Yes
Rapid City, SD (Natl. Guard)	--	--	--	--	--	--	--

[a] To determine attainment status, the 3-year average of the annual 98th percentile value is compared to the 35 ug/m³ NAAQS. The 98th percentile value is higher than 98 percent of 24-hour values for the year.

[b] To determine attainment status, the 3-year average of the annual averages is compared to the 15 ug/m³ NAAQS

[c] Scottsbluff site was relocated from 1809 3rd St. (shut-down on 5/11/2009) to the Scottsbluff High School at Hwy 26 and 5th St (start-up 5/13/2010). Combined data for both sites is presented here.

Table 3.6-22 Comparison of Sulfur Dioxide Values for Wind Cave and Badlands, SD Monitor Sites

Table 3.6-22 Comparison of Sulfur Dioxide Values for Wind Cave and Badlands, SD Monitor Sites

Monitor Site	SO_2 Annual Average Concentration	SO_2 1-Hour Design Values (Effective in 2010)		
		99th Percentile Concentration	3-Year Average	Attainment Status
	parts per billion (ppb)			
Wind Cave				
2005	0.4	--	--	
2006	0.8	--	--	
2007	0.4	--	--	
2008	0.2	3	6	Yes
2009	0.5	10		
2010	2.6	5		
Badlands				
2005	3.0			
2006	2.1			
2007	2.4			
2008	1.3	5	6	Yes
2009	0.8	5		
2010	3.3	9		

SD DENR Standards: 1-hour standard at 75 ppb; 24-hour and annual SO_2 standards revoked. Note: Compliance is met when the 99^{th} percentile daily maximum 1-hour SO2 concentration, averaged over 3 years does not exceed 70 parts ppb. The 3 –year averages shown above are used to evaluate compliance with the sulfur dioxide standard.

Table 3.6-23 Comparison of Nitrogen Dioxide 1-Hour 98th Percentile Concentrations for Wind Cave and Badlands, SD

Table 3.6-23 Comparison of Nitrogen Dioxide 1-Hour 98th Percentile Concentrations for Wind Cave and Badlands, SD

Site	98th Percentile Concentration	3-Year Average	Attainment Status
	Parts per billion (ppb)		
Wind Cave			
2008	3	3	Yes
2009	3		
2010	3		
Badlands			
2008	4	4	Yes
2009	4		
2010	5		

Source: SDDNENR 2011