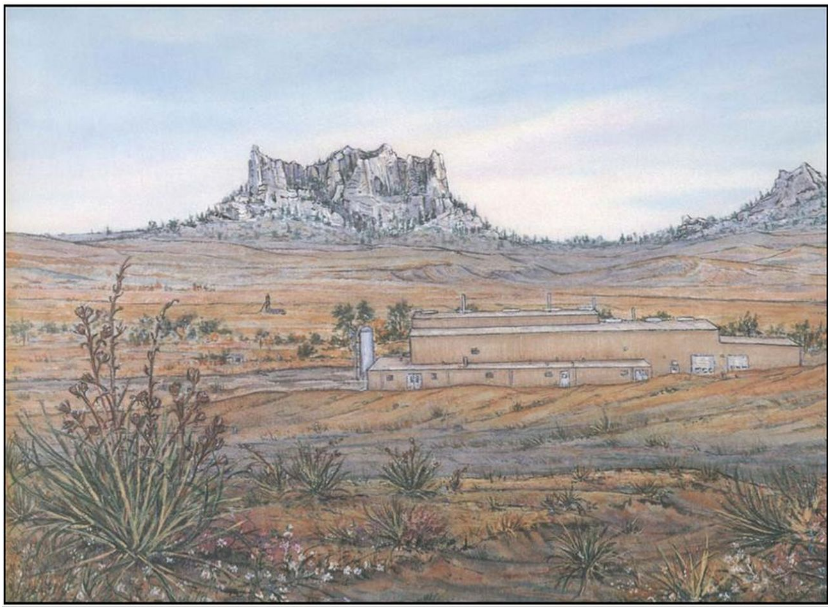
Application for 2024 License Renewal

NRC Source Materials License SUA-1534

Crow Butte Project and Marsland Expansion Area



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LIST OF ACRONYMS

°C	Degree Centigrade
°F	Degree Fahrenheit
ACL	alternate concentration limit
ALARA	as low as reasonably achievable
amsl	above mean sea level
AOR	area of review
API	American Petroleum Institute
ATV	all-terrain vehicle
BBS	breeding bird survey
bgs	below ground surface
BNSF	Burlington Northern Santa Fe
BPT	Best Practicable Technology
CBR	Crow Butte Resources, Inc.
CDP	Census Designated Place
CEDE	Committed Effective Dose Equivalent
CESQG	Conditionally Exempt Small Quantity Generator
CFR	Code of Federal Regulations
cfs	cubic feet per second
cfm	cubic feet per minture
cm/sec	centimeter per second
CPF	Central Processing Facility
cpm	counts per minute
DAC	derived air concentration
dBA	A-weighted decibel
DDE	Deep Dose Equivalent
DDW	deep disposal well
DOT	Department of Transportation
DQO	Data Quality Objective
EA	Environmental Assessment
EDR	electro dialysis reversal
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ER	Environmental Report
ESA	Ecological Study Area
FEMA	Federal Emergency Management Act
FEN	Ferret of Nebraska, Inc.
FESA	Federal Endangered Species Act of 1973
ft/ft	feet per feet
ft/mi	feet per mile
g/L	grams per liter
gpd	gallons per day
gpm	gallons per minute
HPRCC	High Plains Regional Climatic Center
HPT	health physics technician
HSMS	Health and Safety Management Systems
ISR	in-situ recovery

IX	ion exchange
km	kilometer
LAN	local area network
LC	license condition
LEU	low-enriched uranium
LLD	lower limit of detection
LRA	license renewal application
LSA	Low Specific Activity
m/s	meters per second
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols Manual
MCL	maximum contaminant level
MDC	minimum detection concentration
MEA	Marsland Expansion Area
MeV	mega electronvolt
µS/cm	microSiemens per centimeter
$\mu g/m^3$	micrograms per cubic meter
µCi/ml	microCuries per milliliter
mg/L	milligrams per liter
MIT	mechanical integrity test
MPC	Maximum Permissible Concentration
mph	miles per hour
mRem	miliroentgen equivalent, man
MU	mine unit
NAAQS	National Ambient Air Quality Standards
NAIP	National Agriculture Imagery Program
NDEE	Nebraska Department of Environment and Energy
NDEQ	Nebraska Department of Environmental Quality
NDNR	Nebraska Department of Natural Resources
NGPC	Nebraska Game and Parks Commission
NNHP	Nebraska Natural Heritage Program
NNLP	Nebraska Natural Legacy Project
NOAA	National Oceanic Atmospheric Association
NOI	Notice of Intent
NOU	Nebraska Ornithologists Union
NOV	Notice of violation
NPDES	National Pollutant Discharge Elimination System
NRC	United States Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NSHS	Nebraska State Historical Society
NTEA	North Trend Expansion Area
NTU	nephelometric turbidity units
NWI	National Wetlands Inventory
OSHA	Occupational Safety and Health Administration
OSL	Optically-Stimulated Luminescent
PBL	Peformance-Based License
pCi/g	picoCuries per gram
PPE	personal protective equipment

ppb	parts per billion
ppm	parts per million
PPMP	preoperational/preconstruction monitoring program
PVC	polyvinyl chloride
QC	quality control
QAM	Quality Assurance Manual
QAP	Quality Assurance Program
RAI	request for additional information
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RG	Regulatory Guide
RMP	Risk Management Program
RPPA	Respiratory Protection Program Administrator
RO	reverse osmosis
ROI	radius of influence
RSO	radiation safety officer
RWP	Radiation Work Permit
SCADA	Sequential Control and Data Acquisition
SD DANR	South Dakota Department of Agriculture & Natural Resources
SDR	Standard Dimension Ratio
SDS	safety data sheet
SHEQ	Safety, Health, Environment and Quality
SHEQ	Safety, Health, Environment and Quality Management System
SERP	Safety and Environmental Review Panel
SH	State Highway
SHPO	State Historic Preservation Office
SIV	self-identified violation
SOP	standard operating procedure
SPCC	Spill Prevention, Control, and Countermeasure
SS	stainless steel
SSC	structure, system, or component
s.u.	standard unit
SWPPP	Stormwater Pollution Prevention Plan
SRWP	Standing Radiation Work Permit
TCEA	Three Crows Expansion Area
TCP	traditional cultural property
TDS	total dissolved solids
TEDE	Total Effective Dose Equivalent
TER	Technical Evaluation Report
THC	Total hydrocarbon
TOC	top of casing
TR	Technical Report
TSP	total suspended particulates
TSS	total suspended solids
TWE	Time Weighted Exposure
U_3O_8	triuranium octoxide
UCL	Upper Control Limits
UIC	Underground Injection Control

UMTRCA	Uranium Mill Tailings Radiation Control Act
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USDW	Underground source of drinking water
USGS	United States Geologic Survey
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
VMT	vehicle mile travelled
VRM	Visual Resource Management
WFC	Wyoming Fuel Company
WL	working level
WLM	working level month
XRD	X-Ray Diffraction

2.7 HYDROLOGY

Section 2.7 of the 2008 Crow Butte LRA and Section 2.7 of the MEA TR provide information on the surface water and groundwater for each project area. Information from these reports has been incorporated into this Combined ER/TR. This section provides an update to surface water flow at the USGS and NeDNR stream gaging stations and provides updated water levels for the Crow Butte Project. Based on the information presented in this section there is no significant changes between the 2008 Crow Butte LRA, MEA TR and this Combined ER/TR.

2.7.1 Surface Water

2.7.1.1 Drainage Basin Description

2.7.1.1.1 Crow Butte Project

The Crow Butte Project is located within the drainage basin of the White River. The White River heads in Sioux County and flows northeasterly across Dawes County into South Dakota. Northern tributaries in the Crawford area cross upland portions of the Pierre Shale, an impermeable formation. These streams are dry except for runoff flow. The southern tributaries originate in the Pine Ridge escarpment, and flow primarily over forest, range, and agricultural land. These streams are generally ephemeral except where they are spring-fed.

Squaw Creek is one of the southern tributaries of the White River. This creek heads in the Pine Ridge southeast of the Crow Butte Project. From the headwaters, it flows northwest over range and agricultural land to the White River. Contributions to flow come from the springs in the Arikaree Formation, snowmelt, runoff, and the shallow Brule sands. The latter may receive inflow from the creek during periods of high flow. Due to the time-variable nature of these water sources, discharge rates at various points along the creek may experience wide fluctuations monthly and yearly.

Squaw Creek enters the Crow Butte Project on the southeast corner, travels through the entire length of the Crow Butte Project approximately paralleling its long axis and exits to the north. Two branches of an unnamed tributary enter along the southern boundary, join just north of the Mine Unit 1 wellfield, and exit the northern boundary before converging with Squaw Creek.

Figure 2.7-1 illustrates the location of the Crow Butte Project with respect to Squaw Creek and English Creek watercourses and the locations of the commercial evaporation ponds.

2.7.1.1.2 Marsland Expansion Area

The MEA is located within the drainage basin of the Niobrara River, with the southernmost license boundary being located approximately 0.4 km (0.24 mile) from the Niobrara River (Figure 2.7-2). The distance from the southern boundary of Mine Unit MU-F to the nearest point on the Niobrara River is approximately 0.7 km (0.42 mile)

The Niobrara River originates near Manville, Niobrara County, eastern Wyoming and flows in an east-southeast direction into western Nebraska. The river flows across Sioux County in Nebraska, east through the Agate Fossil Beds National Monument, past Marsland to the south of the MEA, and through Box Butte Reservoir. From the reservoir, the river flows east across northern Nebraska, and joins the Snake River approximately 20.9 km (13 miles) southwest of Valentine. The Niobrara River joins the Keya Paha River approximately 9.6 km (6 miles) west of Butte, Nebraska. The river eventually joins the Missouri River northwest of Niobrara, Nebraska in northern Knox County.

2.7.1.2 Surface Water Flow

2.7.1.2.1 Crow Butte Project

Table 2.7-1 shows the mean monthly discharge of the White River as compared to the mean monthly precipitation over several years. These extended data show that a general correlation can be made between the direct precipitation and discharge. Higher flows are recorded in spring and early summer with the lowest flow rates in late summer to early fall, reflecting seasonal changes related to precipitation. Between 1931 and 2004, the average normal annual mean discharge at the White River Station at Crawford was 20.3 cubic feet per second (cfs) with a standard deviation of 2.8 cfs. The maximum was 27 cfs and minimum was 13 cfs.

Peak rainfall at Harrison and Scottsbluff, Nebraska occurs in May and June (NOAA 1976 and 1980), and this precipitation pattern appears to be representative of the Crawford area. Table 2.7-2 provides mean monthly discharge information for the White River for 2001 through July 2024. The recent data for the White River are comparable to the stream flow data shown in Table 2.7-1.

2.7.1.2.2 Marsland Expansion Area

The NeDNR maintains several stream gaging stations on the upper reaches of the Niobrara River. Description of the stream gaging stations used for this analysis and their locations is presented in Table 2.7-3. A graph of the average flow in cfs for the four Niobrara River stream gaging stations from 2011 through July 2024 is shown on Figure 2.7-3. The figure shows that flows for the gaging stations above the Niobrara River are fairly consistent over this time period. The average flow of the Niobrara River at the Wyoming/Nebraska state line is consistently lower than the average flows at the gaging stations located at Agate and above the Box Butte Reservoir. Figure 2.7-3 also shows the time periods during which water is stored and released from Box Butte Reservoir. These data can be correlated with the flow data presented in Table 2.7-4. In the Niobrara River west of Valentine, NE, which includes the area of the river in the vicinity of MEA, groundwater is the primary source of flow into the Niobrara River (Alexander et al 2010). In this area of the river, the discharge of the river is steady and persistent, with overbank flooding being uncommon except during winter ice jams (Shaffer 1975).

2.7.1.3 Impoundments

2.7.1.3.1 Crow Butte Project

Eight surface water impoundments are located near or within the boundaries of the Crow Butte Project. Figure 2.7-1 shows the locations of these impoundments. These eight impoundments are identified as I-1 through I-8. Impoundments I-1, I-2, I-7, and I-8 are outside the license area, while impoundments I-3 through I-6 are inside the license area.

Impoundment I-1 consists of a low earthen berm constructed across an unnamed ephemeral drainage course, which is a tributary to Squaw Creek. This berm forms a small seasonal pond which is used for livestock watering. Impoundment I-2 is formed by a small earthen dam on White Clay Creek. Water from these ponds is used for livestock watering and crop irrigation. Impoundments I-3, I-4, I-5, and I-7 are formed by small earthen dams across English Creek. Water from these ponds is used for livestock watering. Impoundment I-6 is formed by an earthen dam across Squaw Creek. Water from this pond is used for livestock watering. Impoundment I-8 is located in the alluvial valley of White Clay Creek and is also used for livestock watering.

2.7.1.3.2 Marsland Expansion Area

Based on available maps and site investigations conducted by CBR, no surface water impoundments, lakes, or 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.

Box Butte Reservoir is located approximately 3 miles (4.8 km) to the east of the southeast corner of the MEA license boundary (Figure 2.7-2). The Box Butte Reservoir was constructed from 1941 to 1946 and is under the control of the U.S. Bureau of Reclamation (USBR). The primary purpose of the reservoir is for irrigation with secondary benefits for recreation, fish, and wildlife (USBR 2008). The total storage capacity of the Box Butte Reservoir is 29,161 acre-feet (USBR 2008) and the pool elevation is 3997.6 feet. The reservoir occupies approximately 1,600 surface acres with 14 miles (22.5 km) of shoreline.

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.

2.7.1.4 Assessment of Surface Water Features

2.7.1.4.1 Crow Butte Project

The potential for flooding or erosion that could impact the in-situ mining processing facilities and surface impoundments have been assessed based on data from the Federal Emergency Management Agency (FEMA 2007). FEMA has not mapped unincorporated Dawes County north of Crawford, Nebraska; however, FEMA maps are available for the City of Crawford, which depict the flooding potential of the White River in Crawford. All surface facilities within the Crow Butte Project occur outside of the 100-year flood plain of the White River and are not likely to be within a “flood-prone” area. Therefore, consistent with NUREG-1623, erosion modeling was not considered necessary or performed.

2.7.1.4.2 Marsland Expansion Area

CBR conducted hydrologic and erosion studies to determine the potential for flooding and erosion in the MEA. The study determined that there is low to high risk for erosion. The MEA is not located within a FEMA designated flood zone; however, portions of the MEA may be subject to concentrated water flow during storm runoff and may also be at risk of damage.

2.7.1.5 *Surface Water Quality*

2.7.1.5.1 Crow Butte Project

Preoperational background surface water samples were collected from the White River and all surface bodies of water within the Crow Butte Project (FEN 1987a). Surface water sampling began in 1982 and continued into 1987 for specified locations. These data were included in the 1987 application and supporting environmental report for USNRC Source Material License for the Crow Butte Project, which was submitted to the NRC by Ferret of Nebraska, Inc. (previous owner) in August 1987 (FEN 1987a). The water quality data are presented in Section 2.9-4.

White River water quality data were assembled by the U.S. Environmental Protection Agency (EPA) for various years from 1968 to 1973, 1981 and 1994 (Table 2.7-5). Water quality data collected by the NDEQ for the year 2003 is presented in Table 2.7-6.

Data for the White River at Crawford (60 sampling events from 1968 to 1980) indicate an average specific conductance of 380 microSiemens per centimeter (µS/cm) (EPA 2007). Data from the White River tributaries in the vicinity of the NTEA (Soldier Creek [west of Crawford]; Squaw Creek, White Clay Creek and English Creek [all east of Crawford]; and Dead Man's Creek [south of Crawford]) indicated that the specific conductance for these tributaries ranged from 36 to 507 µS/cm (eight sampling events from 1981 to 1995).

Based on NDEE data collected from the White River at the Crawford sampling station in 2003, specific conductance ranged from 349 to 386 µS/cm, with an average of 374 µS/cm (EPA 2007).

2.7.1.5.2 Marsland Expansion Area

Surface water quality for the MEA is provided in Section 2.9.4 of the MEA TR and has been incorporated into Section 2.9.5 of this Combined ER/TR.

2.7.2 Groundwater

This section provides a summary of 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 Crow Butte Project and the MEA (Section 2.7.2 of the MEA TR).

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

- Alluvium
- Arikaree Group (MEA only)
- Brule Formation (including the first "aquifer" in the Brule sand/clay)
- Chadron Formation (Upper Confining unit including the Upper Chadron confining layer, Middle/Upper Chadron sand [aquifer, where present], and Middle Chadron confining layer)
- Basal Chadron Sandstone (Mining Unit)

- Pierre Shale (Lower Confining Unit)

The two sources of groundwater of interest in the Crow Butte Project and MEA are the Brule Formation and the Basal Chadron Sandstone. The latter contains the uranium mineralization.

2.7.2.1 Regional Groundwater Hydrology

A map prepared by Souders (2004) indicates that the water table configuration in the region trends north-northeast. No published regional water level maps are available for the Basal Chadron Sandstone or the local Brule sands. Souders (2004) states that aquifers within the White River Basin, which encompasses the northern half of Dawes County, are "nearly nonexistent". He indicates that a groundwater divide occurs to the south of the Crow Butte Project along the Pine Ridge; groundwater north of this divide flows to the north, northwest, and northeast, depending on location with respect to the White River. The Brule, Chadron, and Pierre Shale outcrop progressively northward from the Pine Ridge divide through the White River Basin, and Souder states that none of these formations "are considered major sources of groundwater".

Souder indicates that the Brule is a tight formation with a minimal hydraulic conductivity of less than 25 feet per day (feet/day), although in a few areas, there may be a significant saturated thickness, presumably where sandier intervals are present. The Chadron is described as consisting of claystones with extensive volcanic ash that is tight with low hydraulic conductivity comparable to the Brule Formation, except where fractured, although the coarse Basal Chadron Sandstone is present at the bottom of the formation. The Pierre is described by Souders (2004) as a dark grey, bentonitic shale that is "very tight and is not considered to hold any extractable groundwater" except where fractured. Fractures may increase Brule and Chadron permeability in localized areas (Souders 2004). It is noted that CBR operations at the Crow Butte Project to date do not support evidence of fracturing in the Pierre to a degree such that it would impact the designation of the Pierre as a lower confining unit below the Basal Chadron Sandstone.

Prior to mining at the Crow Butte Project, water levels were measured in existing wells throughout the Crawford-Crow Butte area for the local Brule sand and the Basal Chadron Sandstone. Maps showing the historical (1982-1983) potentiometric surfaces for these two aquifers are included as Figures 2.7-4a and 2.7-5a.

Water level maps for more recent water levels collected from the Crow Butte Project in March-April 2008, October 2008, February-March 2009, and August 2024 are provided as Figures 2.7-4b through 2.7-4e. Groundwater flow within the Brule Formation converges in the vicinity of the White River, with southeast and east-directed flow north of the White River and northwest-directed flow south of the White River. It is highly likely that the White River is a significant groundwater discharge point for the Brule Formation. Water levels collected from the Brule Formation within the Crow Butte Project in 1982-1983 indicate groundwater flow to the northwest with an average hydraulic gradient of 0.012 ft/ft. Water levels collected from the Brule Formation in March-April 2008, October 2008, February-March 2009, and August 2024 similarly all indicate groundwater flow to the northwest with slightly higher average hydraulic gradients of 0.025, 0.041, 0.043, and 0.010 ft/ft, respectively. As was described in the 2007 LRA, steeper gradients generally occur south of Mine Unit 8 compared to the 1982-1983 time period. Water levels in the Brule Formation have not significantly changed within Crow Butte Project when comparing the 1982-1983 water levels to the 2024 water levels.

The Basal Chadron Sandstone is an artesian (confined) aquifer, and wells completed in it may flow to the surface near the White River. Historical water levels collected from the Basal Chadron sandstone in 1982-1983 indicate groundwater flow to the south and southwest north of the Town of Crawford and flow to the north and northwest within the Crow Butte Project. More recent water levels collected from the Basal Chadron Sandstone (Figures 2.7-5b and 2.7-5e) indicate groundwater flow in the vicinity of the White River is predominantly directed to the southeast across the White River structural feature toward the Crow Butte Project. Water levels collected in December 2025 indicate that groundwater flow is directed inward to the Mine Units 7 and 8 areas, which are in active restoration.

Local hydraulic gradients are highly variable within the permit area as a result of production activities and ranged from 0.001 to 0.031 ft/ft in December 2025. Water levels in the Basal Chadron Sandstone have decreased over 100 feet across the permit area between the 1982-1983 and 2024 time period. Water levels have been lowered across the permit area in order to maintain a cone of depression. Within each mine unit, more water is produced than injected by using a bleed stream in order to create an overall hydraulic cone of depression in the production zone.

Historical water level data for a one-year period from wells located in the Crow Butte Project are included on Tables 2.7-7(Brule wells) and Table 2.7-8 (Basal Chadron wells).

Regionally, the principal water bearing rocks below the Pierre Shale are the G Sand, J Sand, and the Dakota, Morrison and Sundance Formations. The total dissolved solids (TDS) concentrations of the water below the Pierre Shale have been interpreted from deep oil and gas exploration logs. The Dakota Sandstone is at a depth of 2,972 to 3,020 feet in the Bunch No. 1 hole (Section 5, T31N, R52W). The minimum TDS of the water in the Dakota Sandstone, calculated from the spontaneous potential and sonic logs, is estimated to range from 14,000 to 26,000 milligrams per liter (mg/L) (as NaCl). Based on samples collected during the installation and testing of the Crow Butte deep disposal well (DW #1, Section 19, T31N, R51W) TDS levels in the Morrison Formation (3,580 feet midpoint depth) and Sundance Formation (3,784 feet) are approximately 24,000 and 40,000 mg/L, respectively.

The Pierre is essentially impermeable which precludes its use as a water supply. A number of shallow wells are reported as having the Pierre Shale as the bedrock unit (Spalding 1982) in T32N, R51-52W. These wells range in depth from 18 to 100 feet with an average depth of 44 feet and were drilled in areas that have considerable alluvium atop the Pierre, including locations along Spring Creek and the White River between Crawford and Whitney Lake. These wells produce water from a few tens of feet of Quaternary Alluvium overlying the Pierre Shale, with the bottom few tens of feet in those wells providing storage. Spalding (1982) states that, "In very shallow wells (a few tens of feet) significant amounts of water utilized may be contained in the thin Quaternary sediments overlying the designated hydrogeologic unit. This situation is particularly true for those wells noted as completed in the Pierre Shale". In the geologic summary of the Spalding report, the groundwater potential of the Pierre Shale is discussed as (page 14), "The oldest bedrock unit in the area, the Pierre Shale of Cretaceous Age, is not considered as a potential aquifer. It is, however, included in the discussion of completion horizons and hydrogeologic units. A few of the shallow wells produce from the Quaternary sediments immediately overlying the Pierre Shale".

2.7.2.2 *Crow Butte Project Hydrology*

The hydrogeologic system within and surrounding the Crow Butte Project is similar to that found regionally. Alluvial deposits occur intermittently in ephemeral drainages but are not considered to be a reliable water source. Over most of the Crow Butte license area, the Brule Formation outcrops, and is underlain by the Chadron Formation (including the Basal Chadron Sandstone) and the Pierre Shale. The occurrence and thickness of these geologic units within the license area have been confirmed during exploratory drilling and logging activities. Based on these data, the relationship of the hydrostratigraphic units within the Crow Butte Project is shown on a cross-section location map (Figure 2.7-6) and two cross-sections (Figures 2.7-7 and 2.7-8).

The Basal Chadron Sandstone, the aquifer, which is host to the uranium mineralization, is bounded above and below by strata which form aquicludes. The term "aquiclude" is used to describe strata capable of transmitting only minor amounts of fluid either vertically or horizontally. Typical values for vertical and horizontal permeability of "aquicludes" are in the range of 10^{-4} to 10^{-5} darcys (Todd 1980), which is equivalent to a hydraulic conductivity of 10^{-7} to 10^{-8} centimeters per second (cm/sec). The vertical hydraulic conductivities of the aquicludes calculated from pumping tests conducted in the CSA are on the order of 10^{-11} cm/sec (FEN 1987b). Laboratory analysis of cores from wells in the CSA indicates vertical hydraulic conductivities on the order of 10^{-10} to 10^{-11} cm/sec (FEN 1987b). Local groundwater flow within the Basal Chadron is to the east, with a gradient of 0.0016 feet per feet (ft/ft) or 8.5 feet per mile (ft/mile).

The sandstones and sandy siltstones in the upper part of the Brule Formation may be water-bearing locally. However, these sandstones, siltstones, and clay stringers are difficult to correlate over any large distance and are discontinuous lenses rather than laterally continuous strata. As stated previously, these different sand lenses may exhibit different water levels. Brule wells PM-6 and PM-7, monitor wells in the R&D wellfield, exhibit differences in water levels which average 1 foot and range from 0.7 to 2.4 feet. In addition, recharge capacity is low in these lenses as evidenced by the low productivity of these wells and the difficulty in developing these wells. Based on only four data points, flow in the Brule is to the east/northeast at 0.005 ft/ft or 26.4 ft/mile.

Water level data support hydrologic isolation of the Basal Chadron Sandstone with respect to the other water-bearing intervals of interest in the Crow Butte Project. Groundwater production rates within the Brule and Upper/Middle Chadron sands are low to exceptionally low.

The geochemical groundwater characteristics of the Brule and Chadron further indicate that the two zones are not naturally interconnected.

2.7.2.2.1 *Aquifer Testing*

The NDEE authorized CBR to operate the mine according to Underground Injection Control (UIC) regulations via UIC Permit Number NE 0122611. This permit requires CBR to complete aquifer pumping tests to demonstrate the integrity of the confining layer above the mining zone prior to mine development within the license area. Data collected and analyzed as part of these aquifer pumping tests included pumping rate, test duration, formation characteristics, transmissivity, hydraulic conductivity, storativity, and radius of influence (ROI) so the hydraulic characteristics of the aquifer and the integrity of the confining layers near the mining sites can be evaluated.

In general, aquifer pumping tests are field experiments performed to evaluate an aquifer's recovery to the induced stress of pumping. Typically, aquifer pump tests involve the design and construction of multiple wells, both a pump well and observation wells, to monitor the aquifer's response to pumping. During the pump test, groundwater is pumped from pump wells at determined rate and for a fixed time, and water levels are measured in the surrounding observation wells throughout the test to determine the effect of pumping on the aquifer and adjacent water bearing formations. Aquifer pump tests usually involve monitoring water levels during the pumping phase, as well as after pumping has stopped, in order to determine the aquifer's recovery time. The well data are then analyzed to compute hydraulic properties of the aquifer including hydraulic conductivity, transmissivity, storativity, and ROI (Heath 1982).

CBR performed four groundwater pumping tests within the License area boundary between 1982 and 2002 in order to comply with the requirements of the UIC permit. Figure 2.7-9 illustrates the locations of the four pumping tests within the license area. This section of the report summarizes the hydrogeologic characteristics of the License area and the methods used in the aquifer pumping tests, test results, and conclusions regarding the aquifer and integrity of the confining layer within the License area.

Purpose & Objectives of Aquifer Testing

The objectives of the aquifer pumping tests are to assess the integrity of the confining layer above the mining zone and characterize the hydrogeology of the ore-bearing aquifer in order to comply with NDEE and NRC permit requirements. The hydrogeologic investigation was also designed to address environmental and operational questions pertinent to ISL uranium mining at the site raised by the NRC. Specifically, these tests address requirements that are outlined by the NRC in RG 3.46, Section 2.7.1 and Draft Staff Technical Position Paper WM-8203, Section 3.1.2. In general, the hydrogeologic investigation was oriented toward the characterization of the hydraulic properties of the ore-bearing aquifer and the hydraulic relationship of the aquifer to the overlying and underlying confining strata.

In addition to its use in the commercial permit application, the information gathered from the aquifer pump tests may be used for:

- design of the commercial wellfield,
- selection of commercial production parameters,
- design of the groundwater monitoring system, and
- prediction of the mining and restoration efficiency.

Site Characterization

CBR developed the mine to recover uranium from the Chadron Sandstone Formation. The uranium-bearing aquifer is formed by coarse-grained arkosic sandstone which is locally known as the Basal Sandstone Member of the Chadron Formation. The Basal Sandstone is believed to be the depositional product of a large, vigorous, braided-stream system which occurred during the early Oligocene age (approximately 36 to 40 million years before present).

Ore-grade uranium deposits underlying the CBR site are predominantly located in the Chadron Sandstone Formation, which occurs at depths ranging from 400 to 1,200 feet and averages 50 feet in thickness, of which 35 feet are net sand. A confining layer exists above the Chadron Sandstone Formation that is composed of the Upper Chadron and Brule Formations, which averages 300 feet thick across the site. The general stratigraphy of the site in both the northern and southern portions of the license area is summarized in Section 2.6.

The Pierre Shale of late Cretaceous age forms the underlying confining layer for the Basal Chadron Sandstone. The Pierre Shale is a widespread dark gray to black marine shale which is essentially impermeable. Regionally, the Pierre Shale is up to 5,000 feet thick. In Dawes County, deep oil test holes have encountered thicknesses of 1,200 to 1,500 feet of Pierre Shale. The clays, claystones, and siltstones of the Middle and Upper Members of the Chadron Formation and the Lower Brule Formation form the overlying confining layer for the Basal Chadron Sandstone.

Further geologic characterization of the general area surrounding the CBR project site is available in "Application and Supporting Environmental Report for the State of Nebraska Underground Injection Control Program Commercial Permit" (FEN 1987b).

Aquifer Pumping Tests

Four aquifer pumping tests were performed at the CBR mine area between November 1982 and August 2002 in order to evaluate hydraulic characteristics of the Chadron Sandstone in the License area, assess the integrity of the confining layer above the mining zone, and to comply with requirements outlined in the UIC permit.

The methods, results and conclusions regarding the hydrogeologic properties of the aquifer and confining layer above the mining zone are discussed below.

Methods

In general, the four aquifer tests employed the following methodology.

- Review of existing geologic and hydrogeologic data for the area,
- Design of appropriate aquifer test,
- Design and construction of appropriate well array for aquifer test,
- Laboratory tests of core samples from confining layers,
- Performance of aquifer test,
- Analysis of data from aquifer test, and
- Interpretation of results of test.

Aquifer pump test data collected as part of this investigation were analyzed using a variety of the following methods.

- Theis' Non-Equilibrium Method (Theis 1935) for analyzing non-equilibrium pumping test data.
- Theis' Recovery Method (Theis 1935) for analyzing recovery test data.
- Jacob's Modified Non-Equilibrium Method (Cooper and Jacob 1946) for analyzing non-equilibrium pumping test data.
- Cooper and Jacob's Distance-Drawdown Method (Cooper and Jacob 1946) for determining radius of influence.
- Hantush's Method (Hantush 1966) for determining the magnitude and direction of the major the minor horizontal axes of transmissivity in an anisotropic aquifer.
- Neuman and Witherspoon's Method (Neuman and Witherspoon 1972) for determining the hydraulic diffusivity and vertical hydraulic conductivity of confining layers.
- Darcy's Law to determine the average pore velocity and the groundwater flux across the aquifer test site.
- Standard Consolidation Test (ASTM 1985) to determine the coefficient of consolidation, compression index, coefficient of compressibility, and vertical hydraulic conductivity of the confining layer.

Tests 1 and 2 were carried out in the central portion of the License area within Section 19 of Township 31 North, Range 51 West. Test number 3 was performed in the northwestern portion of the License area on the border between Sections 12 and 13 of Township 31 North, Range 52 West. Test number 4 was performed in the southeastern section of the License area within Section 30 of Township 31 North, Range 51 West.

First Aquifer Test

The first multiple-well aquifer test (Test #1) was conducted in the R&D wellfield in November 1982. The pumping period of this test was 50.75 hours and the recovery period was 27.6 hours. During this test, water levels were measured in four production zone observation wells in addition, two shallow Brule monitor wells were measured. The data from the first aquifer test were analyzed using the Theis Non-Equilibrium Method (1935), the Jacob Modified Non-Equilibrium Method (1946) and the Theis Recovery Method (1935). The results of these analyses show that the Basal Chadron Sandstone, which is the ore-bearing aquifer at the Crow Butte site, is a non-leaky, confined, anisotropic aquifer. The effective transmissivity of the Basal Chadron Sandstone ranged from 2,453 gpd/ft (327 ft^2/day) to 3,863 gpd/ft (516 ft^2/day). The average thickness of the aquifer at the test site was about 40 feet. Average hydraulic conductivity ranged from about 61 gpd/ft^2 (8.2 ft/day) to about 97 gpd/ft^2 (13 ft/day). The average coefficient of storage ranged from 9.66×10^{-5} to 1.75×10^{-4}. The azimuth and magnitude of the major axis of transmissivity were about 2° and 3,000 gpd/ft (401 ft^2/day), respectively. The azimuth and magnitude of the minor axis of transmissivity were about 92° and 2169 gpd/ft (290 ft^2/day), respectively. Evidence from the test showed that the Basal Chadron Sandstone is not hydraulically connected to the overlying aquifer in the Brule Sand.

Results from Test #1 imply that aquicludes which overlie and underlie the Basal Chadron Sandstone probably yielded some small amount of water as recharge (or leakage) to the aquifer during the pump test. However, the amount of this recharge or leakage was extremely small as evidenced by the results of the laboratory test of the core samples and the drawdown analysis of the Basal Chadron Sandstone. The lack of substantial leakage was the result of the extremely low vertical hydraulic conductivity of the confining layers. The vertical hydraulic conductivity of the overlying confining layer, as determined from the laboratory tests of core samples, was about 7.8×10^{-7} ft/day (2.8×10^{-10} cm/sec), and that of the underlying confining layer was about 9.6×10^{-8} ft/day (3.4×10^{-11} cm/sec). Confining layers with vertical hydraulic conductivities this low are, by definition, called aquicludes rather than aquitards.

The integrity of confinement of the ore-zone aquifer (Basal Chadron Sandstone) may be characterized by the hydraulic resistance factor. The hydraulic resistance factor of an aquitard to vertical flow (c) is defined as the reciprocal of the leakage coefficient K/B, where K is the vertical hydraulic conductivity of the aquitard, and B is the aquitard thickness; thus c=B/K and has the dimensions of time. Hydraulic resistance is typically expressed in units of days or years. The hydraulic resistance of the overlying aquiclude is about 1,050,000 years and that of the underlying aquiclude is about 34,000,000 years. The time needed for a water molecule to travel through the entire thicknesses of the aquicludes is calculated as the hydraulic resistance times the effective porosity. Assuming an effective porosity of 2.0 percent and a unit gradient of 1 foot of head loss per foot of movement in the direction of flow, these result in travel time of about 21,000 years for the overlying aquiclude and about 685,000 years for the underlying aquiclude.

The piezometric surface of the Basal Chadron Sandstone dips toward the north at a gradient of about 0.04 percent (0.0004) which is equal to 1 foot per 2500 feet. Using a directional hydraulic conductivity of 10 ft/day, a gradient of 4×10^{-4} and a porosity of 29 percent, the average pore velocity across the R&D site was computed to be 5.0 ft/year. The groundwater flux across the site was computed to be 0.16 ft^3/day per unit width of the aquifer.

Second Aquifer Test

A second multiple-well aquifer test (Test #2) was performed between 10 June and 3 July 1987 in the mineralized area near the northern boundary of Section 19, Township 31 North, Range 51 West and approximately 2,800 feet north of the R&D site. The second aquifer pumping test was performed in order to characterize the hydrogeology of the mining area developed in 1987. At the Test #2 site, the Basal Sandstone is approximately 550 to 600 feet below ground surface and averages 40 feet in thickness. The Chadron Formation lies with marked unconformity on top of the Pierre Shale.

The well array used for Test #2 consisted of five wells and two high-sensitivity piezometers. One pumping well (CPW-1) and three observation wells (COW-1, COW-2, COW-3) were completed in the ore-bearing aquifer (Basal Chadron Sandstone). The three observation wells were located in an equiangular arrangement around the central pumping well. This configuration provided the data needed to define the magnitude and direction of the major and minor axes of transmissivity, the effective transmissivity, the hydraulic conductivity and the storativity of the ore-bearing aquifer. One monitor well (BMW-1) was completed in the first overlying sand of the Brule Formation. This well was used to monitor the water level in the first overlying sand during the aquifer test. Two piezometers (UCP-1, LCP-1) were completed in the confining layers which overlie and underlie the ore-bearing aquifer to provide data to calculate the vertical hydraulic conductivities of these confining layers under in-situ field conditions.

During Test #2, the pumped well (CPW-1) was equipped with a 7.5 HP submersible pump which was set at a depth of about 500 feet. Discharge pumped from the well was measured with an electronic pressure transducer and was recorded by the data-logger throughout the course of the test. The pumping phase of the aquifer test endured 72 hours between June 30, 1987 and July 3, 1987. Prior to the start of the pumping, static water levels of all the wells were measured and recorded. The recovery phase of the test lasted 72.5 hours between July 3, 1987 and July 6, 1987.

The average discharge rate during the pumping phase of the test was 47.74 gpm, and the total volume of water discharged was 206,288 gallons. Throughout the pumping phase, the discharge rate was regularly monitored to ensure that it remained constant. The static water level in the pumped well was approximately 484 feet above the top of the aquifer.

The calculated maximum drawdown in the pumped well was 36.86 feet, which is approximately 447 feet above the top of the aquifer. Barometric pressure did vary considerably during the 6-day test, which was likely the result of the passage of a low pressure system and a cold front with associated thunderstorms and subsequent high pressure.

The Jacob Non-Equilibrium Method, the Theis Non-Equilibrium Method and the Theis Recovery Method were used to analyze the aquifer test data from the three Basal Chadron Sandstone wells. A confined non-leaky type of analysis was made because leakage effects were not apparent in the test data and the piezometric surface is well above the top of the aquifer. Inspection of the results of the analyses verifies that these assumptions are valid. The Neuman-Witherspoon Method (1972) to determine the vertical hydraulic conductivity of both the over- and underlying confining area of the ore-bearing aquifer under in-situ conditions.

The transmissivities calculated from the drawdown data from the three Basal Chadron Sandstone observation wells (COW-1, COW-2, COW-3), ranged from 2682 gpd/ft (359 ft^2/day) to 2795 gpd/ft (374 ft^2/day). The storage coefficients for these wells, calculated from the same analyses, ranges from $8.44x10^{-5}$ to $1.31x10^{-4}$. The transmissivities calculated from the recovery data from the three observation wells are slightly lower, ranging from 2604 gpd/ft (348 ft^2/day) to 2659 gpd/ft (355 ft^2/day). The average thickness of the aquifer at the test site is 40 feet. Therefore, the hydraulic conductivities calculated from the drawdown data ranged from approximately 67 gpd/ft^2 (8.96 ft/day) to 70 gpd/ft^2 (9.34 ft/day). The hydraulic conductivities calculated from the recovery data ranged from approximately 65 gpd/ft^2 (8.7 ft/day) to about 66 gpd/ft^2 (8.89 ft/day).

The Hantush Method was used to determine the direction and magnitude of the major and minor axes of transmissivity of the Basal Chadron Sandstone. The major axis of transmissivity in the Basal Chadron Sandstone lies along an azimuth of about 51° and has a magnitude of 2760 gpd/ft (369 ft^2/day). The minor axis of transmissivity has an azimuth of about 141° and a magnitude of 2692 gpd/ft 360 ft^2/day.

The overlying confining layer piezometer (UCP-1) showed no response to the pumping from the Basal Chadron Sandstone during the aquifer test. However, this piezometer did respond to the rapid changes in barometric pressure from the low pressure weather front. Because UCP-1 did not respond to pumping, laboratory data from the consolidation tests of core samples from UCP-1 were used to calculate the hydraulic properties of the overlying confining layer. The calculated average coefficient of compressibility, av, of the red clay portion of the overlying confining layer, is 3.99×10^{-7} cm^2/g, and the calculated average vertical hydraulic conductivity is 3.49×10^{-11} cm/sec. Using these consolidation test data, the calculated specific storage of the red clay portion of the overlying confining layer is 3.08×10^{-7} cm-1, and the calculated hydraulic diffusivity is 1.13×10^{-4} cm^2/sec. Given that the red clay is approximately 30 feet thick and the total overlying confining layer is approximately 325 feet thick, the hydraulic resistance is about 830,200 years for the red clay and 9,000,000 years for the entire confining layer. Assuming an average effective porosity of the overlying confining layer of 2.0 percent, the travel time through the red clay portion of the upper confining layer would be about 16,600 years and that of the entire upper confining layer would be about 180,000 years under unit gradient.

Because the vertical hydraulic conductivity of the underlying confining layer (Pierre Shale), as determined from the laboratory consolidation tests, is of the same order of magnitude as the vertical hydraulic conductivity of the upper confining layers (10 to 11 cm/sec) little drawdown of LCP-1 resulted. The calculated average coefficient of compressibility, av, of the Pierre Shale is 5.13×10^{-7} cm^2/g, and the calculated average vertical permeability is 3.63×10^{-11} cm/sec. Using these consolidation test data, the calculated specific storage of the top 5 feet of the underlying confining layer (Pierre Shale) is 2.78×10^{-7} cm^{-1}, and the calculated hydraulic diffusivity is 5.22×10^{-3} cm^2/sec. Applying the Neuman-Witherspoon Method to the data from the aquifer test and the consolidation test produces a field vertical hydraulic conductivity of 1.45×10^{-9} cm/sec. Oil test holes have shown that the Pierre Shale is approximately 1,200 feet thick in the vicinity of the aquifer test site. Therefore, the calculated hydraulic resistance, c, using field measured vertical hydraulic conductivity, is about 799,900 years. The calculated hydraulic resistance using the vertical hydraulic conductivity calculated from the laboratory consolidation tests is about 31,919,000 years. The average effective porosity of the Pierre Shale is estimated to be 2.0 percent. Therefore, the travel time through the Pierre Shale would be about 16,000 years using field determined vertical hydraulic conductivity and about 638,000 years using laboratory determined vertical hydraulic conductivity under unit gradient.

The overlying aquifer monitor well, BMW-1, showed no response to the pumping from the Basal Chadron Sandstone during the aquifer test. However, this well did respond to barometric changes that occurred during the aquifer test. Because BMW-1 did not respond to pumping, it is evident that the overlying aquifer is not in hydraulic communication with the Basal Chadron Sandstone. Therefore, the test data from BMW-1 were not further analyzed. Further, the piezometric surface of the Basal Chadron Sandstone is approximately 495 feet above the top of the aquifer, and the piezometric surface of the overlying aquifer is about 204 feet above the top of the Brule Sand. The difference between the piezometric surfaces of the two aquifers is about 59 feet. This also supports the theory that the Basal Chadron Sandstone is confined and that it is not hydraulically connected to the overlying aquifer.

The results of Test #2 indicate the Basal Chadron Sandstone, which is the ore-bearing aquifer, is a non-leaky, confined, slightly anisotropic aquifer. The effective transmissivity of the Basal Chadron Sandstone is 2726 gpd/ft. The average thickness of the aquifer at the test site is about 40 feet. Therefore, the average hydraulic conductivity is about 68 gpd/ft^2 (9.10 ft/day). The average storativity is 1.04×10^{-4}. The azimuth and magnitude of the major axis of transmissivity are about 51° and 2760 gpd/ft (369 ft^2/day). The azimuth and magnitude of the minor axis of transmissivity are about 141° and 2692 gpd/ft (360 ft^2/day).

The aquiclude which overlie and underlie the Basal Chadron Sandstone probably yielded some small amount of water as recharge (leakage) to the aquifer during the pumping of the aquifer test. However, the amount of this recharge or leakage was extremely small, as evidenced by the piezometer responses and the drawdown analysis of the Basal Chadron Sandstone. The overlying confining layer piezometer did not show any response attributable to the pumping. The underlying confining layer piezometer did show a maximum drawdown of 0.06 foot about 4300 minutes after pumping began. However, it is suspected that this small amount of drawdown is attributable to leakage at the annulus of the packer and borehole rather than to leakage from the confining layer.

The lack of substantial drawdown in the confining layer piezometers is attributable to the extremely low vertical hydraulic conductivity of the confining layers. The vertical hydraulic conductivity of the overlying confining layer is about 2.8×10^{-10} cm/sec to 3.49×10^{-11} cm/sec, and that of the underlying confining layer is about 1.45×10^{-9} to 3.63×10^{-11} cm/sec, based on the first and second aquifer test results, which is evident of an aquiclude. The calculated hydraulic resistance of the entire thickness of the overlying aquiclude is between 1,050,000 and 9,000,000 years and that of the underlying aquiclude is between 799,900 years and 31,919,000 years. The times needed for a given water molecule to travel through the entire thicknesses of the aquiclude under unit gradient (one foot of head loss per foot of movement in the direction of flow) are about 21,000 to 180,000 years for the upper aquiclude and about 16,000 years to 638,000 years for the lower. Because the gradients would be much smaller during mining, actual travel times would be much longer than those stated above.

The piezometric surface of the Basal Chadron Sandstone dips approximately to the north at a gradient of 7.84×10^{-4}, which is equal to 1 foot per 1,275 feet. Using a directional hydraulic conductivity of 9.11 ft/day, a gradient of 7.84×10^{-4}, and a porosity of 29 percent, the average pore velocity across this part of the commercial study area was about 9.00 ft/year. The groundwater flux across the test site was computed to be about 0.29 ft^3/day per unit width of the aquifer.

Using the Cooper-Jacob Distance-Drawdown Method (Cooper and Jacob 1946), the ROI of the aquifer test in the Basal Chadron Sandstone was calculated to be about 5,000 feet. Therefore, the area investigated and characterized by Test #2 was approximately 1,803 acres.

Third Aquifer Test

A third groundwater pumping test (Test #3) was conducted in Sections 12 and 13, Township 31 North, Range 51 West, Dawes County, Nebraska between September 11, 1996 and September 13, 1996 for a duration of 55 hours. The recovery period monitoring was conducted between September 13, 1996 and September 15, 1996 and endured 44 hours. This test consisted of pumping one well (CPW96.1) completed in the Chadron Sandstone and monitoring groundwater levels in three wells (COW96.1, RC-4, A251/62) in the Chadron Sandstone, and in one well (BOW96.1) in the overlying Brule Formation. The pump test was performed using a 5 HP electrical submersible pump powered by a portable generator, which was set at a depth of 200 feet in well CPW96.1. Discharge pumped from the well was measured and recorded using a digital flow meter, and water levels were measured manually with a battery-powered level meter. Water levels in each observation well were digitally measured with a pressure transducer and recorded using a data-logger.

Aquifer pump test data were analyzed using conventional techniques including, log-log, semi-log, and distance drawdown methods developed by Theis, Jacob, and Cooper and Cooper and Jacob, respectively, using the Aquifer Test software package (Waterloo Hydrogeologic, Inc.). Data were analyzed to determine aquifer response to pumping and assess the hydraulic properties of the Chadron Sandstone.

The average pumping rate was determined to be 51.2 gpm, and the drawdown of the pumping well (CPW96.1) was 65 feet. The drawdowns measured in the observation wells COW96.1, RC-4, A251/62 were 11.3 ft, 9.2 ft, and 4.5 ft, respectively. Average transmissivity (T) ranged from 300 to 350 ft^2/day. Average hydraulic conductivity (k) ranged from 8.9 to 10.3 ft/day, and average storativity ranged from $1.1x10^{-4}$ to $7.0x10^{-5}$. Results of T, k, and storativity analyses are based on type-curve match points derived from late-time data during both pumping and recovery periods. No response to pumping or recovery period was observed in the well completed in the Brule Formation (BOW96.1). Minor fluctuations, however, in water level were observed in the Brule well, which may be attributed to barometric variations and changes in ambient temperature. The ROI was determined to be approximately 5,700 ft and to span the entire portion of the northern License area.

Test results demonstrate the integrity of the confining layer above the mining zone and the homogeneity and isotropy of the Chadron Sandstone in the northern portion of the CBR License area. Therefore, results confirm the integrity of the confining layer between the Chadron Sandstone and the Brule Formation.

Fourth Aquifer Test

A fourth aquifer test (Test #4) was performed in the areas of new mining development in the southeastern portion of the CBR License area, Township 31 North, Range 52 West, between August 19, 2002 and August 25, 2002. The pump test endured 64.5 hours and recovery monitoring was completed between 22 and 26 August. Test #4 involved the installation of one new pumping well (CPW2002) at a depth of 740 ft and four new observation wells (COW2002, CM9-04, CM9-13 and CM9-14) at depths ranging from 740 to 840 ft in the Chadron Sandstone. Also, one new monitoring well (SM9-10) was installed in the Brule Formation at a depth of 250 ft.

Test #4 was performed using a 7.5 HP electrical submersible pump powered by a portable generator and set to an approximate depth of 440 ft in well CPW2002. Water levels in each well were measured using pressure transducers and recorded using data loggers for the duration of the test. The average pumping rate was 50.2 gpm. The drawdown in the pumping well at the end of the pumping period was 45.3 ft. Drawdown in the Chadron observation wells (CM9-04, CM9-13, CM9-14, and COW2002) were 4.9 ft, 5.8 ft, 5.2 ft, and 2.4 ft, respectively. No drawdown was observed in the Brule Formation observation well (SM9-10).

Similar to Test #3, aquifer pump data for Test #4 were analyzed using conventional techniques including, log-log, semi-log, and distance drawdown methods developed by Theis, Jacob, and Cooper and Cooper and Jacob, respectively, using the Aquifer Test software package (Waterloo

Hydrogeologic, Inc.) and based on an average aquifer thickness of 40 ft. Analyses of T, k, and storativity are based on type-curve match points derived from middle-time data during both pumping and recovery periods. Assumptions made in the analyses included a constant flow rate in an infinite, homogeneous, and isotropic aquifer. ROI was determined based on distance-drawdown analysis of data from pumping well COW2002 and observation wells CM9-04, CM9-13, and CM9-14, as well as a minimum drawdown of 1.0 ft.

T values for the observation wells in the Chadron Sandstone ranged from 658 ft^2/day (CM9-14) to 1,261 ft^2/day (COW2002) and averaged 826 ft^2/day. Hydraulic conductivity (k) values ranged from 16.4 ft/day (CM9-14) to 31.5 ft/day (COW2002) and averaged 20.6 ft/day. Storativity values ranged from $4.8x10^{-5}$ to $8.2x10^{-5}$. Distance-drawdown analysis of observation well data produced a T value of 747 ft^2/day and a storativity of $8.1x10^{-5}$. No significant response to pumping or recovery period was observed in the Brule Formation observation well. The ROI was found to be approximately 5,500 ft and to encompass the entire southern portion of the License area.

Analysis of pumping well COW2002 data produced the highest T and k values. Storativity values imply a highly confined aquifer. Minor water level fluctuations observed in the wells during the test may be attributed to mining operations occurring in Mine Units 5 and 7 as well as barometric effects.

Results

Table 2.7-9 summarizes the results of the four aquifer tests performed at the Crow Butte Project between 1982 and 2002. Duration of the four pump tests ranged from 51 to 72 hours and averaged 61 hours. Test pumping rates ranged from about 24 to 51 gpm and averaged 43 gpm. Minimum transmissivity was 330 ft^2/day (Test #2) and maximum transmissivity was 836 ft^2/day (Test #4). Average transmissivity was 479 ft^2/day. Hydraulic Conductivities ranged from 9.0 ft/day to 20.6 ft/day and averaged 12.13 ft/day. Average storativity was calculated to be $8.8x10^{-5}$ and ranged from $9.0x10^{-5}$ to $1.0x10^{-4}$. Average ROI was 5,050 ft and ranged from 4,000 (Test #1) to 5,700 ft (Test #3).

Analysis of Results

The increase in transmissivity from Test #1 to Test #4 is expected as average aquifer thickness is about 33 ft in the northern License area and 45 ft in the southern License area. Tests #1 and #2 characterized the aquifer as anisotropic to slightly anisotropic, whereas Tests #3 and #4 characterized the aquifer as isotropic. The differences in isotropy may be attributed to more variability in hydraulic conductivities in the central portion of the License area (sites of Test #1 and #2) compared to the northern (site of Test #3) and southern portions (site of Test #4) of the License area. Higher k values found in Test #4 may indicate that higher quality sand is found in the southern portion of the License area compared to the northern portions of the property. Even though the k value was determined to be higher for Test #4 than the other tests, they are all the same order of magnitude, which indicate a homogeneous aquifer. Low storativity values from all tests indicate a confined aquifer. Decreasing storativity values from north to south within the License area may imply a more deeply confined aquifer in the south. Test results also indicated a non-leaky aquifer.

Conclusions

In general, pump test results indicate that the Chadron Sandstone is relatively homogeneous within the Crow Butte Project. Results demonstrate the integrity of the confining layer above the mining zone throughout the License area. Due to the stability of the confining layer above the mining zone, it is likely that the mining development at the site will not significantly impact the aquifer.

2.7.2.3 Marsland Expansion Area Hydrology

Groundwater occurrence and flow direction is described in Section 2.7.2.1 of the MEA TR and incorporated into this Combined ER/TR.

In the vicinity of the MEA, 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. 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, in areas where the Arikaree Group is deeply dissected by erosion, the Arikaree Group is not typically considered to be a reliable water source; however, within the MEA, the Arikaree Group is locally used for domestic and livestock purposes.

The Arikaree Group and Brule Formation within the MEA meet the NDEE 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. 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.

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 is 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 and water quality data (Figure 2.7-10). Nine of the ten wells encountered measurable water (Figure 2.7-11a through 2.7-11d; Table 2.7-10). 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 measurable water during well development or monitoring, even though a review of the well completion data indicate that the screened interval is below the observed potentiometric surface shown in Figure 2.7-11a. This well demonstrates the potential for locally restricted groundwater flow and overall unreliable nature of water within the Arikaree Group that has been observed elsewhere in Dawes and Sioux Counties.

A total of 10 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 $1.0x10^{-4}$ to $2.9x10^{-3}$ cm/sec. By contrast, the remaining core samples from the Arikaree Group are silt-dominated and have calculated hydraulic conductivity values ranging from $2.3x10^{-5}$ to $9.2x10^{-5}$ cm/sec. Based on grain size distributions, the average intrinsic permeability of sand-dominated units within the Arikaree Group is estimated to be approximately $1.5x10^{-6}$ cm^2.

Brule Formation

Within the Brown Siltstone Member of the Brule Formation, sandy siltstones, overbank sheet sandstones, and occasional thick 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, 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 from a 16-inch well. This variability in flow rate between 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 Brown Siltstone Member is a channel sandstone that has incised into the underlying Whitney Member 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. Figures 2.9-12a through 2.9-12d shows the potentiometric surface as determined by groundwater level gauging of the 11 water wells that are 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 overlying 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 13 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 13 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 $1.4x10^{-4}$ cm/sec and 2.3×10^{-4} cm/sec, respectively. By comparison, the geometric mean of all samples collected from the Brule Formation is 8.9×10^{-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.

Falling Head Permeameter Testing (ASTM D5084) of core sample (M-2169c, Run 5, Sample 1) from the Brule Formation returned an average measured hydraulic conductivity value of 1.31×10^{-7} cm/s. The same core sample (M-2169c, Run 5, Sample 1); using the Kozeny-Carmen equation to calculate hydraulic conductivity based on particle grain size, results in an estimate of 5.4×10^{-5} cm/s. The difference between the two results is most likely due to the presence of high plasticity clay-sized particles that can result in an over estimated hydraulic conductivity value when calculated using the Kozeny-Carmen equation.

The coefficient of variation (standard deviation divided by geometric mean) for all Brule Formation samples calculated using Kozeny-Carmen are 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.

Basal Sandstone of the Chadron Formation

Water levels for the basal sandstone of the Chadron Formation were measured at 13 sites in October 2013, January 2014, April 2014, July 2014. The static water level for wells screened in the basal sandstone of the Chadron Formation in the vicinity of the MEA typically ranges from approximately 399 to 680 feet bgs. Groundwater elevations measured during the measurement events ranged from approximately 3,687 to 3,704 feet amsl. Potentiometric surface maps and groundwater flow directions for the sampling events are depicted on Figures 2.9-13a through 2.9-13d. Groundwater in the basal sandstone of the Chadron Formation flows predominantly to the northwest toward the White River drainage at a lateral hydraulic gradient of 0.0004 ft/ft (Aqui-Ver 2011). It does not appear, based on the four consecutive quarterly measurements that there are seasonal or annual changes in the groundwater flow. Regional water level information for the basal sandstone of the Chadron Formation is currently only available in the vicinity of the Crow Butte Project.

2.7.2.3.1 Aquifer Testing

Prior to initiation of ISR mining activities, the NDEE 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. Testing activities and findings from pumping test activities in the MEA are summarized below.

Prior to testing activities, CBR installed 14 monitoring wells in the basal sandstone of the Chadron Formation (CPW-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 2.7-2). Well information for wells used during the 2011 pumping test is summarized in Table 2.7-11. 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 a period of 7 days before initiating the pumping test. The locations of wells used during pumping test #8 are shown in Figure 2.7-14. 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.

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.

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 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 2.7-12. 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 8.82×10^{-3} cm/sec based on an average net sand thickness of 40 feet and a mean transmissivity of 1,012 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 2.56×10^{-4} (ranging from 1.7×10^{-3} to 8.32×10^{-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 Crow Butte Project, TCEA, and NTEA (Table 2.7-13). 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-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.

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.

2.7.2.3.2 Hydrologic Conceptual Model for the Marsland Expansion Area

Discussions below describe the upper and lower confining units and the hydrologic conditions for the water-bearing intervals present at the MEA.

<u>Confining Layers</u>

Upper confinement for the basal sandstone of the Chadron Formation within the MEA is represented by 360 to 450 feet of smectite-rich mudstone and siltstones of the upper Chadron and middle Chadron. Particle grain-size analyses of five core samples from the upper confining layer within the MEA indicate the samples were predominately siltstone. All MEA core samples were laboratory tested using ASTM D4464 methods for determining particle-size distributions by laser light scattering. The procedure is a modification of ASTM D4464-85 used to measure particle sizes of catalytic material. The procedure has been extended to include measurement of unconsolidated soils and sediments and is recognized as an alternative to ASTM D422 (hydrometer) and the pipette method. X-Ray Diffraction (XRD) analyses indicate that the chemical compositions 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 contributing source of materials for the overlying middle Chadron.

The estimated hydraulic conductivities for the upper confining units were developed using the Kozeny-Carmen method based on particle grain-size distribution data from the five core samples collected from the upper Chadron and middle Chadron. Use of the Kozeny-Carmen method is acceptable for developing hydraulic conductivity estimates for sands and silts, but not for cohesive clayey soils with a high degree of plasticity. Results of the particle size distribution analyses indicate sediments dominated by silts and fine sand with less than 25% clay. Estimated hydraulic conductivities of the three core samples collected within the upper Chadron ranged from $4.3x10^{-5}$ to $5.9x10^{-5}$ cm/sec. Estimated hydraulic conductivities of the two core samples collected within the middle Chadron ranged from $1.7x10^{-5}$ to $2.9x10^{-5}$ cm/sec.

Falling Head Permeameter Testing (ASTM D5084) of core sample (M-1635c, Run 3, Sample 1) from the upper Chadron Formation returned an average measured hydraulic conductivity value of $1.32x10^{-7}$ cm/s. The same core (M-1635c, Run 3, Sample 1) using the Kozeny-Carmen equation to calculate hydraulic conductivity based on particle grain size returned an estimate of $4.3x10^{-5}$ cm/s. The difference between the two results is most likely due to the presence of high plasticity clay-sized particles that can result in an over estimated hydraulic conductivity value when calculated using the Kozeny-Carmen equation.

Hydraulic resistance to vertical flow is expected to be high due to the significant thickness of the upper confining zone which ranges from 360 to 450 feet. Vertical anisotropy will result in even lower vertical hydraulic conductivities across both the upper and lower confining layers. As a result, the Brule Formation and Arikaree Group are vertically and hydraulically isolated from the underlying aquifer.

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. 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. The swelling nature of these clays in the presence of water makes it unlikely that any fractures or penetrations within the Pierre 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 $1x10^{-10}$ cm/sec (WFC 1983a), 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. Kozeny-Carman estimated hydraulic conductivities for the seven core samples collected within the Pierre Shale were not reported due to significant levels (up to 76 weight percent) of clay.

Results of the particle size distribution analyses indicate sediments dominated by silts and clays. Estimated hydraulic conductivities of the four core samples collected within the upper Chadron and middle Chadron ranged from $1.7x10^{-5}$ to $5.9x10^{-5}$ cm/sec. Estimated hydraulic conductivities of the two core samples collected from within the middle Chadron ranged from $1.7x10^{-5}$ to $2.9x10^{-5}$ cm/sec. Hydraulic conductivities for the seven core samples collected 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 700 ft.

Hydrologic Conditions

Potentiometric maps and cross-sections of the basal sandstone of the Chadron Formation indicate confined groundwater. 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.

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 Crow Butte Project 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 Brown Siltstone 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. 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.

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 discernable drawdown in the overlying Brule Formation observation wells screened throughout the MEA.
- 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.
- Significant historical differences exist in geochemical groundwater characteristics between the basal sandstone of the Chadron Formation and the Brule Formation.
- Site-specific XRD analyses, particle grain-size distribution analyses, and geophysical logging confirm the presence of a thick (between 360 and 450 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.
- Falling Head Permeameter testing of two core samples M-2169c, Run 5, Sample 1 (Brule Formation) and M-1635c, Run3 (Chadron Formation), measured hydraulic conductivities of 1.31×10^{-7} and 1.32×10^{-7} cm/s, respectively.
- Analyses of particle size distribution results using the Kozeny-Carmen equation suggests a conservative maximum hydraulic conductivity of 5.9×10^{-5} cm/s for core samples from the upper confining layer and an average estimated hydraulic conductivity of 3.7×10^{-5} cm/s. Actual hydraulic conductivities are expected to be at least one to two orders of magnitude lower as demonstrated by Falling Head Permeameter Testing of the core samples.
- Hydraulic resistance to vertical flow is expected to be high 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.

2.7.2.4 Groundwater Quality

2.7.2.4.1 Crow Butte Project

Monitoring was conducted to establish baseline groundwater quality conditions in the Crow Butte Project. The program was conducted in 1996 and 1997 and included samples from a Basal Chadron well (Well 81) and Brule well (Well 78). The radiological results of baseline sampling for these wells and a detailed analysis are included in Chapter 6. These data establish the groundwater conditions associated with the mineralized Basal Chadron sandstone and Brule in the Crow Butte Project at a location immediately outside and northeast of the license area.

Table 2.7-14 through Table 2.7-23 are the Baseline and Restoration Values for Mine Units 1 through 10 in the Crow Butte Project. The ore body 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 concentration of these parameters outside of the zone.

Available groundwater data for both the Brule and Chadron do not indicate that there are any documented flow rate variations or recharge issues that would impact groundwater quality. There are no surface water ponds within the area, and only limited stream flow (Section 2.7.1). The Brule, while considered an overlying aquifer, is not an extensive or exceptionally productive system. The available monitoring data do not indicate any seasonality or pumping effects by domestic wells within this zone. With respect to the Basal Chadron sandstone, there are no domestic wells completed within this interval in the immediate License area, and there is no information to indicate that there are recharge or flow rate issues associated with the Basal Chadron sandstone that would affect groundwater quality.

During the course of mining, the water quality is expected to change as outlined in Table 2.7-24. The chemicals used in the mining and recovery process will include sodium bicarbonate, an oxidizer (such as oxygen), carbon dioxide, and chloride for elution. 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 ion exchange 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. Historic restoration activities at the Crow Butte Project have demonstrated the ability to successfully restore groundwater to established restoration standards.

2.7.2.4.2 Marsland Expansion Area

Baseline groundwater quality for the MEA is provided in Section 2.9.3 of the MEA TR and has been incorporated into Section 2.9.4 of this Combined ER/TR.

2.7.3 References

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Table 2.7-1. Comparison of Mean Monthly Precipitation with Normal Mean Monthly Discharge of the White River at Crawford, Nebraska

Month	Mean Precipitation [a]		Mean Discharge [b]	
	inches	centimeters	ft^3/sec	m^3/sec
January	0.61	1.55	21	0.59
February	0.76	1.93	23	0.65
March	1.74	4.42	27	0.76
April	2.65	6.73	25	0.71
May	3.11	7.9	27	0.76
June	2.42	6.15	22	0.62
July	2.77	7.04	16	0.45
August	1.21	3.07	13	0.37
September	1.38	3.51	14	0.4
October	1.66	4.22	17	0.48
November	0.82	2.08	19	0.54
December	0.79	2.01	20	0.57

Notes:
[a] - Climatology of the US No. 81, 1971-2000, NOAA, 25-Nebraska
[b] – USGS National Water Information System for USGS gaging station 06444000
m^3/sec = cubic meters per second

Table 2.7-2. Normal Mean Monthly Discharge of the White River at Crawford (06444000), Nebraska, 2001 through July 2024

Month	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
January	21.0	22.9	22.6	23.0	23.5	24.1	20.7	29.2	30.0	31.0	33.2	25.9
February	24.3	23.6	24.0	24.8	--	26.0	27.2	20.6	22.8	28.2	38.1	26.5
March	27.0	26.8	26.4	25.9	--	26.4	22.9	23.8	24.1	28.5	29.3	29.3
April	26.4	25.3	26.5	22.7	--	25.9	23.3	22.6	30.4	28.3	26.6	24.7
May	24.7	23.9	25.9	21.1	--	23.2	20.2	25.4	26.0	35.6	32.7	20.7
June	18.6	16.6	23.2	17.1	24.2	17.8	15.9	21.1	32.5	39.0	29.0	15.4
July	14.4	10.3	13.2	17.4	32.7	11.0	10.0	13.8	26.3	26.2	19.9	10.9
August	12.5	10.1	11.7	11.3	17.8	9.9	4.1	10.3	20.9	18.1	16.6	8.5
September	12.9	13.7	23.3	17.8	12.1	14.9	8.8	13.5	18.8	16.7	15.9	10.8
October	17.2	18.1	17.5	22.2	18.5	18.6	14.3	15.6	21.3	20.8	20.4	16.1
November	22.0	22.3	22.6	--	21.0	21.4	17.7	17.5	23.2	24.7	23.3	19.0
December	22.2	22.2	23.1	22.9	36.4	21.5	24.3	29.7	30.7	25.3	26.6	21.8
Average	**20.3**	**19.7**	**21.6**	**20.6**	23.3	20.1	17.4	20.3	25.6	26.9	26.0	19.1
Monthly	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
January	24.4	25.3	31.0	27.2	32.8	29.5	27.2	30.3	24.4	28.4	24.0	42.1
February	21.3	30.8	27.7	27.9	29.5	29.1	28.3	30.4	33.3	25.7	26.4	31.5
March	22.9	37.2	27.8	29.1	28.2	31.0	71.3	31.4	27.3	25.4	25.5	31.2
April	25.1	28.5	27.7	30.8	28.9	31.3	37.0	30.0	28.2	24.9	27.3	34.1
May	22.2	32.1	37.1	31.9	31.4	34.9	39.0	26.1	25.8	24.8	43.1	29.3
June	20.0	26.1	35.5	21.4	23.1	25.3	32.1	20.8	18.8	20.6	36.1	22.2
July	14.8	19.9	26.9	16.2	19.2	19.5	23.7	15.1	14.6	14.5	30.3	15.9
August	13.7	17.7	19.2	21.4	17.4	17.5	21.1	11.3	11.6	16.3	21.1	
September	12.2	21.1	16.3	18.5	15.2	16.0	20.6	14.7	13.5	13.8	21.1	
October	22.4	21.4	23.0	21.3	21.6	21.8	25.0	19.1	18.2	17.2	26.3	
November	26.3	30.8	24.6	24.6	22.0	25.4	28.4	21.7	20.8	19.8	27.9	
December	27.2	27.7	22.4	30.7	28.6	24.4	30.3	23.7	22.5	41.3	28.5	
Average	**21.0**	**26.5**	**26.6**	**25.1**	**24.8**	**25.5**	**32.0**	**22.9**	**21.6**	**22.7**	**28.1**	**29.5**

Source: USGS 2024 and NeDNR 2024

Table 2.7-3. Stream Gaging Stations on Niobrara River in Vicinity of Headwaters of Niobrara River

Location ID	Name	Latitude (WGS 84)	Longitude (WGS 84)	Period of Record
06454000	Niobrara River at Wyoming-Nebraska State	42° 39′ 9″	104° 3′ 5″	10/1/94 - current
06454050	Niobrara River at 33 Ranch	42° 34′ 31″	103° 56′ 7″	1/1/94 - current
06454100	Niobrara River at Agate	42° 25′ 24″	103° 47′ 33″	10/1/91 – current
06454500	Niobrara River above Box Butte Reservoir	42° 27′ 34″	103° 10′ 15″	10/1/45 - current
06455500	Niobrara River below Box Butte Reservoir	42° 27′ 23″	103° 4’ 9″	10/1/41 - current

Table 2.7-4. Water Flow Measurements for Upper Reaches of Niobrara River – 2011 to 2024

Year	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Niobrara River at Wyoming State Line (USGS 0645400)													
2011	Mean	3.3	17.7	16.6	5.1	7.3	5.4	3.4	2.8	2.7	3.2	3.7	3.7
	Max	4.5	136.0	142.0	5.7	11.4	8.1	4.5	2.9	2.9	3.6	3.8	3.9
	Min	2.8	3.1	5.2	4.9	4.7	4.3	2.7	2.7	2.6	2.9	3.5	3.6
2012	Mean	3.8	3.9	7.2	3.6	3.3	2.2	2.3	2.3	2.2	2.6	3.0	3.2
	Max	3.9	4.3	45.7	3.9	4.1	2.7	3.0	2.6	2.5	2.9	3.1	3.4
	Min	3.8	3.7	3.7	3.4	2.6	2.0	1.8	2.0	2.0	2.5	2.9	3.0
2013	Mean	2.7	3.3	3.8	5.0	3.9	2.2	1.9	1.7	1.4	4.0	3.2	3.4
	Max	3.5	3.5	4.2	9.1	4.5	3.4	2.5	2.0	1.9	9.8	3.4	4.5
	Min	1.4	2.9	3.4	4.2	3.3	1.6	1.6	1.4	1.2	1.9	2.8	2.6
2014	Mean	3.5	3.4	38.2	5.0	4.3	3.5	3.0	2.5	2.9	3.2	3.3	3.6
	Max	4.1	9.0	346.0	5.9	5.2	4.4	3.4	3.1	4.4	3.6	3.4	3.7
	Min	2.8	2.2	2.1	4.7	3.7	2.9	2.5	2.1	2.7	3.1	3.1	3.4
2015	Mean	3.7	4.0	4.2	5.0	8.9	30.0	6.0	4.5	3.4	3.8	4.4	4.5
	Max	4.0	4.2	4.3	6.6	17.3	429.0	27.1	6.2	3.5	4.5	4.8	5.0
	Min	3.6	3.9	3.9	4.0	6.1	5.5	4.3	3.5	3.2	3.4	3.8	3.8
2016	Mean	4.7	5.1	6.2	7.4	8.9	3.6	3.0	2.7	2.5	2.9	2.8	3.1
	Max	4.8	5.7	7.7	10.5	10.9	5.6	4.5	3.7	2.8	3.1	3.1	3.4
	Min	4.5	4.4	5.4	6.3	5.8	2.7	1.9	2.5	2.4	2.7	2.6	3.0
2017	Mean	3.7	4.6	5.6	5.5	4.2	3.0	1.9	2.1	2.3	3.0	3.5	3.7
	Max	4.3	4.9	6.3	6.9	5.5	3.5	2.2	2.5	2.8	3.3	3.8	4.0
	Min	3.3	4.2	5.0	5.0	3.4	2.3	1.6	1.8	1.9	2.8	3.3	3.3
2018	Mean	3.4	3.9	5.8	6.5	5.3	4.9	3.0	2.8	2.9	3.5	3.8	4.1
	Max	3.5	7.8	7.4	11.4	8.4	6.7	3.9	2.9	3.4	4.3	4.4	4.5
	Min	3.1	3.0	4.8	5.4	4.3	3.9	2.5	2.6	2.7	3.4	3.5	3.8
2019	Mean	3.7	3.4	15.6	8.4	7.0	4.6	4.1	2.9	3.1	3.6	4.1	4.8
	Max	3.9	3.9	111.0	11.9	8.1	5.8	6.0	3.4	3.4	3.9	4.8	5.0
	Min	3.4	3.2	2.1	7.5	5.9	3.9	3.3	2.8	2.8	3.3	3.4	4.6
2020	Mean	4.4	4.7	8.7	7.0	5.0	3.5	2.5	2.5	2.2	2.8	3.2	3.1
	Max	4.8	5.9	10.1	8.9	5.5	4.4	2.9	3.1	2.5	3.3	3.4	3.5
	Min	4.2	4.0	6.1	5.5	4.3	2.3	2.2	1.9	1.9	2.4	2.9	2.8
2021	Mean	3.5	3.5	4.1	4.7	3.9	3.2	2.3	2.3	2.5	3.2	3.6	3.3
	Max	3.9	4.0	6.7	5.6	4.4	7.4	2.7	2.8	2.6	3.9	3.7	3.6
	Min	3.3	3.3	3.4	4.1	3.4	2.3	2.1	2.1	2.4	2.5	3.3	2.8

Table 2.7-4. Water Flow Measurements for Upper Reaches of Niobrara River – 2011 to 2024 (Cont.)

Year	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2022	Mean	3.2	3.5	4.2	4.0	3.6	2.9	2.3	1.7	1.9	2.5	2.9	4.6
	Max	3.5	3.8	5.2	7.7	7.9	6.8	3.6	2.1	2.3	2.9	3.2	10.2
	Min	2.8	3.1	3.7	3.3	2.3	2.1	1.7	1.6	1.7	2.1	2.7	3.1
2023	Mean	3.3	3.7	4.5	5.7	4.2	8.3	8.1	3.2	3.5	4.4	4.4	4.2
	Max	3.8	4.7	7.2	9.0	7.9	86.7	18.6	4.4	4.3	9.0	5.0	4.5
	Min	3.0	3.3	3.6	3.9	3.3	2.9	3.1	2.9	3.2	3.9	4.0	3.7
2024	Mean	4.0	5.3	5.0	7.2	5.2	4.0	3.0	N/A	N/A	N/A	N/A	N/A
	Max	5.7	6.4	5.8	16.4	6.7	5.0	3.4	N/A	N/A	N/A	N/A	N/A
	Min	2.4	4.3	4.3	5.0	4.3	3.0	2.8	N/A	N/A	N/A	N/A	N/A
Niobrara River at 33 Ranch (USGS 06454050)													
2015	Mean	N/A	N/A	3.4	3.4	12.5	16.9	N/A	5.1	4.5	6.1	7.8	9.1
	Max	N/A	N/A	8.4	5.2	23.4	19.0	N/A	5.2	5.1	7.1	9.2	12.6
	Min	N/A	N/A	1.8	2.0	1.8	14.5	N/A	5.1	4.0	5.2	5.8	5.1
2016	Mean	4.8	8.3	10.4	8.6	8.8	4.0	2.6	3.2	3.7	4.4	5.2	5.4
	Max	6.6	12.0	13.3	13.9	14.7	6.1	6.2	4.4	4.3	4.9	5.9	5.9
	Min	4.2	5.6	8.7	5.3	4.3	2.2	1.4	2.4	3.2	3.7	5.0	4.8
2017	Mean	5.3	9.4	13.3	12.2	7.0	6.5	2.3	3.1	2.9	4.2	6.1	5.2
	Max	6.0	17.1	15.3	16.4	9.6	10.7	4.9	3.5	3.5	4.7	7.4	6.0
	Min	4.6	5.4	9.8	10.0	5.7	5.0	1.3	2.1	2.7	3.5	4.8	4.8
2018	Mean	5.8	5.7	15.8	10.9	6.7	5.4	3.7	2.7	2.7	5.2	6.6	5.3
	Max	6.3	6.1	34.2	14.7	9.4	6.8	4.5	3.4	4.4	6.1	7.2	7.0
	Min	5.2	4.8	5.9	5.9	5.2	4.3	3.3	2.2	2.2	4.1	5.8	3.4
2019	Mean	4.8	6.8	34.8	16.5	10.9	7.6	5.4	3.4	4.0	6.2	7.6	6.3
	Max	10.8	9.9	135.0	24.1	13.5	9.5	8.1	4.7	5.2	7.4	8.4	8.6
	Min	2.6	5.0	6.6	11.8	8.6	5.7	3.5	2.5	3.0	5.1	6.2	5.1
2020	Mean	5.9	7.6	19.0	12.4	6.2	3.2	4.1	2.4	2.5	4.3	7.5	7.0
	Max	7.8	8.0	25.7	16.7	7.9	3.9	6.9	4.3	4.2	8.6	9.3	7.2
	Min	4.3	7.2	7.9	6.0	3.7	2.5	2.3	1.6	1.5	1.9	7.0	6.7
2021	Mean	7.0	7.6	19.2	13.3	6.8	3.2	1.8	1.7	3.5	4.3	4.0	5.1
	Max	7.5	9.1	38.1	16.9	9.6	4.9	2.3	2.8	5.0	5.6	5.0	6.2
	Min	6.7	6.6	7.2	5.8	4.8	2.3	1.4	1.2	2.0	3.1	3.3	3.8
2022	Mean	4.4	5.7	14.0	10.4	9.8	13.6	1.6	1.0	2.1	4.7	5.1	4.8
	Max	4.9	8.3	22.5	15.9	17.9	26.5	3.0	1.4	3.9	6.0	7.1	6.4
	Min	3.9	4.4	7.1	4.4	6.9	3.0	0.9	0.6	1.1	2.0	2.6	3.6

Table 2.7-4. Water Flow Measurements for Upper Reaches of Niobrara River – 2011 to 2024 (Cont.)

Year	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2023	Mean	5.2	5.9	14.0	18.1	11.4	10.5	15.3	4.4	5.0	8.8	8.3	8.3
	Max	5.9	22.8	20.7	26.5	19.5	33.0	41.6	6.9	7.7	17.6	11.3	10.4
	Min	4.1	4.4	5.4	12.6	6.9	2.1	6.9	2.1	2.9	5.3	4.5	7.0
2024	Mean	7.0	15.2	13.9	15.5	8.9	4.2	2.4	N/A	N/A	N/A	N/A	N/A
	Max	10.6	17.4	16.1	20.6	12.1	5.6	4.2	N/A	N/A	N/A	N/A	N/A
	Min	4.9	11.6	12.1	8.5	6.5	2.7	1.5	N/A	N/A	N/A	N/A	N/A
Niobrara River at Agate (USGS 0645100)													
2011	Mean	12.6	22.9	32.4	18.2	24.8	14.8	7.5	5.9	7.2	10.4	14.3	11.6
	Max	16.0	63.0	102.0	22.0	36.0	25.0	10.0	9.0	10.0	13.3	15.6	14.3
	Min	10.0	12.0	20.0	16.0	17.0	9.0	6.0	4.0	6.0	6.9	12.4	10.1
2012	Mean	11.0	12.4	22.6	13.2	6.9	5.2	2.5	2.9	3.6	3.8	7.7	8.2
	Max	11.8	14.6	48.7	18.2	9.8	6.9	3.8	4.1	5.3	7.4	9.3	9.0
	Min	9.7	11.2	15.2	10.2	4.4	2.4	1.8	1.6	2.6	0.0	6.5	6.9
2013	Mean	8.4	11.3	15.0	16.1	8.6	6.4	3.4	5.3	5.0	13.4	9.9	6.6
	Max	11.1	12.8	18.5	23.0	14.9	8.8	6.0	16.3	8.0	22.9	11.6	10.3
	Min	4.5	9.8	12.5	5.2	6.1	2.8	2.2	2.9	2.7	2.3	7.5	3.9
2014	Mean	8.8	8.2	48.0	19.0	13.3	7.9	5.5	3.3	7.1	13.1	10.4	9.8
	Max	12.3	11.1	240.0	25.6	17.9	11.2	7.5	7.9	24.3	28.3	11.0	10.7
	Min	5.2	5.5	4.9	13.5	9.2	5.1	2.8	1.7	4.5	11.0	9.5	9.4
2015	Mean	10.9	18.6	16.9	15.6	26.0	75.9	13.9	9.6	9.8	13.2	16.0	14.4
	Max	15.3	21.5	19.0	20.6	44.5	783.0	20.1	12.6	10.8	15.1	18.4	18.9
	Min	9.4	15.4	15.0	14.5	13.6	13.7	8.3	7.0	9.4	11.0	14.9	8.2
2016	Mean	12.2	19.1	20.7	19.8	20.7	6.4	5.6	8.9	9.1	10.4	13.0	8.8
	Max	14.1	23.3	24.1	25.7	27.5	12.1	8.7	11.4	10.8	12.5	14.1	10.8
	Min	10.2	12.8	18.1	15.7	13.7	2.4	2.5	5.9	8.4	8.3	11.3	4.2
2017	Mean	9.0	17.6	21.4	19.6	15.7	9.2	4.9	6.1	5.7	8.5	11.4	11.1
	Max	10.5	22.5	23.4	24.0	21.5	12.0	6.7	12.3	8.2	10.2	12.2	12.5
	Min	7.5	10.7	16.4	15.7	11.5	6.9	3.2	3.3	4.2	6.4	10.6	9.1
2018	Mean	10.7	12.1	22.1	24.2	22.2	17.2	10.4	9.3	8.9	12.3	14.8	16.5
	Max	11.7	14.1	26.1	25.2	26.0	24.6	15.2	11.2	10.6	13.2	18.7	20.0
	Min	9.4	9.5	14.7	23.2	16.4	13.0	7.9	8.1	8.1	11.0	11.9	14.2
2019	Mean	15.5	15.7	93.7	32.9	25.3	19.1	14.0	12.1	10.4	13.2	15.8	15.3
	Max	19.1	18.2	320.0	48.2	31.4	27.9	37.0	23.5	12.8	14.0	17.2	17.9
	Min	13.0	13.6	15.8	24.6	19.2	13.4	8.0	9.0	9.0	11.9	14.2	9.5

Table 2.7-4. Water Flow Measurements for Upper Reaches of Niobrara River – 2011 to 2024 (Cont.)

Year	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2020	Mean	15.9	18.3	27.7	22.8	15.6	8.8	4.1	4.3	8.0	10.9	14.3	13.8
	Max	18.5	19.7	36.8	26.7	23.0	11.4	5.8	6.1	10.2	16.8	17.7	15.0
	Min	9.4	16.3	19.4	16.5	9.8	5.5	3.3	3.2	5.6	5.6	12.3	12.0
2021	Mean	14.6	15.4	28.1	22.3	12.1	7.8	3.6	3.8	5.5	6.9	8.2	9.5
	Max	15.4	18.4	45.4	27.9	14.8	10.5	5.4	7.8	6.1	8.9	8.9	12.2
	Min	11.5	12.3	10.6	15.8	10.7	5.7	2.7	2.5	4.9	6.0	7.0	6.5
2022	Mean	10.2	11.8	21.5	18.1	15.1	12.2	4.6	3.8	6.6	13.5	11.3	9.0
	Max	12.1	14.9	27.5	20.2	23.6	21.6	7.7	11.0	7.7	20.0	13.7	12.3
	Min	7.6	7.2	16.5	15.1	10.1	4.7	3.0	2.7	5.2	8.1	8.5	5.9
2023	Mean	10.1	11.4	19.4	23.9	17.4	12.1	17.4	9.0	9.8	14.1	14.7	15.3
	Max	11.4	13.0	25.9	32.1	23.2	18.5	36.1	13.0	11.6	17.7	15.6	16.9
	Min	9.3	10.6	13.2	18.1	13.0	9.2	9.6	6.2	8.0	10.6	11.9	12.6
2024	Mean	13.0	19.9	18.6	20.6	14.9	7.0	3.8	N/A	N/A	N/A	N/A	N/A
	Max	17.6	22.3	20.2	25.0	18.9	9.3	5.0	N/A	N/A	N/A	N/A	N/A
	Min	11.0	16.3	16.9	19.1	7.7	4.3	3.0	N/A	N/A	N/A	N/A	N/A
Niobrara River above Box Butte Reservoir (USGS 0645500)													
2011	Mean	17.9	20.9	49.6	36.8	48.4	34.0	15.7	10.7	12.0	16.1	20.8	21.4
	Max	26.7	26.0	68.1	43.3	95.2	59.0	25.7	13.0	13.2	19.0	23.0	23.7
	Min	12.7	14.0	37.4	32.0	26.0	24.7	7.4	7.0	10.1	12.6	17.9	18.4
2012	Mean	21.1	23.1	38.5	27.2	10.7	7.4	5.8	5.7	5.9	9.1	10.8	11.7
	Max	25.9	27.9	48.8	42.3	12.9	8.4	6.8	6.4	7.3	10.3	11.4	12.6
	Min	15.9	21.5	23.3	13.5	8.3	6.8	5.2	5.0	3.3	7.3	10.3	10.3
2013	Mean	12.0	13.9	20.5	29.8	16.8	9.7	7.3	6.4	6.6	24.3	9.2	7.2
	Max	13.7	15.4	23.9	56.9	35.5	13.1	8.9	8.2	10.4	141.0	14.3	10.1
	Min	10.2	12.6	15.1	17.5	8.3	8.0	6.1	4.8	4.9	7.8	5.1	4.5
2014	Mean	11.9	13.0	38.7	25.6	23.0	15.9	14.7	6.7	10.6	18.3	26.2	22.6
	Max	19.5	20.8	73.7	34.6	45.3	28.1	22.6	13.1	38.2	35.8	37.3	29.4
	Min	4.5	6.7	13.9	11.9	10.2	10.5	6.6	3.6	5.8	13.4	14.5	18.0
2015	Mean	23.2	35.3	33.6	38.9	58.7	73.5	29.0	15.4	14.3	20.1	27.0	25.5
	Max	29.9	47.9	40.3	58.2	88.2	152.0	39.3	20.5	17.3	23.2	29.6	27.4
	Min	20.0	25.5	30.0	28.1	29.3	40.6	19.1	13.1	13.0	17.2	23.2	24.2
2016	Mean	21.8	36.4	39.2	39.4	42.8	14.8	11.5	12.5	14.1	15.8	21.1	19.2
	Max	24.9	55.8	47.8	53.8	61.0	26.5	19.4	18.1	18.7	19.6	23.8	69.6
	Min	17.0	21.8	33.1	32.0	27.5	9.5	8.1	8.4	11.2	12.8	18.4	13.8

Table 2.7-4. Water Flow Measurements for Upper Reaches of Niobrara River – 2011 to 2024 (Cont.)

Year	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2017	Mean	15.0	31.7	41.3	41.1	39.4	18.5	9.7	12.8	9.8	15.7	19.1	19.7
	Max	18.0	55.5	55.0	59.7	60.6	29.2	15.4	22.3	15.0	16.8	20.9	26.8
	Min	12.7	15.5	34.6	30.6	26.9	10.3	8.3	8.8	8.3	13.4	15.7	15.5
2018	Mean	17.7	17.9	37.2	37.6	35.9	26.5	18.8	18.0	13.5	18.6	22.6	24.1
	Max	20.2	21.7	55.5	42.1	69.0	42.2	23.6	22.6	16.3	23.3	27.0	27.0
	Min	14.9	12.4	19.6	33.5	24.2	19.3	14.3	12.7	12.1	16.5	19.3	19.4
2019	Mean	24.5	23.6	109.8	65.6	54.1	43.3	33.4	23.8	20.9	28.1	30.6	26.4
	Max	26.0	25.3	226.0	103.0	83.8	64.6	52.7	34.1	23.3	31.9	32.6	32.0
	Min	22.0	21.7	17.4	50.5	43.0	32.0	17.9	19.1	19.0	23.3	25.9	17.2
2020	Mean	28.6	32.5	32.2	37.3	37.9	15.4	12.2	10.3	11.1	14.4	22.8	23.4
	Max	32.5	40.3	47.0	48.1	52.9	20.0	15.0	13.4	13.1	20.9	25.6	25.2
	Min	23.5	23.6	23.0	22.6	21.7	12.3	7.4	8.5	7.0	10.9	19.7	19.9
2021	Mean	22.5	25.6	48.8	45.5	31.7	19.4	11.7	7.5	8.8	15.0	19.9	20.9
	Max	26.3	35.8	61.0	49.5	40.2	28.4	18.4	9.3	17.0	20.0	21.2	26.3
	Min	18.3	17.6	31.9	36.1	28.2	13.8	7.0	6.7	7.2	8.9	18.8	19.1
2022	Mean	20.1	19.6	35.3	31.3	24.3	21.8	13.2	5.6	3.1	3.3	13.8	12.6
	Max	24.2	28.4	42.3	37.3	34.0	30.9	27.8	14.7	3.5	5.1	16.2	12.8
	Min	17.1	6.8	23.5	23.8	15.0	15.0	6.0	3.2	2.8	2.9	6.9	12.4
2023	Mean	10.8	18.1	30.1	36.1	28.6	21.2	14.9	13.8	14.7	22.4	26.5	28.5
	Max	19.7	31.1	39.2	43.7	36.6	28.7	23.7	17.8	18.5	25.4	27.6	32.8
	Min	5.7	11.3	19.3	28.8	20.8	12.8	6.1	11.5	11.3	18.6	25.5	25.2
2024	Mean	28.7	42.2	38.8	47.7	31.1	15.3	11.2	N/A	N/A	N/A	N/A	N/A
	Max	71.1	48.3	43.0	69.1	38.6	21.4	14.0	N/A	N/A	N/A	N/A	N/A
	Min	4.3	23.5	35.5	38.6	21.7	10.3	9.7	N/A	N/A	N/A	N/A	N/A
Niobrara River below Box Butte Reservoir (USGS 0655500)													
2011	Mean	0.9	0.9	0.9	1.0	1.2	1.3	100.2	76.8	20.2	2.4	0.9	0.9
	Max	0.9	0.9	1.0	1.1	2.1	2.3	138.0	115.0	109.0	31.0	1.0	0.9
	Min	0.9	0.8	0.9	0.9	1.0	1.2	1.2	1.0	0.9	0.8	0.9	0.9
2012	Mean	0.9	1.0	0.9	0.9	3.6	16.0	141.6	46.1	0.7	0.8	0.7	0.7
	Max	0.9	1.0	1.1	1.0	30.6	88.5	158.0	142.0	0.8	0.9	0.7	0.7
	Min	0.9	0.9	0.8	0.8	0.8	0.8	95.1	0.7	0.7	0.7	0.7	0.7
2013	Mean	0.8	0.8	0.8	0.9	0.9	0.9	59.0	47.6	2.8	1.1	1.6	0.8
	Max	0.8	0.8	1.0	1.1	1.1	1.1	129.0	99.9	27.0	1.2	2.9	1.3
	Min	0.7	0.8	0.8	0.9	0.8	0.9	0.9	1.1	1.0	1.0	1.1	0.7

Table 2.7-4. Water Flow Measurements for Upper Reaches of Niobrara River – 2011 to 2024 (Cont.)

Year	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2014	Mean	0.9	1.1	1.1	0.9	0.7	0.7	72.7	91.6	1.0	1.1	1.1	1.1
	Max	1.1	1.2	1.3	1.2	1.0	1.0	163.0	130.0	1.5	1.2	1.2	1.3
	Min	0.7	0.9	0.8	0.8	0.6	0.6	0.8	1.0	0.9	1.0	1.0	1.0
2015	Mean	1.0	1.1	1.1	1.2	1.3	1.2	66.0	81.7	31.1	1.1	1.1	1.1
	Max	1.1	1.1	1.1	1.4	1.7	1.4	125.0	99.5	76.0	1.3	1.6	1.1
	Min	1.0	1.0	1.1	1.1	1.1	1.1	1.1	54.2	1.0	1.0	1.0	1.1
2016	Mean	1.2	1.1	1.0	1.1	22.0	54.3	85.8	63.1	20.3	1.0	1.0	0.9
	Max	1.4	1.1	1.2	1.4	54.8	116.0	112.0	91.8	47.3	1.0	1.1	1.0
	Min	1.1	1.1	0.9	1.0	1.0	1.1	41.3	35.7	1.0	0.9	1.0	0.9
2017	Mean	0.9	1.1	1.1	1.0	14.5	73.4	92.9	105.9	67.9	38.1	0.6	14.4
	Max	1.1	1.2	1.3	1.2	55.5	98.7	117.0	157.0	122.0	60.0	0.7	42.7
	Min	0.8	1.0	1.0	1.0	1.0	60.9	53.2	75.2	31.1	0.6	0.5	0.7
2018	Mean	21.9	21.3	40.0	46.8	34.0	26.9	6.3	3.0	0.6	0.8	0.9	0.9
	Max	44.2	30.0	57.8	69.8	48.6	46.7	28.5	8.3	0.9	1.0	1.0	1.3
	Min	0.3	0.3	0.8	0.3	1.2	0.6	0.4	0.6	0.5	0.6	0.7	0.7
2019	Mean	1.4	1.6	1.6	3.4	2.8	4.2	59.4	67.2	27.5	4.4	3.9	3.0
	Max	2.2	2.0	2.2	4.8	3.4	5.1	123.0	96.3	71.2	4.9	5.0	3.7
	Min	0.9	1.2	1.1	2.3	2.2	3.4	4.7	4.3	3.4	3.7	3.2	1.7
2020	Mean	3.2	3.4	15.2	22.2	4.2	54.3	109.8	81.8	2.4	2.5	2.2	1.8
	Max	4.0	4.0	39.6	48.5	4.8	127.7	149.1	114.7	2.5	2.6	2.6	2.1
	Min	2.9	2.9	3.1	4.2	3.6	3.1	82.4	2.4	2.2	2.5	1.9	1.7
2021	Mean	1.9	2.2	2.3	2.4	2.8	16.2	122.2	87.0	3.9	1.2	1.2	1.2
	Max	2.2	2.5	2.5	2.6	3.0	128.4	144.8	116.4	70.6	1.2	1.2	1.3
	Min	1.7	2.0	2.0	2.2	2.6	2.9	102.2	47.7	0.9	1.1	1.2	1.1
2022	Mean	1.4	1.5	1.7	1.7	2.0	2.4	71.1	83.5	14.5	0.9	1.2	1.2
	Max	1.5	1.7	1.8	1.8	2.3	2.5	137.6	113.9	63.6	1.1	1.6	1.3
	Min	1.4	1.4	1.6	1.7	1.8	2.3	2.5	56.0	0.8	0.8	1.0	1.0
2023	Mean	1.1	1.2	1.4	1.7	1.9	2.3	71.8	73.4	27.4	1.0	1.0	1.3
	Max	1.1	1.3	1.6	1.8	2.1	2.8	194.0	165.8	102.0	1.2	1.1	1.5
	Min	1.0	1.1	1.3	1.5	1.7	2.0	2.7	2.7	0.9	0.8	1.0	1.0
2024	Mean	1.4	1.5	2.1	2.1	2.4	4.0	100.8	N/A	N/A	N/A	N/A	N/A
	Max	1.5	1.8	2.4	3.4	2.9	14.3	152.6	N/A	N/A	N/A	N/A	N/A
	Min	1.2	1.3	1.8	1.5	2.1	3.0	3.5	N/A	N/A	N/A	N/A	N/A

Source: USGS 2024 and NeDNR 2024

Table 2.7-5. Historic White River Water Quality Data, 1968 through 1994*

	RESULTS										
PARAMETER	**8/20/68**	**5/6/69**	**7/15/69**	**5/24/70**	**8/28/70**	**8/5/71**	**6/5/72**	**10/2/72**	**6/4/73**	**9/23/81**	**7/13/94**
Number used in sample accounting procedure	66	66	65	95	77	109	no data	no data	no data	1	1
Temperature, water (degrees centigrade)	21	18	28	18.5	21	19.5	22	12.5	17	no data	20
Temperature, air (degrees centigrade)	32	21	36	23	27	30	21	11.1	23	no data	no data
Flow, stream, mean daily (cfs)	10	22	10	22	21	12	19	12	24	no data	no data
Turbidity (jackson candle units)	41	62	10	45	337	5	36	4	4	no data	no data
Specific conductance (umhos/cm @ 25°C)	400	390	355	353	305	340	340	340	400	330	700
Oxygen, dissolved (mg/l)	7.4	8.5	6.9	7.8	7	8	8.1	9.6	7.9	no data	6.9
Oxygen, dissolved, percent of saturation	82.2321	89.4889	87.3453	82.106	77.7793	85.1096	92.0463	88.8907	81 .4491	no data	75
pH (standard units)	7.7	8.2	8.2	7.9	7	8.5	8.4	8.5	7.6	no data	8.3
Alkalinity, total (mg/l as $CaCo^3$)	208	108	180	184	168	176	192	200	189	188	no data
Residue, total filtrable (dried at 105°C) (mg/l)	258	270	250	250	220	250	240	260	no data	288	no data
Nitrogen, Nitrite (NO_2) + Nitrate (NO_3), (mg/l as N)	0.1	0.1	1	0.1	0.6	0.1	0.2	0.1	no data	no data	no data
Phosphate, total (mg/l as PO4)	0.8	0.1	0.5	0.2	0.3	0.1	0.2	0.1	no data	no data	no data
Hardness, total (mg/l as CaCO3)	176	148	168	160	156	172	160	172	172	no data	159
Calcium, dissolved (mg/l as Ca)	39	35	51	50	52	46	51	56	no data	no data	no data
Magnesium, dissolved (mg/l as Mg)	10	1	10	9	6	14	8	8	no data	no data	no data
Sodium, dissolved (mg/l as Na)	36	24	43	24	22	16	15	15	no data	no data	no data
Sodium adsorption ratio	0.4	0.9	1.5	0.8	0.8	0.5	0.5	0.5	no data	no data	no data
Potassium, dissolved (mg/l as K)	6	8	13	8	9	9	10	9	no data	no data	no data
Chloride, total in water (mg/l)	12	18	4	1	2	4	1	2	7	5	no data
Hardness, Ca Mg calculated (mg/l as $CaCO_3$)	138.563	91.513	168.527	161.912	154.552	172.514	160.291	172.776	no data	174.528	159.437

Source: EPA 2009

Table 2.7-6. Water Quality Data for the White River at Crawford [Station WH1WHITE208], 2003*

PARAMETER	RESULTS											
	1/13	02/01	03/03	04/08	05/06	06/03	07/09	08/04	09/09	10/06	11/03	12/01
Temperature, water (degrees centigrade)	0.81	6.42	5.08	9.32	13.34	18.33	21.5	12.2	No data	12.17	4.45	4.31
Flow, stream, mean daily (cfs)	22E[a]	24	25	28	25	23	15	12	18	17	24	23
Turbidity, (jackson candle units)	0.9	7.5	4.9	4.8	23.6	20.7	11.9	12.2	2711	3.4	4.4	3.8
Specific Conductance (umhos/cm @ 25°C)	386	368	367	381	383	372	374	349	No data	375	375	379
Oxygen, dissolved (mg/l)	14.20	10.9	11.51	10.92	9.56	8.5	8.83	7.85	No data	10.44	10.71	10.48
pH (standard units)	8.11	7.95	8.19	8.48	8.22	8.30	8.25	8.05	No data	8.37	8.06	8.25
Residue, total filterable (dried at 105°C), mg/l	No data	No data	No data	30	48	49	22	14	2900	No data	No data	No data
Nitrogen, Nitrite (NO_2) + Nitrate (NO_3), mg/l[b]	No data	No data	No data	0.38	0.35	0.28	0.18	0.20	0.61	No data	No data	No data
Nitrogen, Ammonia (NH_3) as NH_3, Total (mg/l)	No data	No data	No data	0.05	0.06	0.05	0.05	0.05	0.23	No data	No data	No data
Nitrogen, Kjeldahl, Total (mg/l)	No data	No data	No data	0.5	0.5	0.5	0.5	0.5	8.35	No data	No data	No data
Phosphorus as P, Total (mg/l)	No data	No data	No data	0.04	0.07	0.08	0.07	0.06	2.44	No data	No data	No data
Chloride (mg/l)	No data	No data	No data	3.59	3.67	3.61	3.04	3.65	4.68	No data	No data	No data

Source: EPA 2007 and NeDNR 2024
* Water quality data are summarized.
[a] Estimated

Table 2.7-7. Brule Water Levels (in feet above mean sea level)

Well	1982												1993	
	Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec	April	July
11**	3831.7	3831.5	3831.8	3833	3833	3833.6	3833	3832.6	3831.5	3830.6	3830.3	3830.3	3843.5*	3837
12**	3928	3924	3923	3922.7	3923.7	3921.1	3922.1	3921.5	3922.2	3921.3	3903.3*	3918.7	3922.9	3920
13	3968.5	3968.7	3968.8	3969.4	3969.6	3969.2	3969.5	3968.9	3968.1	3967.5	3968.1	3968.4	3969	3970
17	3865	3863.5	3863.3	3862.6	3863.6	3864.8	3863.3	3862.8	3863.5	3863.8	3865.3	3864.6	3864.8	3862.8
24**	3902	3910.5	3909	3903	3910.9	3910.5	3910.5	3910	3904.7	3901.5	3895.7*	3910.1	3910.4	3911
25	3870	3870.8	3870	3871	3871	3871.3	3869.5	3870.9	3870.6	3870.5	3870.8	3870.9	3870.1	3871.6
31**	3883.1	3883.1	3883.2	3883.1	3883.3	3883	3882.6	3882.3	3882.6	3880	3882.3	3882.5	3882.5*	3872.3*
64	3882	3882.9	3882.6	3883.5	3883.6	3883.8	3881.4	3880.8	3881.5	3880	3880.4	3882	3884.3	3883.5
	1982				1983									
	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	August	Sept	
RA-2	3737.1	3737	3738.5	3737.9	3739.2	3739.1	3739.7	3740.2	3740.9	3741	3739.9	3739.2	3738.1	
RB-3	3962.6	3961.2	3963.5	3963.6	3963.8	3963.8	3963.3	3969.7*	3963.7	3963.7	3964.2	3964.1	3964.2	
PM-6	------	3844.9	3844.9	------	3843.5*	3844.5	3844.9	3845.3	3845.5	3846	3845.9	3945.9	3845.7	
PM-7	------	3845.7	3845.5	------	3845.9	3845.8	3845.7	3846.1	3846.3	3846.9	3846.7	3846.7	3846.6	

Notes:
* Suspect Data
** Well may have been pumped prior to water level reading.
------ = measurement not taken

Table 2.7-8. Basal Chadron Water Levels (in feet above mean sea level)

Well	1982				1983								
	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	August	Sept
62	3748.4	3748	3747.2	3746.6	------	------	3746.1	3746.2	------	------	3746.1	3745.8	3745.4
RC-4	------	------	------	3746.7	------	------	------	3746.2	------	------	3746.2	3746.2	3746.3
RC-5	3753.6	3753.4	3753.4	3753.2	3753	3752.6	3752.7	3752.9	3752.8	3752.9	3752.7	3752.5	3752.4
RC-6	3755.2	3755.2	3755.7	3756.8	3757.5	3754.7	3754.9	3755.7	3755.6	3755.6	3755.4	3755.2	3754.7
RC-7	3755.2	3756.8	3756.3	3756.2	3756.4	3755.8	3756	3756.4	3756.5	3756.7	3756.2	3756.1	3755.9
PM-1	------	3754.5	3754.4	3754.1	3754.3	3754	3753.8	3754	3754.2	3754.1	3753.8	3753.5	3753.5
PM-4	------	3755.2	3755.2	3754.4	3754.4	3754.1	3754.2	3754.4	3754.8	3754.6	3754.3	3753.9	3754.6
PT-2	------	3747.1*	3747.1*	3754	3754.6	3754.3	3754.1	3754.3	3754.5	3754.7	3754.3	3753.9	3753.7
PT-7	------	3755.1	3755	3754.2	3754.2	3754	3754	3754.1	3754.8	3754.6	3754.3	3754.1	3753.9
PT-8	------	3755.5	3755.6	3754.6	3754.4	3754.4	3755.7	3754.4	3754.5	3754.6	3754.2	3753.8	3753.7
PT-9	------	3753.5	3753.5	3754.9	3754.6	3754.6	3754.6	3754.8	3854.8	3754.9	3754.5	3754.3	3754.1

Notes:
* Suspect Data
------ = measurement not taken

Table 2.7-9. Summary of Aquifer Pumping Tests Performed within the Crow Butte Project

Test Number	1	2	3	4	Arithmetic Average
Date Conducted (month, year)	November, 1982	June, 1987	September, 1996	August, 2002	
Test Duration (hours)	51	72	55	64.5	61
Pumping Rate (gpm)	23.8	47.2	51.2	50.2	43.1
Transmissivity (ft^2/day)	400	360	330	826	479
Hydraulic Conductivity (ft/day)	9.0	9.1	9.8	20.6	12.13
Storativity	$1.0x10^{-4}$	$1.0x10^{-4}$	$9.0x10^{-5}$	$6.2x10^{-5}$	$8.8x10^{-5}$
Radius of Influence (ft)	4000	5000	5700	5500	5050

Table 2.7-10. Water Levels - Arikaree Group, Brule Formation and Basal Sandstone of Chadron Formation

Well	TOC Elevation (ft amsl)	10/17/2013 Water Level (ft TOC)	10/17/2013 Groundwater Elevation (ft amsl)	TOC Elevation (ft amsl)	7/14/2014 Water Level (ft TOC)	7/14/2014 Groundwater Elevation (ft amsl)
ARIKAREE GROUP						
AOW-1	4261.64	126.4	4135.24	4261.64	126.3	4135.34
AOW-3	4351.97	142.2	4209.77	4351.97	142.2	4209.77
AOW-4	4161.91	87.3	4074.61	4161.91	86.5	4075.40
AOW-5	4125.42	72.0	4053.42	4125.42	71.8	4053.60
AOW-6	4068.60	20.0	4048.60	4068.60	19.4	4049.20
AOW-7	4243.94	DRY	NA	4243.94	DRY	NA
AOW-8	4365.07	71.7	4293.32	4365.07	71.5	4293.57
AOW-9	4146.41	74.9	4071.51	4146.41	76.0	4070.40
AOW-10	4198.60	113.3	4085.30	4198.60	113.5	4085.10
AOW-11	4091.02	35.4	4055.62	4091.02	34.8	4056.22
BRULE FORMATION						
BOW 2010-1	4260.10	124.9	4135.20	4260.10	124.9	4135.20
BOW 2010-2	4324.96	151.4	4173.56	4323.70	150.0	4173.70
BOW 2010-3	4352.80	139.6	4213.20	4350.50	137.2	4213.30
BOW 2010-4A	4163.13	93.7	4069.43	4163.13	90.4	4072.73
BOW 2010-5	4127.88	74.0	4053.88	4127.88	73.0	4054.88
BOW 2010-6	4100.43	50.3	4050.13	4100.43	49.6	4050.83
BOW-2010-7	4248.37	155.6	4092.77	4248.37	155.2	4093.17
BOW-2010-8	4369.29	74.0	4295.29	4366.89	71.3	4295.59
BOW-9	4145.90	74.6	4071.30	4145.90	74.6	4071.30
BOW-10	4197.84	113.8	4084.04	4197.84	112.7	4085.14
BOW-11	4091.87	37.4	4054.47	4091.87	36.9	4054.97
BASAL SANDSTONE OF CHADRON FORMATION						
CPW-2010-1	4261.35	565.3	3696.05	4261.35	570.8	3690.55
CPW-2010-1A	4263.28	567.0	3696.28	4263.28	572.4	3690.88
Monitor 1	4103.28	399.4	3703.88	4103.28	405.6	3697.68
Monitor 2	4199.50	500.3	3699.20	4199.50	505.5	3694.00
Monitor 3	4261.40	565.5	3695.90	4261.40	570.0	3691.40
Monitor 4A	4329.72	634.3	3695.42	4329.72	640.1	3689.62
Monitor 5	4340.80	645.4	3695.40	4340.80	650.7	3690.10
Monitor 6	4216.40	518.2	3698.20	4216.40	523.3	3693.10
Monitor 7	4246.28	548.0	3698.28	4246.28	553.3	3692.98
Monitor 8	4355.90	660.5	3695.40	4355.90	667.1	3688.80
Monitor 9	4367.02	669.7	3697.32	4367.02	680.1	3686.92
Monitor 10	4163.99	465.0	3698.99	4163.99	469.3	3694.69
Monitor 11	4128.07	427.9	3700.17	4126.67	431.7	3694.97

NOTES:
Groundwater elevations for the Brule Formation and Basal Chadron Sandstone are based on depth to water measurements.
TOC = top of casing
ft TOC = feet below top of casing
ft amsl = feet above mean sea level
DRY = measurable water not present in well at time of sampling

Table 2.7-11. Summary of 2011 Marsland Pumping Test #8 Well Information

Well	Distance to Pumping Well	Northing (ft)	Easting (ft)	Sec	Township Range	TOC Elevation (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.)	Static Water Elevation* (ft amsl)
Basal Chadron Sandstone Pumping Well															
CPW-1A	0.00	446,202	1,121,450	1	T29N R51W	4,262.70	4,261.10	1.60	1,055	1,019	1,022	1,052	30	4.95	NM
Basal Chadron Sandstone Observation Wells															
CPW-1	67	446,225	1,121,528	1	T29N R51W	4,261.85	4,259.80	2.10	1070	1,009	1,015	1,048	33	4.95	3,710.75
Monitor-2	8,800	439,439	1,126,362	18	T29N R50W	4,198.40	4,197.20	1.20	1027	974	970	1,010	40	4.95	3,713.83
Monitor-3	100	446,288	1,121,519	1	T29N R51W	4,261.30	4,260.20	1.10	1069	1,008	1,016	1,043	27	4.95	3,710.27
Monitor-4A	4,067	450,084	1,121,344	1	T29N R51W	4,327.49	4,326.30	1.60	1134	1,079	1,088	1,110	22	4.95	3,709.69
Monitor-5	2,800	447,734	1,119,236	1	T29N R51W	4,339.50	4,337.40	2.10	1120	1,069	1070	1,120	50	4.95	3,711.05
Monitor-6	4,667	442,856	1,124,385	12	T29N R51W	4,215.00	4,213.80	1.20	1050	989	990	1,023	33	4.95	3,712.83
Monitor-7	6,200	440,358	1,120,757	12	T29N R51W	4,244.38	4,243.20	1.20	1050	999	1,000-1,013	1,023-1,043	33	4.95	3,713.39
Monitor-8	6,800	450,974	1,117,005	2	T29N R51W	4,353.70	4,352.40	1.30	1,180	1,079	1,085	1,125	40	4.95	3,709.23
Brule Formation Observation Wells															
BOW-2010-1	133	446,250	1,121,572	1	T29N R51W	4,260.10	4,259.20	0.90	370	279	285-305	325-365	60	4.95	4,133.97
BOW-2010-2	4,167.00	450,154	1,121,367	1	T29N R51W	4,323.40	4,322.30	1.10	400	339	339-369	389-399	40	4.95	4,173.04
BOW-2010-3	6,867	450,974	1,117,056	2	T29N R51W	4,350.30	4,349.80	0.50	415	339	345-365	385-415	50	4.95	4,212.81

Notes:
* = Baseline static water elevations were measured on November 12, 2010.
1. NM = not measured
2. TOC = top of casing
3. ft = feet
4. in. = inches
5. ft bgs = feet below ground surface
6. ft amsl = feet above mean sea level

Table 2.7-12. 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	2,125
		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	1,377	1,140
		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	1,315	1,149
		Hyd. Cond. (ft/day)	25	33	29
		Storativity	3.57E-05	--	3.57E-05
Monitor 8**	6,800	Transmissivity (ft^2/day)	989	1,596	1,293
		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)	1,012
Aquifer Thickness: 40 (feet)				Avg. Hyd. Cond. (ft/day)	25
				Avg. Storativity	7.46E-05

Notes:
1. * = Water level data for CPW-1A and CPW-1 were not corrected for barometric variations due to the logging interval of the pressure transducers.
2. ** = Monitor 2 and Monitor 8 were monitored and analyzed as described in the original pumping test plan but are not part of the formal monitoring network used to establish the radius of influence.
3. Pumping started at 5:03 am on 5/16/2011 and ended at 12:00 pm on 5/20/11.
4. Hydraulic conductivity calculated based on a typical net sand thickness of 40 feet.

Table 2.7-13. 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
Hydraulic Conductivity (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}

Table 2.7-14. Baseline and Restoration Values for Mine Unit 1

Parameter	Groundwater Standard	MU-1 Baseline	MU-1 Standard Deviation	MU-1 NDEE Restoration Value
Ammonium (mg/L)	10.0	<0.372		10.0
Arsenic (mg/L)	0.05	<0.00214		0.05
Barium (mg/L)	1.0	<0.1		1.0
Cadmium (mg/L)[1]	0.01	<0.00644		0.005[1]
Chloride (mg/L)	250.0	203.9	38	250.0
Copper (mg/L)	1.0	<0.017		1.0
Fluoride (mg/L)	4.0	0.686	0.04	4.0
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)	1.0	<0.0689		1.0
Nickel (mg/L)	0.15	<0.0340		0.15
Nitrate (mg/L)	10.0	<0.050		10.0
Lead (mg/L)	0.05	0.0315		0.05
Radium (pCi/L)	5.0	229.7	177.1	584.0
Selenium (mg/L)	0.01	<0.00323		0.05
Sodium (mg/L)	N/A	412	19.2	4120
Sulfate (mg/L)	250.0	356.2	9.4	375
Uranium (mg/L)	5.0	0.0922	0.089	5.0
Vanadium (mg/L)	0.2	<0.0663		0.2
Zinc (mg/L)	5.0	<0.036		5.0
pH (Std. Units)	6.5 - 8.5	8.46	0.2	6.5 – 8.5
Calcium (mg/L)	N/A	12.5	3.2	125.0
Total Carbonate (mg/L)	N/A	351	31.1	585
Potassium (mg/L)	N/A	12.5	1.5	125.0
Magnesium (mg/L)	N/A	3.2	0.8	32.0
TDS (mg/L)	N/A	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.

Table 2.7-15. Baseline and Restoration Values for Mine Unit 2

Parameter	Groundwater Standard	MU-2 Baseline	MU-2 Standard Deviation	MU-2 NDEE Restoration Value
Ammonium (mg/L)	10.0	0.37	0.07	10.0
Arsenic (mg/L)	0.05	<0.001		0.05
Barium (mg/L)	1.0	<0.1		1.0
Cadmium (mg/L)	0.005	<0.007		0.005
Chloride (mg/L)	250.0	208.6	30.8	250.0
Copper (mg/L)	1.0	<0.013		1.0
Fluoride (mg/L)	4.0	0.67	0.04	4.0
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)	1.0	<0.073		1.0
Nickel (mg/L)	0.15	<0.037		0.15
Nitrate (mg/L)	10.0	<0.039		10.0
Lead (mg/L)	0.05	<0.035		0.05
Radium (pCi/L)	5.0	234.5	411.8	1058.0
Selenium (mg/L)	0.05	<0.001		0.05
Sodium (mg/L)	N/A	410.8	18.2	4108
Sulfate (mg/L)	250.0	348.2	10.3	369.0
Uranium (mg/L)	5.0	0.046	0.037	5.0
Vanadium (mg/L)	0.2	<0.07		0.2
Zinc (mg/L)	5.0	<0.026		5.0
pH (Std. Units)	6.5 - 8.5	8.32	0.2	6.5 – 8.5
Calcium (mg/L)	N/A	13.4	2.4	134.0
Total Carbonate (mg/L)	N/A	366.9	13.3	585.0
Potassium (mg/L)	N/A	12.6	2.5	126.0
Magnesium (mg/L)	N/A	3.5	0.4	35.0
TDS (mg/L)	N/A	1170.4	41	1170.4

Table 2.7-16. Baseline and Restoration Values for Mine Unit 3

Parameter	Groundwater Standard	MU-3 Baseline	MU-3 Standard Deviation	MU-3 NDEE Restoration Value
Ammonium (mg/L)	10.0	<0.329		10.0
Arsenic (mg/L)	0.05	<0.001		0.05
Barium (mg/L)	1.0	<0.1		1.0
Cadmium (mg/L)	0.005	<0.01		0.005
Chloride (mg/L)	250.0	197.6	16.7	250.0
Copper (mg/L)	1.0	<0.0108		1.0
Fluoride (mg/L)	4.0	0.719	0.05	4.0
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)	1.0	<0.1		1.0
Nickel (mg/L)	0.15	<0.05		0.15
Nitrate (mg/L)	10.0	<0.0728		10.0
Lead (mg/L)	0.05	<0.05		0.05
Radium (pCi/L)	5.0	165	222.5	611.0
Selenium (mg/L)	0.05	<0.00115		0.05
Sodium (mg/L)	N/A	428	27.6	4280
Sulfate (mg/L)	250.0	377.0	13.4	404.0
Uranium (mg/L)	5.0	0.115	0.158	5.0
Vanadium (mg/L)	0.2	<0.1		0.2
Zinc (mg/L)	5.0	<0.0131		5.0
pH (Std. Units)	6.5 - 8.5	8.37	0.3	6.5 – 8.5
Calcium (mg/L)	N/A	13.3	3.1	133.0
Total Carbonate (mg/L)	N/A	358.7	24.8	592.0
Potassium (mg/L)	N/A	13.9	4.0	139.0
Magnesium (mg/L)	N/A	3.5	0.9	35.0
TDS (mg/L)	N/A	1183.0	47.4	1183.0

Table 2.7-17. Baseline and Restoration Values for Mine Unit 4

Parameter	Groundwater Standard	MU-4 Baseline	MU-4 Standard Deviation	MU-4 NDEE Restoration Value
Ammonium (mg/L)	10.0	0.288	0.08	10.0
Arsenic (mg/L)	0.05	<0.00209		0.05
Barium (mg/L)	1.0	<0.1		1.0
Cadmium (mg/L)	0.005	<0.01		0.005
Chloride (mg/L)	250.0	217.5	34.9	250.0
Copper (mg/L)	1.0	<0.0114		1.0
Fluoride (mg/L)	4.0	0.745	0.05	4.0
Iron (mg/L)	0.3	<0.0504		0.3
Mercury (mg/L)	0.002	<0.001		0.002
Manganese (mg/L)	0.05	<0.01		0.05
Molybdenum (mg/L)	1.0	<0.1		1.0
Nickel (mg/L)	0.15	<0.05		0.15
Nitrate (mg/L)	10.0	<0.114		10.0
Lead (mg/L)	0.05	<0.05		0.05
Radium (pCi/L)	5.0	154.3	171.5	496.0
Selenium (mg/L)	0.05	<0.00244		0.05
Sodium (mg/L)	N/A	416.6	27.8	4166
Sulfate (mg/L)	250.0	337.2	19.3	375.0
Uranium (mg/L)	5.0	<0.122		5.0
Vanadium (mg/L)	0.2	<0.0984		0.2
Zinc (mg/L)	5.0	<0.0143		5.0
pH (Std. Units)	6.5 - 8.5	8.68	0.3	6.5 – 9.28
Calcium (mg/L)	N/A	11.2	2.9	112.0
Total Carbonate (mg/L)	N/A	374.4	28	610.0
Potassium (mg/L)	N/A	16.7	4.7	167.0
Magnesium (mg/L)	N/A	2.8	0.8	28.0
TDS (mg/L)	N/A	1221.1	73.5	1221.1

Table 2.7-18. Baseline and Restoration Values for Mine Unit 5

Parameter	Groundwater Standard	MU-5 Baseline	MU-5 Standard Deviation	MU-5 NDEE Restoration Value
Ammonium (mg/L)	10.0	0.28	0.05	10.0
Arsenic (mg/L)	0.05	<0.001		0.05
Barium (mg/L)	1.0	<0.10		1.0
Cadmium (mg/L)	0.005	<0.01		0.005
Chloride (mg/L)	250.0	191.9	7.9	250.0
Copper (mg/L)	1.0	<0.01		1.0
Fluoride (mg/L)	4.0	0.64	0.07	4.0
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)	1.0	<0.10		1.0
Nickel (mg/L)	0.15	<0.05		0.15
Nitrate (mg/L)	10.0	<0.1		10.0
Lead (mg/L)	0.05	<0.05		0.05
Radium (pCi/L)	5.0	166.0	184.6	535.0
Selenium (mg/L)	0.05	<0.002		0.05
Sodium (mg/L)	N/A	397.6	14.4	3976
Sulfate (mg/L)	250.0	364.5	10.5	385.0
Uranium (mg/L)	5.0	0.072	0.056	5.0
Vanadium (mg/L)	0.2	<0.10		0.2
Zinc (mg/L)	5.0	<0.02		5.0
pH (Std. Units)	6.5 - 8.5	8.5	0.1	6.5 – 8.5
Calcium (mg/L)	N/A	12.6	1.8	126.0
Total Carbonate (mg/L)	N/A	372	13.0	590.0
Potassium (mg/L)	N/A	11.5	1.2	115.0
Magnesium (mg/L)	N/A	3.4	0.4	34.0
TDS (mg/L)	N/A	1179.5	22.5	1202.0

Table 2.7-19. Baseline and Restoration Values for Mine Unit 6

Parameter	Groundwater Standard	MU-6 Baseline	MU-6 Standard Deviation	MU-6 NDEE Restoration Value
Ammonium (mg/L)	10.0	0.32	0.05	10.0
Arsenic (mg/L)	0.05	0.002		0.05
Barium (mg/L)	1.0	0.100		1.0
Cadmium (mg/L)	0.005	0.009		0.005
Chloride (mg/L)	250.0	206	15.4	250.0
Copper (mg/L)	1.0	0.012		1.0
Fluoride (mg/L)	4.0	0.65	0.03	4.0
Iron (mg/L)	0.3	0.050		0.3
Mercury (mg/L)	0.002	0.001		0.002
Manganese (mg/L)	0.05	0.010		0.05
Molybdenum (mg/L)	1.0	0.102		1.0
Nickel (mg/L)	0.15	0.050		0.15
Nitrate (mg/L)	10.0	0.1		10.0
Lead (mg/L)	0.05	0.050		0.05
Radium (pCi/L)	5.0	80.6	121.9	325
Selenium (mg/L)	0.05	0.001		0.05
Sodium (mg/L)	N/A	400	12.8	4000
Sulfate (mg/L)	250.0	361	14.6	390
Uranium (mg/L)	5.0	0.133	0.212	5.0
Vanadium (mg/L)	0.2	0.098		0.2
Zinc (mg/L)	5.0	0.011		5.0
pH (Std. Units)	6.5 - 8.5	8.6	0.2	6.5 – 9.0
Calcium (mg/L)	N/A	12.8	2.3	128
Total Carbonate (mg/L)	N/A	367.1	22.9	596
Potassium (mg/L)	N/A	11.9	1.7	119
Magnesium (mg/L)	N/A	3.2	0.7	32
TDS (mg/L)	N/A	1192	28.1	1220

Table 2.7-20. Baseline and Restoration Values for Mine Unit 7

Parameter	Groundwater Standard	MU-7 Baseline	MU-7 Standard Deviation	MU-7 NDEE Restoration Value
Ammonium (mg/L)	10.0	0.42	0.08	10.0
Arsenic (mg/L)	0.05	0.001		0.05
Barium (mg/L)	1.0	0.10		1.0
Cadmium (mg/L)	0.005	0.007		0.005
Chloride (mg/L)	250.0	198	22.6	250.0
Copper (mg/L)	1.0	0.01		1.0
Fluoride (mg/L)	4.0	0.70	0.05	4.0
Iron (mg/L)	0.30	0.05		0.30
Mercury (mg/L)	0.002	0.001		0.002
Manganese (mg/L)	0.05	0.01		0.05
Molybdenum (mg/L)	1.00	0.10		1.00
Nickel (mg/L)	0.15	0.05		0.15
Nitrate (mg/L)	10.0	0.1		10.0
Lead (mg/L)	0.05	0.05		0.05
Radium (pCi/L)	5.0	142	148.0	438
Selenium (mg/L)	0.05	0.004		0.05
Sodium (mg/L)	N/A	387	21.6	3,870
Sulfate (mg/L)	250.0	346	20.1	386
Uranium (mg/L)	5.0	0.110	0.138	5.0
Vanadium (mg/L)	0.2	0.10		0.2
Zinc (mg/L)	5.0	0.01		5.0
pH (Std. Units)	6.5 - 8.5	8.6	0.3	6.5 – 9.2
Calcium (mg/L)	N/A	12.2	2.6	122
Total Carbonate (mg/L)	N/A	356		588
Potassium (mg/L)	N/A	12.9	3.0	129
Magnesium (mg/L)	N/A	3.2	0.7	32
TDS (mg/L)	N/A	1,176	40.7	1,217

Table 2.7-21. Baseline and Restoration Values for Mine Unit 8

Parameter	Groundwater Standard	MU-8 Baseline	MU-8 Standard Deviation	MU-8 NDEE Restoration Value
Ammonium (mg/L)	10.0	0.682	0.222	10.0
Arsenic (mg/L)	0.05	0.002	0.001	0.05
Barium (mg/L)	1.0	0.099	0.005	1.0
Cadmium (mg/L)	0.005	0.005		0.005
Chloride (mg/L)	250	196	53.8	250
Copper (mg/L)	1.0	0.01		1.0
Fluoride (mg/L)	4.0	0.638	0.048	4.0
Iron (mg/L)	0.30	0.135	0.086	0.30
Mercury (mg/L)	0.002	0.001		0.002
Manganese (mg/L)	0.05	0.01		0.05
Molybdenum (mg/L)	1.0	0.093	0.023	1.00
Nickel (mg/L)	0.15	0.049	0.003	0.15
Nitrate (mg/L)	10.0	0.2		10.0
Lead (mg/L)	0.05	0.049	0.003	0.05
Radium (pCi/L)	5.0	124.4	151.8	428
Selenium (mg/L)	0.05	0.004		0.05
Sodium (mg/L)	N/A	416.8	41.8	4,168
Sulfate (mg/L)	250	312	33	378
Uranium (mg/L)	5.0	0.188	0.140	5.0
Vanadium (mg/L)	0.2	0.127	0.122	0.2
Zinc (mg/L)	5.0	0.013	0.008	5.0
pH (Std. Units)	6.5 - 8.5	8.67	0.37	6.5 – 9.41
Calcium (mg/L)	N/A	12.3	3.5	123
Total Carbonate (mg/L)	N/A	377	15.6	569
Potassium (mg/L)	N/A	11.8	3.2	117.8
Magnesium (mg/L)	N/A	2.7	0.92	27.1
TDS (mg/L)	N/A	1,137	97.4	1,234

Table 2.7-22. Baseline and Restoration Values for Mine Unit 9

Parameter	Groundwater Standard	MU-9 Baseline	MU-9 Standard Deviation	MU-9 NDEE Restoration Value
Ammonium (mg/L)	10.0	0.40	0.05	10.0
Arsenic (mg/L)	0.05	0.001	0.000	0.05
Barium (mg/L)	1.0	0.1	0.0	1.0
Cadmium (mg/L)	0.005	0.005	0.000	0.005
Chloride (mg/L)	250	203	13	250
Copper (mg/L)	1.0	0.01	0.00	1.0
Fluoride (mg/L)	4.0	0.8	0.0	4.0
Iron (mg/L)	0.3	0.04	0.01	0.3
Mercury (mg/L)	0.002	0.001	0.000	0.002
Manganese (mg/L)	0.05	0.01	0.00	0.05
Molybdenum (mg/L)	1.0	0.1	0.0	1.0
Nickel (mg/L)	0.15	0.05	0.00	0.15
Nitrate (mg/L)	10.0	0.06	0.01	10.0
Lead (mg/L)	0.05	0.05	0.00	0.05
Radium (pCi/L)	5.0	164	238	640
Selenium (mg/L)	0.05	0.003	0.001	0.05
Sodium (mg/L)	N/A	380	11	3,800
Sulfate (mg/L)	250	320	15	350
Uranium (mg/L)	5.0	0.1	0.24	5.0
Vanadium (mg/L)	0.2	0.1	0.0	0.2
Zinc (mg/L)	5.0	0.01	0.00	5.0
pH (Std. Units)	6.5 - 8.5	8.35	0.30	6.5 – 9.41
Calcium (mg/L)	N/A	13.6	4.6	136
Total Carbonate (mg/L)	N/A	383	14	595
Potassium (mg/L)	N/A	13.9	3.0	139
Magnesium (mg/L)	N/A	3.5	1.2	35.0
TDS (mg/L)	N/A	1,152	38	1,190

Table 2.7-23. Baseline Well Restoration Table Mine Unit 10

Parameter	Groundwater Standard	MU-10 Baseline	MU-10 Standard Deviation	MU-10 NDEE Restoration Value
Ammonia (NH_4 as N) (mg/L)	10.0	0.34	0.07	10.0
Arsenic (As) (mg/L)	0.010	0.001	0.001	0.010
Barium (Ba) (mg/L)	2.0	0.1	0.00	2.0
Cadmium (Cd) (mg/L)	0.005	0.005	0.000	0.005
Calcium (Ca) (mg/L)	---	11.8	2.6	118.0
Chloride (Cl) (mg/L)	250	185	14	250
Copper (Cu) (mg/L)	1.3	0.01	0.01	1.3
Fluoride (F) (mg/L)	4.0	0.72	0.10	4.0
Iron (Fe) (mg/L)	0.3	0.03	0.01	0.3
Lead (Pb) (mg/L)	0.015	0.001	0.0	0.015
Magnesium (Mg) (mg/L)	---	3.4	0.7	34.0
Manganese (Mn) (mg/L)	0.05	0.01	0.0	0.05
Mercury (Hg) (mg/L)	0.002	0.001	0.0	0.002
Molybdenum (Mo) (mg/L)	1.0	0.1	0.0	1.0
Nickel (Ni) (mg/L)	0.15	0.05	0.0	0.15
Nitrite + Nitrate as N (NO_3 + NO_2)[1] (mg/L)	10.0	0.1	0.0	10.0
pH (Std. Units)	6.5 - 8.5	8.51	0.19	6.5 - 8.89
Potassium (K) (mg/L)	---	10.1	1.6	101
Radium-226 (mg/L)	5.0	87.3	161.0	409.3
Selenium (Se) (mg/L)	0.05	0.003	0.002	0.05
Sodium (Na) (mg/L)	---	388	12	3880
Sulfate (SO4) (mg/L)	250.0	329	25	379
Total Carbonate (CO_3 + HCO_3)[2] (mg/L)	---	394	15	550.5
Total Dissolved Solids (mg/L)	---	1101	26	1127
Uranium (U) (mg/L)	0.03	0.0378	0.0351	0.108
Vanadium (V) (mg/L)	0.2	0.1	0.0	0.2
Zinc (Zn) (mg/L)	5.0	0.01	0.01	5.0

1 Nitrate was reported by the lab as NO_3 + NO_2 instead of NO_3 as required in the permit. However, only two samples, well 4024 collected 6/09/06 and well CM8-6 collected 5/02/02, were above the detection limits. The restoration value is 10.0 mg/L while the average is 0.1 mg/L. Therefore, including NO_2 has no bearing on determining the restoration value. Nitrite, NO_2, was also analyzed for and all samples were below the detection limit of 0.10 mg/L.

2 Total carbonate = alkalinity as $CaCO_3$ x 1.2

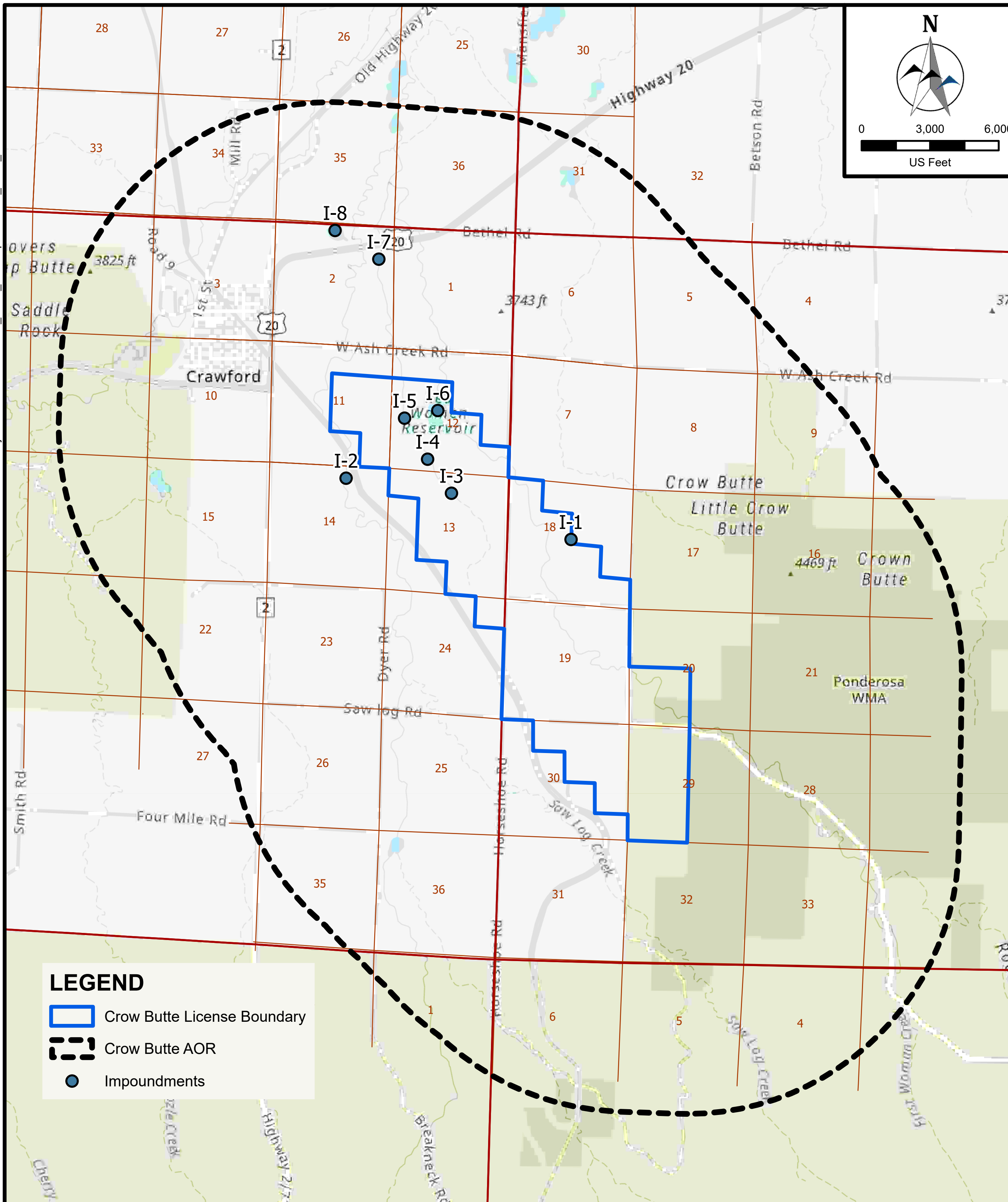
Standard formulas were used to calculate the average and standard deviation but the true values, especially for the standard deviation, are most likely significantly smaller than shown. This results in a conservative estimate of the standard deviation.

--- no NDEE standard

Table 2.7-24. Changes in Water Quality during Mining

Average Ore Zone Water Quality			
Analyte	**Units**	**MU 1-10 Pre-Mining Average**	**Typical Water Quality During Mining at CSA**
Total Carbonate (HCO_3 + CO_3)	mg/L	370	1,920
Calcium	mg/L	12.6	77
Chloride	mg/L	201	600
Fluoride	mg/L	0.697	0.6
Magnesium	mg/L	3.2	23
Ammonia as N	mg/L	0.38	<0.05
Nitrate+Nitrite as N	mg/L	0.094	0.46
Potassium	mg/L	12.8	35
Sodium	mg/L	404	1,310
Sulfate	mg/L	345	900
pH	s.u.	8.51	7.8
TDS	mg/L	1,168	4,080
Arsenic	mg/L	0.001	0.06
Barium	mg/L	0.10	<0.1
Cadmium	mg/L	0.007	<0.005
Copper	mg/L	0.011	0.04
Iron	mg/L	0.054	<0.030
Lead	mg/L	0.042	<0.05
Manganese	mg/L	0.01	0.05
Mercury	mg/L	0.001	<0.001
Molybdenum	mg/L	0.094	0.5
Nickel	mg/L	0.047	<0.05
Selenium	mg/L	0.002	0.07
Uranium	mg/L	0.102	44
Vanadium	mg/L	0.096	2.5
Zinc	mg/L	0.016	0.02
Radium 226	pCi/L	155	1,090

K:\Sheridan\Cameco Resources\2023078 Crow Butte LRA\06GIS\SENV New ArcPro Project\ArcPro Files\23078_Crow_Butte\23078_Crow_Butte.aprx 23078_Crow_Butte 9/17/2024 7:02 AM



PERMIT TO MINE NO.			
NO.	REVISION	BY	DATE
4	---	---	---
3	---	---	---
2	---	---	---
1	---	---	---
0	---	---	---

CROW BUTTE RESOURCES, INC., 86 CROW BUTTE ROAD, CRAWFORD, NE 69339

CROW BUTTE RESOURCES, INC.

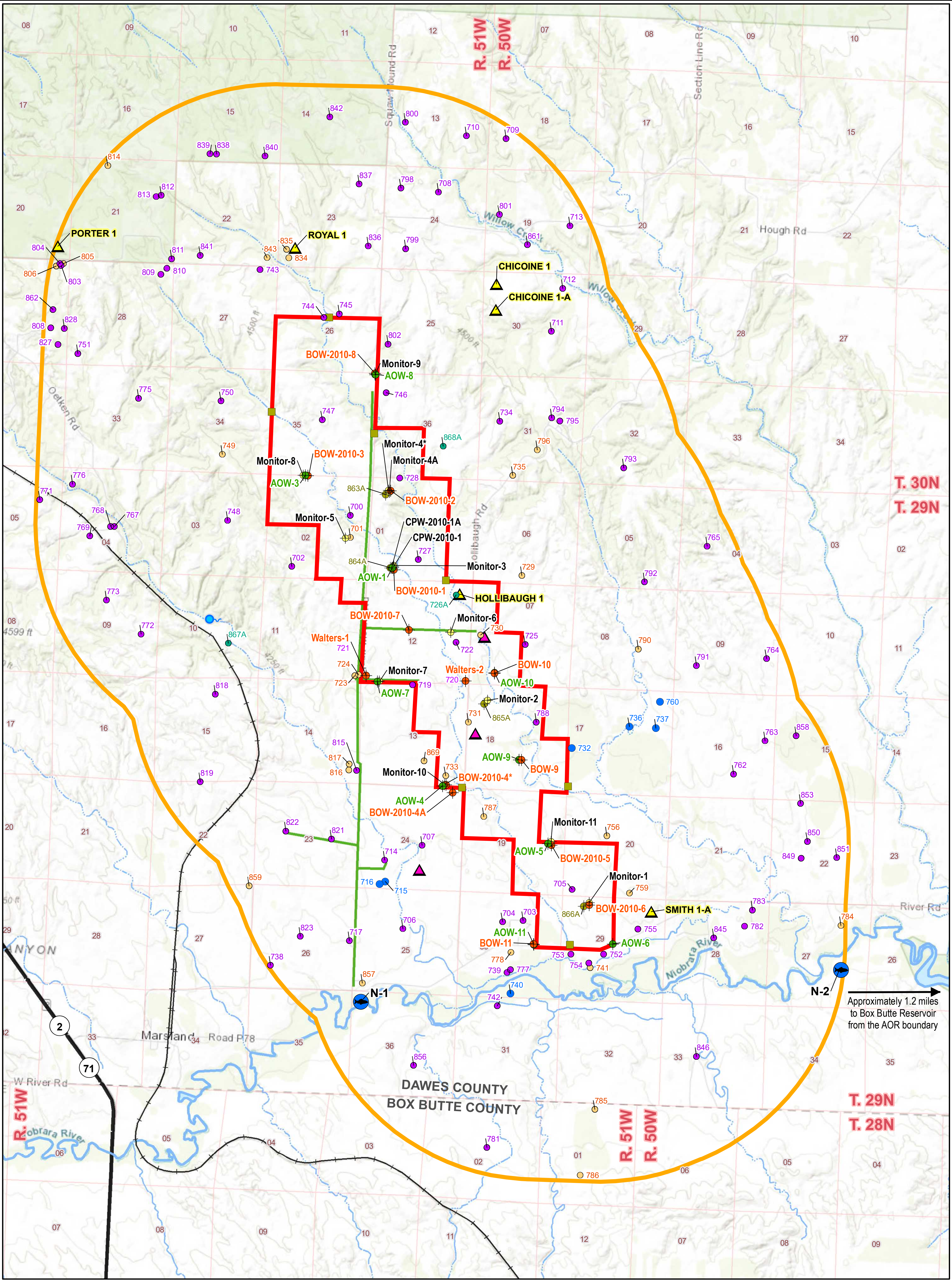
DAWES COUNTY, NEBRASKA

DRAWN BY:	RAV
CHECKED BY:	BAW
APPROVED BY:	--
DATE:	09/2024

CROW BUTTE PROJECT
SURFACE WATER IMPOUNDMENTS

FIGURE
2.7-1

Path: K:\Sheridan\Cameco Resources\2023078 Crow Butte LRA\06GIS\Figure 2_7-2 Major Surface Features_n_Structures within AOR.mxd | Last Saved By: rventling | Last Saved On: 9/17/2024



LEGEND

- Proposed Marsland Expansion Area
- Area of Review (AOR)
- Surface Water/Fish Sampling Location
- Ephemeral Drainage Sediment Sampling Point
- Natural Spring

Pumping Test Monitoring Wells

- Monitor-5 — Basal Sandstone of the Chadron Formation Well and Well ID
- BOW-2010-6 — Brule Formation Well and Well ID
- AOW-3 — Arikaree Group Well and Well ID
- 865A — Abandoned Chadron Monitor Well and Well ID
- Sand/Gravel Pit, Inactive
- Dry Hole, Dry and Abandoned

Private Water Supply Wells

- 732 — Seasonal Well and Well ID
- 781 — Active Well and Well ID
- 786 — Inactive Well and Well ID
- 726A — Abandoned Well and Well ID
- Powerline
- Railroad

* BOW-2010-4 and Monitor-4 are inactive and scheduled to be abandoned.

N

0 0.5 1
Miles

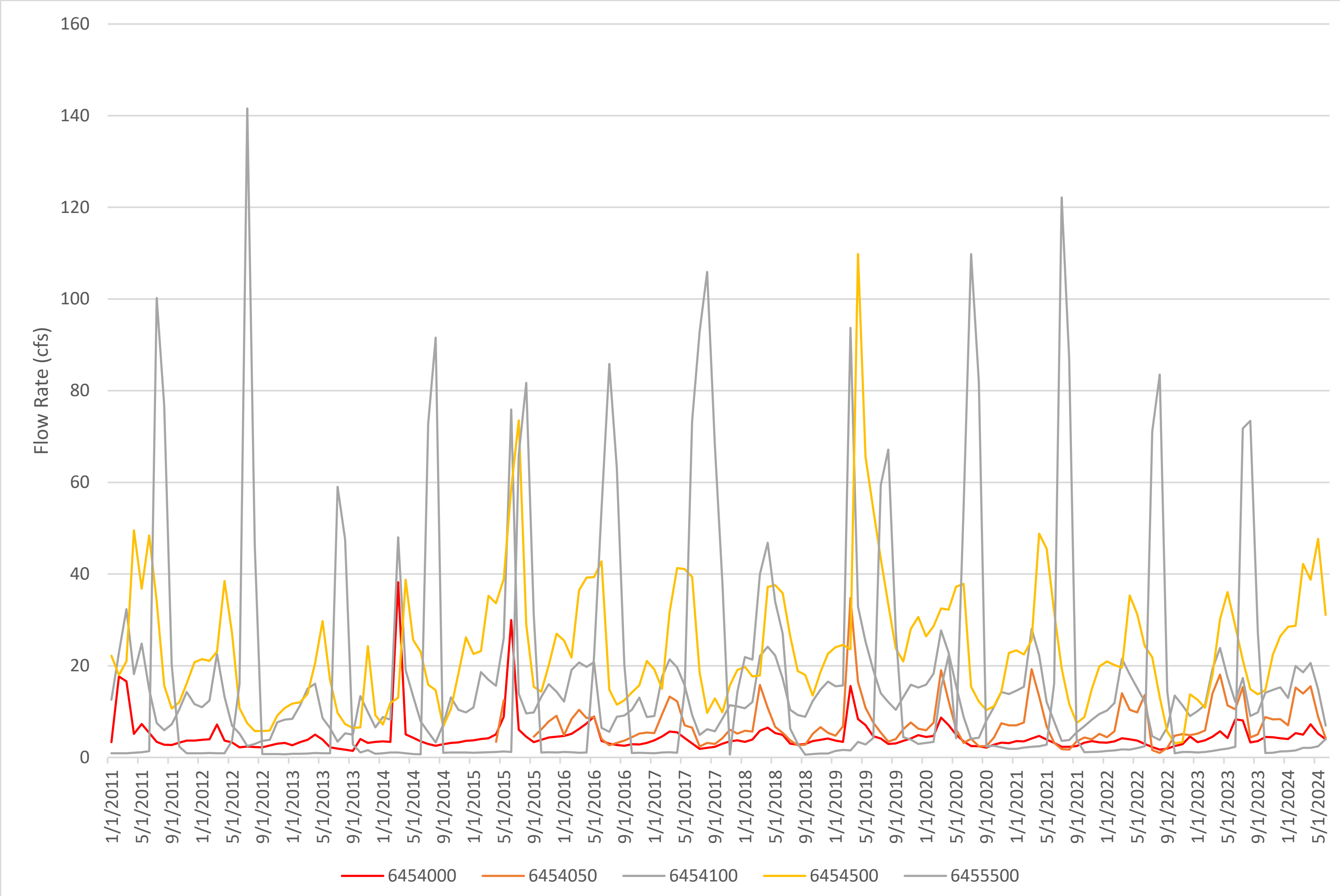
PROJECTION: NAD 1983, STATE PLANE NEBRASKA NORTH, FIPS 2600
SOURCES: US TOPO MAPS, SERVICED BY ESRI ARCGIS ONLINE

CROW BUTTE RESOURCES, INC.

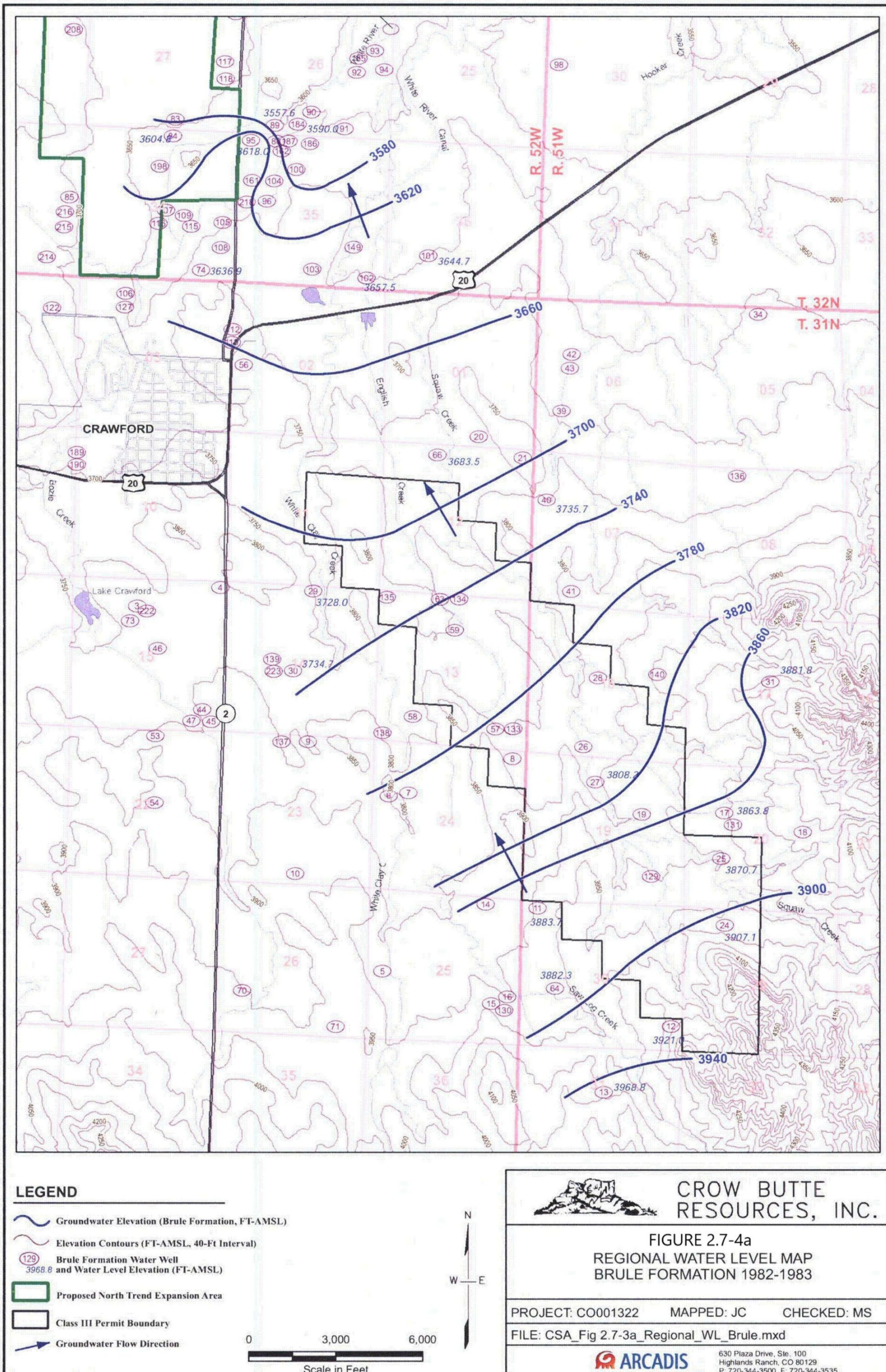
FIGURE 2.7-2
MAJOR SURFACE FEATURES/STRUCTURES WITHIN AOR AS PER TITLE 122, CHAPTER 11, SECTION 006.09

PROJECT: CO001636 | MAPPED BY: JC | CHECKED BY: JEC

Figure 2.7-3. Niobrara River Flow at Five NeDNR Gaging Stations



Source: NeDNR 2024


LEGEND
Groundwater Elevation (Brule Formation, FT-AMSL)
Elevation Contours (FT-AMSL, 40-Ft Interval)
Brule Formation Water Well and Water Level Elevation (FT-AMSL)
Proposed North Trend Expansion Area
Class III Permit Boundary
Groundwater Flow Direction
0 3,000 6,000
Scale in Feet
CRAWFORD
Lake Crawford
R. 52W
R. 51W
T. 32N
T. 31N
CROW BUTTE RESOURCES, INC.
FIGURE 2.7-4a
REGIONAL WATER LEVEL MAP
BRULE FORMATION 1982-1983
PROJECT: CO001322 MAPPED: JC CHECKED: MS
FILE: CSA_Fig 2.7-3a_Regional_WL_Brule.mxd
ARCADIS
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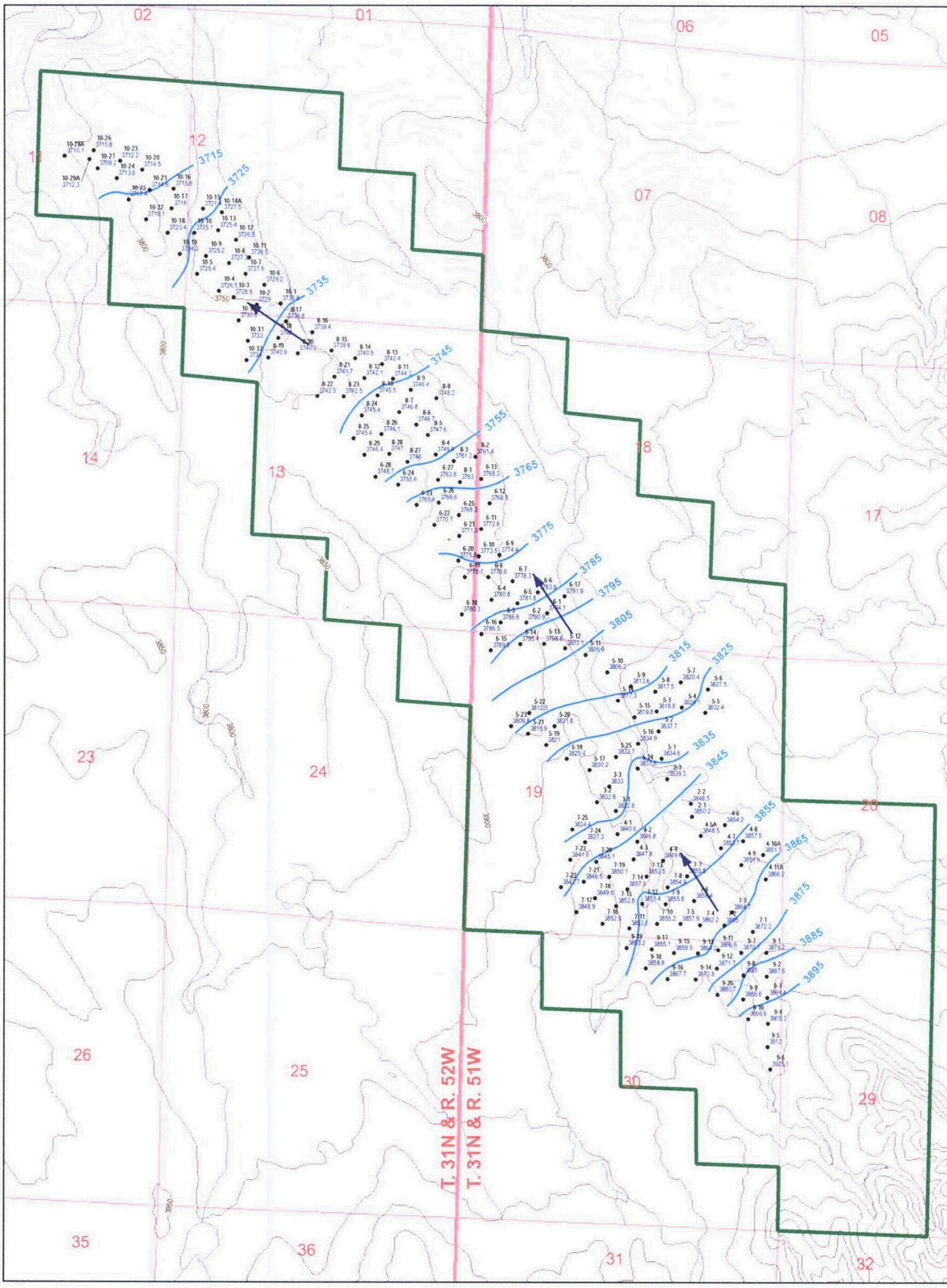

LEGEND

- 7-25 — Well ID; Brule Formation Water Well; 3834.3 — Groundwater Elevation (FT-AMSL)
- Elevation Contours (FT-AMSL)
- Groundwater Elevation Contour (10-FT Interval); 3895 — Groundwater Elevation (FT-AMSL)
- Stream or Canal
- Direction of Groundwater Flow
- Class III Permit Boundary

N / W — E

0 | 1,500 | 3,000
Scale in Feet

CROW BUTTE RESOURCES, INC.

FIGURE 2.7-4b
CURRENT LICENSE AREA
WATER LEVEL MAP -
BRULE FORMATION (3/31/08 – 4/14/08)

PROJECT: CO001322 | MAPPED: JC | CHECKED: MS

FILE: CSA_BF_WATERLEVEL_0308.MXD

ARCADIS
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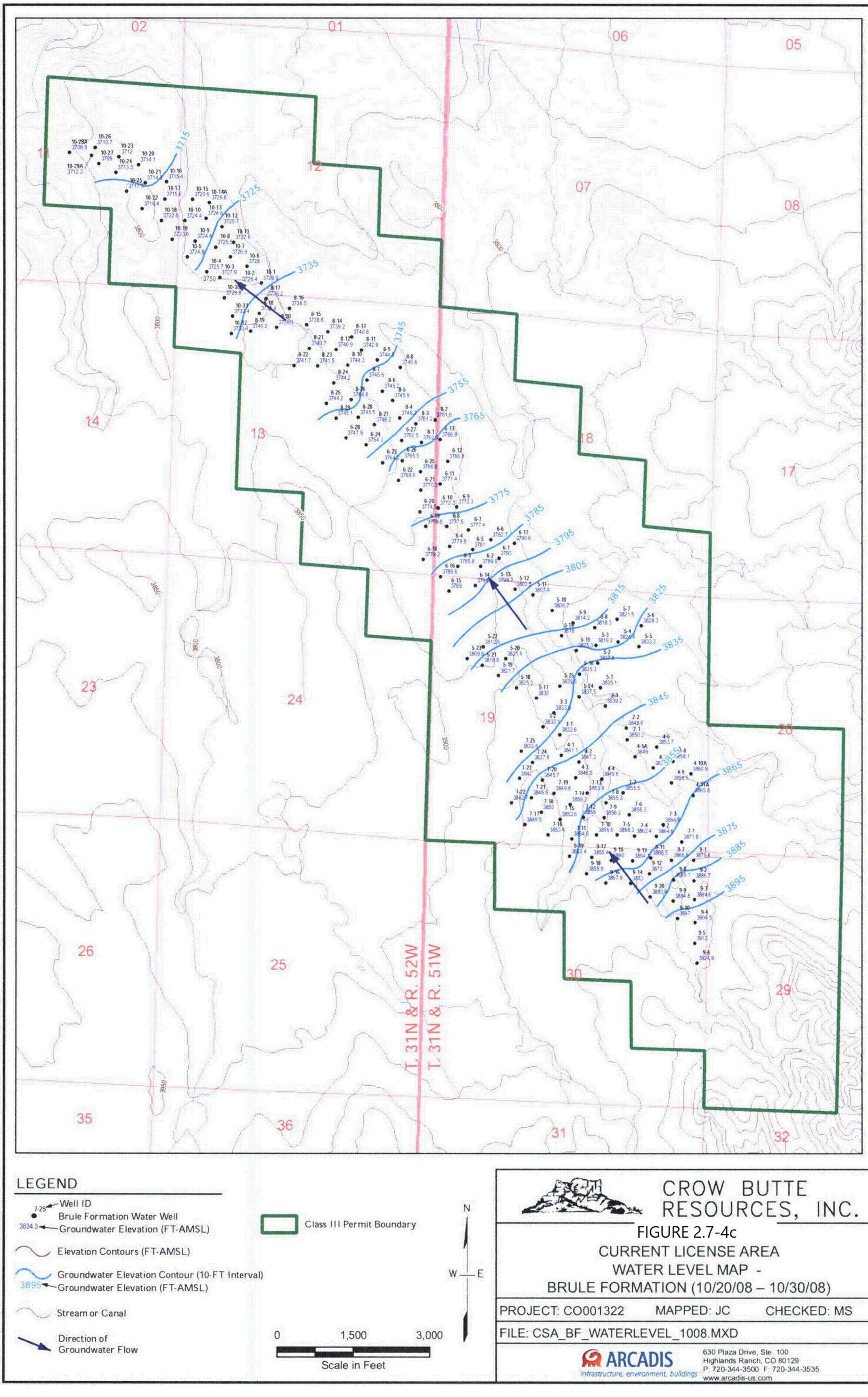
T. 31N & R. 52W
T. 31N & R. 51W
LEGEND
Well ID
Brule Formation Water Well
Groundwater Elevation (FT-AMSL)
Elevation Contours (FT-AMSL)
Groundwater Elevation Contour (10-FT Interval)
Groundwater Elevation (FT-AMSL)
Stream or Canal
Direction of Groundwater Flow
Class III Permit Boundary
N
W
E
0
1,500
3,000
Scale in Feet
CROW BUTTE RESOURCES, INC.
FIGURE 2.7-4c
CURRENT LICENSE AREA
WATER LEVEL MAP -
BRULE FORMATION (10/20/08 – 10/30/08)
PROJECT: CO001322
MAPPED: JC
CHECKED: MS
FILE: CSA_BF_WATERLEVEL_1008.MXD
ARCADIS
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Highlands Ranch, CO 80129
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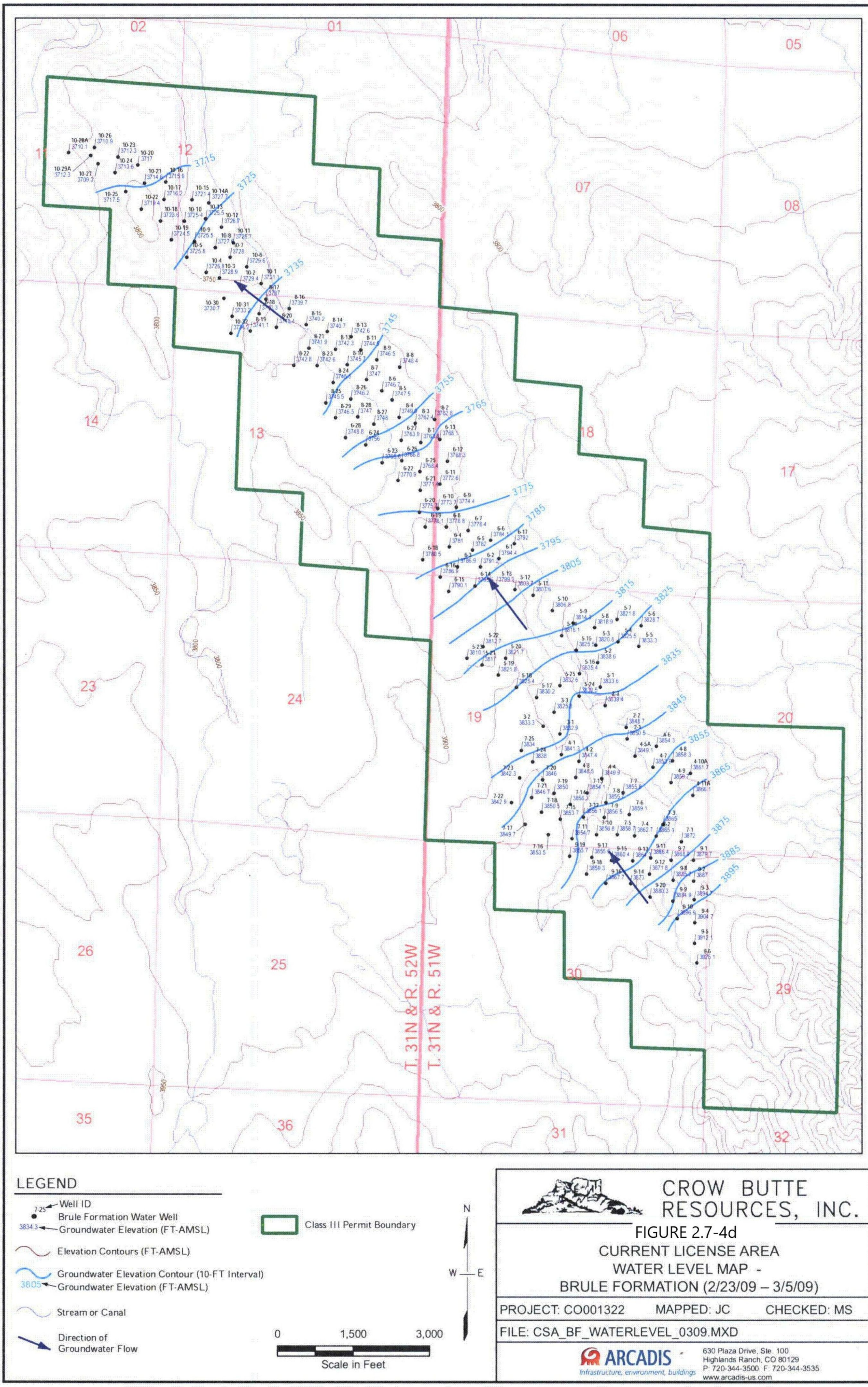
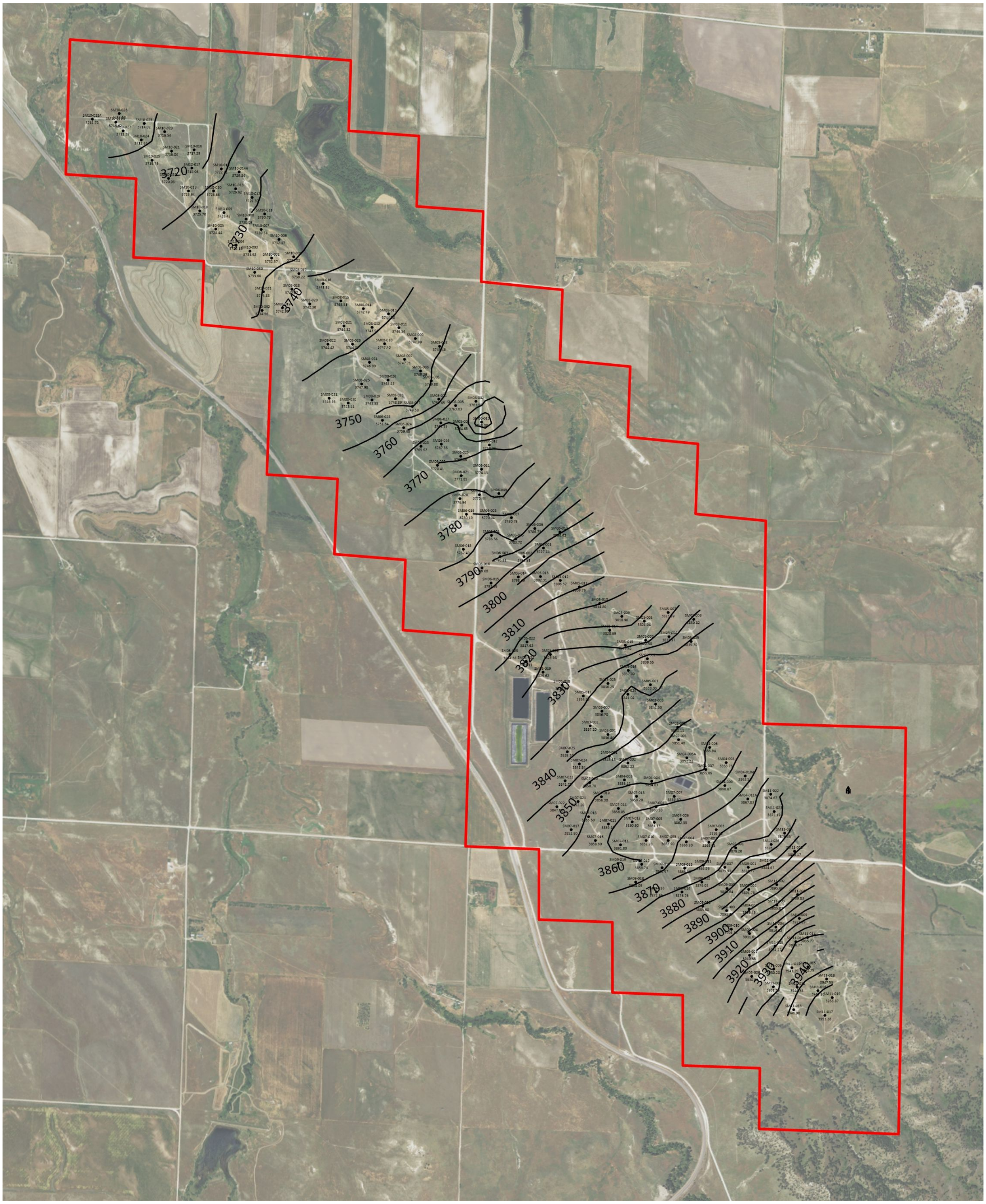
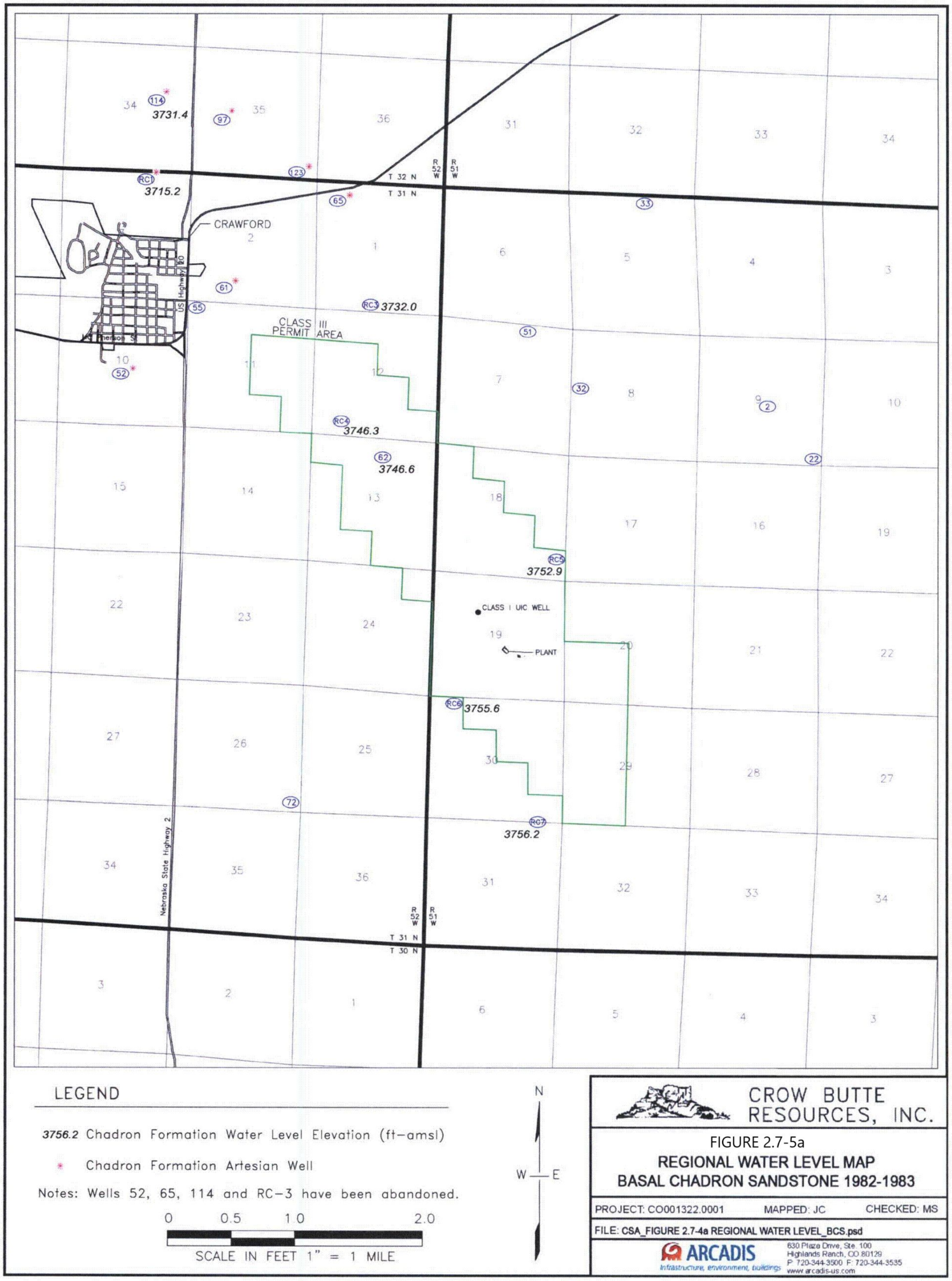
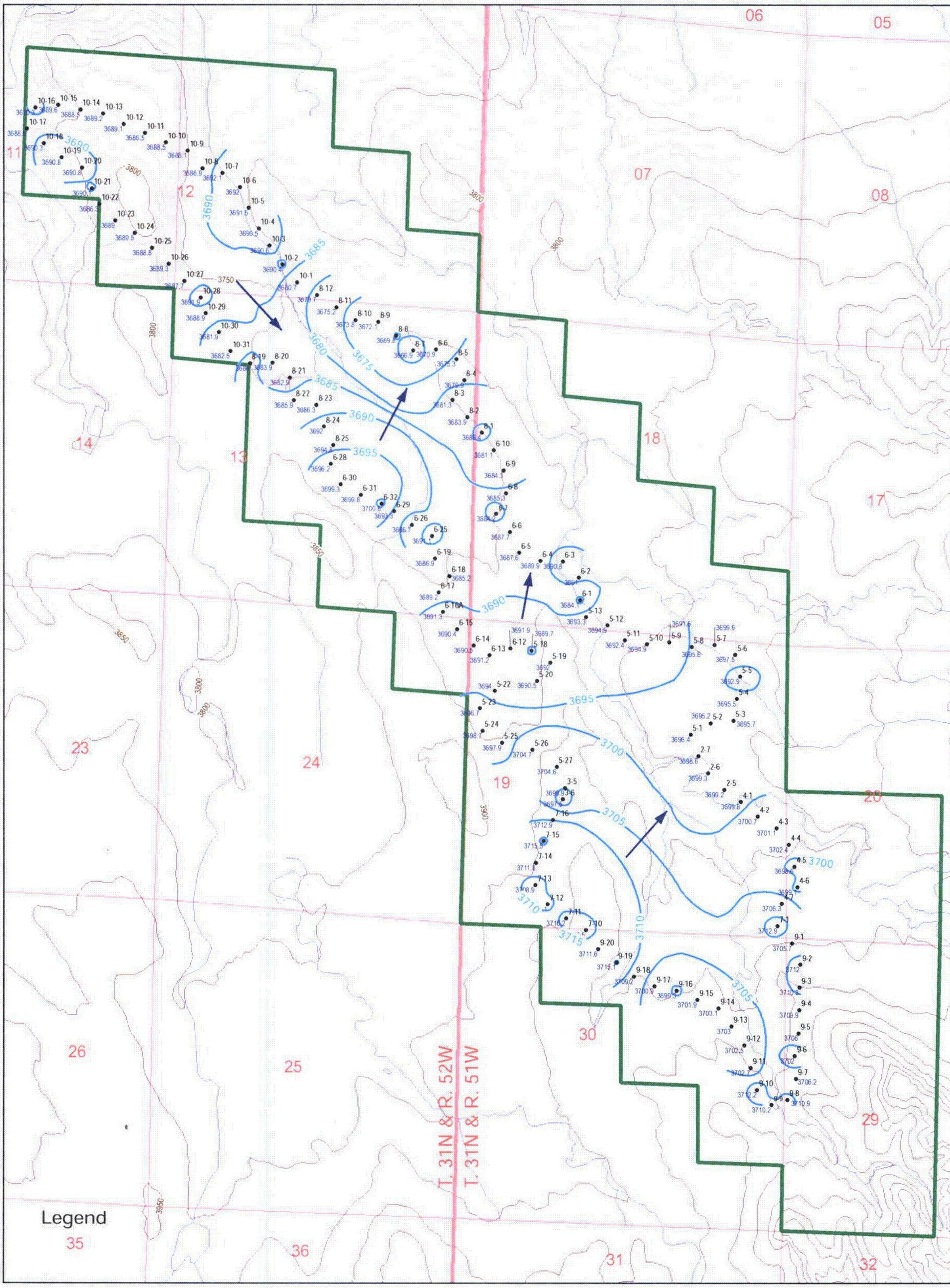


FIGURE 2.7-4d
CURRENT LICENSE AREA
WATER LEVEL MAP -
BRULE FORMATION (2/23/09 – 3/5/09)

Figure 2.7-4e. Crow Butte Project Water Level Map Brule Formation (2024)




CRAWFORD
CLASS III PERMIT AREA
CLASS I UIC WELL
PLANT
3731.4
3715.2
3732.0
3746.3
3746.6
3752.9
3755.6
3756.2
T 32 N
T 31 N
T 30 N
R 52 W
R 51 W
US Highway 20
Nebraska State Highway 2
LEGEND
3756.2 Chadron Formation Water Level Elevation (ft–amsl)
Chadron Formation Artesian Well
Notes: Wells 52, 65, 114 and RC–3 have been abandoned.
0 0.5 1.0 2.0
SCALE IN FEET 1" = 1 MILE
N
W E
CROW BUTTE RESOURCES, INC.
FIGURE 2.7-5a
REGIONAL WATER LEVEL MAP
BASAL CHADRON SANDSTONE 1982-1983
PROJECT: CO001322.0001
MAPPED: JC
CHECKED: MS
FILE: CSA_FIGURE 2.7-4a REGIONAL WATER LEVEL_BCS.psd
ARCADIS



LEGEND

- 10-1 Well ID
- Basal Chadron Sandstone Water Well
- 3694.2 Groundwater Elevation (FT-AMSL)
- Elevation Contours (FT-AMSL)
- Groundwater Elevation Contour (5-FT Interval)
- 3690 Groundwater Elevation (FT-AMSL)
- Stream or Canal
- Direction of Groundwater Flow
- Class III Permit Boundary

N / W — E

0 1,500 3,000

Scale in Feet

CROW BUTTE RESOURCES, INC.

FIGURE 2.7-5b
CURRENT LICENSE AREA
POTENTIOMETRIC SURFACE -
BASAL CHADRON SANDSTONE (3/31/08 – 4/15/08)

PROJECT: CO001322 MAPPED: JC CHECKED: MS

FILE: CSA_BCS_POTENTIOMETRIC_0308.MXD

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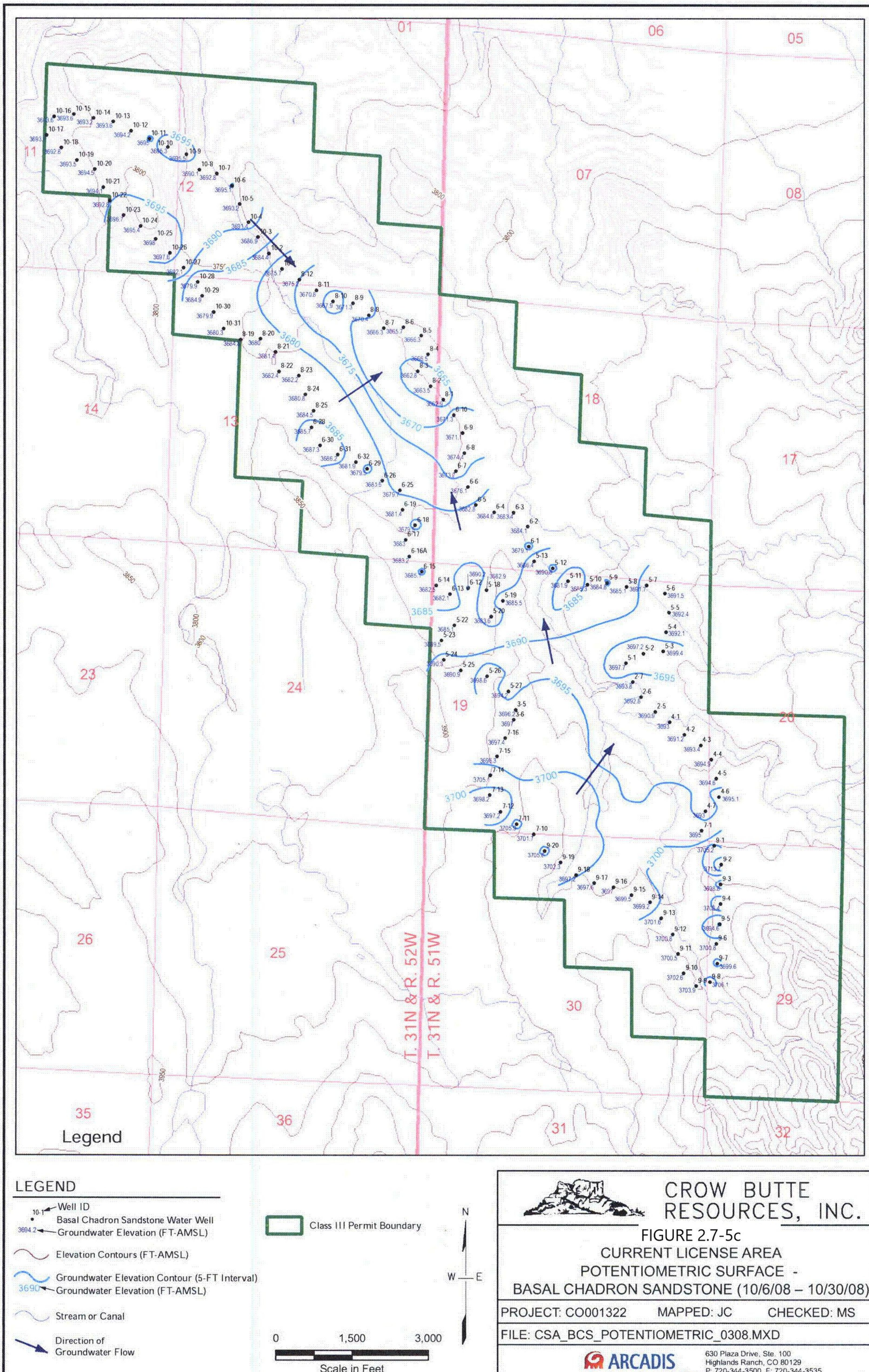


FIGURE 2.7-5c
CURRENT LICENSE AREA
POTENTIOMETRIC SURFACE -
BASAL CHADRON SANDSTONE (10/6/08 – 10/30/08)

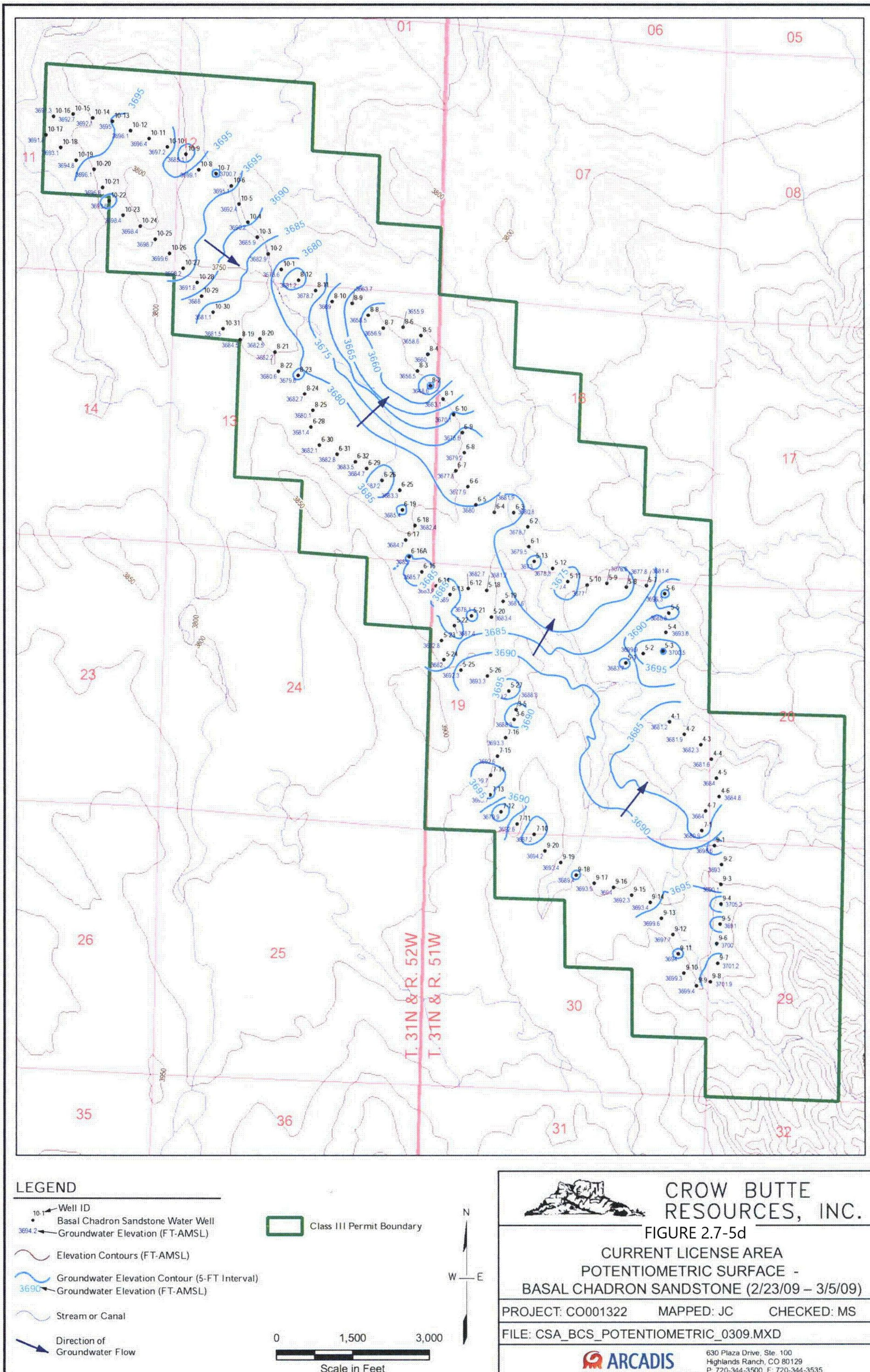


FIGURE 2.7-5d
CURRENT LICENSE AREA
POTENTIOMETRIC SURFACE -
BASAL CHADRON SANDSTONE (2/23/09 – 3/5/09)

Figure 2.7-5e. Crow Butte Project Potentiometric Surface Basal Chadron Sandstone (2024)

Figure 2.7-6. Crow Butte Project Hydrostratigraphic Cross-Section Location Map

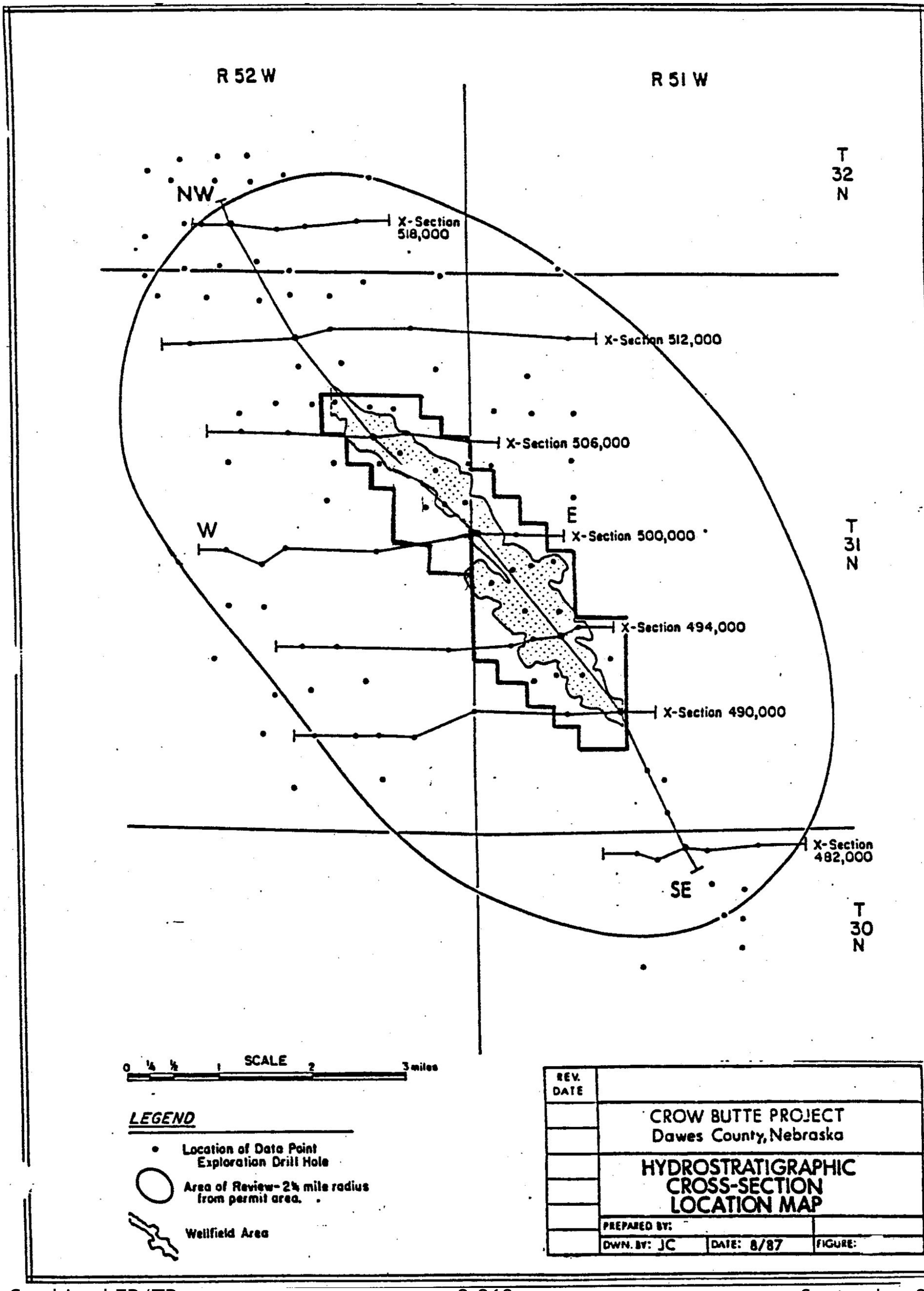


Figure 2.7-7. Crow Butte Project Northwest-Southeast Cross Section

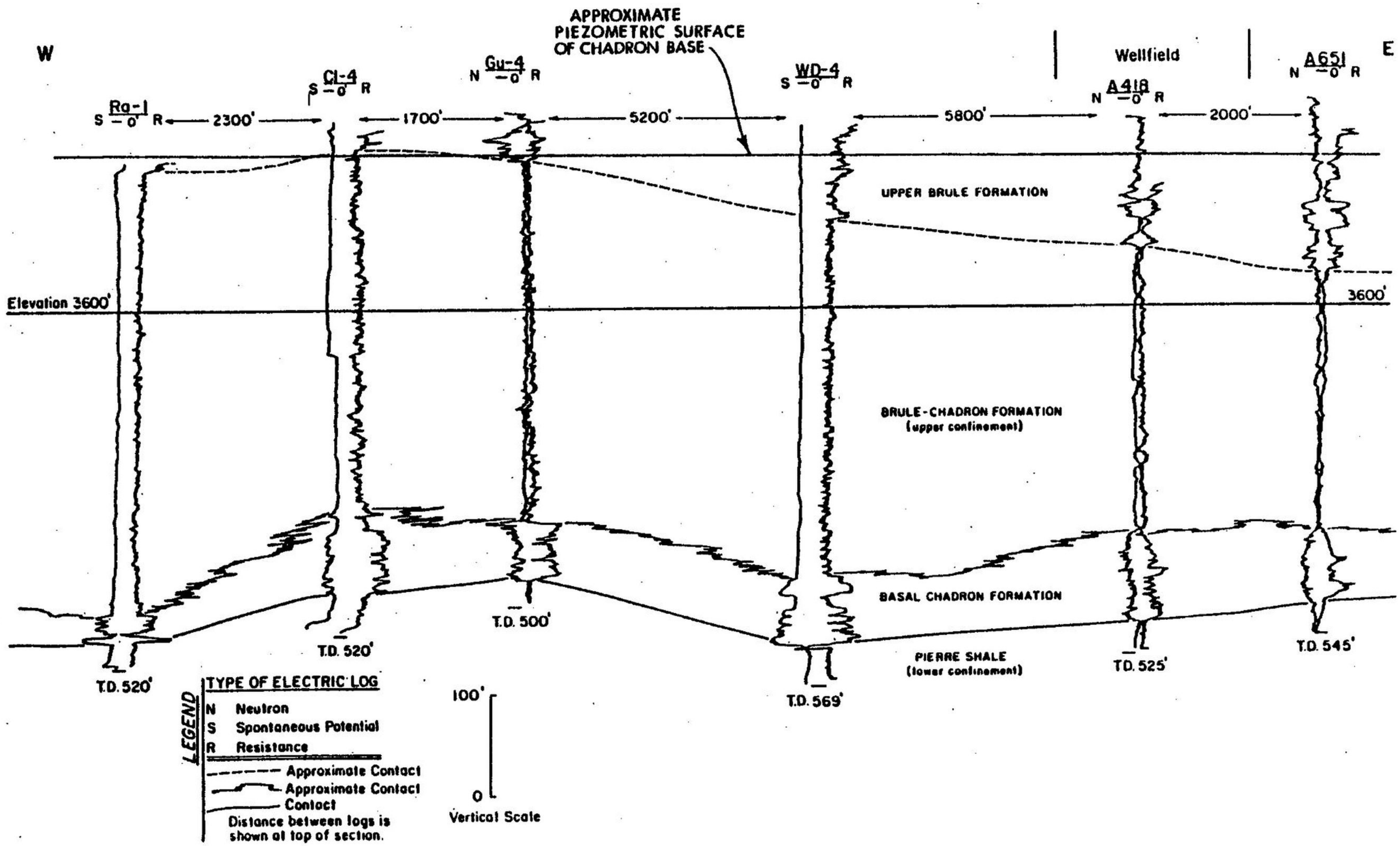


Figure 2.7-8. Crow Butte Project East-West Cross Section

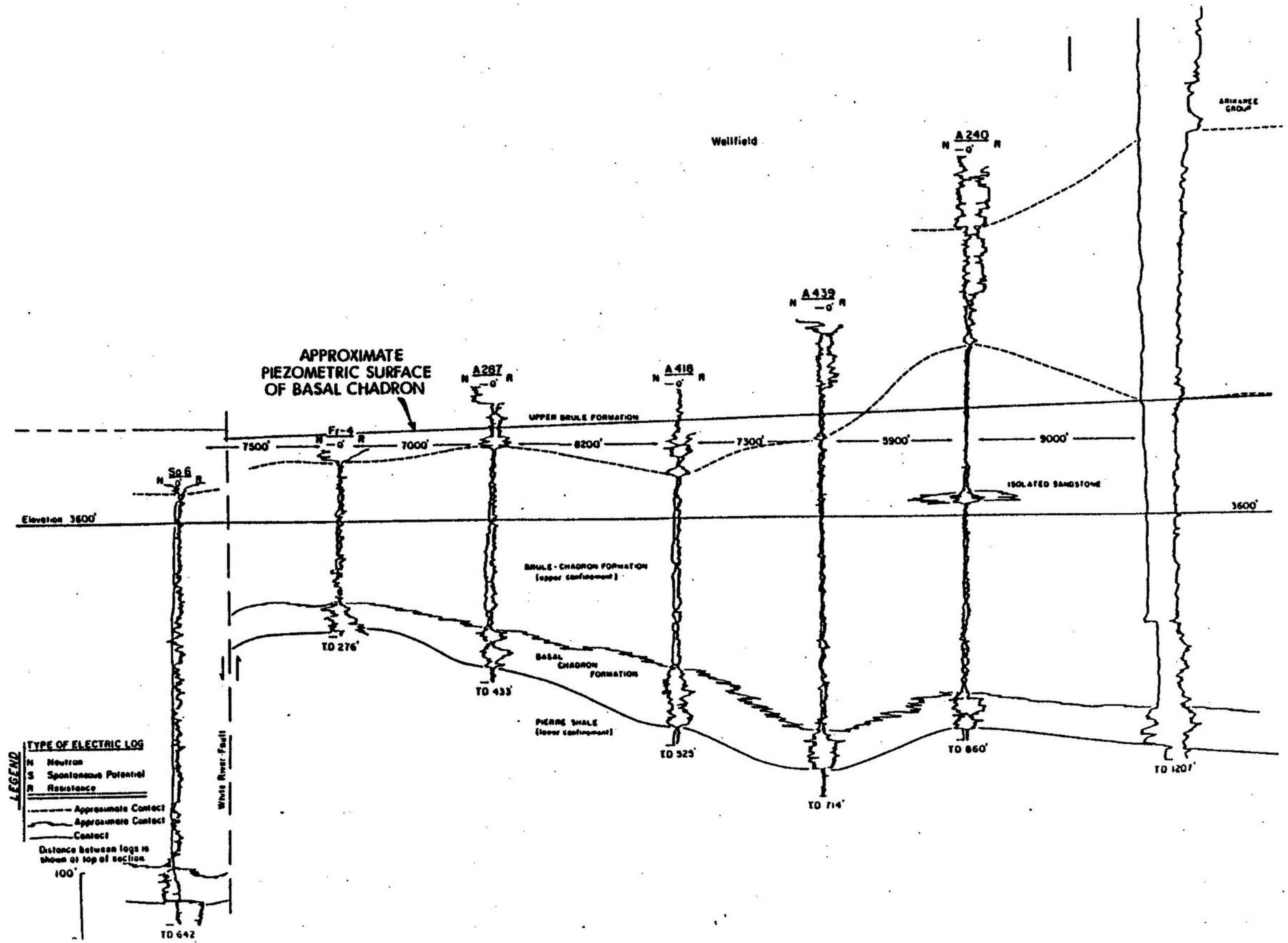
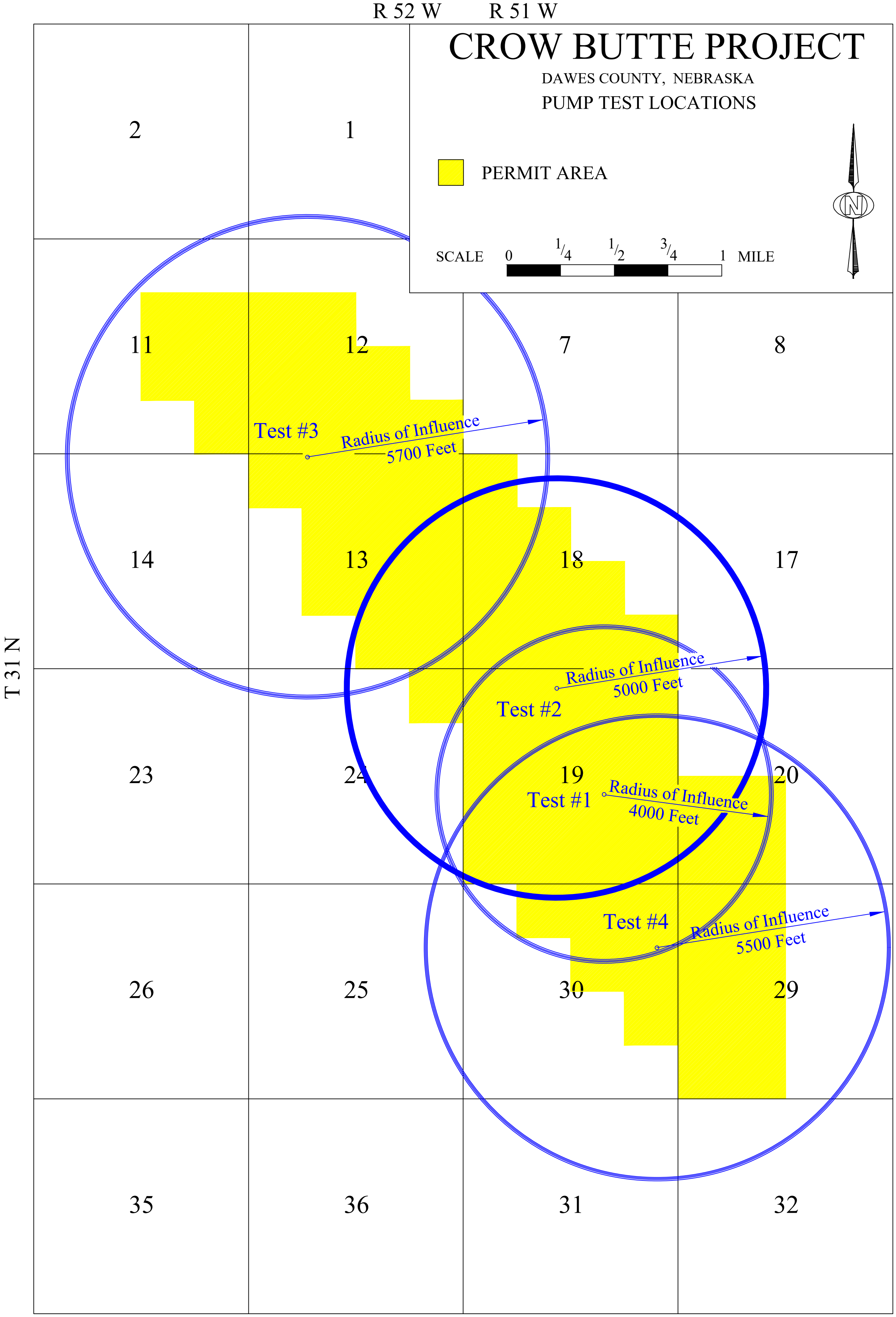
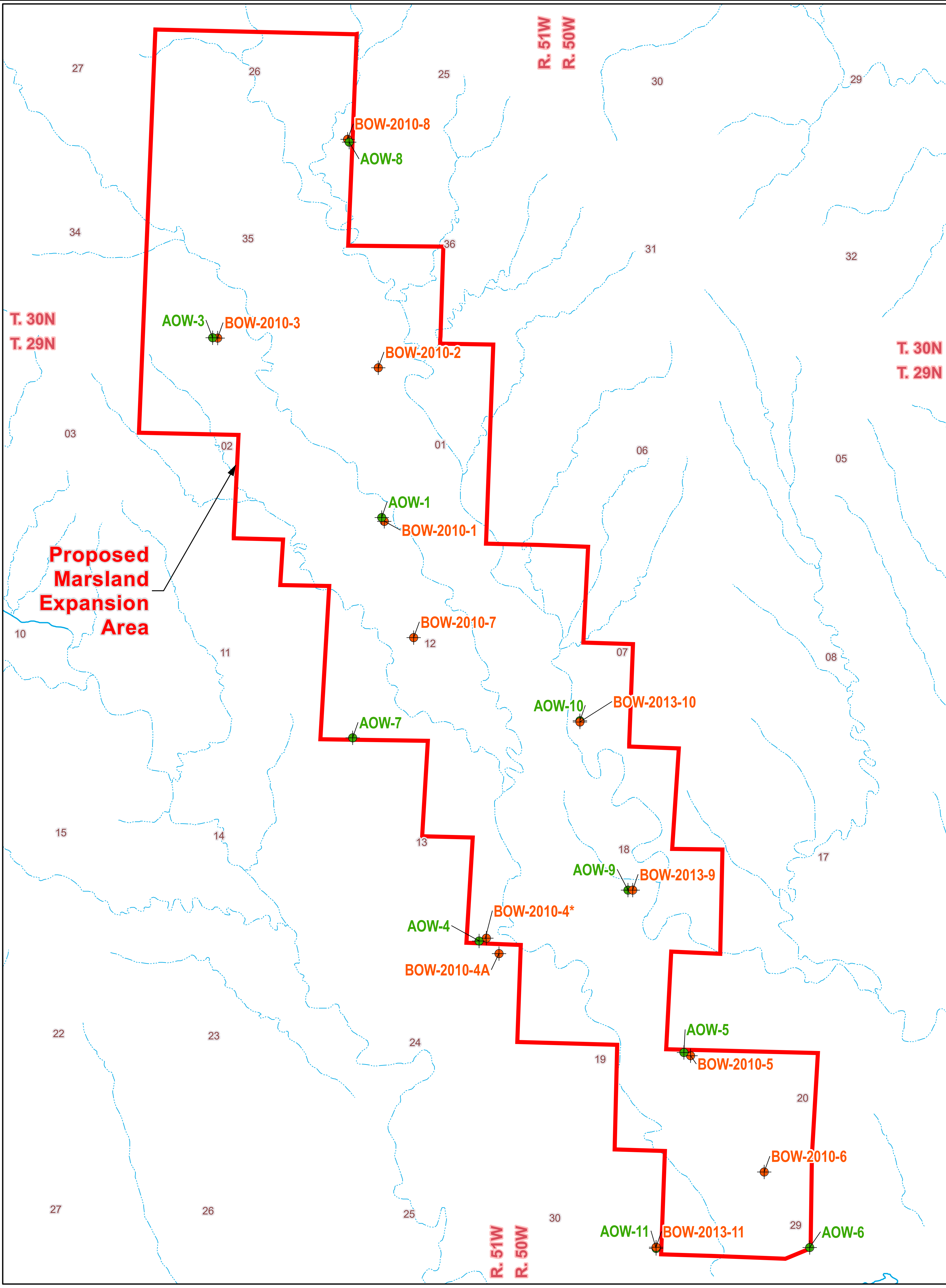


FIGURE 2.7-9


R 52 W
R 51 W
CROW BUTTE PROJECT
DAWES COUNTY, NEBRASKA
PUMP TEST LOCATIONS
PERMIT AREA
SCALE
0
1/4
1/2
3/4
1
MILE
N
T 31 N
2
1
11
12
7
8
14
13
18
17
23
24
19
20
26
25
30
29
35
36
31
32
Test #3
Radius of Influence
5700 Feet
Test #2
Radius of Influence
5000 Feet
Test #1
Radius of Influence
4000 Feet
Test #4
Radius of Influence
5500 Feet



LEGEND

- Arikaree Group Well
- Brule Formation Well
- Proposed Marsland Expansion Area
- Intermittent Stream/River

* BOW-2010-4 is inactive and scheduled to be abandoned.

N

0 1,250 2,500
Feet

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

FIGURE 2.7-10
MARSLAND
ARIKAREE AND BRULE MONITOR WELLS

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: MS

Figure 2.7-11a. Marsland Expansion Area Potentiometric Surface – Arikaree Group (10/17/2013)

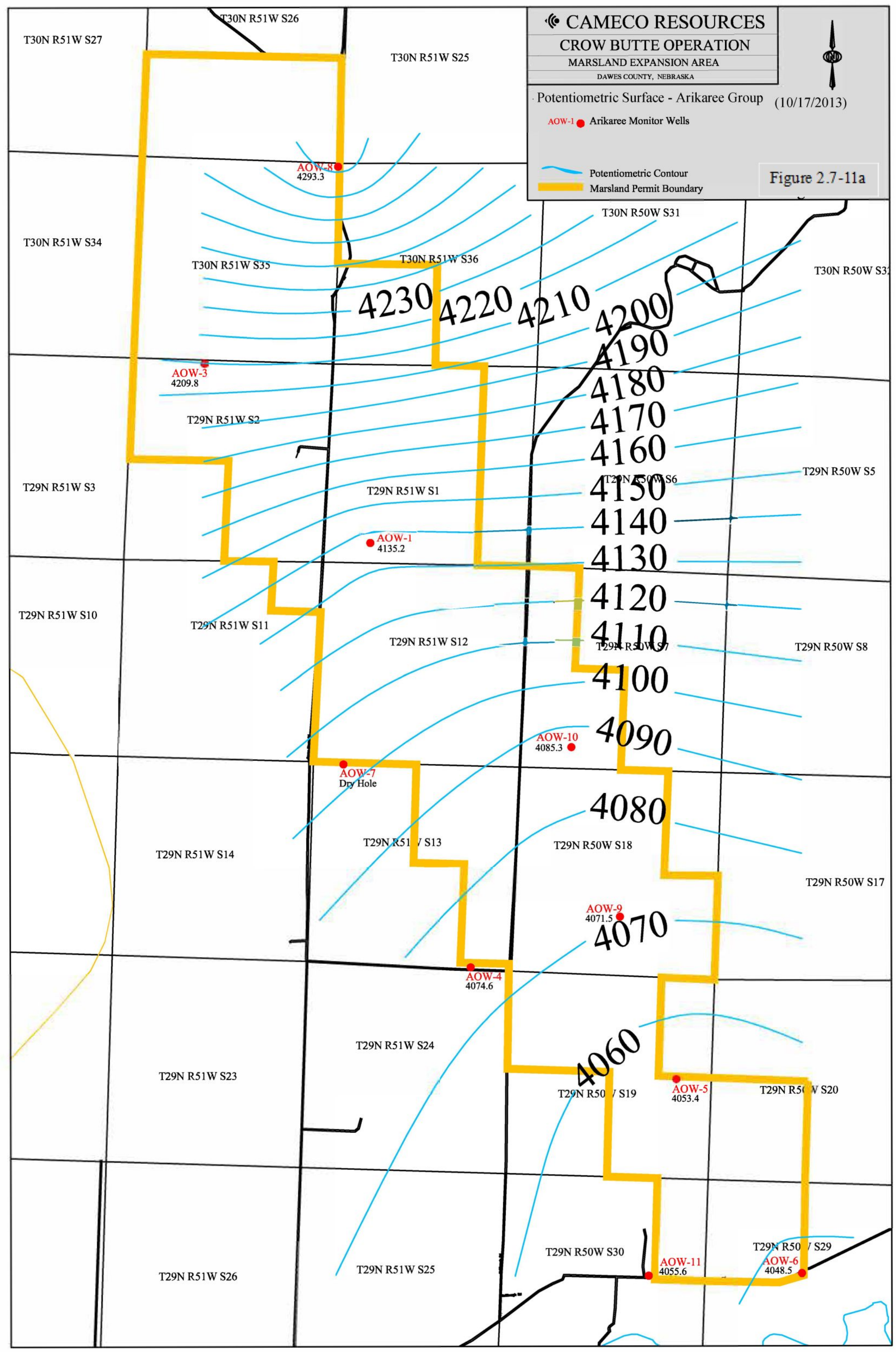


Figure 2.7-11b. Marsland Expansion Area Potentiometric Surface – Arikaree Group (1/21/2014)

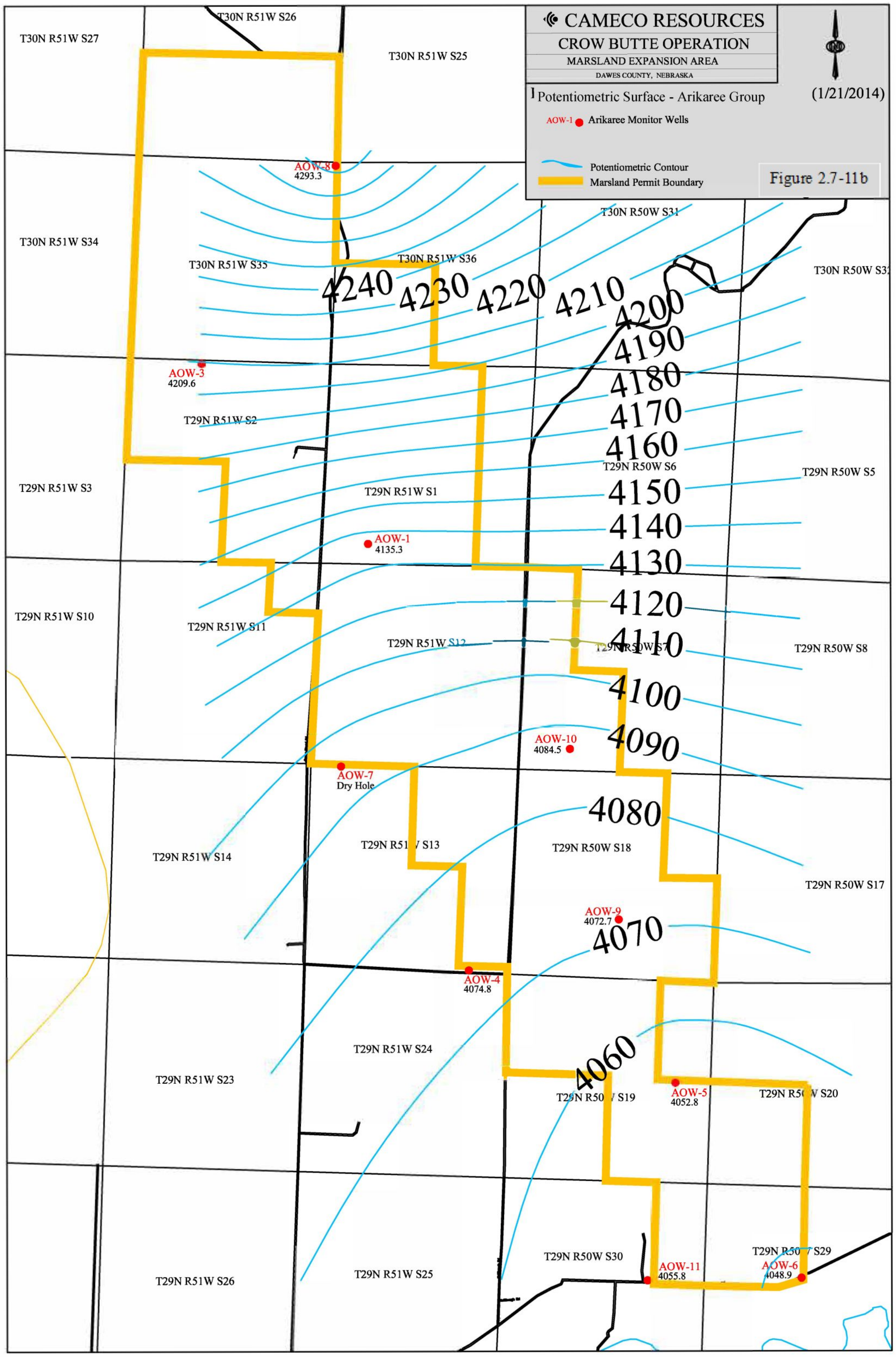


Figure 2.7-11c. Marsland Expansion Area Potentiometric Surface – Arikaree Group (4/22/2014)

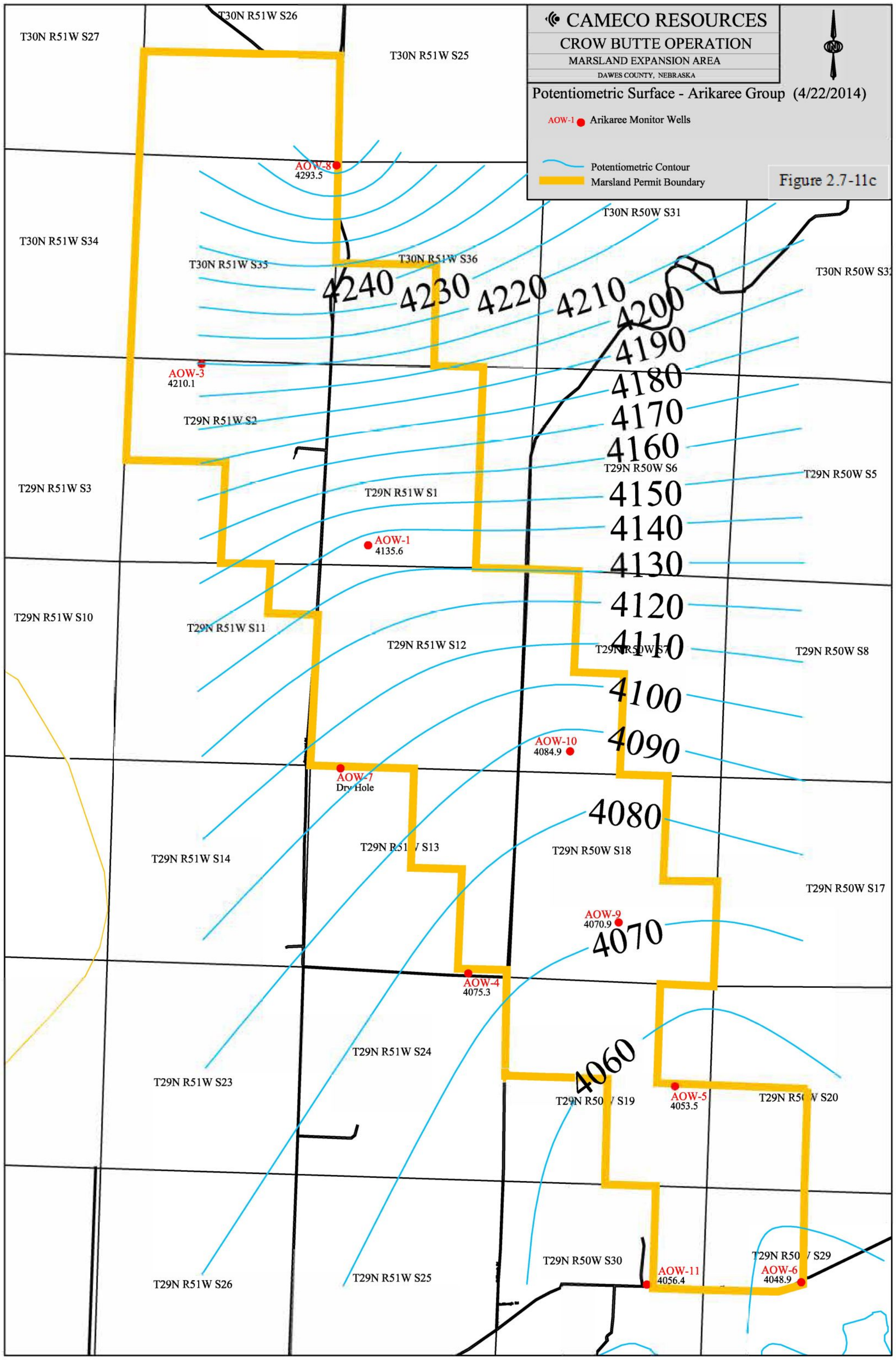


Figure 2.7-11d. Marsland Expansion Area Potentiometric Surface – Arikaree Group (7/14/2014)

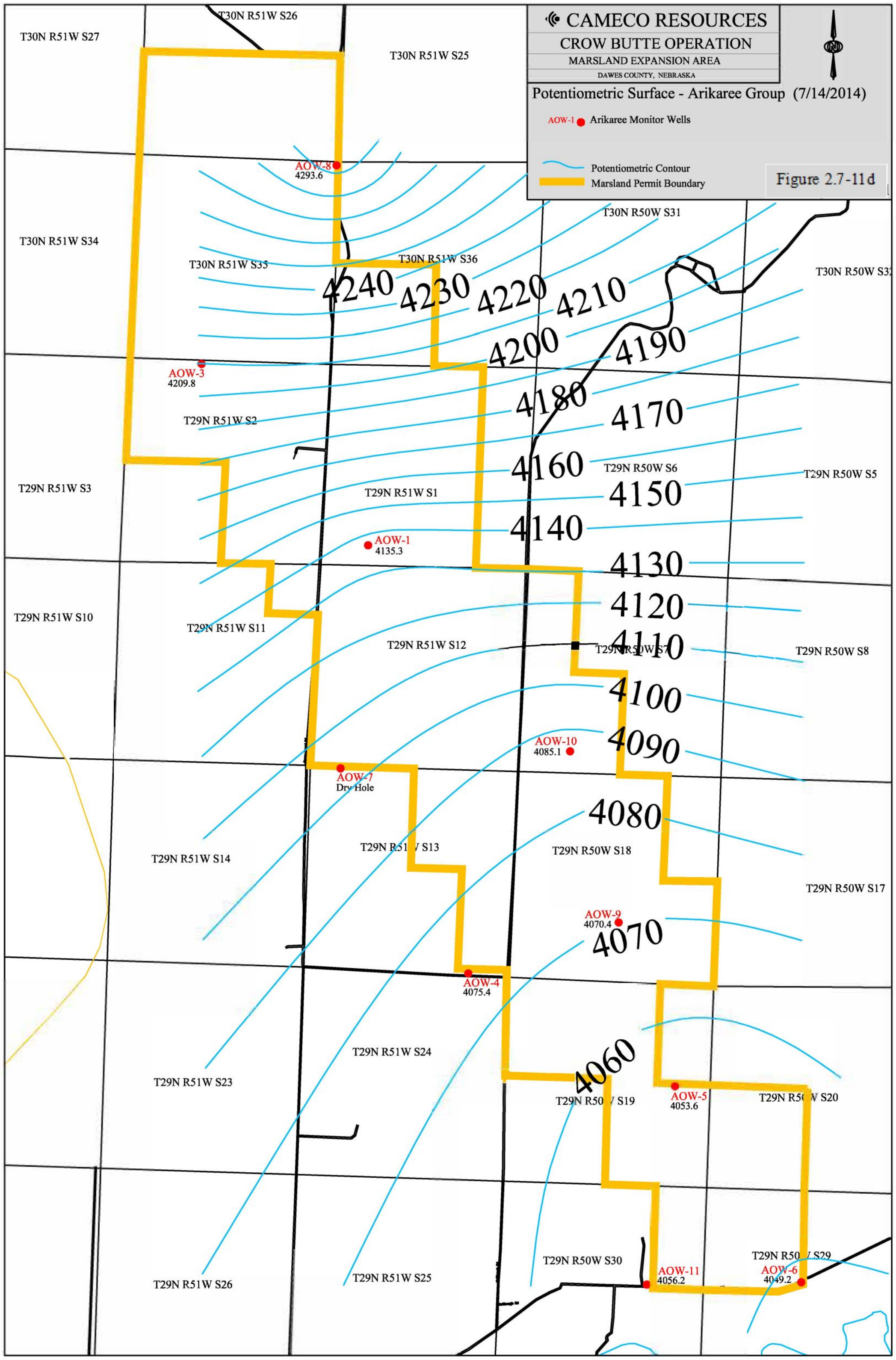


Figure 2.7-12a. Marsland Expansion Area Potentiometric Surface – Brule Formation (10/17/2013)

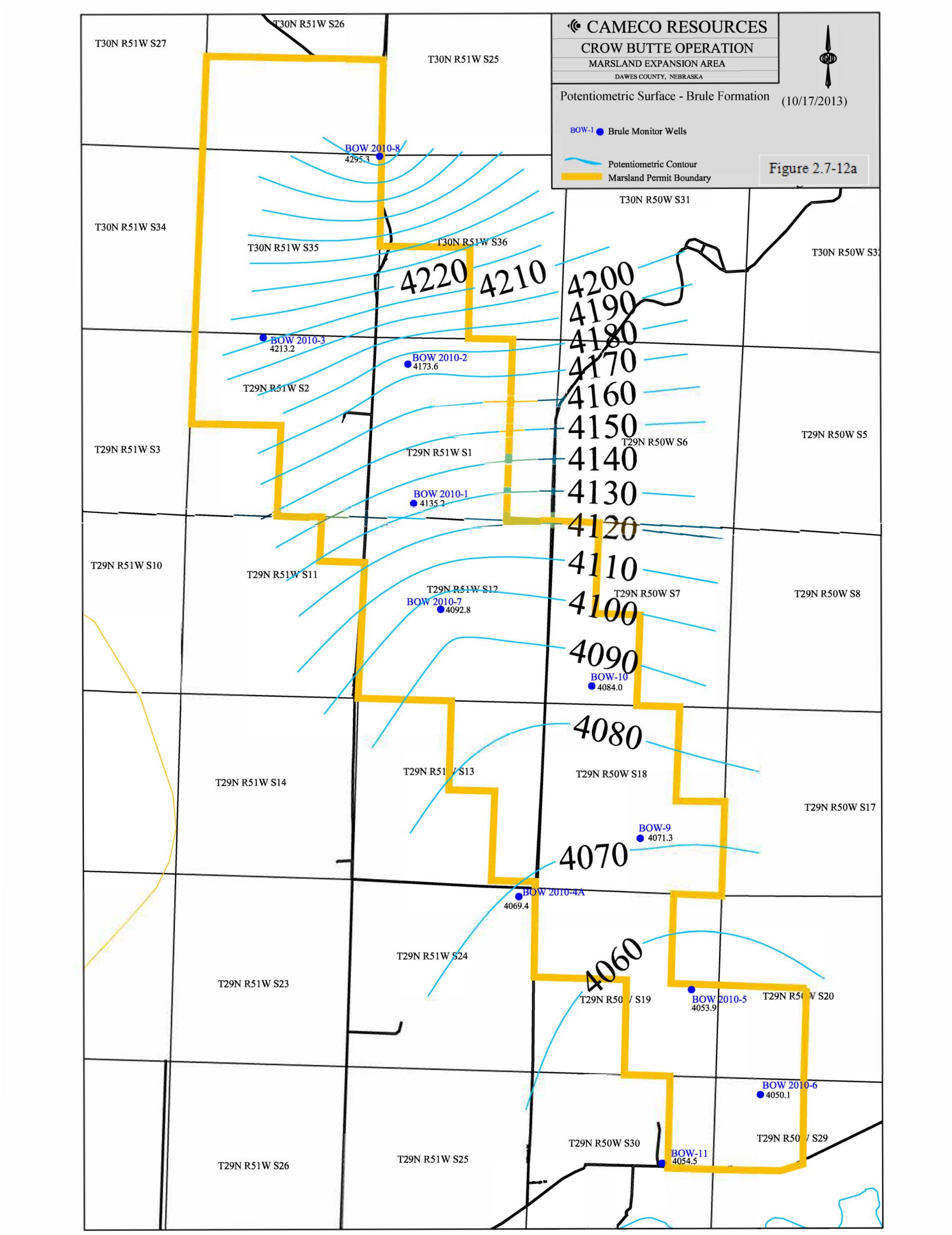


Figure 2.7-12b. Marsland Expansion Area Potentiometric Surface – Brule Formation (1/21/2014)

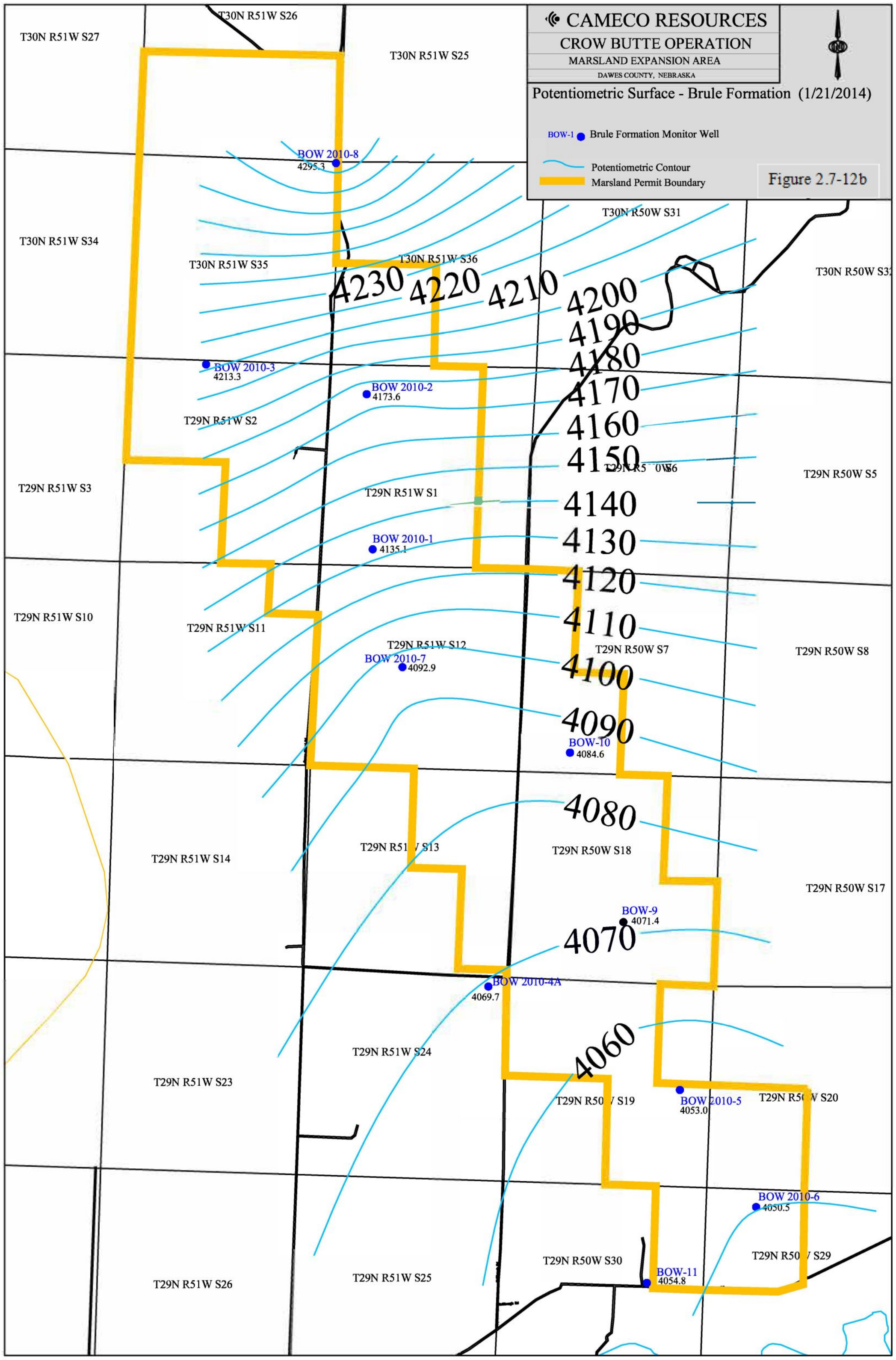


Figure 2.7-12c. Marsland Expansion Area Potentiometric Surface – Brule Formation (4/22/2014)

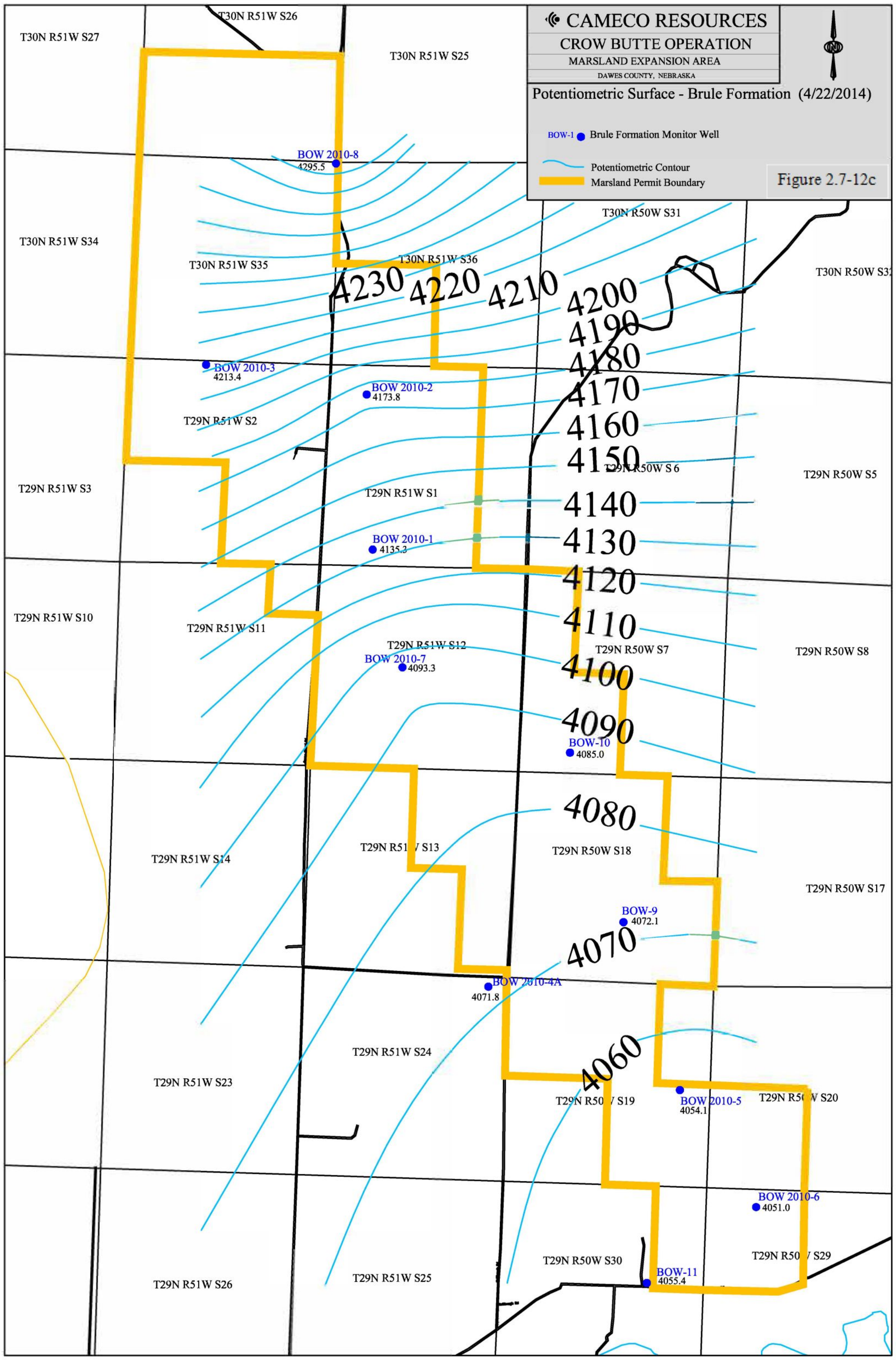


Figure 2.7-12d. Marsland Expansion Area Potentiometric Surface – Brule Formation (7/14/14)

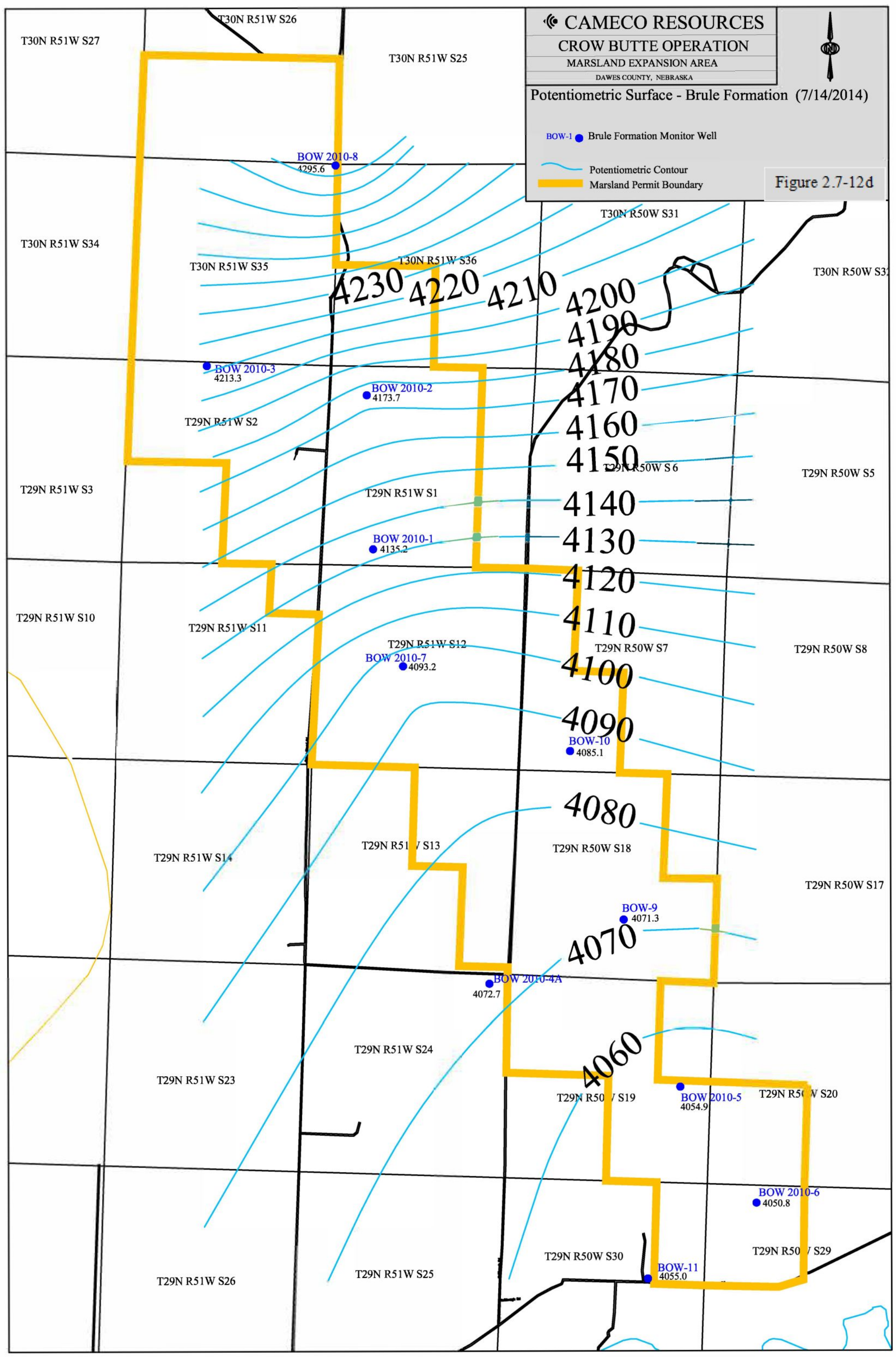


Figure 2.7-13a. Marsland Expansion Area Potentiometric Surface – Basal Sandstone of the Chadron Formation (10/17/2013)

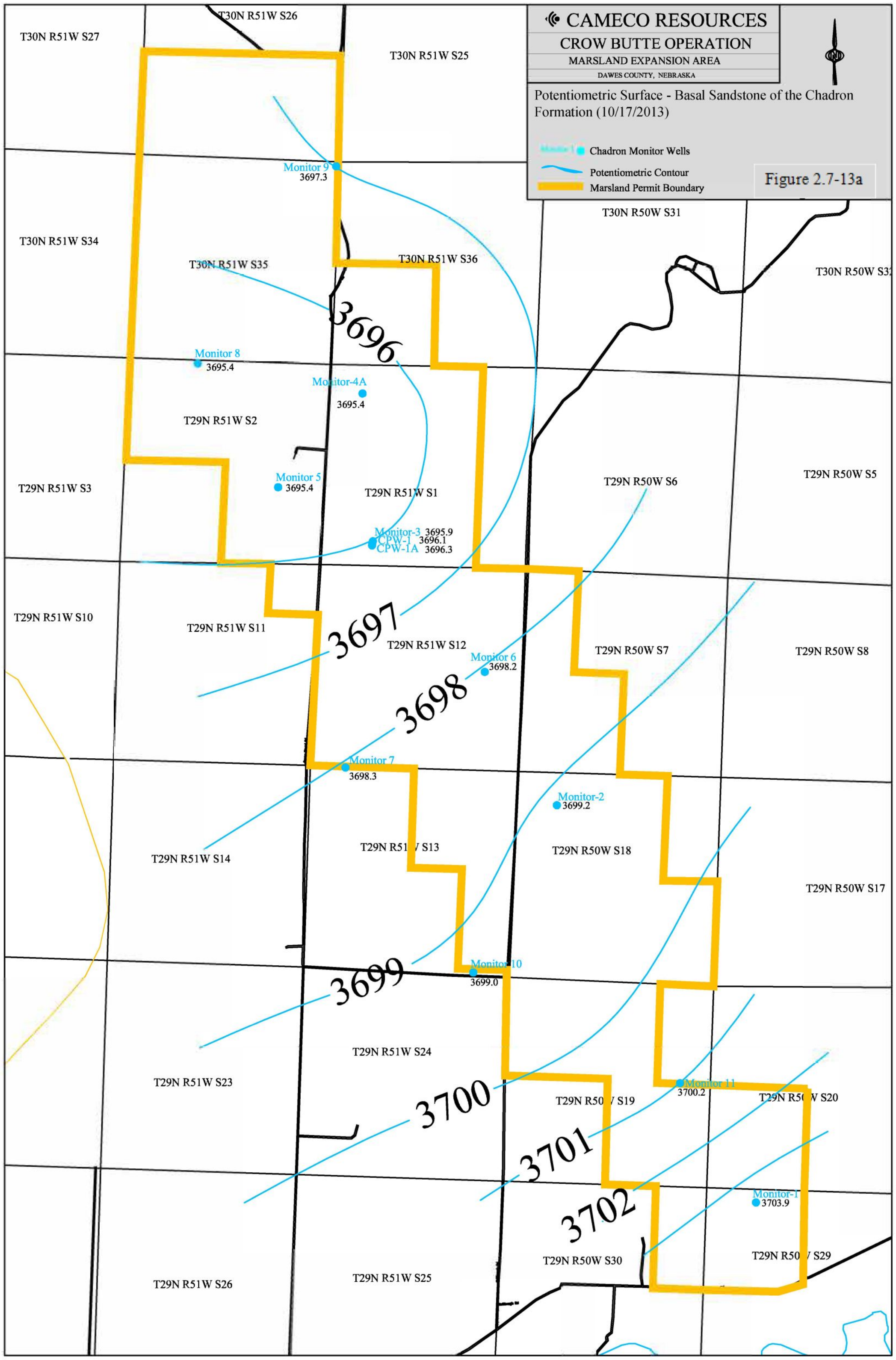


Figure 2.7-13b. Marsland Expansion Area Potentiometric Surface – Basal Sandstone of the Chadron Formation (1/21/2014)

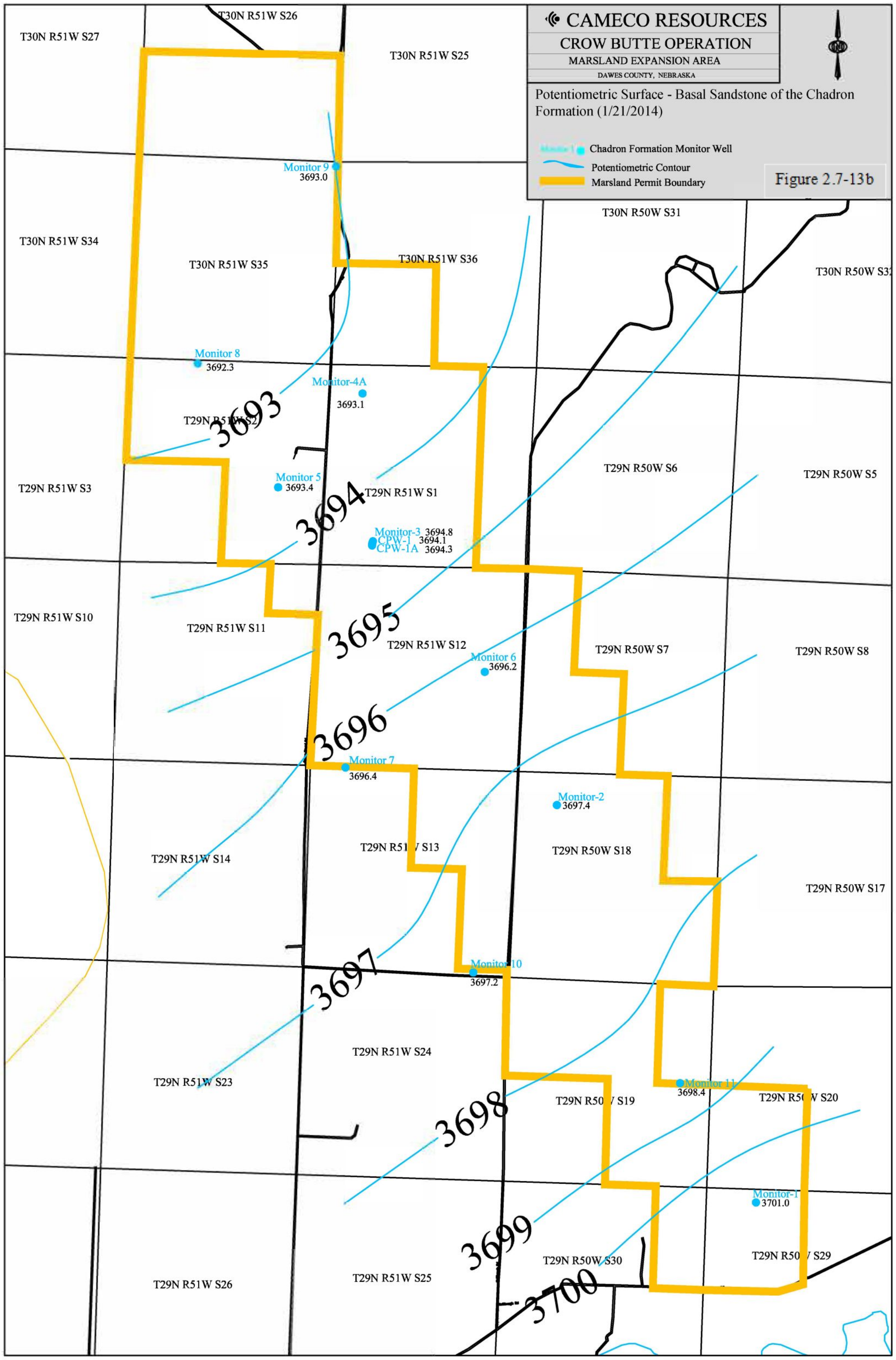


Figure 2.7-13c. Marsland Expansion Area Potentiometric Surface – Basal Sandstone of the Chadron Formation (4/22/2014)

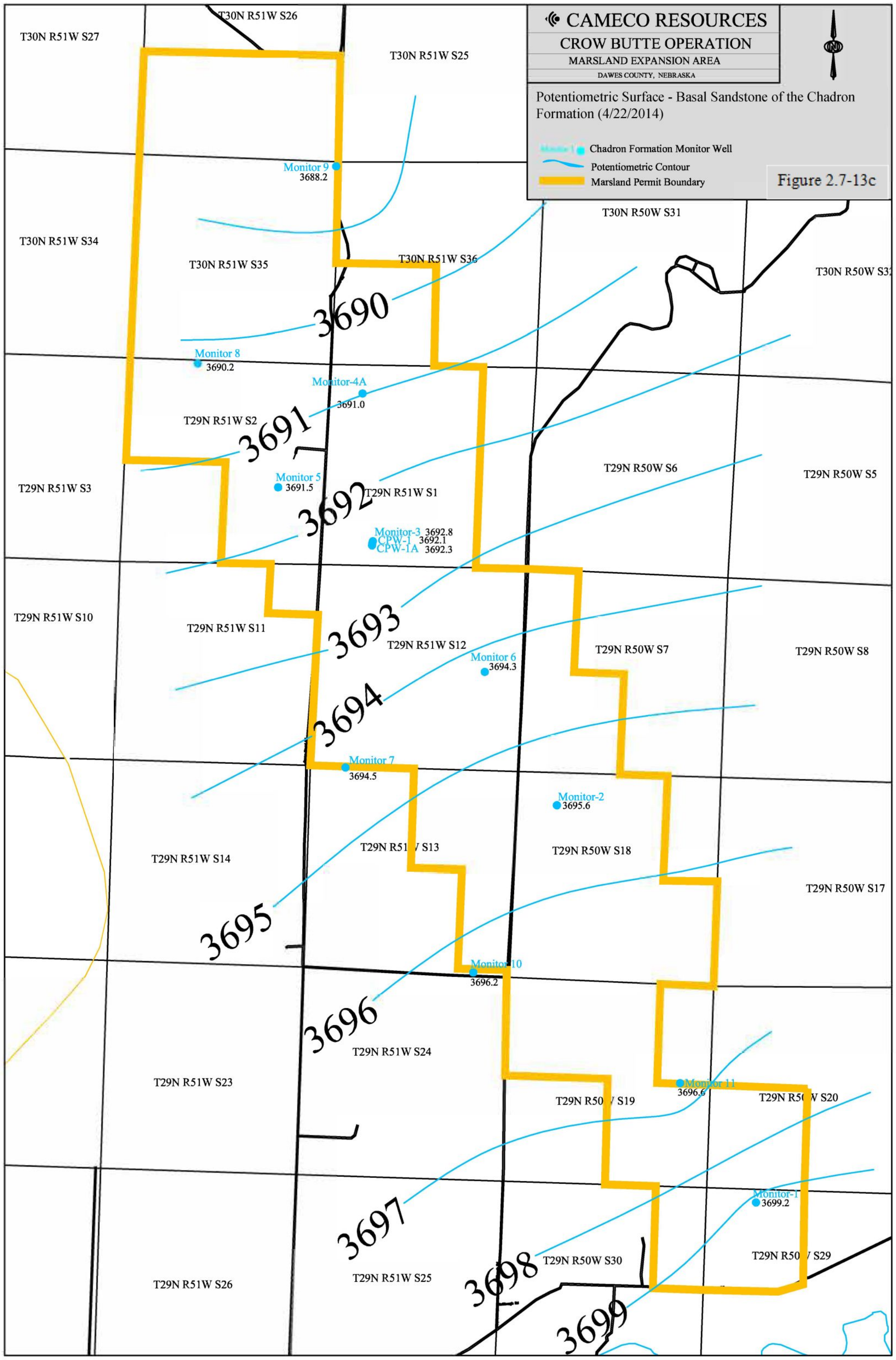
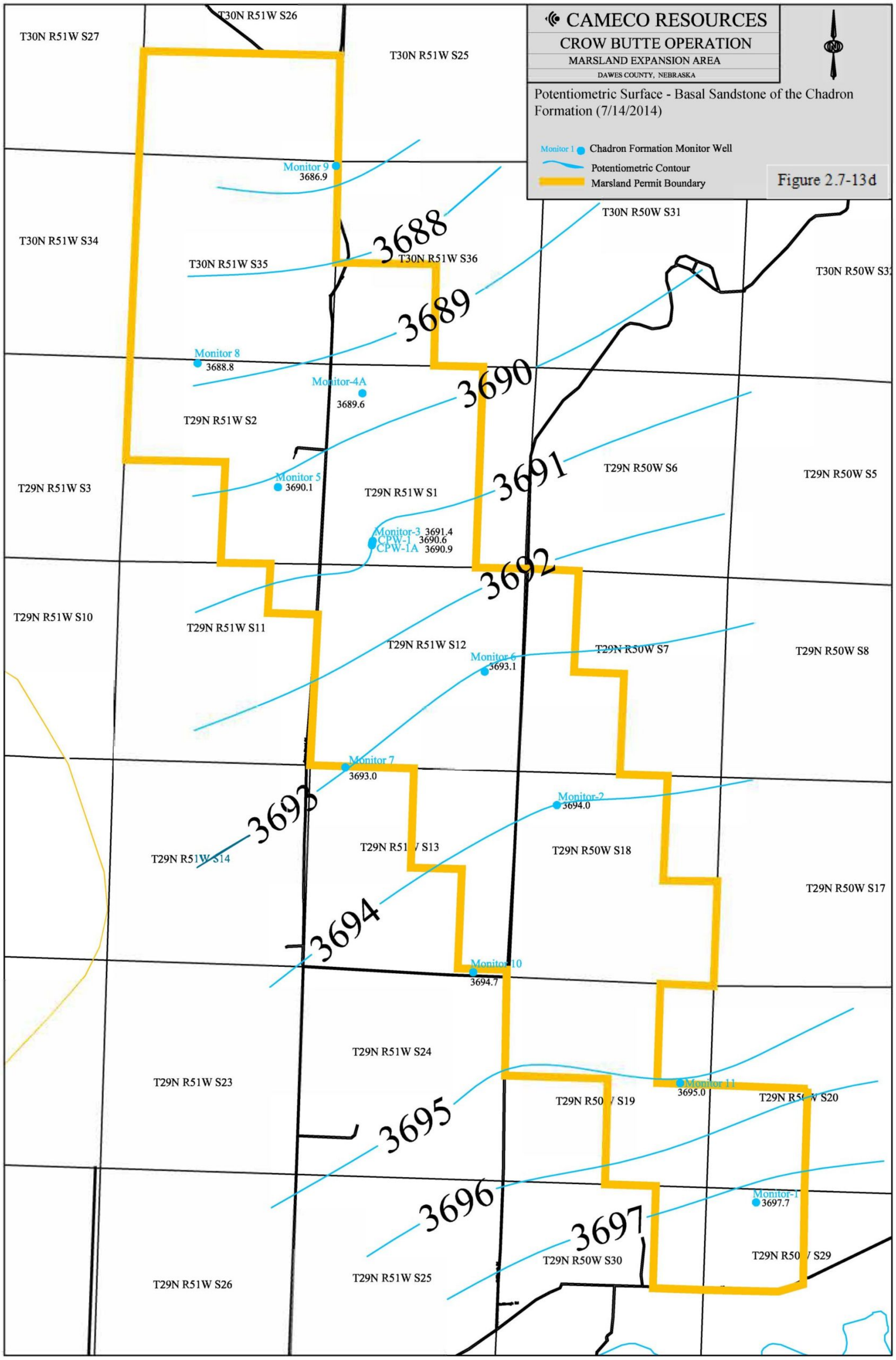
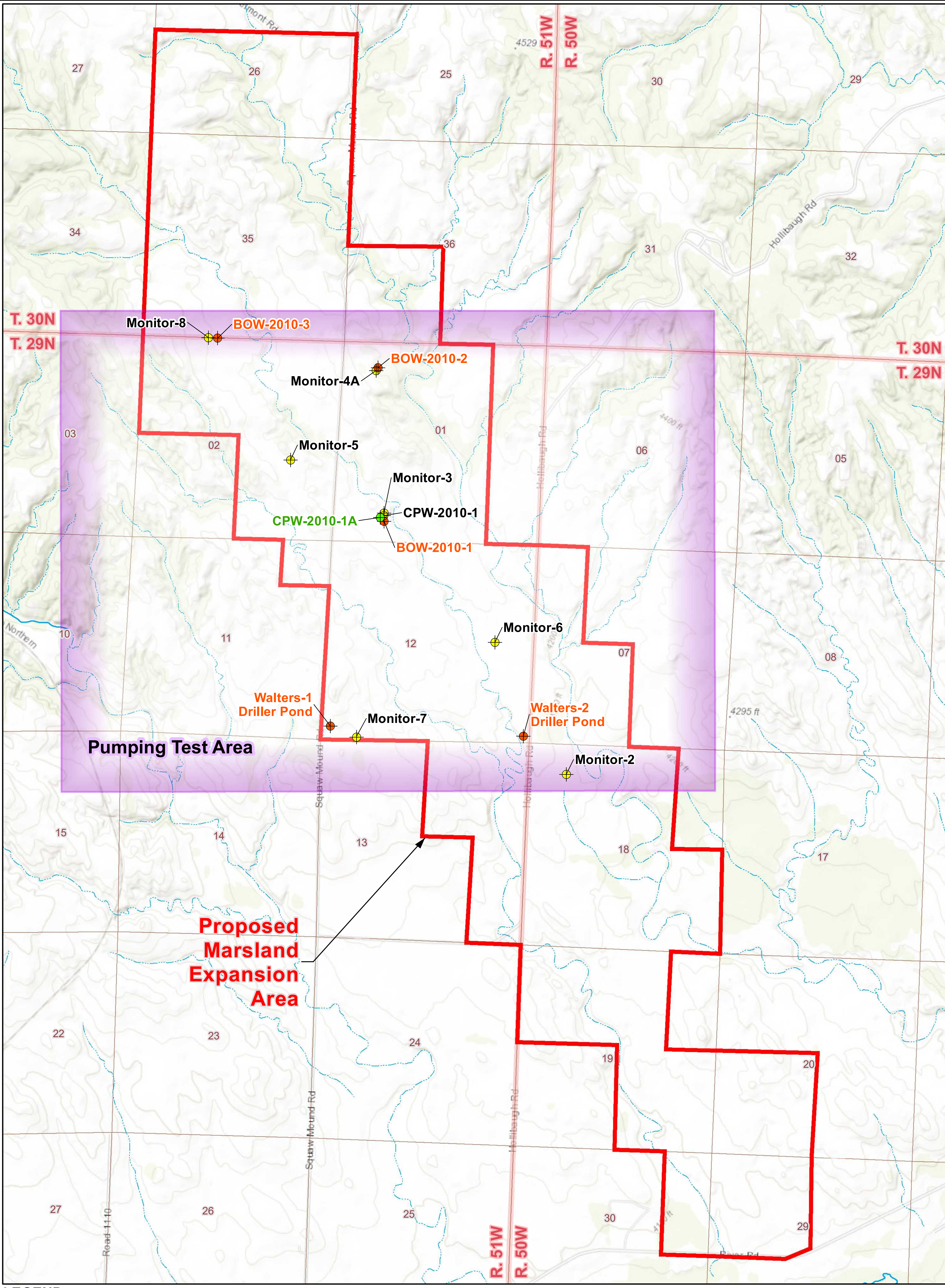


Figure 2.7-13d. Marsland Expansion Area Potentiometric Surface – Basal Sandstone of the Chadron Formation (7/14/14)





LEGEND

Pumping Test Monitoring Wells

- Basal Sandstone of the Chadron Formation Well
- Basal Sandstone of the Chadron Formation Well (Pumping Well)
- Brule Formation Well
- Pumping Test Area
- Proposed Marsland Expansion Area
- Intermittent Stream/River

N

0 1,250 2,500

Feet

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

CROW BUTTE RESOURCES, INC.

FIGURE 2.7-14
MARSLAND EXPANSION AREA
PUMPING TEST WELL LOCATIONS

PROJECT: CO001636	MAPPED BY: JC	CHECKED BY: MS

2.8 ECOLOGICAL RESOURCES

Section 2.8 of the 2008 Crow Butte LRA and Section 2.8 of the MEA TR provide information on the ecological resources for each project area. Information from these reports has been incorporated into this Combined ER/TR. This section provides an update to threatened, endangered, and candidate species that have the potential of occurring within the project areas. Based on the information presented in this section there is no significant change between the 2008 Crow Butte LRA, MEA TR and this Combined ER/TR.

2.8.1 Regional Setting

2.8.1.1 Crow Butte Project

The Crow Butte Project occurs at the confluence of two Nebraska ecoregions – the Western High Plains and the Northwestern Great Plains (Chapman et al. 2001). The transition from Central Great Plains in the eastern part of the state to the Western high Plains westward is primarily a factor of the reduction in effective precipitation associated with the Western High Plains. There is a general conformity in the composition of the plant cover, as many species are common to both ecoregions. Physiographically, this area is comprised of smooth to slightly irregular plains that support native communities, croplands, or grazing.

The Western High Plains ecoregion is characterized by a semi-arid to arid climate, with annual precipitation ranging between 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 with a high percentage of dryland agriculture. Natural vegetation is dominated by drought-tolerant, short-grass prairie and large areas of mixed-grass prairie in the northwest portion of the state.

The Northwestern Great Plains ecoregion encompasses the Missouri Plateau portion of the Great Plains. It is a semi-arid rolling plain of shale and sandstone punctuated by occasional buttes. Native grasslands persist in areas of steep or broken topography, but they have been largely replaced by spring wheat and alfalfa over most of this ecoregion. Agriculture exists on level to rolling hills and is generally limited by erratic precipitation patterns and limited opportunities for irrigation.

Nearly 470 plant species are described in the Chadron State college herbarium for Dawes County (WFC 1983). The Institute of Agriculture and Natural resources lists 603 native and 123 introduced species that occur in Dawes County. During the 1982 baseline study, more than 400 species of plants were collected (WFC 1983).

2.8.1.2 Marsland Expansion Area

The project area also occurs within the Western High Plains Level III ecoregion (details in Crow Butte portion above). Unlike the Crow Butte Project, the MEA does not overlap a portion of the Northwestern Great Plains ecoregion.

2.8.2 Terrestrial Ecology

2.8.2.1 Crow Butte Project

An ecological study was performed for the Crow Butte Project application in 1982. Baseline flora and fauna data were collected to fulfill the objectives specified in RG 3.46. The 1982 baseline study focused on conducting intensive research within the principal License area, which included both the commercial License area and the five-mile adjacent area, and less intensive research within the 50-mile outer area. Additional baseline data was collected within the three areas in 1987, 1995, 1996, and 1997.

For more detailed descriptions of the data, please refer to *the Crow Butte Uranium Project Application and Supporting Environmental Report for USNRC Research and Development Source Material License* (WFC 1983) or the *Crow Butte Uranium Project Application and Supporting Environmental Report for USNRC Commercial Source Material License* (FEN 1987).

The information presented in this report summarizes the baseline data collected for the Crow Butte Project between 1982 and 2008

2.8.2.1.1 Methods

Methods of investigation were chosen to describe the principal floral and faunal species of the area. Whenever possible, methods were used that would provide continuity and compatibility with ongoing investigations in the state and the region.

Plant collections were conducted throughout the growing season to prepare a comprehensive voucher of plant species within the study area. Vegetation communities mapping was completed at a scale of 1:12,000 for the Crow Butte Project, and 1:24,000 for the adjacent area. Vegetation/Habitat types were chosen according to the system developed by the Montana Agriculture Experiment Station, modified to conform to the ecological characteristics of the Crow Butte area. The system was deemed appropriate to describe floristic characteristics and to describe wildlife habitat affinities.

General observation was used to generate a species list for the study area and to obtain information on faunal distribution. In addition to routine sightings, time was devoted specifically for 1) aircraft raptor nest surveys, 2) aircraft big game surveys, 3) movement and migration route delineation, 4) game bird winter concentrations, 5) game bird brood counts, 6) grouse strutting ground “lek” surveys, 7) waterfowl breeding pair counts, 8) waterfowl brood surveys and production counts, 9) prairie dog colony surveys, 10) small mammal trapping, 11) carnivore spotlight surveys, and 11) reptile and amphibian surveys. Refer to WFC (1983) for detailed descriptions of these methodologies.

2.8.2.1.2 Vegetation

The Pine Ridge area of Nebraska, as with the adjacent Black Hills of South Dakota, is represented by two principal vegetation regions. These are described briefly below:

- Plains and Prairie Flora - The main features that describe this vegetation region are a dominance of grasses, absence of trees, rolling topography, and a characteristic xerophytic flora. Species occurring on the study area include big bluestem, little bluestem, Canada wild rye, Kentucky bluegrass, sage, purple cornflower, breadrood scurf pea, golden rod and related species.

- Rocky Mountain Forest Flora (Black Hills Montane Element) - Although geographically separated from the Rocky Mountains, the Pine Ridge and Black Hills have affinities to this region, which lies principally 200 km to the west. Floral species suggest that the two areas were contiguous during Pleistocene times. Species on the study area typical of this region include Oregon grape, Rocky Mountain juniper, ponderosa pine and Mariposa lily.

Many non-native plant species occur in the study area. The 1982 study estimated that 30 percent of species and more than 50 percent of plant cover consists of non-native plant species that are conspicuously successful and include smooth brome, cheatgrass, white sweetclover, yellow sweetclover and several Brassicaciae, including the species tumble mustard, tansy mustard, pennycress charlock, and Shephard’s purse. Cultivated species include wheat, oats, rye, corn, milo and alfalfa.

<u>Plants</u>

During the baseline study between March and Mid-July, 1982, more than 400 species of plant were collected within the study area. Of that number, 163 species were recorded within a specific Section 19 study (Table 2.8-1).

2.8.2.1.3 Habitat Types

Table 2.8-2 summarizes the habitat types and amounts of each that comprise the Crow Butte Project. Specific descriptions of each habitat classification are given in 1983 WFC.

Sixteen habitat types were originally identified in the License area as described in the 1983 report. These have remained relatively unchanged and include; wet meadow, mixed prairie-riparian, wet meadow–riparian, deep marsh–riparian, riverine, impoundment, deciduous streambank forest, shelterbelts and tree plantings, ponderosa pine, mixed grass prairie, range rehabilitation, cultivated, surface disturbance, human biotopes, cemeteries, and roads and roadside complex. These broad categories often represent several vegetation community types that are generally defined by both species composition and relative abundance.

Wetlands perform many important hydrologic functions such as floodwater storage, regulating stream flows, streambank stabilization, nutrient removal and uptake, and groundwater recharge. Wetlands and/or waterbodies (classification numbers 002, 051, 052, 054, 055, and 059) make up only 3.17 percent (273.92 acres) of the habitat within the Crow Butte Project.

Woodlands are generally defined as vegetation communities that contain structure dominated by trees where canopy foliage covers 10 to 30 percent of the ground area (Butler et al. 1997). Forested habitat (classification numbers 110, 130, and 140) makes up 9.96 percent (863.55 acres) of the Crow Butte Project.

Grasslands are characterized by grasses and other erect herbs, usually without trees or shrubs (Butler et al. 1997). The mixed-grass prairie vegetation community is dominated by cool- and warm-season midgrasses, short-grasses, and sedges. Mixed grass prairie (classification number

410) is a large habitat component of the Crow Butte Project and accounts for 32.74 percent (2,840.18 acres).

The remaining land uses within the Crow Butte Project (classification numbers 610, 630, 640, and 650) includes farmsteads and associated buildings, gravel and dirt roads, and highways and associated rights-of-way. Urban or developed land includes areas of intensive use with much of the land covered by structures (e.g., houses and farm outbuildings). Human disturbed lands account for only 5.41 percent (189.88 acres) of the land use within the Crow Butte Project.

2.8.2.1.4 Mammals

Thirty-six species of wild mammals were documented during the 1982 baseline study, and another 28 species, mostly bats, insectivores, and small rodents, were deemed likely to occur in the region (Table 2.8-3).

Big Game Mammals

Big game species that may occur in suitable habitats throughout the project area include pronghorn antelope (*Antilocapra americana*), white-tailed deer (*Odocoileus virginianus*), and mule deer (*Odocoileus hemionus*). Elk (*Cervus elaphus*) and bighorn sheep (*Ovis canadensis*) may occur as transient species because of their known distribution in the Pine Ridge area (Nordeen 2004).

Pronghorn Antelope

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. Typically, daily movement does not exceed 6 miles. Some pronghorns migrate seasonally 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).

Nebraska is on the eastern fringe of the pronghorn's range, and there are large areas within the range boundary where pronghorns do not occur. According to Nordeen (2004), a large herd of approximately 60 to 100 antelope may use the area north of Crawford as winter range.

Mule Deer

In Nebraska, mule deer occur in foothills, broken hill country, prairie grasslands, and shrublands. Browse is an important component of the mule deer’s diet throughout the year, making up as much as 60 percent of total intake during autumn, while forbs and grasses typically make up the rest of their diet (Fitzgerald et al. 1994). This species tends to be more migratory than white-tailed deer, traveling from higher elevations in the summer to winter ranges that provide more food and cover.

Mule deer are distributed primarily along the foothills and escarpments, ranging outward into mixed-grass prairie and cultivated land. However, the distribution and abundance of mule deer varies by vegetation type in the project area. According to Nordeen (2004), approximately 100 to 200 mule deer and white-tailed deer may occupy a 1 to 2 square-mile area within the project area.

White-tailed Deer

White-tailed deer are found throughout the state of Nebraska, typically concentrated in riparian woodlands, mixed shrubs riparian, and associated irrigated agricultural lands, and are generally absent from dry grasslands and coniferous forests (Clark and Stromberg 1987).

In the License area, white-tailed deer are expected to be more widely distributed than mule deer. However, because of the high amount of cultivated land, white-tailed deer distributions may be primarily associated with riparian habitats along the White River and associated intermittent and ephemeral stream drainages. In addition, white-tailed deer may be absent from large expanses of mixed-grass prairie and shrub land habitats because they lack sufficient cover and browse.

Elk

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.

Elk ranges are concentrated in the Pine Ridge area and associated habitats in the Bordeaux and Hat Creek units. Over the past 40 years, elk populations have grown to greater than 2,500 animals (NGPC 2021). Occasionally, elk may occur within the project area as transients primarily between the summer and winter range movements.

Bighorn Sheep

Prior to the 1900s, the Audubon bighorn sheep 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.

Bighorn sheep were reintroduced into Nebraska in 1981. The reintroduction project began in 1981, when 12 bighorn sheep were first released in Fort Robinson State Park. Subsequent releases in 1988, 2001, 2005, 2007, and 2012 have reestablished bighorn sheep populations in the Wildcat Hills and Pine Ridge area. As a result of disease, herd growth is limited; consequently, hunting opportunities are limited through the issuance of auction and lottery permits (NGPC 2024a). No bighorn sheep are expected to occur within the license area because of insufficient habitat.

<u>Carnivores</u>

The coyote (*Canis latrans*), red fox (*Vulpes vulpes*), and long-tailed weasel (*Mustela frenata*) are expected to range freely and widely throughout the project area. Bobcat (*Lynx rufus*), badger (*Taxidea taxus*), and striped skunk (*Mephitis mephitis*) may also occur in the License area, but they are less common.

<u>Small Mammals</u>

The deer mouse (*Peromyscus maniculatus*), white-footed mouse (*Peromyscus leucopus*), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), meadow jumping mouse (*Zapus hudsonius*), northern pocket gopher (*Thomomys talpoides*), and meadow vole (*Microtus* *pennsylvanicus*) are expected to occur in the highest abundances. The highest densities of these small mammals are expected to occur in the deciduous forest areas, whereas the lowest abundance of small mammals would most likely occur in the cultivated fields. According to results of the 1982 baseline study (WFC 1983), the greatest diversity of small mammals was detected in the mixed- and short-grass community, and the lowest diversity was observed in the non-wooded riparian and lower deciduous forest areas.

Muskrat (*Ondatra zibethicus*) may occur along watercourses, and beaver (*Castor canadensis*) may occur in the White River Basin. Porcupine (*Erethizon dorsatum*), fox squirrel (*Sciurus niger*), white-tailed jackrabbit (*Lepus townsendii*), black-tailed jackrabbit (*Lepus californicus*), and eastern cottontail (*Sylvilagus floridanus*) are also expected to occur throughout the License area.

2.8.2.1.5 Birds

Researchers documented 201 species during the 1982 baseline study (Table 2.8-4). Common birds likely to occur within the cultivated fields include the American robin (*Turdus migratorius*), red-winged blackbird (*Agelaius phoeniceus*), mourning dove (*Zenaida macroura*), house wren (*Troglodytes aedon*), violet-green swallow, (*Tachycineta thalassina*), and horned lark (*Eremophila alpestris*). Birds associated with riparian and woodland habitats include pine siskin (*Carduelis pinus*), red crossbill (*Loxia curvirostra*), black-capped chickadee (*Poecile atricapillus*), rufous-sided towhee (*Pipilo erythrophthalmus*), yellow warbler (*Dendroica petechia*), and house wren (*Troglodytes aedon*).

Upland game birds such as wild turkey (*Meleagris gallopavo*), ring-necked pheasants (*Phasianus colchicus*), and sharp-tailed grouse (*Tympanuchus phasianellus*) may occur in the area as well. Waterfowl may occur throughout the region primarily during both the spring and fall migrations. However, because there are only a few low productivity wetlands and waterbodies (approximately 274 acres, or 3 percent), the diversity and abundance of waterfowl is extremely low in the project area.

Several raptor species are expected to occur in the project area, a reflection of the diversity in habitat types and the existence of many suitable nesting sites, such as tall trees. Golden eagles are permanent residents of the area, occurring in a variety of habitats. The most common permanent resident raptors occurring in the cultivated fields and mixed-grass prairies may include red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), northern harrier (*Circus cyaneus*), prairie falcon (*Falco mexicanus*), turkey vulture (*Cathartes aura*), and great horned owl (*Bubo virginianus*). In addition, rough-legged hawks (*Buteo lagopus*) are common winter residents of the Pine Ridge area (WFC 1983).

2.8.2.1.6 Reptiles and Amphibians

Of the 22 species of reptiles and amphibians recorded in Dawes and Sioux Counties (Ferraro 2004) (Table 2.8-5), 13 were documented during the 1982 baseline investigation. Documented toads and frogs included Woodhouse’s toad (*Bufo woodhousii*), great plains toad (*Bufo cognatus*), plains spadefoot (*Spea bombifrons*), western striped chorus frog (*Pseudacris triseriata*), northern leopard frog (*Rana pipiens*), and bullfrog (*Rana catesbeiana*). Two species of turtles observed were the snapping turtle (*Chelydra serpentina*) and painted turtle

(*Chrysemys picta*). Snakes identified included the bullsnake (*Pituophis catenifer*), plains garter snake (*Thamnophis radix*), red-sided garter snake (*Thamnophis sirtalis*), and racer (*Coluber constrictor*).

2.8.2.2 Marsland Expansion Area

Baseline ecological studies are described in Section 2.8.5 of the MEA TR and have been incorporated into the Combined ER/TR.

2.8.2.2.1 Methods

Baseline studies were performed during 2011 to determine presence or absence of federally or state-listed species 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 within a 2.5-mile (4.0-km) radius of the project area, referred to as the Ecological Study Area (ESA). The 2.5-mile (4.0-km) ESA boundary overlaps the 2.25-mile (3.62 km) AOR buffer. Aerial surveys conducted included the entire 2.5-mile (4.0-km) ESA, but groundwork was almost entirely restricted to the project area due to limited access to private lands. Thus, certain ecological resources within the 2.5-mile (4.0-km) 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 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.

2.8.2.2.2 Vegetation

Vegetation classifications were applied to the MEA through heads-up digitizing of NAIP imagery and categorized into eight vegetation communities (Figure 2.8-1). These communities include mixed-grass prairie, degraded rangeland, mixed-conifer, cultivated, drainage, structure biotope, range-rehabilitation, and deciduous streambank forest. 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 2.8-6 summarizes the abundance of vegetation types within the MEA.

Mixed-Grass Prairie

The most common vegetation type present in the MEA is mixed-grass prairie, comprising 64 percent of the area. 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.

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 (*Bromus tectorum*) and Kentucky bluegrass (*Poa pratensis*). 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, the southern portion of the project area had sections that were particularly dominated by these species. The degraded rangeland vegetation type comprises 14 percent of the project area.

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. 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 (*Bromus inermus*) being particularly abundant in low-lying areas. Pussytoes was a commonly observed forb. Mixed-conifer forests comprise 9.1 percent of the project area, making this the most common of the forested vegetation types.

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. 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. 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 1.5 percent of the project area. 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 1.5 percent of the project area.

2.8.2.2.3 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.

Big Game Mammals

Pronghorn

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. Pronghorn were observed regularly throughout the project area in 2011 and they appear to be relatively common year-round.

Mule Deer

The MEA is located within the Pine Ridge Mule Deer Hunt Unit, which encompasses areas of Box Butte, Dawes, Sheridan, and Sioux Counties north of the Niobrara River and west of Nebraska Highway 27. Mule deer were seen within the project area during field work in 2011 but not in high numbers, though numbers are likely higher during winter.

White-tailed Deer

White-tailed deer hunting in the region encompasses the same unit as previously described for mule deer. According to the NGPC (2011), the fall white-tailed deer population in Nebraska is estimated to be between 150,000 and 180,000 animals. 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

NGPC estimates the state elk population at approximately 2,500 individuals, and most of the population inhabits the Pine Ridge area (NGPC 2021). The MEA 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. 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

Bighorn sheep were reintroduced into Nebraska in 1981. The reintroduction project began in 1981, when 12 bighorn sheep were first released in Fort Robinson State Park. Subsequent releases in 1988, 2001, 2005, 2007, and 2012 have reestablished bighorn sheep populations in the Wildcat Hills and Pine Ridge area. As a result of disease, herd growth is limited; consequently, hunting opportunities are limited through the issuance of auction and lottery permits (NGPC 2024a). 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.

<u>Carnivores</u>

The following species 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. The NGPC approved mountain lion hunting in the Pine Ridge area starting in 2014. 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 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. No swift fox were detected using the remote cameras. Grass height is unsuitable throughout the majority of the MEA, where dense fields of cheatgrass exceed 14 inches in many areas during summer (HWA 2011).

<u>Small Mammals</u>

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 HWA 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 a 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 2.5-mile (4.0-km) 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.

2.8.2.2.4 Birds

The Nebraska Ornithologists Union lists 291 bird species occurring in Dawes County 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). 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*]).

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 (16 USC, §703 et seq.) protects 836 migratory bird species (to date) and their eggs, feathers, and nests from disturbances (USFWS 2011a).

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).

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).

<u>Raptors</u>

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 Migratory Bird Treaty Act (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 2.5-mile (4.0-km) 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 2.5 ESA due to minimal access to private lands. Additional ground surveys for determining productivity of known nests, including nests in the 2.5-mile (4.0-km) 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 2.8-2). An additional 19 nests were documented within the 2.5-mile (4.0-km) 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 2.5-mile (4.0-km) ESA (HWA 2011). Of the five species documented to be 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 productive (i.e., at least one fledged chick) at the time of the last survey. Both great horned owl nests in the 2.5-mile (4.0-km) ESA had large chicks during the first ground survey and both likely fledged young, and red-tailed hawk nest #12 in the 2.5-mile (4.0-km) 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 which are located in the northern portion of the project area and in the 2.5-mile (4.0-km) 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 2.5-mile (4.0-km) ESA of the project 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 2.5-mile (4.0-km) 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 2.5 miles (4.0 km) of the MEA 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 2.5-mile (4.0-km) ESA. The results suggest 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).

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 2.5-mile (4.0-km) ESA, 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 2.5-mile (4.0-km) ESA.

2.8.2.2.5 Reptiles and Amphibians

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 2011).

2.8.3 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. As of April 2025, there are five species listed by the USFWS (USFWS 2025) in the ESA (2.5-mile (4.0-km) buffer of the project areas and primary access route between the Crow Butte Project and MEA).

Northern Long-eared Bat

The northern long-eared bat (*Myotis septentrionalis*) is listed by the USFWS as endangered. White-nose syndrome, a fungal disease, has contributed to the decline in populations particularly in the northeast where the species has declined by up to 99 percent from pre-white-nose syndrome levels at many hibernation sites. The northern long-eared bat has not been observed in either the Crow Butte Project or the MEA. In addition, no recent surveys have been completed to the determine the presence of the northern long-eared bat. It should be noted that the habitat for the northern long-eared bat includes caves and mines which are not present at either the Crow Butte Project or the MEA.

Piping Plover

The piping plover (*Charadrius melodus*) is listed as threatened by the USFWS. The piping plover has the potential of occurring in the project areas; however, the USFWS indicates that Dawes County does not overlap with critical habitat. As indicated in Table 2.8-4, the piping plover was reported by knowledgeable individuals within the Crow Butte Project. No recent surveys have been completed to determine the presence of the piping plover.

Monarch Butterfly

The USFWS lists the monarch butterfly (*Danaus Plexippus*) as a candidate species. During the breeding season, monarchs lay their eggs on their obligate milkweed host plant (primarily *Asclepias spp.*). Previous surveys done at the Crow Butte Project (Table 2.8-1) indicated the presence of Showy milkweed (*Asclepias speciosa*). No recent surveys have been completed to determine the presence of the monarch butterfly.

Western Regal Fritillary

The western regal fritillary (*Argynnis idalia occidentalis*) is listed as proposed threatened by the USFWS. During the breeding season, western regal fritillary lay their eggs on various violets (*Viola sp.*). Previous surveys done at the Crow Butte Project (Table 2.8-1) indicated the presence of two violet species: Canada violet (*Viola canadensis*) and Yellow prairie violet (*Viola nuttallii*). No recent surveys have been completed to determine the presence of the monarch butterfly.

Suckley's Cuckoo Bumble Bee

The Suckley's cuckoo bumble bee (*Bombus suckleyi*) is listed as proposed endangered by the USFWS as of December 2024. The USFWS is in the process of developing consultation guidance, including a range map. No recent surveys have been completed to determine the presence of the Suckley's cuckoo bumble bee.

In addition, the USFWS iPaC indicates that there are Bald Eagles and/or Golden Eagles and migratory birds in the ESA. Both the Bald and Golden eagles are protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act (MBTA). Migratory birds are also protected under the MBTA.

Nebraska's Conservation and Environmental Review Tool (CERT) was used to obtain a species list that includes Nebraska's threatened and endangered species for Dawes County (CERT 2025).

There are currently two threatened species (Northern Redbelly Dace [*Chrosomus eos*] and Finescale Dace [*Chrosomus neogaeus*]) and three endangered species (Northern Long-eared Myotis [*Myotis septentrionalis*], Blacknose Shiner [*Notropis heterolepis*], and Swift Fox [*Vulpes velox*].

The northern redbelly dace, finescale dace, and blacknose shiner can be found in the Niobrara River. As indicated in Section 2.8.4.2.1, none of these species were observed as part of the baseline sampling completed at the MEA. The swift fox was reported by knowledgeable individuals within the Crow Butte Project (Table 2.8-4) and was not detected during baseline surveys at the MEA (Section 2.8.2.2.3). The northern long-eared bat is discussed above.

2.8.4 Aquatic Ecology

2.8.4.1 Crow Butte Project

Objectives of the aquatic ecology baseline data collections conducted in 1982 were to provide information to assess the aquatic resources occurring within the Crow Butte Project. The data results are summarized below. For more detailed information, refer to the 1983 WFC.

2.8.4.1.1 Aquatic Study Area Description

Aquatic habitats on the Crow Butte Project consist of three streams and eight impoundments. English Creek, Squaw Creek, and White Clay Creek are first-order streams that form the drainage basin within the Crow Butte Project (Figure 2.8-3). Four of the impoundments are on English Creek, two on White Clay Creek, and one on Squaw Creek. The remaining impoundment is a stock pond created by a dam on a small drainage area.

In general, the aquatic habitats on the Crow Butte Project suffer from ongoing environmental stresses. Naturally occurring stresses include unstable substrates and banks, low flows, and periodic flooding. Overgrazing on adjacent rangelands and in riparian areas, and farming practices along the stream courses further compound these problems. Commercial baitfish practices such as poisoning, dewatering, and introducing bait minnows have affected many of the impoundments. Livestock grazing and watering add to impoundment problems. These stresses are reflected in a fishery mostly consisting of non-game, tolerant species. Periodic stocking by the NGPC has created some put-and-take sport fisheries in the area but these are not self-sustaining due to environmental factors.

- English Creek is entirely within the CSA originating from springs and flowing northerly for about 5.6-km where it empties into Squaw Creek. Low flow and a vegetation-choked stream channel provide little suitable fish habitat. On-stream impoundments and pools created by washouts below culverts provide about the only suitable fish habitat.
- Squaw Creek originates in the Nebraska National Forest and the Ponderosa State Wildlife Area and flows through the Crow Butte Project to its confluence with White Clay Creek. Squaw Creek changes dramatically from the upstream areas to the lower reaches. Much of the upper watershed is forested, mainly because it is within the Ponderosa Wildlife Area where livestock grazing and cultivation is minimal. In contrast, the middle and lower watershed consists of heavily grazed rangeland or cultivated small grains.

- At the upper sampling station (S-1) the pine and grass-covered slopes, and thick, undisturbed riparian zone provide a relatively stable watershed. Substrates in this area consist of hardpan, gravel riffle areas, and some silted-in pools. Streambanks are relatively stable with overhanging vegetation and with some undercutting. Log jams, undercut banks, and pools up to 1.5 m deep provide cover and probable overwintering areas for fish.
- From station S-2 downstream to I-6, Squaw Creek looks entirely different. The understory in this lower section has virtually been eliminated by livestock grazing. Stream banks are degraded and unstable and the substrate is mostly sand. Few gravel riffle areas are present and most of the pools are heavily silted. Aquatic vegetation is relatively sparse in this section of stream with some Cladophora growing in shallow fast-flowing areas. The watershed in this lower area is unstable and, as evidenced by high-water debris, is subjected to periodic severe flooding (WFC 1983).
- White Clay Creek drains from the national forest to the south and flows northerly through the Crow Butte Project and empties into the White River. At WC-1, the creek flows through a riparian grass area and has relatively stable stream banks. Habitat consists of mud and sand substrates and no well defined pools or riffles. At station WC-2 the creek flows through pasture land. In this section the substrate consists of sand, gravel and rubble with some silted pools. The stream banks appear to be relatively stable.
- Impoundments range in size from 0.4 ha (I-1) to 7.7 ha (I-6). Impoundments I-4, 5, 6, 7, and 8 have been or are now being, managed for raising baitfish. Impoundment I-9 has been stocked with brook trout for recreational fishing and serves for stock watering.

2.8.4.1.2 Methods

Fish were collected at each location to document their occurrence and to determine their relative abundance. The sampling effort was not standardized due to differences in the types of habitats sampled, sampling equipment, and abundance of fish present at each location.

Quantitative triplicate samples of benthic macroinvertebrates were collected from the stream and impoundment sample locations. Soft substances were sampled with a Ponar Dredge (0.22 m^2) and gravel riffle substrates with a Surber sampler (0.0093 m^2). Shannon-Weaver diversity indices were calculated from all samples.

Single qualitative samples of periphyton were collected at each sampling location by scraping the surface of several rocks, sticks, plant or other substrate material with a pocket knife. Diatom proportional counts were performed at the generic level. Green and blue-green algae were identified and their occurrence noted for each sampling location.

2.8.4.1.3 Fish

The status and distribution of fish species for the study area are presented in Table 2.8-7. Fourteen species of fish were collected from the Crow Butte Project streams and impoundments (Table 2.8-8). Game fish collected included black bullheads, rainbow trout, brown trout, and brook trout.

Brook trout, which are not stocked, were collected in low numbers from Squaw Creek at several locations (Table 2.8-9). Although rainbow trout are periodically stocked by the NGPC in the upstream section, none were sampled at either S-1 or S-2. Periodic severe flooding is probably the most important factor limiting the effectiveness of stocking and reducing the trout population in Squaw Creek.

Brown trout and rainbow trout were collected in the White River at station W-1 and brown trout were collected at W-2. Longnose dace were captured at all White River stations. Fluctuating flows, periodic flooding, sand and silt substrates, and warm water temperatures are probably the most important factors limiting natural trout production in the White River.

Impoundment I-9 has been stocked with brook trout but is not a public area and therefore provides only a limited amount of recreational fishing. The other impoundments have been or are now managed for baitfish production.

2.8.4.1.4 Macroinvertebrates

Macroinvertebrate analyses of the samples indicate that, in general, the study streams and impoundments have stressed environments. More than 90 percent of the total abundance of all stations consisted of organisms considered tolerant. The most abundant groups of these tolerant species were: *chironomidae* – 34 percent, *simulidae* - 20 percent, *oligochaeta* - 19 percent, and *ceratopogonidae* - 15 percent. Exceptions occurred at the upper Squaw Creek stations (S-1 and S-2), where caddisflies and mayflies dominated the riffle habitat. These two taxa typically represent less stressed environments than the above listed organisms.

Macroinvertebrate density and diversity values for the aquatic stations are presented in Table 2.8-10. Additionally, percent contributions of the dominant macroinvertebrate taxa are given. Although densities were high at most sampling stations, diversity values were low. Healthy streams usually have diversity values between 3.0 and 4.0, but many forms of stress reduce diversity by making the environment unsuitable for some species or by giving other species a competitive advantage. The upper Squaw Creek station (S-1) was the only station that had diversity values within this range indicating relatively higher quality and a more stable habitat.

2.8.4.1.5 Periphyton

The Periphyton communities at the aquatic sample stations were composed of 21 diatoms, 8 green algae, and one blue-green alga genera. Diatom percent occurrence and general occurrence of other algae are presented in Table 2.8-11. *Cymbella*, *Navicula*, *Nitzschia*, *Surirella*, and *Synedra*, were the most common diatom genera and were found in every sample. Green algae were found in all sampling locations, with greatest development occurring in the impoundments (WFC 1983). *Cladophora* was the most common and abundant green algae found in the streams and at some locations formed thick mats.

2.8.4.2 Marsland Expansion Area

Aquatic ecology at the MEA is described in Section 2.8.10 of the MEA TR and has been incorporated into this Combined ER/TR.

2.8.4.2.1 Fish

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 EPA'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).

2.8.4.2.2 Macroinvertebrates

Macroinvertebrates were not sampled directly within the MEA, although crayfish (unknown species) were commonly found during the fish sampling in the Niobrara River (HWA 2011).

2.8.4.2.3 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 2011b). 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 2.8-1):

- Site #1 – location identified in the NWI as "freshwater emergent wetland." Low-lying depression in a grassy field with ephemeral open water created by run-off 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.

2.8.5 References

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Table 2.8-1. Crow Butte Project Plant Species List

Species	Scientific Name	Common Name
EQUISETACEAE	*Equisetum laevigatum*	Smooth horsetail
PINACEAE	*Pinus ponderosa*	Ponderosa pine
RANUNCULACEAE	*Anemone patens*	Pasque-flower
	Clematis ligusticifolia	Western clematis
	Ranunculus abortivus	Early wood buttercup
	Thalictrum dasycarpum	Purple meadowrue
PAPAVERACEAE	*Argemone polyanthemos*	Prickle poppy
FUMARIACEAE	*Corydalis aurea*	Golden corydalis
ULMACEAE	*Ulmus americana*	American elm
	Ulmus pumila	Siberian elm
CANNABACEAE	*Humulus lupulus*	Common hop
URTICACEAE	*Urtica dioica*	Stinging nettle
CACTACEAE	*Coryphantha vivipara*	Pincushion cactus
	Opuntia fragilis	Brittle prickly pear
CARYOPHYLLACEAE	*Arenaria hookeri*	Hooker sandwort
	Cerastium arvense	Prairie chickweed
	Paronychia jamesii	James nailwort
	Stellaria media	Common chickweed
CHENOPODIACEAE	*Chenopodium album*	Lamb's-quarters
	Chenopodium fremontii	Fremont goosefoot
	Chenopodium leptophyllum	Maple-leaved goosefoot
	Kochia scoparia	Kochia
	Salsola iberica	Russian thistle
AMARANTHACEAE	*Amaranthus graecizans*	Tumbleweed
	Amaranthus retroflexus	Rough pigweed
POLYGONACEAE	*Polygonum convolvulus*	Wild buckwheat
	Polygonum ramosissimum	Bushy knotweed
MALVACEAE	*Malva rotundifolia*	Common mallow
	Sphaeralcea coccinea	Red false mallow
VIOLACEAE	*Viola canadensis*	Canada violet
	Viola nuttallii	Yellow prairie violet
SALICACEAE	*Populus deltoids*	Plains cottonwood
	Salix exigua	Coyote willow
CAPPARACEAE	*Cleome serrulata*	Rocky mountain beeplant
BRASSICACEAE	*BRASSICACEAE*	
	Arabis holboellii	Rockcress
	Brassica kaber	Charlock
	Capsella bursa-pastoris	Shepherd’s purse
	Chorispora tenella	Blue mustard
	Descurainia pinnata	Tansy mustard
	Descurainia sophia	Flixweed
	Draba reptans	White whitlowwort
	Erysimum asperum	Western wallflower
	Erysimum repandum	Bushy wallflower
	Lesquerella ludoviciana	Bladderpod
	Sisymbrium altissimum	Tumbling mustard
	Thlaspi arvense	Penny cress
PRIMULACEAE	*Androsace occidentalis*	Western rock jasmine
SAXIFRAGACEAE	*Ribes odoratum*	Buffalo currant

Table 2.8-1. Crow Butte Project Plant Species List (Cont.)

Species	*Scientific Name*	Common Name
ROSACEAE	*Prunus americana*	Wild plum
	Prunus virginiana	Chokecherry
	Rosa acicularis	Prickly wild rose
	Rosa arkansana	Prairie wild rose
	Rosa woodsii	Western wild rose
FABACEAE	*Astragalus gracilis*	Slender milkvetch
	Astragalus missouriensis	Missouri milkvetch
	Lupinus argentus	Silvery lupine
	Medicago falcata	Yellow lupine
	Medicago sativa	Alfalfa
	Melilotus alba	White sweetclover
	Melilotus officinalis	Yellow sweetclover
	Oxytropis lambertii	Purple locoweed
	Psoralea argophylla	Silver-leaf scurf pea
	Psoralea esculenta	Breadroot scurf pea
	Psoralea lanceolata	Lemon scurf pea
	Vicia americana	American vetch
ONAGRACEAE	*Gaura coccinea*	Velvety gaura
	Oenothera caespitosa	Gumbo lily
	Oenothera nuttallii	White-stemmed evening primrose
CORNACEAE	*Comandra umbellata*	Bastard toadflax
EUPHORBIACEAE	*Croton texensis*	
	Euphorbia podperae	
VITACEAE	*Parthenocissus vitacea*	Woodbine
ACERACEAE	*Acer negundo*	Box elder
ANACARDIACEAE	*Rhus amomatica*	Aromatic sumac
	Toxicodendron rydbergii	Poison ivy
ZYGOPHYLLACEAE	*Tribulus terrestris*	Puncture vine
LINACEAE	*Linum perenne*	Blue flax
	Linum rigidum	Stiffstem flax
POLYGALACEAE	*Polygala alba*	White milkwort
APIACEAE	*Lomatium nuttallii*	Wild parsley
APOCYNACEAE	*Apocynum cannabinum*	Hemp dogbane
ASCLEPIADACEAE	*Asclepias speciosa*	Showy milkweed
SOLANACEAE	*Solanum rostratum*	Buffalo bur
CONVOLVULACEAE	*Convolvulus arvensis*	Field bindweed
	Convolvulus sepium	Hedge bindweed
POLEMONIACEAE	*Phlox andicola*	Moss phlox
BORAGINACEAE	*Cryptantha jamesii*	James' cryptantha
	Lappula redowskii	Low stickseed
	Lithospermum incisum	Narrow-leaved puccoon
LAMIACEAE	*Mentha arvensis*	Field mint
	Monarda pectinata	Spotted beebalm
PLANTAGINACEAE	*Plantago patagonica*	Buckhorn
OLEACEAE	*Fraxinus pennsylvanica*	Green ash
SCROPHULARIACEAE	*Penstemon albidus*	White beardtongue
	Penstemon angustifolius	Narrow beardtongue
	Penstemon glaber	Smooth beardtongue
	Penstemon grandiflorus	Large beardtongue
	Verbascum thapsus	Common mullein

Table 2.8-1. Crow Butte Project Plant Species List (Cont.)

Species	*Scientific Name*	Common Name
CAMPANULACEAE	*Campanula rotundifolia*	Harebell
RUBIACEAE	*Galium aparine*	Catchweed bedstraw
CAPRIFOLIACEAE	*Symphoricarpos occidentalis*	Western snowberry
ASTERACEAE	*Achillea millefolium*	Yarrow
	Agoseris glauca	False dandelion
	Antennaria rosea	Rose pussytoes
	Artemisia campestris	Western sagebrush
	Artemisia frigida	Fringed sagebrush
	Artemisia ludoviciana	White sage
	Chrysopsis villosa	Golden aster
	Cirsium undulatum	Wavyleaf thistle
	Cirsium vulgare	Bull thistle
	Crepis runcinata	Hawk's-beard
	Echinacea angustifolia	Purple coneflower
	Erigeron pumilus	Low fleabane
	Grindelia squarrosa	Curly-top gumweed
	Gutierrezia sarothrae	Broom snakeweed
	Helianthus annuus	Common sunflower
	Helianthus petiolaris	Plains sunflower
	Lygodesmia juncea	Skeleton-weed
	Ratibida columnifera	Prairie coneflower
	Ridbeckia hirta	Black-eyed susan
	Senecio plattensis	Prairie ragwort
	Taraxacum officinale	Dandelion
	Townsendia exscapa	Easter daisy
	Tragopogon dubius	Goatsbeard
COMMELINACEAE	*Tradescantia occidentalis*	Prairie spiderwort
JUNCACEAE	*Juncus balticus*	Baltic rush
CYPERACEAE	*Carex filifolia*	Thread-leaved sedge
	Carex hystericina	Bottlebrush sedge
	Carex lanuginose	Wooly-headed sedge
	Carex nebraskensis	Nebraska sedge
	Carex rossii	Ross' sedge
POACEAE	*Agropyron cristatum*	Crested wheatgrass
	Agropyron intermedium	Intermediate wheatgrass
	Agropyron pectiniforme	Smooth crested wheatgrass
	Agropyron smithii	Western wheatgrass
	Agropogon scoparius	Little bluestem
	Aristida longiseta	Red threeawn
	Bouteloua gracilis	Blue grama
	Bromus inermis	Smooth brome
	Bromus japonicus	Japanese brome
	Bromus tectorum	Cheatgrass
	Buchloe dactyloides	Buffalo-grass
	Cenchrus longispinus	Field sandbur
	Elymus canadensis	Canada wild rye
	Festuca octoflora	Six-weeks fescue
	Hordeum jubatum	Foxtail barley
	Hordeum pusillum	Little barley
	Koeleria pyramidata	Junegrass

Table 2.8-1. Crow Butte Project Plant Species List (Cont.)

Species	*Scientific Name*	Common Name
POACEAE	*Oryzopsis hymenoides*	Indian ricegrass
	Panicum capillare	Witchgrass
	Poa compressa	Canada bluegrass
	Poa pratensis	Kentucky bluegrass
	Poa sandbergii = (P. secunda)	Sandberg bluegrass
	Setaria glauca	Yellow foxtail
	Setaria viridis	Green foxtail
	Sitanion hystrix	Squirreltail
	Stipa comata	Needle-and-thread
	Stipa viridula	Green needlegrass
	Triticum aestivum	Wheat
LILIACEAE	*Allium textile*	White wild onion
	Calochortus nuttallii	Mariposa lily
	Leucocrinum montanum	Mountain lily
	Smilacina stellata	Spikenard
	Yucca glauca	Yucca
	Zigadenus venenosus	Death camass
IRIDACEAE	*Sisyrinchium montanum*	Blue-eyed grass

Table 2.8-2. Crow Butte Project Habitat Type

Habitat Classification		Acreage	Hectares	Percent
002	Wet Meadow	4.07	1.65	0.05
051	Mixed Prairie - Riparian	119.65	48.42	1.38
052	Wet Meadow - Riparian	47.27	19.13	0.55
054	Deep Marsh - Riparian	23.50	9.51	0.27
055	Riverine	32.86	13.34	0.38
059	Impoundment	46.57	18.84	0.54
110	Deciduous Streambank Forest	510.43	206.56	5.89
130	Shelterbelts, Tree Plantings	27.27	11.04	0.31
140	Ponderosa Pine	325.85	131.86	3.76
410	Mixed Grass Prairie	2840.18	1149.42	32.74
420	Range Rehabilitation	1370.77	554.74	15.80
500	Cultivated	2856.08	1155.86	32.92
610	Surface Disturbance	2.58	1.04	0.03
630	Human Biotopes	105.05	42.51	1.21
640	Cemeteries	5.02	2.03	0.06
650	Roads and Roadside Complex	356.55	144.30	4.11
Totals		**8,673.70**	**3,510.25**	**100.00**

Source: WFC 1983

Table 2.8-3. Crow Butte Project Mammal Species List

Order/Common Name	Scientific Name	Documented Status[1]
CARNIVORES (*Carnivora*)		
Raccoon	*Procyon lotor*	D
Long-tailed weasel	*Mustela frenata*	D
Mink	*Mustela vison*	D
Black-footed ferret	*Mustela nigripes*	E
Badger	*Taxidea taxus*	D
Spotted skunk	*Spilogale putorius*	E
Striped skunk	*Mephitis mephitis*	D
Coyote	*Canis latrans*	D
Swift fox	*Vulpes velox*	R
Red fox	*Vulpes fulva*	D
Bobcat	*Lynx rufus*	D
Mountain lion	*Felis concolor*	R
BIG GAME MAMMALS (*Artiodactyla*)		
Mule deer	*Odocoileus hemionus*	D
White-tailed deer	*Odocoileus virginianus*	D
Pronghorn	*Antilocapra americana*	D
Elk	*Cervus elaphus*	D
Bighorn sheep	*Ovis canadensis*	D
Bison	*Bison*	D
Moose	*Alces*	R
Mule deer/White-tailed deer hybrid	*O. hemionus x virginianus*	D
SMALL MAMMALS (*Chiroptera*)		
Keen myotis	*Myotis keeni*	E
Little brown myotis	*Myotis lucifugus*	E
Fringed myotis	*Myotis thysanodes*	E
Long-eared myotis	*Myotis evotis*	E
Long-legged myotis	*Myotis volans*	E
Small-footed myotis	*Myotis subulatus*	E
Silver-haired bat	*Lasionycteris noctivagans*	E
Red bat	*Lasiurus borealis*	E
Big brown bat	*Eptesicus fuscus*	E
Hoary bat	*Lasiurus cinereus*	E
Western big-eared bat	*Plecotus townsendi*	E
Insectivora		
Masked shrew	*Sorex cinereus*	E
Dwarf shrew	*Sorex nanus*	E
Merriam shrew	*Sorex merriami*	E
Least shrew	*Cryptotis parva*	E
Eastern mole	*Scalopus aquaticus*	D
Lagomorpha		
White-tailed jackrabbit	*Lepus townsendi*	D
Black-tailed jackrabbit	*Lepus californicus*	D
Eastern cottontail	*Sylvilagus floridanus*	D
Desert cottontail	*Sylvilagus auduboni*	D

Table 2.8-3. Crow Butte Project Mammal Species List (Cont.)

Order/Common Name	*Scientific Name*	Documented Status1
Rodentia		
Black-tailed prairie dog	*Cynomys ludovicianus*	D
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*	D
Spotted ground squirrel	*Citellus spilosoma*	D
Least chipmunk	*Eutamias minimus*	D
Eastern fox squirrel	*Sciurus niger*	D
Northern pocket squirrel	*Thomomys talpoides*	D
Plains pocket gopher	*Geomys bursarius*	E
Wyoming pocket mouse	*Perognathus fasciatus*	E
Plains pocket mouse	*Perognathus flavescens*	E
Silky pocket mouse	*Perognathus flavus*	E
Hispid pocket mouse	*Perognathus hispidus*	E
Ord kangaroo rat	*Dipodomys ordii*	D
Beaver	*Castor canadensis*	D
Plains harvest mouse	*Reithrodontomys montanus*	E
Western harvest mouse	*Reithrodontomys megalotis*	E
White-footed mouse	*Peromyscus leucopus*	D
Deer mouse	*Peromyscus maniculatus*	D
Northern grasshopper mouse	*Onychomys leucogaster*	E
Eastern woodrat	*Neotoma floridana*	E
Bushy-tailed woodrat	*Neotoma cinerea*	E
Brown rat	*Rattus norvegicus*	E
House mouse	*Mus musculus*	D
Meadow vole	*Microtus pennsylvanicus*	D
Prairie vole	*Microtus ochrogaster*	D
Muskrat	*Ondatra zibethicus*	D
Meadow jumping mouse	*Zapus hudsonicus*	D
Porcupine	*Erethizon dorsatum*	D

[1] D Documented in the 1982 baseline study.
E Expected to occur - historical or recent evidence.
R Reported by knowledgeable individual(s).

Table 2.8-4. Crow Butte Project Bird Species List

Common Name	Scientific Name	Status[1]
GAVIIFORMES		
Common loon	*Gavia immer*	R
Arctic loon	*Gavia arctica*	R
PODICIPEDIFORMES		
Red-necked grebe	*Podiceps grisegena*	R
Horned grebe	*Podiceps auritus*	D
Eared grebe	*Podiceps caspicus*	D
Western grebe	*Aechmophorus occidentalis*	D
Pied-billed grebe	*Podilymbus podiceps*	
PELECANIFORMES		
White pelican**	*Pelicanus erythrorhynchos*	D
Double-crested cormorant**	*Phalacrocorax auritus*	D
CICONIFORMES		
Great blue heron	*Ardea herodias*	D
Green heron	*Butorides virescens*	R
Cattle egret	*Bubulcus ibis*	R
Great egret	*Casmerodius albus*	R
Snowy egret	*Leucophoyx thula*	R
Black-crowned night heron**	*Nycticorax nycticorax*	D
Yellow-crowned night heron	*Nyctanassa violacea*	R
American bittern**	*Botaurus lentiginosus*	D
White-faced ibis	*Plegadia chihi*	R
ANSERIFORMES		
Whistling swan	*Olor columbianus*	R
Trumpeter swan	*Olor buccinator*	D
Canada goose	*Branta canadensis*	D
Brant	*Branta bernicla*	R
White-fronted goose	*Anser albifrons*	D
Snow goose	*Chen hyperborea*	D
Mallard*	*Anas plantyrhynchos*	D
Black duck	*Anas rubripes*	R
Gadwall**	*Anas strepera*	D
Pintail**	*Anas acuta*	D
Green-winged teal**	*Anas carolinensis*	D
Blue-winged teal**	*Anas discors*	D
Cinnamon teal	*Anas cyanoptera*	D
American wigeon	*Mareca americana*	D
Northern shoveler	*Spatula clypeata*	D
Wood duck	*Aix sponsa*	D
Redhead	*Aythya americana*	D
Ring-necked duck	*Aythya collaris*	D
Canvasback	*Aythya valisineria*	D
Lesser scaup	*Aythya affinis*	D
Common goldeneye	*Bucephala clangula*	D
Barrow's goldeneye	*Bucephala islandica*	R

Table 2.8-4. Crow Butte Project Bird Species List (Cont.)

Common Name	Scientific Name	Status[1]
Bufflehead	*Bucephala albeola*	D
Oldsquaw	*Clangula hyemalis*	R
White-winged scoter	*Melanitta deglandi*	R
Surf scoter	*Melanitta perspicillata*	R
Black scoter	*Oidemia nigra*	R
Ruddy duck	*Oxyura jamaicensis*	D
Hooded merganser	*Lophodytes cucullatus*	D
Common merganser	*Mergus merganser*	D
Red-breasted merganser	*Mergus serrator*	R
FALCONIFORMES		
Turkey vulture	*Cathartes aura*	D
Goshawk	*Accipiter gentilis*	D
Sharped-shinned hawk	*Accipiter striatis*	D
Cooper's hawk	*Accipiter cooperi*	D
Red-tailed hawk	*Buteo jamaicensis*	
Red-shouldered hawk	*Buteo lineatus*	R
Broad-winged hawk	*Buteo platypterus*	R
Swainson's hawk	*Buteo swainsoni*	R
Rough-legged hawk	*Buteo lagopus*	D
Ferruginous hawk	*Buteo regalis*	D
Golden eagle	*Aquila chrysaetos*	D
Bald eagles	*Haliaeetus leucocephalus*	D
Northern harrier	*Circus cyaneus*	D
Osprey	*Pandion haliaetus*	R
Gyrfalcon	*Falco rusticolus*	D
Prairie falcon	*Falco mexicanus*	D
Peregrine falcon	*Falco peregrinus*	R
Merlin	*Falco columbarius*	D
American kestrel	*Falco sparverius*	D
GALLIFORMES		
Sharp-tailed grouse*	*Pedioecetes phasianellus*	D
Bobwhite	*Colinus virginianus*	R
Ring-necked pheasant*	*Phasianus colchicus*	D
Turkey*	*Meleagris gallopavo*	D
Gray partridge**	*Perdix perdix*	D
GRUIFORMES		
Sandhill crane	*Grus canadensis*	D
Virginia rail**	*Rallus limicola*	D
Sora rail**	*Porzana carolina*	D
American coot**	*Fulica americana*	D
CHARADRIIFORMES		
Semipalmated plover	*Charadrius semipalmatus*	R
Mountain plover	*Charadrius montainus*	E
Piping plover	*Charadrius melodus*	R
Snowy plover	*Charadrius alexandrinus*	R

Table 2.8-4. Crow Butte Project Bird Species List (Cont.)

Common Name	Scientific Name	Status[1]
Killdeer*	*Charadrius vociferus*	D
American golden plover	*Pluvialis dominica*	R
Black-bellied plover	*Squatarola squatarola*	D
Marbled godwit	*Lemosa fedoa*	D
Whimbrel	*Numenius phaeopus*	R
Long-billed curlew**	*Numenius americanus*	D
Upland sandpiper**	*Bartramia longicauda*	D
Greater yellowlegs	*Totanus melanoleucus*	D
Lesser yellowlegs	*Totanus flavipes*	D
Solitary sandpiper	*Tringa solitaria*	D
Willet**	*Catoptrophorus semipalmatus*	D
Spotted sandpiper**	*Actitis macularia*	D
Common snipe*	*Capella gallinago*	D
Short-billed dowitcher	*Limnodromus griseus*	R
Long-billed dowitcher	*Limnodromus scolopaceus*	D
Red knot	*Calidris canutus*	R
Sanderling	*Calidris alba*	D
Semipalmated sandpiper	*Ereunetes pusillus*	D
Western sandpiper	*Ereunetes mauri*	R
Least sandpiper	*Eriola minutilla*	D
White-rumped sandpiper	*Eriola fuscicollis*	R
Baird's sandpiper	*Eriola bairdii*	D
Pectoral sandpiper	*Eriola melanotos*	R
Stilt sandpiper	*Micropalama himantopus*	D
CHARADRIIFORMES		
Buff-breasted sandpiper	*Tryngites subrufficollis*	R
American avocet**	*Recurvirostra americana*	D
Wilson's phalarope**	*Steganopus tricolor*	D
Northern phalarope	*Lobipes lobatus*	D
Parasitic jaeger	*Stercorarius parasiticus*	R
Herring gull	*Larus argentatus*	R
California gull	*Larus californicus*	R
Ring-billed gull	*Larus delawarensis*	D
Black-headed gull	*Larus ridibundus*	R
Franklin's gull	*Larus pipixcan*	D
Bonaparte's gull	*Larus philadelphia*	R
Forster's tern	*Sterna forsteri*	D
Common tern	*Sterna hirundo*	R
Least (Least interior) tern	*Sterna albifrons*	R
Black tern**	*Chlidonias niger*	D
COLUMBIFORMES		
Mourning dove*	*Zenaidura macroura*	D
Rock dove*	*Columba livia*	D
CUCULIFORMES		
Yellow-billed cuckoo**	*Coccyzus americanus*	D

Table 2.8-4. Crow Butte Project Bird Species List (Cont.)

Common Name	*Scientific Name*	Status[1]
Black-billed cuckoo**	*Coccyzus erythropthalmus*	D
	STRIGIFORMES	
Barn owl**	*Tyto alba*	D
Screech owl**	*Otus asio*	D
Great horned owl*	*Bubo virginianus*	D
Snowy owl	*Nyctea scandiaca*	R
Burrowing owl*	*Speotyto cunicularia*	D
Barred owl	*Strix varia*	R
Long-eared owl	*Asio otus*	R
Short-eared owl**	*Asio flammeus*	D
Saw-whet owl**	*Aegolius acadicus*	D
	CAPRIMULGIFORES	
Common poor-will**	*Phalaenoptilus nuttallii*	D
Common nighthawk**	*Chordeiles minor*	D
	APODIFORMES	
Chimney swift**	*Chaetura pelagica*	D
White-throated swift**	*Aeronautes saxatalis*	D
Broad-tailed hummingbird	*Selasphorus platycercus*	R
Rufous hummingbird	*Selasphorus rufus*	R
	CORACIIFORMES	
Belted kingfisher**	*Megaceryle alcyon*	D
	PICIFORMES	
Common flicker*	*Colaptes auratus*	D
Red-bellied woodpecker	*Centurus carolinus*	R
Red-headed woodpecker*	*Melanerpes erythrocephalus*	D
Lewis' woodpecker**	*Asyndesmus lewis*	D
Yellow-bellied sapsucker	*Sphyrapicus varius*	R
Hairy woodpecker**	*Dendrocopos villosus*	D
Downy woodpecker**	*Dendrocopos pubescens*	D
	PASSERIFORMES	
Eastern kingbird*	*Tyrannus tyrannus*	D
Western kingbird*	*Tyrannus verticalis*	D
Cassin's kingbird	*Tyrannus vociferans*	R
Scissor-tailed flycatcher	*Muscivora forfic*	R
Great crested flycatcher**	*Myiarchus crinitus*	D
Eastern phoebe**	*Sayornis phoebe*	D
Say's phoebe**	*Sayornis saya*	D
Black phoebe	*Sayornis nigricans*	D
Willow flycatcher**	*Empidonax traillii*	D
Least flycatcher	*Empidonax minimus*	D
Hammond's flycatcher	*Empidonax hammondii*	R
Western flycatcher	*Empidonax difficilis*	R
Eastern pewee**	*Contopus virens*	D
Western pewee*	*Contopus sordidulus*	D
Olive-sided flycatcher	*Nuttalornis borealis*	R

Table 2.8-4. Crow Butte Project Bird Species List (Cont.)

Common Name	Scientific Name	Status[1]
Horned lark*	*Eremophila alpestris*	D
Violet-green swallow**	*Tachycineta thallassina*	D
Tree swallow**	*Iridoprocne bicolor*	D
Bank swallow*	*Riparia riparia*	D
Rough-winged swallow**	*Stelgidopteryx ruficollis*	D
Barn swallow*	*Hirundo rustica*	D
Cliff swallow*	*Petrochelidon pyrrhonota*	D
Purple martin	*Progne subis*	R
Gray jay	*Perisoreus canadensis*	R
Blue jay**	*Cyanocitta cristata*	R
Stellar's jay	*Cyanocitta stelleri*	R
Black-billed magpie*	*Pica pica*	D
American crow*	*Corvus branchyrhynchos*	D
Pinyon jay**	*Gymnorhinus cyanocephalus*	D
Clark's nutcracker	*Nucifraga columbiana*	R
Black-capped chickadee**	*Parus atricapillus*	D
Tufted titmouse	*Parus bicolor*	R
White-breasted nuthatch**	*Sitta carolinensis*	D
Red-breasted nuthatch**	*Sitta canadensis*	D
Pygmy nuthatch**	*Sitta pygmaea*	D
Brown creeper**	*Certha familiaris*	D
Dipper	*Cinclus mexicanus*	R
Northern house wren**	*Troglodytes aedon*	D
Winter wren	*Troglodytes troglodytes*	R
Bewick's wren	*Thryomanes bewickii*	R
Carolina wren	*Thryothorus ludovicianus*	R
Marsh wren**	*Telmatodytes palustris*	D
Canyon wren	*Catherpes mexicanus*	R
Rock wren**	*Salpinctes obsoletus*	D
Mockingbird	*Mimus polyglottos*	R
Gray catbird**	*Dumetella carolinensis*	D
Brown thrasher**	*Toxostoma rufum*	D
Sage thrasher	*Orescoptes montanus*	R
American robin*	*Turdus migratorius*	D
Wood thrush	*Hylocichla mustelina*	D
Hermit thrush	*Hylocichla guttata*	D
Swainson's thrush	*Hylocichla ustalata*	D
Gray-cheeked thrush	*Hylocichla ustalata*	D
Veery	*Hylocichla fuscenscens*	D
Eastern bluebird	*Sialia sialis*	R
Mountain bluebird**	*Sialia currucoides*	D
Townsend's solitaire**	*Myadestes townsendi*	D
Blue-gray gnatcatcher	*Polioptila caerulea*	R
Golden-crowned kinglet	*Rugulus satrapa*	R
Ruby-crowned kinglet	*Rugulus calendula*	D

Table 2.8-4. Crow Butte Project Bird Species List (Cont.)

Common Name	Scientific Name	Status[1]
Water pipit	*Anthus spinoletta*	D
Bohemian waxwing	*Bombycilla garrulus*	D
Cedar waxwing**	*Bombycilla cedrorum*	D
Northern shrike	*Lanius excubitor*	D
Loggerhead shrike**	*Lanius ludovicianus*	D
European starling*	*Sturnus vulgaris*	D
White-eyed vireo	*Vireo griseus*	R
Bell's vireo**	*Vireo bellii*	D
Yellow-throated vireo	*Vireo flavifrons*	R
Solitary vireo	*Vireo solitarius*	R
Red-eyed vireo**	*Vireo olivaceus*	D
Philadelphia vireo	*Vireo philadelphicus*	R
Warbling vireo**	*Vireo gilvus*	D
Black and white warbler	*Mniotilta varia*	D
Prothonotary warbler	*Protonotaria citrea*	R
Tennessee warbler	*Vermivora peregrina*	D
Orange-crowned warbler	*Vermivora celata*	D
Nashville warbler	*Vermivora ruficapilla*	D
Northern parula	*Parula americana*	R
Yellow warbler**	*Dendroica petechia*	D
Magnolia warbler	*Dendroica magnolia*	R
Cape May warbler	*Dendroica tigrina*	R
Yellow-rumped warbler	*Dendroica coronata*	
(Audubon race)**	*Dendroica coronata*	D
(Myrtle race)	*Dendroica coronata*	D
Townsend's warbler	*Dendroica townsendi*	R
Black-throated green warbler	*Dendroica virens*	R
Cerulean warbler	*Dendroica cerulea*	R
Blackburnian warbler	*Dendroica fusca*	R
Chestnut-sided warbler	*Dendroica pensylvanica*	R
Blackpoll warbler	*Dendroica striata*	D
Palm warbler	*Dendroica palmarum*	R
Ovenbird**	*Seiurus aurocapillus*	D
Northern waterthrush	*Seiurus noveboracensis*	D
PARULIDAE		
Mourning warbler	*Oporornis philadelphia*	R
MacGillivray's warbler	*Oporornis tolmiei*	R
Common yellowthroat**	*Geothlypis trichas*	D
Yellow-breasted chat**	*Icteria virens*	D
Hooded warbler	*Wilsonia citrina*	R
Wilson's warbler	*Wilsonia pusilla*	D
American redstart**	*Setophaga ruticilla*	D
House sparrow*	*Passer domesticus*	D
Bobolink**	*Dolichonyx oryzivorus*	D
Eastern meadowlark**	*Sturnella magna*	D

Table 2.8-4. Crow Butte Project Bird Species List (Cont.)

Common Name	*Scientific Name*	Status[1]
Western meadowlark*	*Sturnella neglecta*	D
Yellow-headed blackbird**	*Xanthocephalus xanthocephalus*	D
Red-winged blackbird*	*Agelaius phoeniceus*	D
Orchard oriole**	*Icterus spurius*	D
Northern (Bullock) oriole**	*Icterus galbula*	D
Rusty blackbird	*Euphagus carolinus*	R
Brewer's blackbird**	*Euphagus cyanocephalus*	D
Common grackle**	*Quiscalus quiscula*	D
Brown-headed cowbird**	*Molothrus ater*	D
Western tanager**	*Piranga ludoviciana*	D
Scarlet tanager	*Piranga olivacea*	R
Cardinal	*Richmondena cardinalis*	R
Rose-breasted grosbeak	*Pheucticus ludovicianus*	R
Blue grosbeak**	*Guiraca caerulea*	D
Indigo bunting**	*Passerina cyanea*	D
Lazuli bunting**	*Passerina amoena*	D
Indigo x lazuli hybrid**	*P. cyanea x amoena*	D
FRINGILLIDAE		
Dickcissel	*Spiza americana*	R
Evening grosbeak	*Herperiphona vespertina*	D
Purple finch	*Carpodacus purpureus*	R
Cassin's finch	*Carpodacus cassinii*	R
House finch	*Carpodacus mexicanus*	D
Pine grosbeak	*Pinicola enucleator*	R
Gray-crowned rosy finch	*Leucosticte tephrocotis*	R
Common redpoll	*Acanthis flammea*	R
Pine siskin**	*Spinus pinus*	D
American goldfinch**	*Spinus tristis*	D
Red crossbill**	*Loxia curvirostra*	D
White-winged crossbill	*Loxia leucoptera*	R
Green-tailed towhee	*Chlorura chlorura*	R
Rufous-sided towhee**	*Pipilo erythrophthalmus*	D
Lark bunting**	*Calamospiza melanocoryx*	D
Savannah sparrow	*Passerculus sandwichensis*	D
Grasshopper sparrow	*Ammodramus savannarum*	D
Vesper sparrow**	*Pooecetes gramineus*	D
Lark sparrow*	*Chondestes grammacus*	D
Black-throated sparrow	*Amphispiza bilineata*	R
Dark-eyed junco	*Junco hyemalis*	
(White-winged race)**	*Junco hyemalis*	D
(Slate-colored race)	*Junco hyemalis*	D
(Oregon race)	*Junco hyemalis*	D
(Gray-headed race)	*Junco hyemalis*	D
Tree sparrow	*Spizella arborea*	D
Chipping sparrow**	*Spizella passerina*	D

Table 2.8-4. Crow Butte Project Bird Species List (Cont.)

Common Name	*Scientific Name*	Status[1]
Clay-colored sparrow**	*Spizella pallida*	D
Brewer's sparrow**	*Spizella breweri*	D
Field sparrow	*Spizella pusilla*	R
Harris' sparrow	*Zonotrichia querula*	R
White-crowned sparrow	*Zonotrichia leucophrys*	D
White-throated sparrow	*Zonotrichia albicollis*	R
Fox sparrow	*Passerella iliaca*	R
Lincoln's sparrow	*Melospiza lincolnii*	D
Swamp sparrow	*Melospiza georgiana*	R
Song sparrow	*Melospiza melodia*	D
McCown's longspur**	*Rhynchophanes mccownii*	D
Lapland longspur	*Calcarius lapponicus*	D
Chestnut-collared longspur**	*Calcarius ornatus*	D
Snow bunting	*Plectyrophenax nivalis*	D

1 - Documentation:
D Documented in the 1982 study.
E Expected to occur - historical or recent evidence.
R Reported by knowledgeable individual(s).
*confirmed breeder
**suspected breeder

Table 2.8-5. Crow Butte Project Reptiles and Amphibians

Common Name	Scientific Name	Status
AMPHIBIANS		
Eastern tiger salamander	*Ambystoma tigrinum*	
Great plains toad	*Bufo cognatus*	
Woodhouse's toad	*Bufo woodhousii*	
Western chorus frog	*Pseudacris triseriata*	
Plains spadefoot	*Spea bombifrons*	
Northern leopard frog	*Rana pipiens*	
Bullfrog	*Rana catesbeiana*	
REPTILES		
Lesser earless lizard	*Holbrookia maculata*	
Short-horned lizard	*Phrynosoma hernandesi*	
Prairie lizard	*Sceloporus undulatus*	
Many-lined skink	*Eumeces multivirgatus*	R
Bullsnake	*Pituophis catenifer*	
Yellow-bellied racer	*Coluber constrictor*	
Plains garter snake	*Thamnophis radix*	
Red-sided/Common garter snake	*Thamnophis sirtalis*	
Plains hognose snake	*Heterodon nasicus*	
Prairie rattlesnake	*Crotalus viridis*	
W. terrestrial garter snake	*Thamnophis elegans*	R
Plains milk snake	*Lampropeltis triangulum*	R
Northern water snake	*Nerodia sipedon*	R
Common snapping turtle	*Chelydra serpentina*	
Painted turtle	*Chrysemys picta*	

R = Rare

Table 2.8-6. Marsland Expansion Area Vegetation and Land Cover Types

Habitat	Acres	Percent
Mixed-grass prairie	2,978.2	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	**4,622.3**	**100.0**

Source: HWA 2011

Table 2.8-7. Crow Butte Project Fish Species List

Family/Common Name	Scientific Name	Status[1]
CATOSTOMIDAE		
River sucker	*Carpiodes carpio*	R
Longnose sucker	*Catostomus catostomus*	R
White sucker	*Catostomus commersoni*	D
CENTRARCHIDAE		
Green sunfish	*Lepomis cyanellus*	D
Bluegill	*Lepomis macrochirus*	D
Smallmouth bass	*Micropterus dolomieui*	R
Largemouth bass	*Micropterus salmoides*	D
Rock Bass	*Amblo plites rupestrinis*	D
Black crappie	*Pomoxis nigromaculatus*	D
CYPRINIDAE		
Carp	*Cyprinus carpio*	D
Plains minnow	*Hybognathus placitus*	D
Flathead chub	*Hybopsis gracilis*	R
Common shiner	*Luxilus cornutus*	D
Golden shiner	*Notemigonus crysoleucas*	D
Red shiner	*Notropis lutrensis*	R
Sand shiner	*Notropis stramineus*	D
Flathead minnow	*Pimephales promelas*	D
Longnose dace	*Rhinichthys cataractae*	D
Creek chub	*Semotilus atromaculatus*	D
CYPRINODONTIDAE		
Plains topminnow	*Fundulus sciadicus*	D
ESOCIDAE		
Northern pike	*Esox lucius*	R
HIODONTIDAE		
Goldeye	*Hiodon alosoides*	R
ICTALURIDAE		
Black bullhead	*Ictalurus melas*	D
Channel catfish	*Ictalurus punctatus*	R
Stonecat	*Noturus flavus*	R
PERCICHTHYIDAE		
White bass	*Morone chrysops*	D
PERCIDAE		
Walleye	*Stizostedion vitreum*	D
SALMONIDAE		
Rainbow trout	*Oncorhynchus mykiss*	D
Brown trout	*Salmo trutta*	D
Brook trout	*Salvelinus fontinalis*	D

Notes
[1] Documentation:
D Documented in the course of the present study.
E Expected to occur - historical or recent evidence.
R Reported by knowledgeable individual(s).

Table 2.8-8. Crow Butte Project Occurrence of Fish Species by Habitat

FISH SPECIES	STREAMS					IMPOUNDMENTS								
	English Creek	Squaw Creek	White Clay Creek	White River		1	2	3	4	5	6	7	8	9
SALMONIDAE														
Brook trout		X												X
Brown trout				X										
Rainbow trout				X										
CYPRINIDAE														
Creek chub	X		X	X			X							
Fathead minnow	X	X	X	X						X	X	X		
Longnose dace		X	X	X										
Plains minnow			X											
Sand shiner				X			X							
Golden shiner	X		X							X	X			
CATOSTOMIDAE														
White sucker			X	X			X							
ICTALURIDAE														
Black bullhead			X											
Stone Cat				X										
CYPRINODONTIDAE														
Plains topminnow	X		X											
CENTRARCHIDAE														
Green sunfish	X		X	X			X			X				
NUMBER OF SPECIES	5	3	9	9		0	4	0	0	3	2	1	0	1
SAMPLING METHOD														
Electrofishing	X	X	X	X			X			X				X
Gill Netting														
Pond Netting														
Minnow Trapping	X	X	X	X			X			X				X
Rod and Reel Angling														X

Table 2.8-9. Crow Butte Project Relative Abundance (Percent Occurrence) of Fish Collected at Each Sampling Location (1982)

	STREAMS									IMPOUNDMENTS								
FISH SPECIES	**E-3**	**S-1**	**S-2S-3**	**S-4**	**WC-1**	**WC-2**	**W-1**	**W-2**		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
SALMONIDAE																		
Brook trout		5.7	1.2															100
Brown trout							18.5	3.2										
Rainbow trout							3.7											
CYPRINIDAE																		
Creek chub	0.3				44.8	1.1												
Fathead minnow	71.1	11.3	65.5	100	30.6	64.1								89.0	100	100		
Longnose dace		83.0	33.3		6.0	11.1	59.3	76.3										
Plains minnow						0.3												
Sand shiner																		
Golden shiner	3.9					0.6								2.4				
CATOSTOMIDAE																		
White sucker					2.2	1.1	18.5	20.4										
Black bullhead						0.9												
CYPRINODONTIDAE																		
Plains topminnow						0.3												
CENTRARCHIDAE																		
Green sunfish	24.7				16.4	20.5					100		100	8.6				
Electrofishing Total	55	106	174	18	112	335	27	93						193	126			
Minnow Trap Total	249			31	71	16					3		21	52	21	5		
Angling Total																		6
GRAND TOTAL	304	106	174	49	183	351	27	93			3		21	245	147	5		6

Table 2.8-10. Benthic Macroinvertebrate Community Values for Crow Butte Project Study Area Streams and Impoundments Derived from Samples Taken in April 1982

Parameter/ Sample	Sampling Locations																				
	Streams												Impoundments								
	E-1	E-2	E-3	S-1	S-2	S-2	S-3	S-4	WC-1	WC-2	W-1	W-2	1	2	3	4	5	6	7	8	9
Sampling Method*	D	D	D	S	D	S	S	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Density (Org./m^2)																					
1	5695	3766	3674	549	8451	377	8468	4777	322	459	505	3261	0	6992	6155	4731	5190	138	965	505	12998
2	15387	1378	2251	785	6071	1754	3325	1883	9186	367	276	5741	0	1288	6063	7165	8543		1010	138	10151
3	18188	92	4271	785	2664	560	5896	2526	6798	459	276	8451	46	13432	14698	2480	459		965	184	7578
Ö	13090	1745	3399	706	5729	897	5896	3062	5435	428	352	5818	15	7237	8972	4792	4731	138	980	276	10242
Diversity (d)																					
1	0.75	1.40	0.71	3.07	0.10	1.59	1.09	1.44	1.38	0.72	1.24	1.28		1.07	0.96	0.85	1.06	0	1.37	0	1.48
2	0.48	1.60	1.33	3.07	0.13	1.22	1.24	2.00	1.95	1.41	0.92	1.37		1.09	1.17	1.31	0.17		1.37	0	2.10
3	0.24	0	1.01	3.41	0.34	1.20	1.13	2.09	0.65	1.36	0.92	0.78	0	0.64	0.66	1.47	1.96		2.07	0	1.49
Ö	0.49	1.0	1.02	3.18	0.19	1.34	1.15	1.84	1.33	1.16	1.03	1.14	0	0.93	0.93	1.21	1.06	0	1.60	0	1.69
No. of Taxa	11	9	7	22	5	8	16	9	8	4	3	7	1	8	8	9	6	1	7	1	13
Community Structure (% Occurrence)																					
Taxon																					
Chironomidae	0.9	17.5	82.0	10.7	98.1	18.0	14.1	45.5	71.8	42.9	47.8	72.4		3.8	19.2	12.3	87.7	48.4	100	37.4	33.6
Oligochaeta		1.8	5.0	3.6	0.8	3.2	0.2	36.0	14.4	50.0	47.8	19.7	100	89.8	78.3	81.3	3.6	39.1		39.5	19.1
Ephemeroptera				20.3		65.2	6.8					7.9				0.9		4.7		16.6	7.0
Trichoptera			0.5	37.1	0.5	0.4	0.5				4.3	0.5									1.4
Ceratopogonidae	94.5	56.1		0.5		0.4	0.2	1.0	8.7	7.1		0.3		1.7	0.6					4.2	14.5
Simulidae				8.6		11.6	76.8														20.0

*D = Ponar Dredge Sample; S = Surber Sample

Table 2.8-11. Diatom Proportional Counts (Percent Occurrence) and Occurrence of Other Algae by Sample Location (April 1982) at the Crow Butte Project

	STREAMS											IMPOUNDMENTS							
	E-1	**E-2**	**E-3**	**S-1**	**S-2**	**S-3**	**S-4**	**WC-1**	**WC-2**	**W-1**	**W-2**	**1**	**2**	**3**	**4**	**5**	**7**	**8**	**9**
DIATOMS																			
Acnanthes	17.9	1.2	0.3	76.7		14.3	19.7	22.3	2.0	40.3			2.8				4.3	2.6	2.1
Amphora	0.5			0.5				0.3									0.3	1.8	
Cocconeis			0.3	2.4	0.7	4.8	1.7	1.2	11.3	1.9	0.3	1.1			0.4	0.6	0.3	1.4	0.7
Cyclotella			2.1		2.2	1.0	8.2	7.6		0.6				0.3		6.6	6.0	1.0	0.9
Cymatopleura							0.4												
Cymbella	6.3	0.3	0.3	1.9	6.1	2.9	8.2	25.9	7.0	7.8	1.8		7.1	1.3	11.8	3.9	1.4	8.5	13.7
Diatoma		0.6		1.9				6.4	1.0	0.9	21.6		0.7						17.9
Epithemia	1.1						1.3		0.4					12.6	2.1	1.7	2.6	4.4	
Fragilaria	3.3	66.5	0.3	0.5	2.9			0.3					0.7		9.3		0.6		0.2
Gomphonema	14.4	0.3	80.5	3.4	4.3			0.3			7.5		17.3	0.3	1.7	5.8	2.3	9.9	0.7
Gyrosigma									0.4							0.3			
Hantzschia													0.4	0.5	0.4		0.3		
Melosira																	0.6		
Meridion	0.8		0.3				2.1												
Navicula	3.8	2.6	8.2	5.3	15.8	16.2	13.7	9.8	58.6	33.4	47.7		3.2	6.2	5.5	2.5	18.2	21.0	1.2
Nedium	0.3																		
Nitzschia	13.0	6.6	3.8	5.3	65.9	58.1	13.7	15.2	10.6	11.3	19.1		6.0	12.9	7.6	3.6	30.4	12.1	34.4
Rhopalodia									0.4					3.2		0.3	1.4	0.2	
Stauroneia	0.3													0.3				0.4	
Surirella	0.5	0.3	1.0	0.5	0.4	1.9	3.9	1.2	6.6	3.4	0.5		0.7	0.3	2.5	5.8	12.5	1.0	0.2
Synedra	37.8	22.0	2.7	1.5	1.8	1.0	27.0	9.5	2.0	0.3	1.5		60.1	62.2	58.6	69.1	19.0	35.6	27.9
GREEN ALGAE																			
Ceratophylum															x				
Chara															x	x			
Cladophora			x	x	x	x	X	x	x	x	x								
Mougeotia	x	x												x					
Oedigonium															x		x		
Rhizoclonium							X												
Spirogyra	x	x					X	x							x		x		
Zygnema	x	x					X								x		x		
BLUE-GREEN ALGAE																			
Anabaena																	x		

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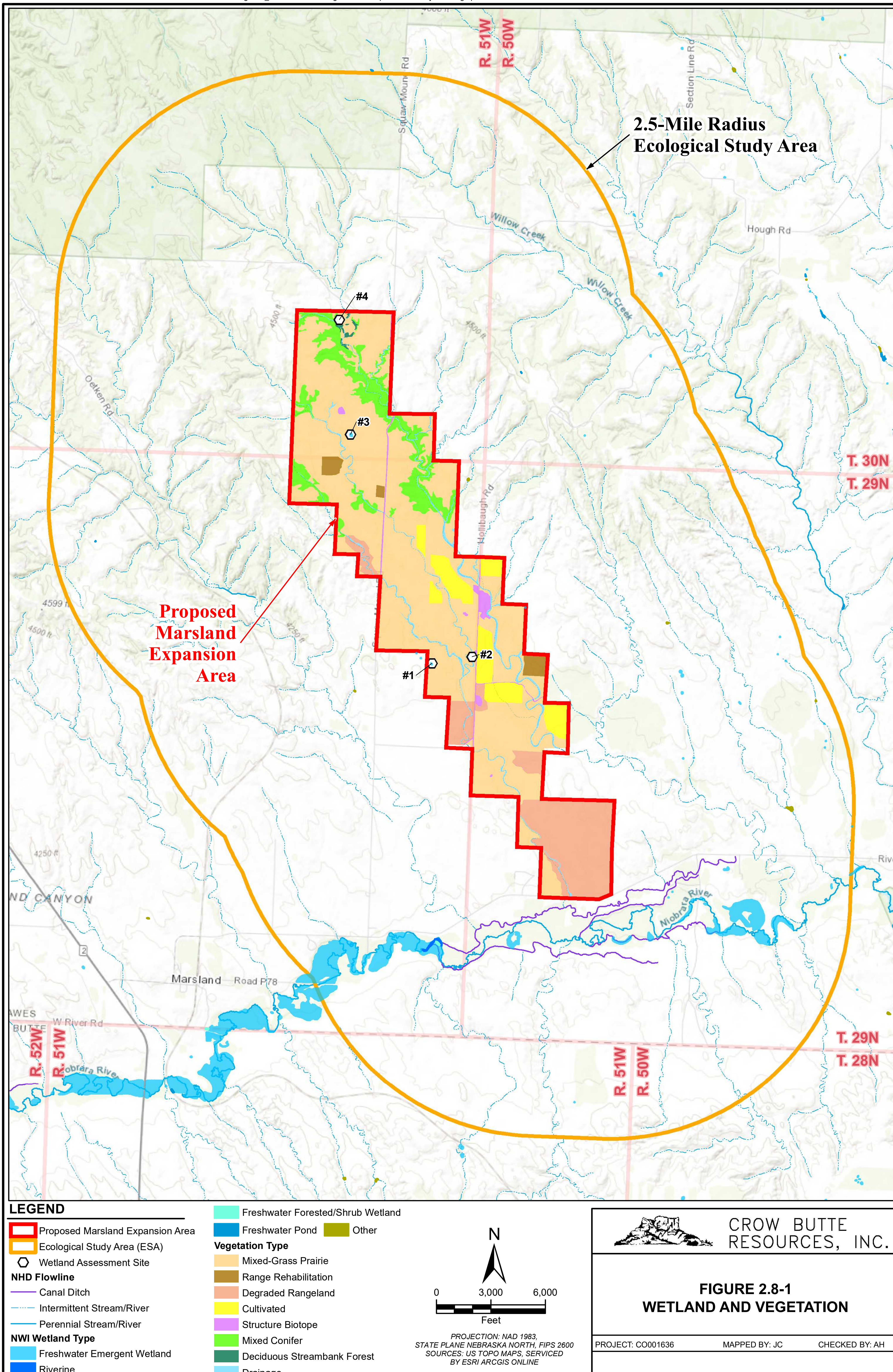


FIGURE 2.8-1
WETLAND AND VEGETATION

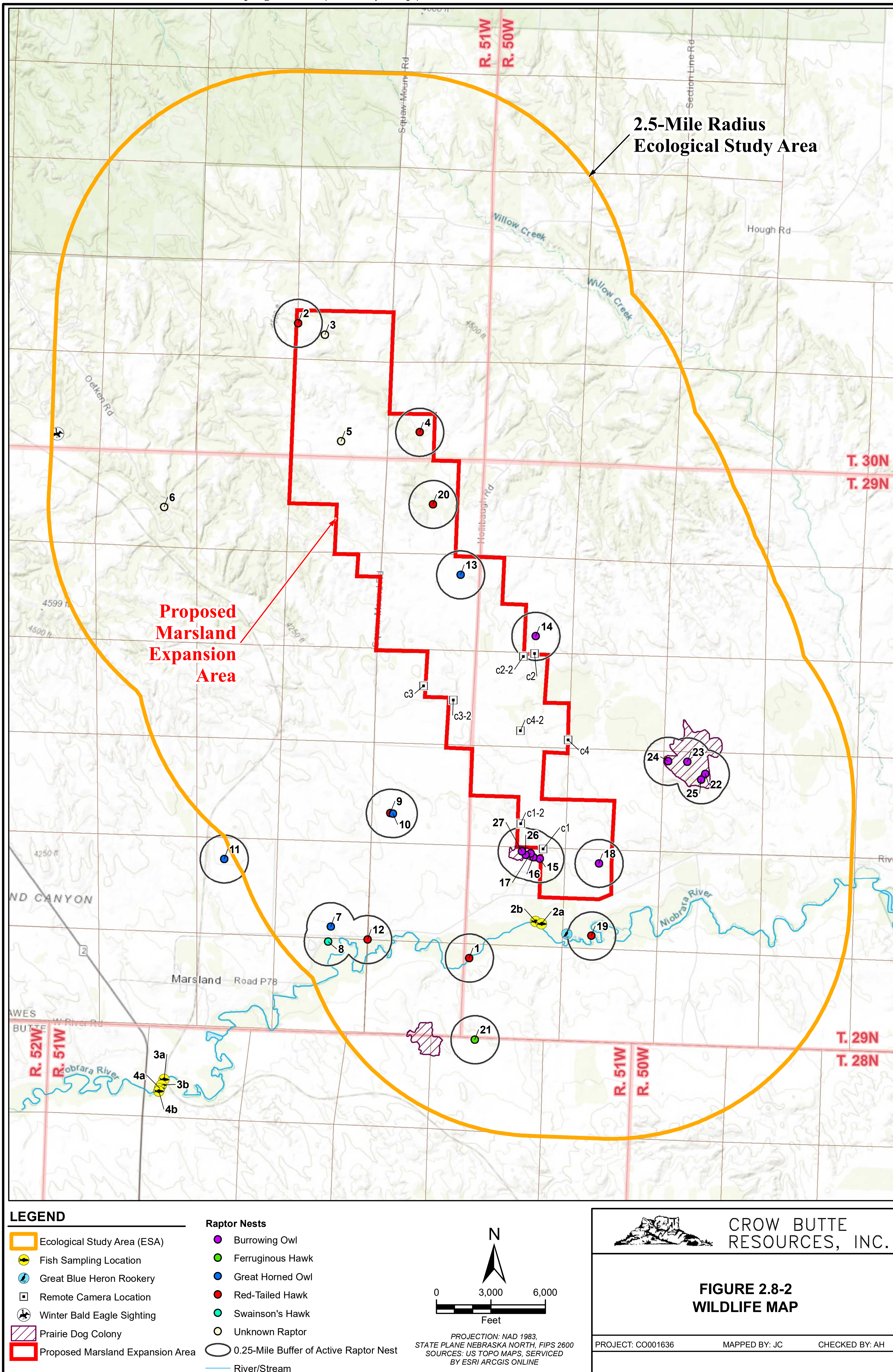
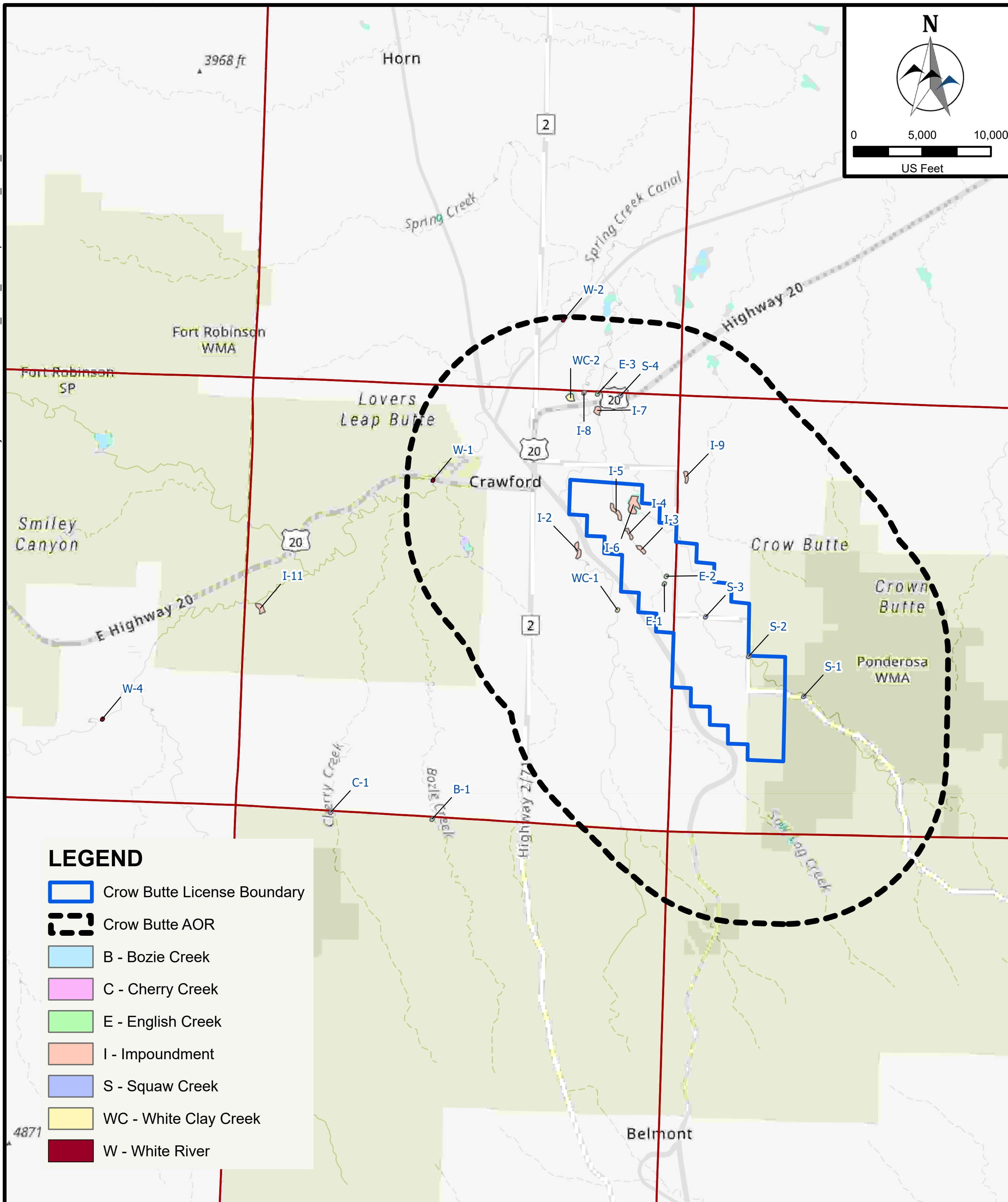


FIGURE 2.8-2
WILDLIFE MAP



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1	---	---	---
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CROW BUTTE RESOURCES, INC., 86 CROW BUTTE ROAD, CRAWFORD, NE 69339

CROW BUTTE RESOURCES, INC.

DAWES COUNTY, NEBRASKA

DRAWN BY:	RAV
CHECKED BY:	BAW
APPROVED BY:	--
DATE:	09/2024

CROW BUTTE PROJECT 1982 AND 1996 AQUATIC AQUATIC SAMPLING SITE LOCATIONS

FIGURE **2.8-3**

2.9 BACKGROUND NONRADIOLOGICAL AND RADIOLOGICAL CHARACTERISTICS

Section 2.9 of the 2008 Crow Butte LRA and Section 2.9 of the MEA TR provide information on the background nonradiological and radiological characteristics of each project area. Information from these reports has been incorporated into this Combined ER/TR. There have been no updates to the background nonradiological and radiological characteristics from those previously described. Based on the information presented in this section there is no significant change between the 2008 Crow Butte LRA, MEA TR and this Combined ER/TR.

2.9.1 Introduction

2.9.1.1 Crow Butte Project

In order to establish baseline conditions of the commercial scale site and surrounding areas, a preoperational monitoring program was conducted for non-radiological characteristics. Categories chosen for sampling included water, sediment and soils. Wherever possible, sites for radiological and non-radiological samples were the same. Table 2.9-1 provides a summary of the preoperational monitoring program implemented for the Crow Butte Project. All preoperational non-radiological sample points identified in this section are shown in Figure 2.9-1.

During the year of 1982 and continuing into 1983, a preoperational non-radiological environmental monitoring program was conducted for the Crow Butte Project. This program was designed to collect baseline environmental data for both the R&D and the commercial scale operations simultaneously. Coordination of these two programs allowed more comprehensive surveys plus availability of regional data for the R&D phase. The results of the R&D project preoperational monitoring are presented in this section. The R&D operational monitoring and the commercial preoperational data that were collected from 1985 through 1987 are also presented in this section.

The non-radiological monitoring program was adapted from the monitoring recommended in NRC RG 4.14 to provide companion data to the Crow Butte preoperational radiological monitoring program described in Section 2.10 of the initial licensing application (FEN 1987). The 2014 SER stated that based on the previously provided data “staff previously concluded that operation of the Crow Butte Project is protective of health and safety (NRC 1989). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC 2003), staff is not reexamining the results of the applicant’s background radiological data.”

2.9.1.2 Marsland Expansion Area

Background nonradiological and radiological characteristics are described in Section 2.9 of the MEA TR and incorporated into this Combined ER/TR. This section discusses the environmental sampling program that has been implemented to assess preoperational/preconstruction monitoring program (PPMP) radiological background conditions in the vicinity of the MEA. The results of the PPMP, in contrast to the operational monitoring program implemented during satellite operations, will be used to determine the effects on the environment, if any, of the satellite facility and associated operations. The PPMP monitoring program is summarized in Table 2.9-2.

2.9.2 Baseline Air Monitoring

2.9.2.1 Crow Butte Project

Baseline air monitoring for the Crow Butte Project was provided in Section 2.10 of the initial licensing application.

2.9.2.2 Marsland Expansion Area

The MEA PPMP and operational monitoring plans are designed to be consistent with the criteria outlined in RG 4.14. Monitoring began in the fourth quarter of 2011 and was completed in the fourth quarter 2012.

2.9.2.2.1 Selection of Air Monitoring Locations

In accordance with the criteria in RG-4.14, Figure 2.9-2 shows the locations of the five sampling stations (MAR-1, MAR-2, MAR-3, MAR-4, and MAR-5), three sampling sites were located at the project boundary (Sites MAR-1, MAR-3 and MAR-4). MAR-2, near the project boundary, was located directly south of the proposed mill. Due to landowner preference, MAR-2 was placed 2,891 ft. south and 1,371 ft. west of the permit boundary. MAR-1 coincides with the nearest, and most likely to be impacted, occupiable structure. A fifth sampling site (Site MAR-5) was selected to represent background conditions. Because the on-site wind rose indicates northeasterly winds to be the least frequent, this background monitoring site was located southwest of the project boundary at a distance of approximately 4 miles (6.4 km).

Five quarters of air particulate monitoring have been conducted and are discussed in this section. The PPMP monitoring program will be incorporated into the operations monitoring program. The results of the air monitoring data at sampling sites MAR-1 through MAR-5 for the fourth quarter of 2011 through the fourth quarter 2012 are presented in Table 2.9-3 are summarized as follows:

- Lead 210 measurements were a consistent 2E-14 microCuries per milliliter (µCi/ml) at all monitor sites (reporting limit of 2E-15 µCi/ml) for all quarters except for the second quarter of 2012, when the lead level was 1E-14 µCi/ml (reporting limit of 2E-15 µCi/ml).
- Radium 226 levels at all monitor sites for all quarters exhibited a level at or less than 1E-16 µCi/ml (reporting limit of 1E-16 µCi/ml), except for the third quarter of 2012 when the radium-226 µCi/ml level was 5E-10 µCi/ml.
- Thorium 230 levels at monitor sites MAR-1 through MAR-4 for all quarters were at or less than 1E-16 µCi/ml, while the thorium 230 level at M-3 was 2E-16 µCi/ml (reporting limit of 1E-16 µCi/ml).
- Uranium levels at all monitor sites for all quarters were measured at <1E-16 µCi/ml (reporting limit of 1E-16 µCi/ml), with the exception of the first quarter of 2012, when levels of 3E-16 µCi/ml (reporting limit of 1E-16 µCi/ml) were measured at MAR-2, MAR-

3 and MAR-4, with MAR-5 exhibiting a level of 2E-16 µCi/ml (reporting limit of 1E-16 µCi/ml.

2.9.3 Baseline Radon Monitoring

2.9.3.1 Crow Butte Project

Baseline radon monitoring for the Crow Butte Project was provided in Section 2.10 of the initial licensing application.

2.9.3.2 Marsland Expansion Area

RG 4.14 recommends collection of radon gas samples at each of the air particulate monitoring stations (five or more sample points). Samples were analyzed for radon gas. Monitoring is being performed using RadTrak® Type DRNF outdoor air radon detectors located approximately 80 inches above the ground surface. The semiannual interval was chosen to ensure that monitoring results meet the lower limit of detection (LLD) requirement of 0.2 pCi/L ($2x10^{-10}$ µCi/ml) from RG 4.14 and to be consistent with the semiannual intervals approved by NRC for the current operational monitoring.

Radon-222 monitoring for sampling site MAR-1 through MAR-5 was conducted from the fourth quarter of 2011 through the fourth quarter of 2012 (Table 2.9-4). The gross count for the entire time period for all sampling points ranged from 43 to 362, with an average of 168. The gross count for sampling points MAR-1 through MAR-4 ranged from 43 to 362 (average of 163), compared to MAR-5 (background location) with a range of 70 to 255 (average of 191). The average radon concentration for the entire sampling period ranged from 0.07 to 1.6 µCi/ml (average of 0.5 µCi/ml). The average radon concentrations for sampling points MAR-1 through MAR-4 ranged from 0.07 to 1.6 µCi/ml (average of 0.5), compared to MAR-5 (background location) with a range of 0.1 to 1.0 µCi/ml (average of 0.6 µCi/ml).

2.9.4 Baseline Groundwater Monitoring

2.9.4.1 Crow Butte Project

Preoperational radiological baseline groundwater quality data for the CBR site was provided in Section 2.10 of the initial licensing application. The following describes the non-radiological baseline groundwater quality data.

The non-radiological groundwater parameters that were analyzed are shown in Table 2.9-5. Water samples were taken from selected representative wells within the License area and surrounding areas. The objective of this sampling was to characterize the water quality in the mineralized production zone and any overlying aquifer(s).

Eleven wells originally drilled by WFC and taken over by CBR expressly for baseline determination were sampled. The well screening interval, total depth and formation in which the baseline wells were completed are listed in Table 2.9-6. Four are completed in the Brule Formation and seven in the Chadron Sandstone (production zone). A summary of the analytical results (Brule and Chadron formations) for the eleven baseline wells drilled by WFC is given in Table 2.9-7.

2.9.4.2 Marsland Expansion Area

This section discusses the results of the radiological and non-radiological analyses for private water supply wells with the MEA and CBR monitor wells installed within the MEA for purposes of assessing the MEA site.

Radiological and non-radiological water quality analyses for private water wells in the area of review are provided in Tables 2.9-8 and 2.9-9, respectively. Groundwater samples for the CBR monitor wells were collected from December 2013 to September 2014 for the Brule monitor wells (radiological results are provided in Table 2.9-10 and non-radiological results are provided in Table 2.9-11), November 2013 to September 2014 for the Arikaree monitor wells (radiological results provided in Table 2.9-12 and non-radiological results provided in Table 2.9-13)and November 2011 to August 2012 for the basal sandstone of the Chadron Formation monitor wells (radiological results are provided in Table 2.9-14 and non-radiological results are provided in Table 2.9-15).

During sampling for the private water supply wells, there were a total of 43 wells sampled for four quarters. Twelve wells were sampled less than four quarters, seven were seasonal wells and did not operate year-round and five became inoperable during the sampling event. An additional 17 water supply wells were not sampled due to inoperability; including broken wells, power off, not working, and not in use. These wells are privately owned and in the control of the private land owners.

A summary of the groundwater quality data collected to date in the vicinity of the MEA, are presented in Table 2.9-16. The data are presented for the three water-bearing zones at the MEA: the Arikaree Group, Brule Formation, and basal sandstone of the Chadron Formation.

Suspended uranium concentrations for the private wells completed in the Arikaree and Brule Formations were at a range of <0.0003 to 0.001 mg/L (average of 0.00021 mg/L), and dissolved uranium levels were 0.0028 to 0.0373 mg/L (average of 0.00745 mg/L]). Suspended uranium activity for the private wells ranged from <2.0E-10 to 0.4 µCi/mL (average of 0.000151 µCi/mL), and dissolved uranium ranged from 3.8E-10 to 18.1 µCi/mL (average of 1.3349 µCi/mL).

Suspended radium-226 values for the private wells ranged from <6E-11 to 2E-10 µCi/mL (average of 7E-11 µCi/mL) and dissolved radium-226 ranged from <1E-10 to 9.5E-9 µCi/mL (average of 2.5E-10 µCi/mL). The majority of the values for suspended and dissolved lead-210, polonium-210, and thorium-230 were below the reporting limit.

The non-radiological analytical results for the private wells were at levels consistent with what would be expected for background concentrations for the area. Concentrations of the parameters for the private wells versus CBR monitor wells completed in the Brule Formation are comparable, with some parameters for the private wells having somewhat lower average values than for the CBR monitor wells (e.g., dissolved sodium, sulfate, chloride, and conductivity). The average values for sodium and sulfate for the private wells versus CBR Brule Formation monitor wells was 9.8 versus 104 mg/L and 10.2 versus 26.2 mg/L, respectively. The average values for sodium and sulfate for the Brule Formation monitor wells versus the CBR basal sandstone of the Chadron Formation monitor wells was 104 versus 408 mg/L and 26.2 versus 173 mg/L, respectively.

2.9.5 Baseline Surface Water Monitoring

2.9.5.1 Crow Butte Project

Baseline radiological surface water monitoring for the Crow Butte Project was provided in Section 2.10 of the initial licensing application.

2.9.5.2 Marsland Expansion Area

Surface water sampling in RG 4.14 calls for sampling of surface water passing through the project site or offsite surface waters that may be subject to drainage from potentially contaminated areas or that could be affected by a "tailings impoundment failure". No impoundments are planned at the MEA. The only offsite impoundment in the vicinity is Box Butte Reservoir. Grab samples were collected monthly and analyzed for suspended and dissolved natural uranium, radium-226, and thorium-230.

Lack of water flow in ephemeral drainages in the MEA has prevented collection of surface water samples. Water samples were collected from the Niobrara River, which flows east to west to the south of the MEA license boundary. The results of this sampling program are discussed below.

Box Butte Reservoir was not sampled. Box Butte Reservoir could be subject to drainage from potentially contaminated areas by way of the Niobrara River. In fact, any drainage from potentially contamination areas would be detected first in the Niobrara River and at far higher concentrations than the greatly attenuated contaminant levels that would be present in the reservoir itself. For that reason, the Niobrara River samples were collected to establish baseline water quality and to assess the environmental impacts from operations.

In addition, pesticides and herbicides were and are not monitored in surface waters as these contaminants are not relevant to the MEA ISR operation.

Water quality data for the NDEQ Niobrara River sampling stations were obtained from the NDEQ (Ihrie 2013). Water quality data presented in this report are for the years 2003 through 2011, and consisted of major ions, physical properties, and metals, but no radiological analyses. Water samples were collected at a sampling station above the Niobrara River (USGS 06454500) and a sampling point below Box Butte Reservoir (NDEQ sample station USGS 06455500).

Niobrara River Above Box Butte Reservoir

A summary of the water quality data for 2003 through 2011 is presented in Table 2.9-17. Water quality samples were analyzed for eight major ions. The dominant cation at the sampling location above Box Butte Reservoir was calcium (range of 42.82 to 58.20 mg/L), followed by sodium (range of 21.4 to 40.6 mg/L), magnesium (range of <0.15 to 11.5 mg/L), and chloride (range of 3. 46 to 7. 35 mg/L).

The average of the dissolved oxygen readings was 8.85 mg/L, ranging from 3.34 to 12.9 mg/L. There were only six readings below 6.0 mg/L and three between 6.1 and 6.3 mg/L, with 148 of the total samples being above 6.5 mg/L. Lower readings appeared to occur during low or high flows.

The NDEE water quality standards state that, in order for water to support aquatic life, the pH standard unit (s.u.) should be maintained between 6.5 and 9.0 unless the pH values are outside this range due to natural conditions. One of 91 of the pH readings for the Niobrara River (9.92 s.u.) was outside the acceptable range of 6.5 to 9 s.u. The average of the pH values was 8.09 s.u. and ranged from 7.1 to a maximum value of 9.92 s.u. recorded on May 21, 2007.

Temperature readings averaged 11.13 °C and ranged from -0.26 to 29.0 °C. Seasonal fluctuations indicate that water temperature is primarily dependent upon the ambient air temperatures.

Turbidity field measurements indicated an average of 27.7 nephelometric turbidity units (NTU), with a range of 0.2 to 233. The majority of the turbidity measurements were 30 NTU or less (103 of 13 readings [74 percent]). The majority of the turbidity measures above 30 NTU were during periods of either high flow or low flow conditions. There were only 18 readings above 40 NTU.

Total suspended solids (TSS) measurements ranged from <5 to 297 mg/L, with an average of 24.7 mg/L. The maximum value of 297 mg/L was the only value to exceed 100 mg/L, and the cause of the exceptionally high value is unknown based on available information. Daily readings for the months before and after this high reading were 49.5 and 61 mg/L, respectively. TSS values of 103 of the total number of 138 samples (75 percent) analyzed were 30 mg/L or lower. Specific conductance values ranged from 100 to 539 µmhos/cm, with an average of 386 µmhos/cm. All 91 readings were 314 µmhos/cm and above except for two readings of 244 and 297 µmhos/cm.

Niobrara River Below Box Butte Reservoir

NDEE water quality data were only available for 2008 for the Niobrara River below Box Butte Reservoir Table 2.9-18.

Box Butte Reservoir

CBR established two water quality sampling locations on the Niobrara River, with one sampling point (N-1) established upstream (west) of the MEA license boundary and one point (N-2) located downstream (east) of the license boundary (Figure 2.7-2). Water quality and sediment samples are collected at N-1 and N-2.

Based on Requests for Additional Information (RAI) by the NRC and further discussions, the downstream sampling location on the Niobrara River was moved approximately 2.3 river miles (3.7 km) upstream to the USGS/NeDNR 06454500 Gaging Station, which is referred to as the Niobrara River above Box Butte Reservoir for sampling purposes. N-1 and N-2 are located such that potential impacts from either of the two major ephemeral drainages that drain the MEA site from northwest to southeast and connect to the Niobrara River between N-1 and N-2.

CBR collected monthly samples for baseline water quality analysis for radiological parameters from September 2013 through August 2014 for sampling locations N1 and N2. A summary of the baseline suspended and dissolved radiological parameters is presented in Table 2.9-19. The results of the radiological analyses indicated that background levels were low, with the majority of the results at or below the RL.

2.9.6 Baseline Vegetation, Food, and Fish Monitoring

2.9.6.1 Crow Butte Project

Baseline vegetation, food, and fish monitoring for the Crow Butte Project was provided in Section 2.10 of the initial licensing application.

2.9.6.2 Marsland Expansion Area

2.9.6.2.1 Vegetation

RG 4.14 recommends sampling of grazing areas near the site in different sectors that will exhibit the highest predicted air particulate concentrations during the milling operations.

Forage vegetation was sampled following guidance in RG 4.14. The factors used to select the vegetation sampling locations within the MEA were; the three dominate wind directions, the grazing area availability and private landowner access. The forage vegetation sampling locations are shown on Figure 2.9-3. Three samples were collected three times during the grazing season and analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. Results from the vegetation sampling are shown in Table 2.9-20.

2.9.6.2.2 Food

Crops

RG 4.14 recommends that crops raised within ~1.86 miles (3 km) of the mill site be sampled at the time of harvest. The NRC has indicated that other food sources should be explored for sampling, such as private gardens in the area (e.g., sampling a variety of available garden plants). Grab samples should be analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210.

An alternative approach to estimating baseline radionuclide concentrations in vegetables was selected to protect the private owner's crops. Because the quantity of vegetables required to meet LLDs is very large, and in many instances would decimate a private garden owner's crop, an alternative approach to estimating baseline radionuclide concentrations in vegetables was used. This approach relies heavily on the approach developed by Powertech for use at the Dewey Burdock site (ML11208B714).

The PPMP baseline plan employed a ~1.86-mile (3 km) area around the license boundary to identify gardens for soil sampling. Seven garden/crop locations were selected (Figure 2.9-3) and soil samples were taken from the vegetable gardens rather than the vegetables. To estimate the radionuclide concentrations, Equation 1, Section 5 (Equation 5.5) of NUREG-5512 was used to calculate the vegetable concentration factors.

$$C_{svhj} = 1000(ML_v + B_{jv})\, W_v\, A\{C_{sj},\ t_{gv}\}/C_{si}(0) \quad \text{(Equation 1)}$$

Where:

C_{svhj} = concentration factor for radionuclide j in plant v at harvest from an initial unit concentration of parent radionuclide i in soil (pCi/kg wet-weight plant per pCi/g dry-weight soil)

B_{jv} = concentration factor for uptake of radionuclide j from the soil in plant v (pCi/kg dry-weight plant per pCi/g dry-weight soil)
ML_v = plant soil mass-loading factor for re-suspension of soil to plant v (pCi/kg dry-weight plant per pCi/g dry-weight soil)
W_v = dry to wet-weight conversion factor (unitless)
$A\{C_{sj}, t_{gv}\}$ = decay operator notation used to develop the concentration of radionuclide j in soil at the end of the crop growing period t0' (pCi/g dry-weight)
C_{sj} = concentration of radionuclide j in soil during the growing period (pCi/g dry-weight)
$C_{si}(0)$ = initial concentration of radio nuclide j in soil during the growing period (pCi/g dry-weight)
t_{gv} = growing period for food crop (days)
1000 = unit conversion factor (g/kg)

RG 4.14 specifies analysis of natural uranium, thorium-230, radium-226, lead-210, and polonium-210 in vegetables. With the exception of polonium-210, these radionuclides have long half-lives when compared to the growing season. For that reason, the decay correction can be ignored. For polonium-210, CBR assumed that the initial soil concentration and the soil concentration during the growing season remain identical. Thus, Equation 1 is simplified to Equation 2:

$$C_{svhj} = 1000(ML_v + B_{jv})W_v \qquad \text{(Equation 2)}$$

Based upon Equation 2, Table 2.9-21 presents both the parameters that will be used to estimate wet-weight vegetable concentrations from dry-weight soil concentrations and the average value for each plant type and each radionuclide in pCi/kg wet-plant weight from the seven gardens sampled.

2.9.6.2.3 Livestock

NRC RG 4.14 recommends sampling and analysis of the edible portions of livestock raised within 3 km of the site at the time of slaughter. Grab samples should be analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. With the cooperation of a local landowner in March of 2014, animal tissue samples were collected from locally raised beef cattle at the time of slaughter within 3 km of the MEA. The locations of livestock samples are shown on Figure 2.9-3. Samples were analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. Table 2.9-22 presents the radionuclide analysis for beef samples collected in the MEA.

2.9.6.2.4 Game Animals

No preoperational samples of game animals were collected due to the following considerations:

- Hunting access is limited by private landowners.
- There are a limited number of game animals in the licensed area.
- Due to the migratory nature of game animals, it would be difficult to attribute any radionuclide concentration origins to the site.

Livestock is the primary food source in the MEA and more likely to be in the pathway-to-man. Therefore, livestock was determined to be a better food sample.

2.9.6.2.5 Fish

RG 4.14 requires that fish be collected, if available, from lakes and streams in the project site area that may be subject to seepage or direct surface runoff from potentially contaminated areas or that could be affected by a tailings impoundment failure. Fish should be collected, sampled, and analyzed semiannually for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. There are no streams or water impoundments located within the MEA license boundary. There are only two dry drainages that cross the license area. Therefore, fish sampling within the MEA license boundary is not feasible.

The nearest permanent stream is the Niobrara River located just to the south of MEA license boundary which flows into Box Butte Reservoir. Given the large sample size required to attain LLDs (14 pounds) and the limited fish population present in the stream, the fish sampling focused on northern pike in the inlet of Box Butte Reservoir. At the time of sampling, Box Butte Reservoir was overpopulated with northern pike, which allowed for a larger bag limit than elsewhere in Nebraska. As the most prevalent species, a popular gamefish and known human food source, sampling the meat of the northern pike is the only feasible approach to assessing potential dietary contribution to humans. Northern pike fish tissue samples were collected from the inlet of the Box Butte Reservoir on May 25, 2014 and September 26, 2014. The samples were analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210 (Table 2.9-23).

Collection of fish tissue at N-1 and N-2 was not feasible due to the small fish population with insufficient fish biomass. Attempting to collect the required amount of fish tissue needed for the analytical laboratory to obtain the required LLD would decimate the limited fish population.

Due to the lack of background data from the study area with which to compare the current findings, radionuclide data interpretation is impracticable at this time, other than that the concentrations are considered low. The radiological results will serve as background information for potential future sampling events and the development of long-term trends.

2.9.7 Baseline Soil Sampling

2.9.7.1 Crow Butte Project

Soil samples were collected to determine baseline concentrations of selected elements in the different soil types. Nine samples were collected in the Crow Butte Project. Six locations were chosen within and nearby Section 19 to provide background information on where the commercial process facility is located and where maximum surface disturbance will occur. Seven sites were also sampled in the proposed restricted area. At the plant and pond locations, another set of samples were obtained before commercial construction and also after topsoil removal and excavation was complete.

Material collected for non-radiological analysis was in the form of surface samples. These were collected as follows: A two-meter transect was laid out in either a north-south or east-west direction at the desired location. Points along this line were situated at 0, 0.67, 1.33 and 2 meters. At each point soil was removed from a 5 to 7.6 cm (2 to 3 in.) diameter circular area to a depth of 5 cm (2 in.).

Three trace elements were chosen for consideration in this sampling. Arsenic, selenium and vanadium are commonly associated with uranium ore deposits. This is especially true in roll-front type deposits where halos of metal sulfides and other reduced compounds occur at the "nose" or in front of the uranium mineralization. When leaching takes place during mining, varying concentrations of companion compounds will be solubilized. Thus, a surface spill of leach solution might contain small amounts of these three elements. The leach solution will also contain uranium and radium-226. The baseline uranium and radium-226 levels in the soil are found in Section 2.10 of the original license application.

Results of the soil sampling are found in Table 2.9-24 and Table 2.9-25. As can be seen from the data in Table 2.9-24 the arsenic concentration ranges from 0.59 to 3.30 µg/g and the selenium concentration ranges from <0.01 to 0.06 µg/g. There does not appear to be any relationship between the soil type and the levels of these elements. The vanadium analyses shown in Table 2.9-25 indicates that the vanadium levels in the restricted area are very consistent with a range of 22 to 29 µg/g.

2.9.7.2 Marsland Expansion Area

All baseline soil samples were collected as described in RG 4.14. Tetra Tech conducted the RG 4.14 soil sampling field investigation in May and June 2014. The field investigation included collection of the following: (1) surface radial grid soil samples, (2) subsurface radial grid soil samples, and (3) air particulate monitoring station soil samples. Table 2.9-26 provides a summary of the soil sampling types, number of samples collected for each type, sample depth, and analytes tested.

The soil samples were collected and submitted for analysis to Inter-mountain Laboratories (IML) in Sheridan, Wyoming. The laboratory testing frequency and reporting limits used in this investigation meet the requirements of Section 2.2 of RG 4.14. The surface radial grid soil samples were all analyzed for Ra-226; 10 percent (four samples) were also analyzed for lead-210 (Pb-210), U-nat, and thorium-230 (Th-230). An additional 13 surface radial grid soil samples, located within the boundary of the proposed disturbed area, were analyzed for U-nat, results to be used in the background analysis. The air particulate monitoring soil samples were analyzed for Ra-226, Pb-210, Th-230, and U-nat. Subsurface radial grid soil samples were all analyzed for Ra-226; one set was analyzed for Ra-226, Pb-210, Th-230, and U-nat.

Tables 2.9-27 and 2.9-28 provides the summary statistics for the surface radial grid soils samples and subsurface radial grid soil samples, respectively. Table 2.9-29 provides the results for the air particulate monitoring station soil samples.

2.9.8 Baseline Sediment Sampling

2.9.8.1 Crow Butte Project

Baseline sediment monitoring for the Crow Butte Project was provided in Section 2.10 of the initial licensing application.

2.9.8.2 Marsland Expansion Area

RG 4.14 recommends that sediment samples be collected from sediments of surface water passing through the project site or offsite surface waters that may be subject to drainage from potentially contaminated areas. The PPMP and operational monitoring plan will be designed to meet the criteria outlined in RG 4.14. Samples are to be collected once following spring runoff and in late summer following a period of extended low flow.

Sediment sampling in RG 4.14 requires samples from each large onsite body of water or offsite surface waters that may be subject to direct surface drainage from potentially contaminated areas that could be affected by a tailings impoundment failure. There are no onsite surface impoundments, so such sampling is not required. Sediment samples were collected from the Niobrara River, which could receive surface water runoff by means of ephemeral drainages located on the MEA project site. Sediments of the Niobrara River were sampled at designated upstream and downstream sampling locations (sample points N-1 and N-2) (Figure 2.7-2). Sediment samples at N-1 and N-2 sampling points were collected on October 25, 2013 and May 2, 2014. The radiological sample analytical results for lead-210, radium-226, thorium-230, and natural uranium are shown in Table 2.9-30.

There are two major ephemeral drainages that traverse across the MEA license area north to south. Seven sampling points in the channel bottom were selected on these drainages to measure radiological concentrations in the sediment at stations MED-1 through MED-7 (Figure 2.9-3).

The ephemeral drainages at the designated sampling points were sampled twice, once following spring runoff, and in late summer following period of extended low flow. Samples were analyzed for natural uranium, radium-226, thorium-230, and lead-210.

Sediment sampling at MED-1 through MED-6 was conducted in the fourth quarter of 2013 and the second quarter of 2014. Sediment sampling at MED-7 was conducted in the fourth quarter of 2014 and the second quarter of 2015 (Table 2.9-31).

2.9.9 Baseline Direct Radiation Monitoring

2.9.9.1 Crow Butte Project

Baseline direct radiation monitoring for the Crow Butte Project was provided in Section 2.10 of the initial licensing application.

2.9.9.2 Marsland Expansion Area

RG 4.14 recommends direct radiation measurements be collected at 150-meter intervals to a distance of 4,921.26 feet (1,500 meters) in each of eight directions from the centerpoint of the milling area or at a point equidistant from the milling area and tailings disposal area. The direct gamma radiation sampling at MEA was designed to meet or exceed this guidance. Because there are no milling or tailings disposal areas, CBR used the satellite facility as the centerpoint.

The PPMP baseline radiation monitoring program includes routine monitoring of direct radiation levels at the air monitoring stations. The PPMP and operational monitoring plan has been designed to meet the criteria outlined in RG 4.14. As with air particulate and radon-220 monitoring, gamma monitoring began in the fourth quarter of 2011 and was completed in the fourth quarter of 2012 (five quarters of data).

Monitoring has been conducted by placing Inlight® Systems Dosimeters, provided by Landauer, Inc., quarterly at the air particulate monitoring sites (Figure 2.9-2). The monitors were located approximately 1 meter above ground level. They were exchanged with new monitors quarterly, and the exposed monitors were returned to the vendor for processing. These devices provide an integrated exposure for the period between annealing and processing.

The results of gamma measurements conducted at the air particulate monitoring stations (MAR-1 through MAR-5) for the fourth quarter of 2011 through the fourth quarter 2012 are presented in Table 2.9-32. The gross and net measurements for all sampling locations over the entire sampling period ranged from 19.9 to 40.9 (average of 33.3) and 4.5 to 14.5 (average of 8.0) mRems ambient dose equivalent, respectively. The range of the gross and net measurements for MAR-1 through MAR-4 was 19.9 through 40.9 (average of 33.8) and 4.6 to 14.5 (average of 8.5), respectively, compared to MAR-5 with a range of 20.9 through 38.1 (average of 31.8) and 4.5 to 7.7 (average of 6.2), respectively.

In addition to the environmental gamma monitors, NRC recommends that the background gamma radiation in the area of the facility be measured with a scintillometer. As per RG 4.14, CBR performed PPMP gamma radiation measurements at 150-meter intervals as discussed above.

Tetra Tech performed two gamma survey approaches: (1) RG 4.14 direct gamma field investigation, and (2) continuous gamma survey field investigation. Both of these approaches used NRC guidance documents for ISR uranium projects. Background radiation, as described in NUREG-1757 Vol. 1, Rev. 2 Consolidated Decommission Guidance and NUREG-1757 Vol. 2, Rev. 1 Characterization, Survey, and Determination of Radiological Criteria, is radiation from cosmic sources, naturally occurring radioactive material (including radon), and global fallout.

2.9.10 References

Ferret of Nebraska, Inc. (FEN), 1987, Application and Supporting Environmental Report for USNRC Commercial Source Material License, September 1987.

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U.S. Nuclear Regulatory Commission, 1989, Safety Evaluation Report (SER) for Ferret Exploration Company of Nebraska, Crow Bute Project, December 12, 1989. ADAMS Accession No. ML080730272.

U.S. Nuclear Regulatory Commission, 2003, NUREG-1569 Standard Review Plan for In Situ Leach Uranium Extraction License Applications – Final Report.

Table 2.9-1. Crow Butte Project Non-Radiological Preoperational Monitoring Program

Sample Collection					Sample Analysis	
Type of sample	**Number**	**Location**	**Method**	**Frequency**	**Frequency**	**Type of Analysis**
WATER						
Groundwater						
	One from each water supply well	All wells within 1 km of restricted area boundary	Grab	3 Times	Each Sample	Complete Table 2.9-2 list
	One from each well	Selected Regional wells	Grab	3 Times	Each Sample	Same
	One from each DEQ baseline & monitor well	As required by DEQ	Grab	Quarterly	Quarterly	Complete Table 2.9-2 list once; common ions only other quarters
Surface Water						
	One from each pond or impoundment		Grab	Once	Once	Complete Table 2.9-9 list
	Two from. Squaw Creek	One up-stream, one down stream of restricted area	Grab	Quarterly	Quarterly	Complete Table 2.9-9 list once; common ions only other quarters
	Two from White Clay Creek	Upstream and down stream of License area.	Grab	Four Times	Quarterly	Complete Table 2.9-9 list once; common ions other quarters
	Two from English Creek	Upstream and down stream of License area	Grab	Four Times	Quarterly	Complete Table 2.9-9 once; common ions other quarters
	Two from Squaw Creek	One upstream and one down stream of restricted area	Grab	Quarterly	Quarterly	Suspended sediment
Water Levels						
	One from each monitor well, baseline well, and selected private wells	.	Electric line	Monthly	Monthly	Map
Flow						
	Two from Squaw Creek	One upstream and one down stream of restricted area	Flow	Monthly through 1982; then quarterly	Monthly	Tabular

Table 2.9-1. Crow Butte Project Non-Radiological Preoperational Monitoring Program (Cont.)

Sample Collection					Sample Analysis	
Type of sample	**Number**	**Location**	**Method**	**Frequency**	**Frequency**	**Type of Analysis**
SOILS						
Surface						
	One each	Six locations in Section 19	Grab	Once	Once	Arsenic, Selenium
	One each.	Nine locations in License area	Grab	Once	Once	Arsenic, Selenium
	One each	Seven Locations In restricted area	Grab	Once	Once	Vanadium

Table 2.9-2. Marsland Expansion Area Preoperational/Preconstruction Monitoring Program

Sample Collection					Sample Analysis	
Type of Sample	Number	Location	Method	Frequency	Frequency	Type of Analysis
Air Particulates	3	On MEA southern boundary	Continuous	Weekly filter change	Quarterly composite of weekly samples	U-nat, Ra-226, Th-230, and Pb-210
	1	Nearest Residence	Continuous	Weekly filter change	Quarterly composite of weekly samples	U-nat, Ra-226, Th-230, and Pb-210
	1	Control background location west of MEA license boundary	Continuous	Weekly filter change	Quarterly composite of weekly samples	U-nat, Ra-226, Th-230, and Pb-210
Radon Gas	3	On MEA southern boundary	Continuous	Quarterly	Quarterly	Rn-222
	1	Nearest Residence	Continuous	Quarterly	Quarterly	Rn-222
	1	Control background location west of MEA license boundary	Continuous	Quarterly	Quarterly	Rn-222
Groundwater	1	Wells within MEA license boundary and 2 km radius: • Private wells • MEA Arikaree Wells • MEA Brule Wells • MEA Ore Zone Wells	Grab	Quarterly	Quarterly	Suspended and dissolved uranium, Ra-226, Th0210, Pb-210, and Po-210
Surface Water	2[a]	Niobrara River (N-1 and N-2)	Grab	Monthly	Monthly	Suspended and dissolved uranium, Ra-226, Th-230
	1[a]	Ephemeral drainages		Semiannually	Semiannually	Suspended and dissolved Pb-210 and Po-210
Vegetation	3	Grazing areas near the site in different sectors that will have the highest predicted air particulate concentrations during milling operations	Grab	3 times during grazing season	3 times	U-nat, Ra-226, Th-230, Pb-210, and Po-210

Table 2.9-2. Marsland Expansion Area Preoperational/Preconstruction Monitoring Program (Cont.)

Sample Collection					Sample Analysis	
Type of Sample	Number	Location	Method	Frequency	Frequency	Type of Analysis
Food	3	Crops (alternate of garden soil sampling used)	Grab	Time of harvest or slaughter	1	U-nat, Ra-226, Th-230, Pb-210, and Po-210
	3	Livestock				
Fish	Each body of water	Box Butte Reservoir	Grab	Semiannually	2	U-nat, Ra-226, Th-230, Pb-210, and Po-210
Surface Soil[b]	Up to 40	300-meter intervals to a distance of 1500 meters in each of 8 directions from center point of satellite facility; additional transects through wellfields	Grab	Once prior to construction. Repeat for location disturbed by excavation, leveling or contouring	1	All samples for Ra-226, 10% of samples U-nat, Th-230, and Pb-210
	5	Same location used for collection of air particulates	Grab	Once prior to construction	1	U-nat, Ra-226, Th-230, and Pb-210
Subsurface Soil[c]	5	At center point of satellite facility and at distances of 750 meters in each of 4 directions	Grab	Once prior to construction. Repeat for location disturbed by construction	1	Ra-226 (all samples), U-nat, Th-230, and Pb-210 (one set of samples)
Sediment[d]	1 from each stream (2) & ephemeral drainage (7) sampling points	Up and down gradient samples from ephemeral drainages (total of 7 samples) & Niobrara River (N-1 and N-2)	Grab (composite)	Once following spring runoff & late summer following period of extended low flow	2	U-nat, Ra-226, Th-230, and Pb-210

Table 2.9-2. Marsland Expansion Area Preoperational/Preconstruction Monitoring Program (Cont.)

Sample Collection					Sample Analysis	
Type of Sample	Number	Location	Method	Frequency	Frequency	Type of Analysis
Direct Radiation (Survey)	Up to 80	150-meter intervals to a distance of 1500 meters in each of 8 directions from center point of satellite facility	Grab	Once prior to construction. Repeat for areas disturbed by site preparation or construction	1	Gamma exposure using sodium iodide scintillometer
Direct Radiation (Continuous)	5	Same location used for collection of air particulates	Grab	Once prior to construction	1	Gamma exposure using a continuous integrating device
Radon Flux[e]	-					

[a] Two samples from the Niobrara River per sampling event and one from each sampling point (total of 7) located on ephemeral streams
[b] Surface soil samples collected to a depth of 5 cm using a consistent technique
[c] Subsurface soil samples collected to a depth of 1 meter; samples divided into 3 equal sections for analysis
[d] Sediment sample locations shown on Figure 2.9-3
[e] Radon flux measurements are not applicable to ISR facilities.

Table 2.9-3. Airborne Particulate Concentrations for Marsland Expansion Area

Analyte	Result pCi/filter	Precision ± pCi/filter	Result µCi/ml	Precision ± µCi/ml	RL µCi/ml	10 CFR Pt 20 Effluent Limit	Effluent Class	% Effluent Concentration
Fourth Quarter 2011								
MA-1 [Sample Air Volume 3,850,477 liters]								
Lead 210	72.2	6.4	2E-14	2E-15	2E-15	6E-13	Day	3.33
Radium 226	<0.3	--	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.3	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	<0.3	--	<1E-26	--	1E-16	9E-14	Year	0.00
MA-2 [Sample Air Volume 3,851,229 liters]								
Lead 210	86.9	6.9	2E-14	2E-15	2E-15	6E-13	Day	3.33
Radium 226	<0.3	--	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.3	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	<0.3	--	<1E-16	--	1E-16	9E-14	Year	0.00
MA-3 [Sample Air Volume 3,852,794 liters]								
Lead 210	83.0	6.2	2E-14	2E-15	2E-15	6E-13	Day	3.33
Radium 226	<0.3	--	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	0.4	0.4	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	0.3	--	<1E-16	--	1E-16	9E-14	Year	0.00
MA-4 [Sample Air Volume 3,853,046 liters]								
Lead 210	91.2	7.2	2E-14	2E-15	2E-15	6E-13	Day	3.33
Radium 226	<0.3	--	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.3	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	<0.3	--	<1E-16	--	1E-16	9E-14	Year	0.00
MA-5 (Sample Air Volume 3,856,136 liters]								
Lead 210	70.5	6.0	2E-14	2E-15	2E-15	6E-13	Day	3.33
Radium 226	<0.3	--	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	0.4	0.4	1E-16	1E-16	1E-16	3E-14	Year	0.00
Uranium	<0.3	--	<1E-16	--	1E-16	9E-14	Year	0.00

Table 2.9-3. Airborne Particulate Concentrations for Marsland Expansion Area (Cont.)

Analyte	Result pCi/filter	Precision + pCi/filter	Result µCi/ml	Precision + µCi/ml	RL µCi/ml	10 CFR Pt 20 Effluent Limit	Effluent Class	% Effluent Concentration
First Quarter 2012								
MA-1 [Sample Air Volume 6,334,637 liters]								
Lead 210	115	7.5	2E-14	1E-15	2E-15	6E-13	Day	3.33
Radium 226	<0.3	--	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	1.4	--	2E-16	--	1E-16	9E-14	Year	0.22
MA-2 [Sample Air Volume 6,337,547 liters]								
Lead 210	108	7.7	2E-14	1E-15	2E-15	6E-13	Day	3.33
Radium 226	<0.3	--	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	1.8	--	3E-16	--	1E-16	9E-14	Year	0.33
MA-3 [Sample Air Volume 6,322,001 liters]								
Lead 210	109	7.0	2E-14	1E-15	2E-15	6E-13	Day	3.33
Radium 226	0.6	0.2	1E-16	3E-17	1E-16	9E-13	Week	0.01
Thorium 230	1.0	0.4	2E-16	6E-17	1E-16	3E-14	Year	0.67
Uranium	1.9	--	3E-16	--	1E-16	9E-14	Year	0.33
MA-4 [Sample Air Volume 6,333,500 liters]								
Lead 210	120	7.9	2E-14	1E-15	2E-15	6E-13	Day	3.33
Radium 226	0.4	0.1	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	0.3	0.2	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	1.6	--	3E-16	--	1E-16	9E-14	Year	0.33
MA-5 (Sample Air Volume 6,338,171 liters]								
Lead 210	116	7.2	2E-14	1E-15	2E-15	6E-13	Day	3.33
Radium 226	<0.3	--	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	0.2	0.2	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	1.4	--	2E-16	--	1E-16	9E-14	Year	0.22

Table 2.9-3. Airborne Particulate Concentrations for Marsland Expansion Area (Cont.)

Analyte	Result	Precision +	Result	Precision +	RL	10 CFR Pt 20 Effluent Limit	Effluent Class	% Effluent Concentration
	pCi/filter	pCi/filter	µCi/ml	µCi/ml	µCi/ml			
Second Quarter 2012								
MA-1 [Sample Air Volume 6,196,200 liters]								
Lead 210	68.9	6.1	1E-14	1E-15	2E-15	6E-13	Day	1.67
Radium 226	<0.3	--	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	<0.3	--	<1E-16	--	1E-16	9E-14	Year	0.00
MA-2 [Sample Air Volume 6,203,400 liters]								
Lead 210	82.7	5.4	1E-14	9E-16	2E-15	6E-13	Day	1.67
Radium 226	<0.3	--	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	<0.3	--	<1E-16	--	1E-16	9E-14	Year	0.00
MA-3 [Sample Air Volume 6,067,000 liters]								
Lead 210	75.7	5.1	1E-14	8E-16	2E-15	6E-13	Day	1.67
Radium 226	0.5	0.1	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	0.3	--	<1E-16	--	1E-16	9E-14	Year	0.00
MA-4 [Sample Air Volume 6,049,000 liters]								
Lead 210	78.2	7.9	2E-14	9E-16	2E-15	6E-13	Day	1.67
Radium 226	0.3	0.1	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.2	0.2	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	0.4	--	3E-16	--	1E-16	9E-14	Year	0.00
MA-5 (Sample Air Volume 5,575,200 liters]								
Lead 210	62.2	4.8	1E-14	9E-16	2E-15	6E-13	Day	1.67
Radium 226	<0.3	--	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	<0.3	--	<1E-16	--	1E-16	9E-14	Year	0.00

Table 2.9-3. Airborne Particulate Concentrations for Marsland Expansion Area (Cont.)

Analyte	Result pCi/filter	Precision ± pCi/filter	Result µCi/ml	Precision ± µCi/ml	RL µCi/ml	10 CFR Pt 20 Effluent Limit	Effluent Class	% Effluent Concentration
Third Quarter 2012								
MA-1 [Sample Air Volume 6,108,764 liters]								
Lead 210	116	7.0	2E-14	1E-15	2E-15	6E-13	Day	3.33
Radium 226	0.4	0.1	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	0.3	--	<1E-16	--	1E-16	9E-14	Year	0.00
MA-2 [Sample Air Volume 6,002,630 liters]								
Lead 210	122	7.4	2E-14	1E-15	2E-15	6E-13	Day	3.33
Radium 226	3.0	0.4	5E-16	7E-17	1E-16	9E-13	Week	0.06
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	0.4	--	<1E-16	--	1E-16	9E-14	Year	0.00
MA-3 [Sample Air Volume 6,532,003 liters]								
Lead 210	129	7.6	2E-14	1E-15	2E-15	6E-13	Day	3.33
Radium 226	0.9	0.2	1E-16	3E-17	1E-16	9E-13	Week	0.01
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	0.4	--	<1E-16	--	1E-16	9E-14	Year	0.00
MA-4 [Sample Air Volume 5,889,397 liters]								
Lead 210	103	6.3	2E-14	1E-15	2E-15	6E-13	Day	3.33
Radium 226	0.6	0.2	1E-16	3E-17	1E-16	9E-13	Week	0.01
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	0.5	--	<1E-16	--	1E-16	9E-14	Year	0.00
MA-5 (Sample Air Volume 5,337,479 liters]								
Lead 210	103	6.6	2E-14	1E-15	2E-15	6E-13	Day	3.33
Radium 226	<0.3	--	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	<0.3	--	<1E-16	--	1E-16	9E-14	Year	0.00

Table 2.9-3. Airborne Particulate Concentrations for Marsland Expansion Area (Cont.)

Analyte	Result	Precision ±	Result	Precision ±	RL	10 CFR Pt 20 Effluent Limit	Effluent Class	% Effluent Concentration
	pCi/filter	pCi/filter	µCi/ml	µCi/ml	µCi/ml			
Fourth Quarter 2012								
MA-1 [Sample Air Volume 6,682,410 liters]								
Lead 210	129	5.8	2E-14	9E-16	2E-15	6E-13	Day	3.33
Radium 226	0.3	0.1	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	0.4	--	<1E-16	--	1E-16	9E-14	Year	0.00
MA-2 [Sample Air Volume 6,581,476 liters]								
Lead 210	128	6.1	2E-14	9E-16	2E-15	6E-13	Day	3.33
Radium 226	<0.3	--	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.2	0.2	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	<0.3	--	<1E-16	--	1E-16	9E-14	Year	0.00
MA-3 [Sample Air Volume 6,575,697 liters]								
Lead 210	128	5.8	2E-14	9E-16	2E-15	6E-13	Day	3.33
Radium 226	0.4	0.1	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	<0.3	--	<1E-16	--	1E-16	9E-14	Year	0.00
MA-4 [Sample Air Volume 6,582,882 liters]								
Lead 210	132	5.8	2E-14	9E-16	2E-15	6E-13	Day	3.33
Radium 226	0.4	0.1	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	<0.3	--	<1E-16	--	1E-16	9E-14	Year	0.00
MA-5 (Sample Air Volume 6,584,474 liters]								
Lead 210	134	6.1	2E-14	9E-16	2E-15	6E-13	Day	3.33
Radium 226	<0.3	--	<1E-16	--	1E-16	9E-13	Week	0.00
Thorium 230	<0.2	--	<1E-16	--	1E-16	3E-14	Year	0.00
Uranium	<0.3	--	<1E-16	--	1E-16	9E-14	Year	0.00

Table 2.9-4. Ambient Atmospheric Radon-222 Concentration for Marsland Expansion Area

Location	Date	Gross Count	Average Radon Concentration	Accuracy	Percent Effluent Concentration
			x 10^{-9} µCi/ml		
MA-1	11/11/2012-1/4/2012	132	0.3	0.03	3.0
MA-2		136	0.3	0.03	3.0
MA-3		130	0.2	0.02	2.0
MA-4		167	0.6	0.05	6.0
MA-5		173	0.7	0.05	7.0
	Average	**148**	**0.4**	**0.04**	**4.2**
MA-1	1/4/2012-4/2/2012	120	0.7	0.06	7.0
MA-2		87	0.3	0.03	3.0
MA-3		47	0.07	0.01	0.7
MA-4		43	0.07	0.01	0.7
MA-5		251	1.0	0.06	10.0
	Average	**110**	**0.4**	**0.03**	**4.2**
MA-1	4/2/2012-6/29/2012	241	0.8	0.05	8.0
MA-2		362	1.6	0.08	16.0
MA-3		271	1.0	0.06	10.0
MA-4		244	0.9	0.06	9.0
MA-5		255	0.9	0.06	9.0
	Average	**275**	**1.0**	**0.06**	**10.0**
MA-1	6/29/2012-10/1/2012	76	0.2	0.02	2.0
MA-2		81	0.2	0.02	2.0
MA-3		77	0.2	0.02	2.0
MA-4		79	0.2	0.02	2.0
MA-5		70	0.1	0.01	1.0
	Average	**77**	**0.2**	**0.02**	**2.0**
MA-1	10/1/2012-1/2/2013	290	0.8	0.05	8.0
MA-2		256	0.6	0.04	6.0
MA-3		216	0.4	0.03	4.0
MA-4		196	0.3	0.02	3.0
MA-5		206	0.3	0.02	3.0
	Average	**233**	**0.5**	**0.03**	**5.0**

LLD (x 10^{-9} µCi/ml): 0.2
Effluent Concentration Limit, 10 CFR 20 App B Column 2: 10
Equipment: Track Etch Cup
LLD – Lower Limit of Detection
µCi/ml – microcuries per milliliter

Table 2.9-5. Crow Butte Project Baseline Groundwater Quality Indicators

Physical Indicators	
Specific Conductivity	Temperature
Alkalinity	Ph
Total Dissolved Solids	
Common Constituents	
Ammonia	Chloride
Silica	Magnesium
Sodium	Calcium
Nitrate	Total Carbonate
Nitrite	Sulfate
Potassium	
Trace and Minor Elements	
Arsenic	Fluoride
Nickel	Iron
Selenium	Barium
Lead	Vanadium
Cadmium	Manganese
Zinc	Mercury
Copper	Molybdenum
Radionuclides	
Radium-226	Uranium

Table 2.9-6. Crow Butte Project Baseline Wells Originally Drilled by WFC

Well Number	Formation	Screen Interval (ft)	Depth (ft) to Bottom of Screen Assembly
RA-1	Brule	7 - 27	32
RA-2	Brule	7 - 27	32
RB-1	Brule	100 - 110	115
RB-3	Brule	95 - 115	120
RC-1	Chadron	330 - 350	355
RC-2	Chadron	572 - 592	597
RC-3	Chadron	260 - 270	275
RC-4	Chadron	340 - 360	365
RC-5	Chadron	672 - 692	697
RC-6	Chadron	713 - 733	738
RC-7	Chadron	708 - 718	723

Table 2.9-7. Crow Butte Project Aquifer Water Quality Summary

Parameter	Units	Range	Mean
Brule Formation*			
Calcium	mg/L	7.1 - 98	48
Magnesium	mg/L	0.3 - 16	6.6
Sodium	mg/L	12 - 340	104
Potassium	mg/L	4.1 - 15.9	9.9
Bicarbonate	mg/L	137 - 627	364
Sulfate	mg/L	1 - 23	10
Chloride	mg/L	1.6 - 192	48
Conductance	µmhos/cm	246 - 1481	714
pH	s.u.	6.8 - 8.5	7.8
Uranium	mg/L	0.001 - 0.021	0.0064
Radium-226	pCi/L	0.1 - 3.0	0.7
Chadron Formation*			
Calcium	mg/L	11 - 41	20
Magnesium	mg/L	0.8 - 7.2	3.2
Sodium	mg/L	340 - 540	411
Potassium	mg/L	7.0 - 19.8	12.4
Bicarbonate	mg/L	308 - 411	368
Sulfate	mg/L	254 - 620	407
Chloride	mg/L	134 - 250	176
Conductance	µmhos/cm	1500 - 2500	1932
pH	s.u.	7.6 - 8.7	8.2
Uranium	mg/L	<0.001 - 2.40	0.092
Radium-226	pCi/L	0.1 - 619	53

* Summary of average values for baseline wells drilled by WFC listed in **Table 2.9-6**.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review

	Location ID:	700		700		700		700		702		702		702		702		703		703	
	Date Collected:	6/18/2012		9/17/2012		11/26/2012		3/18/2013		6/18/2012		9/17/2012		11/26/2012		3/18/2013		6/20/2012		9/7/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<8E-10 U	8E-10	1.3E-10 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	1.9E-9	1E-9
Lead 210 MDC	µCi/mL	8E-10		-		8E-10		-		8E-10		-		7E-10		-		8E-10		-	
Lead 210 precision (±)	µCi/mL	5E-10		4E-10		5E-10		-		5E-10		-		4E-10		-		5E-10		6E-10	
Polonium 210	µCi/mL	1.7E-19	6E-10	<1E-10 U	1E-9	<1E-9	1E-9	<1E-9	1E-9	<7E-10 U	7E-10	<1E-9	1E-9	<8E-10	8E-10	<1E-9	1E-9	<6E-10 U	6E-10	<1E-9	1E-9
Polonium 210 MDC	µCi/mL	6E-10		-		1E-9		-		7E-10		-		8E-10		-		6E-10		-	
Polonium 210 precision (±)	µCi/mL	9e-10		-		4E-10		-		5E-10		-		3E-10		-		4E-10			
Radium 226	µCi/mL	<1.8E-10 U	1.8E-10	<2E-10 U	2E-10	<1.4E-10 U	1.4E-10	<2E-10 U	2E-10	<1.5E-10 U	1.5E-10	<2E-10 U	2E-10	<1.5E-10	1.5E-10	<2E-10 U	2E-10	<1.5E-10	1.5E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.8E-10		-		1.4E-10		-		1.5E-10		-		1.5E-10		-		1.5E-10		-	
Radium 226 precision (±)	µCi/mL	7E-11		-		1E-10		-		1E-10		-		6E-11		-		9E-10		-	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10U	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	2E-10		-		2E-10		-		1E-10		-		1E-10		-		2E-10		-	
Thorium 230 precision (±)	µCi/mL	5E-11		-		6E-11		-		4E-11		-		4E-11		-		8E-11		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<6E-10 U	6E-10	1.3E-9	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	6E-10		-		5E-10		-		6E-10		-		5E-10		-		5E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		-		3E-10		-		4E-10		-		3E-10		-		3E-10		-	
Polonium 210	µCi/mL	3E-10	2E-10	<1E-9	1E-9	<9E-10 U	9E-10	<1E-9 U	1E-9	6E-10	3E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<3E-10	3E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	2E-10		-		9E-10		-		3E-10		-		7E-10		-		3E-10		-	
Polonium 210 precision (±)	µCi/mL	2E-10		-		3E-10		-		4E-10		-		3E-10		-		2E-10		-	
Radium 226	µCi/mL	<1.2E-10 U	1.2E-10	-2E-10 U	2E-10	<1.2E-10 U	1.2E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.1E-10 U	1.1E-10	<2E-10 U	2E-10	<1.2E-10	1.2E-10	<2E-10	2E-10
Radium 226 MDC	µCi/mL	1.2E-10		-		1.2E-10		-		1.3E-10		-		1.1E-10		-		1.2E-10		-	
Radium 226 precision (±)	µCi/mL	7E-11		-		6E-11		-		7E-11		-		6E-11		-		7E-11		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	-2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10	1E-10	<2E-10	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10		-		2E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	4E-11		-		4E-11		-		5E-11		-		7E-11		-		6E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0060	0.0003	0.0066	0.0003	0.0073	0.0003	0.0072	0.0003	0.0034	0.0003	0.0039	0.0003	0.0041	0.0003	0.0040	0.0003	0.0036	0.0003	0.0049	0.0003
Uranium Activity	µCi/mL	4.1E-9	2E-10	4.5E-9	2E-10	4.9E-9	2E-10	4.9E-9	2E-10	2.3E-9	2E-10	2.6E-9	2E-10	2.8E-9	2E-10	2.7E-9	2E-10	2.5E-9	2E-10	3.3E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2.E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	703		703		704 [a]		704 [a]		704 [a]		704 [a]		705 [a]		705 [a]		705 [a]		705 [a]	
	Date Collected:	11/27/2012		3/21/2013		6/20/2012		9/7/2012		11/27/2012		3/21/2013		6/20/2012		9/19/2012		11/28/2012		3/21/2013	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<7E-10 U	7E-10	<1E-9	1E-9	<8E-10 U	8E-10	1.3E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<9E-10 U	9E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	7E-10		-		8E-10		-		7E-10		-		9E-10		-		7E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		-		5E-10		5E-10		4E-10		-		5E-10		-		4E-10		-	
Polonium 210	µCi/mL	<7E-10 U	7E-10	<1E-9	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<9E-10 U	9E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	1.3E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	7E-10		-		6E-10		-		9E-10		-		6E-10		-		7E-10		-	
Polonium 210 precision (±)	µCi/mL	4E-10		-		6E-10		-		3E-10		-		3E-10		8E-10		3E-10		-	
Radium 226	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<1.7E-10 U	1.7E-10	<2E-10 U	2E-10	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<1.8E-10	1.8E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	2E-10		-		1.7E-10		-		1.6E-10		-		1.6E-10		-		1.8E-10		-	
Radium 226 precision (±)	µCi/mL	1.2E-10		-		9E-10		-		9E-11		-		9E-10		-		8E-10		-	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	2E-10		-		2E-10		-		2E-10		-		1E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	6E-11		-		7E-11		-		8E-11		-		6E-11		-		7E-11		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<5E-10 U	5E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	3.8E-9 B	1E-9	9E-10	6E-10	1E-9	1E-9
Lead 210 MDC	µCi/mL	5E-10		-		6E-10		-		5E-10		-		8E-10		-		6E-10		-	
Lead 210 precision (±)	µCi/mL	3E-10		-		4E-10		-		3E-10		-		5E-10		6E-10 B		4E-10		4E-10	
Polonium 210	µCi/mL	<7E-10 U	7E-10	<1E-9 U	1E-9	<3E-10 U	3E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<2E-10 U	2E-10	<1E-10 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	7E-10		-		3E-10		-		7E-10		-		2E-10		-		7E-10		-	
Polonium 210 precision (±)	µCi/mL	3E-10		-		1E-10		-		5E-10		-		2E-10		-		5E-10		-	
Radium 226	µCi/mL	<1.E-10 U	1E-10	<2E-10 U	2E-10	<1.2E-10 U	1.2E-10	<2E-10 U	2E-10	<1.1E-10 U	1.1E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	1.7E-10	1.2E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1E-10		-		1.2E-10		-		1.1E-10		-		1.3E-10		-		1.2E-10		-	
Radium 226 precision (±)	µCi/mL	6E-11		-		6E-11		-		5E-11		-		5E-11		-		1E-10		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1.E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10		-		1E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	5E-11		-		6E-11		-		5E-11		-		4E-11		-		7E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0051	0.0003	0.0055	0.0003	0.0032	0.0003	0.0052	0.0003	0.0053	0.0003	0.0051	0.0003	0.0056	0.0003	0.0064	0.0003	0.0059	0.0003	0.0052	0.0003
Uranium Activity	µCi/mL	3.5E-9	2E-10	3.7E-9	2E-10	2.2E-9	2E-10	3.5E-9	2E-10	3.6E-9	2E-10	3.5E-9	2E-10	3.8E-10	2E-10	4.3E-9	2E-10	4E-9	2E-10	3.5E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	706 [a]		706 [a]		706 [a]		706 [a]		707 [a]		707 [a]		707 [a]		707 [a]		714 [b]		714 [b]	
	Date Collected:	6/20/2012		9/7/2012		11/28/2012		3/20/2013		6/19/2012		9/7/2012		11/28/2012		3/21/2013		6/21/2012		9/18/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<9E-10 U	9E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	1.2E-9	1E-9	<7E-10 U	7E-10	1.1E-9	1E-9	<9E-10 U	9E-10	1.1E-9	1E-9
Lead 210 MDC	µCi/mL	9E-10		-		7E-10		-		8E-10		-		7E-10		-		9E-10		-	
Lead 210 precision (±)	µCi/mL	5E-10		-		4E-10		-		5E-10		5E-10		4E-10		4E-10		5E-10		5E-10	
Polonium 210	µCi/mL	<1E-9 U	1E-9	1.2E-10	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<3E-10 U	3E-10	<1.E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<1E-9 U	1E-9	<1E-10 U	1E-9
Polonium 210 MDC	µCi/mL	1E-9		-		8E-10		-		3E-10		-		7E-10		-		1E-9		-	
Polonium 210 precision (±)	µCi/mL	7E-10		8E-10		4E-10		-		2E-10		-		3E-10		-		8E-10		-	
Radium 226	µCi/mL	<1.6E-10	1.6E-10	<2E-10 U	2E-10	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<1.4E-10 U	1.4E-10	<2E-10	2E-10	<1.7E-10	1.7E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.6E-10		-		1.6E-10		-		1.6E-10		-		1.4E-10		-		1.7E-10		-	
Radium 226 precision (±)	µCi/mL	1E-10		-		8E-10		-		9E-11		-		9E-11		-		1E-10		-	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<9E-11 U	9E-11	<2E-10	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	2E-10		-		1E-10		-		2E-10		-		9E-11		-		2E-10		-	
Thorium 230 precision (±)	µCi/mL	1E-10		-		3E-11		-		6E-11		-		6E-11		-		5E-11		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<5E-10 U	5E-10	<1E-9 U	1E-9	6E-10	6E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	7E-10	6E-10	1.1E-9	1E-9	<6E-10 U	6E-10	1.4E-9	1E-9
Lead 210 MDC	µCi/mL	5E-10		-		6E-10		-		8E-10		-		6E-10		-		6E-10		-	
Lead 210 precision (±)	µCi/mL	3E-10		-		4E-10		-		5E-10		-		4E-10		4E-10		4E-10		4E-10	
Polonium 210	µCi/mL	<2E-10 U	2E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<3E-10 U	3E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<3E-10 U	3E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	2E-10		-		5E-10		-		3E-10		-		7E-10		-		3E-10		-	
Polonium 210 precision (±)	µCi/mL	1E-10		-		4E-10		-		2E-10		-		5E-10		-		1E-10		-	
Radium 226	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<1.2E-10 U	1.2E-10	<2E-10 U	2E-10	<1.2E-10 U	1.2E-10	<2E-10 U	2E-10	<1.2E-10	1.2E-10	<2E-10	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1E-10		-		1.2E-10		-		1.2E-10		-		1.2E-10		-		1.3E-10		-	
Radium 226 precision (±)	µCi/mL	5E-11		-		7E-10		-		5E-11		-		7E-10		-		6E-11		-	
Thorium 230	µCi/mL	<9E-11 U	9E-11	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	9E-11		-		1E-10		-		1E-10		-		1E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	4E-11		-		5E-11		-		6E-11		-		6E-11		-		9E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0038	0.0003	0.0056	0.0003	0.0059	0.0003	0.0058	0.0003	0.0036	0.0003	0.005	0.0003	0.0048	0.0003	0.0052	0.0003	0.0086	0.0003	0.0055	0.0003
Uranium Activity	µCi/mL	2.5E-9	2E-10	3.5E-9	2E-10	4E-9	2E-10	3.9E-9	2E-10	2.4E-9	2E-10	3.4E-9	2E-10	3.2E-9	2E-10	3.5E-9	2E-10	5.8E-9	2.00E-10	3.7E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	714 [b]		714 [b]		715 [c]		716 [c]		719		719		719		719		720 [e]		720 [e]	
	Date Collected:	11/28/2012		3/21/2013		6/21/2012		6/21/2012		6/21/2012		9/18/2012		11/27/2012		3/18/2013		6/21/2012		9/17/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<7E-10 U	7E-10	<1E-9	1E-9	<9E-10 U	9E-10	<9E-10 U	9E-10	<9E-10 U	9E-10	1.4E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	7E-10		-		9E-10		9E-10		9E-10		-		7E-10		-		8E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		-		5E-10		5E-10		5E-10		5E-10		4E-10		-		5E-10		-	
Polonium 210	µCi/mL	<8E-10 U	8E-10	<1E-9	1E-9	<1E-9 U	1E-9	<1E-9	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<9E-10 U	9E-10	<1E-9 U	1E-9	1.5E-9	7E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	8E-10		-		1E-9		1E-9		6E-10		-		9E-10		-		9E-10		-	
Polonium 210 precision (±)	µCi/mL	3E-10		-		5E-10		4E-10		4E-10		-		3E-10		-		7E-10		-	
Radium 226	µCi/mL	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<1.7E-10 U	1.7E-10	<1.7E-10 U	1.7E-10	<1.7E-10 U	1.7E-10	<2E-10 U	2E-10	<1.7E-10 U	1.7E-10	<2E-10 U	2E-10	<1.8E-10	1.8E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.6E-10		-		1.7E-10		1.7E-10		1.7E-10		-		1.7E-10		-		1.8E-10		-	
Radium 226 precision (±)	µCi/mL	8E-11		-		1E-10		8E-11		8E-11		-		5E-11		-		9E-11		-	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	2E-10		-		1E-10		1E-10		2E-10		-		2E-10		-		2E-10		-	
Thorium 230 precision (±)	µCi/mL	7E-11		-		6E-11		5E-11		6E-11		-		8E-11		-		9E-11		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<5E-10 U	5E-10	3.5E-9	1E-9	<7E-10 U	7E-10	<7E-10 U	7E-10	<7E-10 U	7E-10	1.3E-9 B	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	5E-10		-		7E-10		7E-10		7E-10		-		5E-10		-		8E-10		-	
Lead 210 precision (±)	µCi/mL	3E-10		6E-10		4E-10		4E-10		4E-10		5E-10 B		3E-10		-		5E-10		-	
Polonium 210	µCi/mL	<7E-10 U	7E-10	2.9E-9	1E-9	<3E-10 U	3E-10	<4E-10 U	4E-10	<3E-10 U	3E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<3E-10 U	3E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	7E-10		-		3E-10		4E-10		3E-10		-		7E-10		-		3E-10		-	
Polonium 210 precision (±)	µCi/mL	3E-10		9E-10		2E-10		1E-10		2E-10		-		4E-10		-		2E-10		-	
Radium 226	µCi/mL	<1.1E-10 U	1E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<1.3E-10 U	1.3E-10	1.1E-10 U	1.1E-10	<2E-10 U	2E-10	<1.1E-10 U	1.1E-10	<2E-10 U	2E-10	<1.5E-10	1.5E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.1E-10		-		1.3E-10		1.3E-10		1.1E-10		-		1.1E-10		-		1.5E-10		-	
Radium 226 precision (±)	µCi/mL	7E-11		-		6E-11		0.07		6E-11		-		6E-11		-		6E-11		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<9E-11 U	9E-11	<1E-10 U	1E-10	<9E-11	9E-11	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10	1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		9E-11		1E-10		9E-11		-		1E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	5E-10		-		6E-11		8E-11		6E-11		-		4E-11		-		6E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.006	0.0003	0.006	0.0003	0.0058	0.0003	0.0059	0.0003	0.0072	0.0003	0.0087	0.0003	0.0065	0.0003	0.006	0.0003	0.0067	0.0003	0.0073	0.0003
Uranium Activity	µCi/mL	4.1E-9	2E-10	4.1E-9	2E-10	3.9E-09	2E-10	4E-9	2E-10	4.9E-9	2E-10	5.9E-9	2E-10	4.4E-9	2E-10	4.1E-9	2E-10	4.6E-9	2E-10	4.9E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

Location ID:		720 [e]		720 [e]		721 [e]		721 [e]		721 [e]		721 [e]		722		722		722		722	
Date Collected:		11/27/2012		3/21/2013		6/21/2012		9/17/2012		11/27/2012		3/18/2013		6/21/2012		9/17/2012		11/27/2012		3/21/2013	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<7E-10 U	7E-10	<1E-9 U	1E-9	<9E-10 U	9E-10	1.3E-9	1E-9	<7E-10 U	7E-10	1E-9	1E-9	<9E-10 U	9E-10	1.3E-9	1E-9	<7E-10 U	7E-10	1.6	1E-9
Lead 210 MDC	µCi/mL	7E-10		-		9E-10		-		7E-10		-		9E-10		-		7E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		-		5E-10		4E-10		4E-10		4E-10		5E-10		4E-10		4E-10		7E-10	
Polonium 210	µCi/mL	<7E-10 U	7E-10	<1E-9 U	1E-9	<1.7E-9 U	1.7E-9	<1E-9 U	1E-9	<9E-10 U	9E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<9E-10 U	9E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	7E-10		-		1.7E-9		-		9E-10		-		7E-10		-		9E-10		-	
Polonium 210 precision (±)	µCi/mL	4E-10		-		1E-9		-		3E-10		-		3E-10		-		3E-10		-	
Radium 226	µCi/mL	<1.4E-10	1.4E-10	<2E-10 U	2E-10	1.3E-9 U	1E-10	<2E-10 U	2E-10	<1.5E-10	1.5E-10	<2E-10 U	2E-10	<1.7E-10	1.7E-10	<2E-10 U	2E-10	<1.5E-10	1.5E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.4E-10		-		1E-10		-		1.5E-10		-		1.7E-10		-		1.5E-10		-	
Radium 226 precision (±)	µCi/mL	8E-11		-		2.6E-10		-		9E-11		-		7E-11		-		9E-11		-	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	2E-10		-		2E-10		-		2E-10		-		2E-10		-		2E-10		-	
Thorium 230 precision (±)	µCi/mL	7E-11		-		7E-11		-		7E-11		-		5E-11		-		7E-11		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<5E-10 U	5E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	5E-10		-		7E-10		-		5E-10		-		7E-10		-		5E-10		-	
Lead 210 precision (±)	µCi/mL	3E-10		-		4E-10		-		3E-10		-		4E-10		-		3E-10		-	
Polonium 210	µCi/mL	<9E-10 U	9E-10	<1E-9 U	1E-9	<4E-10 U	4E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<4E-10 U	4E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	9E-10		-		4E-10		-		6E-10		-		4E-10		-		6E-10		-	
Polonium 210 precision (±)	µCi/mL	4E-10		-		1E-10		-		4E-10		-		1E-10		-		4E-10		-	
Radium 226	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.1E-10	1.1E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.1E-10 U	1.1E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1E-10		-		1.3E-10		-		1.1E-10		-		1.3E-10		-		1.1E-10		-	
Radium 226 precision (±)	µCi/mL	6E-11		-		6E-11		-		7E-10		-		6E-11		-		7E-11		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10		-		1E-10		-		2E-10		-	
Thorium 230 precision (±)	µCi/mL	4E-11		-		7E-11		-		4E-11		-		7E-11		-		7E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0082	0.0003	0.0077	0.0003	0.0074	0.0003	0.0055	0.0003	0.0056	0.0003	0.0054	0.0003	0.0088	0.0003	0.0061	0.0003	0.0086	0.0003	0.0084	0.0003
Uranium Activity	µCi/mL	5.6E-9	2E-10	5.2E-9	2E-10	5E-9	2E-10	3.7E-9	2E-10	3.8E-9	2E-10	3.7E-9	2E-10	6E-9	2E-10	4.1E-9	2E-10	5.8E-9	2E-10	5.7E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L- milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	723 [d]		723 [d]		725		725		725		725		725		725		727		727	
	Date Collected:	6/19/2012		9/17/2012		3/31/2011		6/15/2011		6/21/2012		9/18/2012		11/29/2012		3/20/2013		6/19/2012		9/18/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<8E-10 U	8E-10	1.5E-9	1E-9	<8E-10 U	8E-10	<8E-10 U	8E-10	<8E-10 U	8E-10	1.7E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<9E-10 U	9E-10	1.9E-9	1E-9
Lead 210 MDC	µCi/mL	8E-10		-		8E-10		8E-10		8E-10		-		7E-10		-		9E-10		-	
Lead 210 precision (±)	µCi/mL	5E-10		6E-10		5E-10		5E-10		5E-10		6E-10		4E-10		-		5E-10		5E-10	
Polonium 210	µCi/mL	<6E-10 U	6E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<5E-10 U	5E-10	<5E-10 U	5E-10	1.2E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	1.8E-9	1E-9
Polonium 210 MDC	µCi/mL	6E-10		-		5E-10		5E-10		5E-10		-		7E-10		-		7E-10		-	
Polonium 210 precision (±)	µCi/mL	5E-10		-		3E-10		3E-10		4E-10		7E-10		4E-10		-		4E-10		9E-10	
Radium 226	µCi/mL	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	3E-10	9E-11	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<1.5E-10 U	1.5E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.6E-10		-		2E-10		9E-11		1.6E-10		-		1.6E-10		-		1.5E-10		-	
Radium 226 precision (±)	µCi/mL	8E-11		-		6E-11		1E.10		7E-11		-		7E-11		-		7E-11		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		1E-10		2E-10		-		2E-10		-		2E-10		-	
Thorium 230 precision (±)	µCi/mL	6E-11		-		6E-11		7E-11		5E-11		-		6E-11		-		6E-11		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<8E-10 U	8E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<6E-10 U	6E-10	<8E-10 U	8E-10	1.1E-9 B	1E-9	<6E-10 U	6E-10	1.8E-9	1E-9	<8E-10 U	8E-10	1.5E-9 B	1E-9
Lead 210 MDC	µCi/mL	8E-10		-		7E-10		6E-10		8E-10		-		6E-10		-		8E-10		-	
Lead 210 precision (±)	µCi/mL	5E-10		-		4E-10		3E-10		5E-10		5E-10 B		4E-10		5E-10		5E-10		5E-10 B	
Polonium 210	µCi/mL	<3E-10 U	3E-10	<1E-9 U	1E-9	<2E-10 U	2E-10	<2E-10 U	2E-10	<3E-10 U	3E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<3E-10 U	3E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	3E-10		-		2E-10		2E-10		3E-10		-		6E-10		-		3E-10		-	
Polonium 210 precision (±)	µCi/mL	1E-10		-		1E-10		8E-11		1E-10		-		3E-10		-		2E-10		-	
Radium 226	µCi/mL	<1.2E-10 U	1.2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<1E-10 U	1E-10	<1.4E-10 U	1.4E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.2E-10 U	1E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.2E-10		-		1E-10		1E-10		1.4E-10		-		1.3E-10		-		1.2E-10		-	
Radium 226 precision (±)	µCi/mL	6E-11		-		6E-11		5E-11		7E-11		-		9E-11		-		5E-11		-	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<1E-10 U	1E-10	<1E-10 U	1E-10	2E-10	2E-10	<9E-11 U	9E-11	<2E-10 U	2E-10	<1E-10 U	1E-10	2E-10	2E-10
Thorium 230 MDC	µCi/mL	2E-10		-		1E-10		1E-10		1E-10		-		9E-11		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	8E-11		-		7E-11		4E-11		5E-11		1E-10		4E-11		-		6E-11		1E-10	
METALS, DISSOLVED																					
Uranium	mg/L	0.0056	0.0003	0.0078	0.0003	0.0071	0.0003	0.0065	0.0003	0.0047	0.0003	0.006	0.0003	0.0075	0.0003	0.0059	0.0003	0.0089	0.0003	0.009	0.0003
Uranium Activity	µCi/mL	3.8E-9	2E-10	5.3E-9	2E-10	4.8E-9	2E-10	4.4E-9	2E-10	3.2E-9	2E-10	4.1E-9	2E-10	5.1E-9	2E-10	4E-9	2E-10	6.1E-9	2E-10	6.1E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	727		727		728		728		728		728		730 [a, d]		730 [a, d]		731 [d]		731 [d]	
	Date Collected:	11/29/2012		3/18/2013		6/19/2012		9/17/2012		12/5/2012		3/18/2013		6/19/2012		9/17/2012		6/20/2012		9/18/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<7E-10 U	7E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9	1E-9	<7E-10 U	7E-10	1.2E-9	1E-9	<8E-10 U	8E-10	1.5E-9	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	7E-10		-		8E-10		-		7E-10		-		8E-10		-		8E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		-		5E-10		-		4E-10		4E-10		5E-10		5E-10		5E-10		-	
Polonium 210	µCi/mL	<9E-10 U	9E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<1E-9 U	1E-9	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	5E-10	5E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	9E-10		-		6E-10		-		1E-9		-		5E-10		-		5E-10		-	
Polonium 210 precision (±)	µCi/mL	3E-10		-		2E-10		-		6E-10		-		3E-10		-		5E-10		-	
Radium 226	µCi/mL	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<1.7E-10 U	1.7E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.6E-10		-		1.6E-10		-		2E-10		-		1.6E-10		-		1.7E-10		-	
Radium 226 precision (±)	µCi/mL	9E-11		-		6E-11		-		1E-10		-		7E-11		-		1E-10		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		2E-10		-		1E-10		-		1E-10		-		2E-10		-	
Thorium 230 precision (±)	µCi/mL	7E-11		-		5E-11		-		4E-11		-		5E-11		-		6E-11		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	7E-10	6E-10	1.4E-9	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	1.1E-9	1E-9
Lead 210 MDC	µCi/mL	6E-10		-		8E-10		-		6E-10		-		8E-10		-		8E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		4E-10		5E-10		-		4E-10		-		5E-10		-		5E-10		5E-10	
Polonium 210	µCi/mL	<7E-10 U	7E-10	<1E-9 U	1E-9	<2E-10 U	2E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<3E-10 U	3E-10	<1E-9 U	1E-9	<2E-10 U	2E-10	<1E-9U	1E-9
Polonium 210 MDC	µCi/mL	7E-10		-		2E-10		-		5E-10		-		3E-10		-		2E-10		-	
Polonium 210 precision (±)	µCi/mL	4E-10		-		0.07		-		2E-10		-		1E-10		-		2E-10		-	
Radium 226	µCi/mL	<1.2E-10 U	1.2E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.2E-10		-		1.3E-10		-		1E-10		-		1.3E-10		-		1.3E-10		-	
Radium 226 precision (±)	µCi/mL	8E-11		-		7E-11		-		5E-11		-		6E-11		-		5E-11		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	2E-10	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	2E-10	2E-10	<1E-10 U	1E-10	2E-10	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10		-		2E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	5E-11		-		4E-11		1E-10		7E-11		-		6E-11		1E-10		6E-11		1E-10	
METALS, DISSOLVED																					
Uranium	mg/L	0.0104	0.0003	0.0084	0.0003	0.0063	0.0003	0.0066	0.0003	0.0077	0.0003	0.0067	0.0003	0.0056	0.0003	0.0079	0.0003	0.0055	0.0003	0.0073	0.0003
Uranium Activity	µCi/mL	7E-9	2E-10	5.7E-9	2E-10	4.3E-9	2E-10	4.5E-9	2E-10	5.2E-9	2E-10	4.5E-9	2E-10	3.8E-9	2E-10	5.4E-9	2E-10	3.7E-9	2E-10	4.9E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	0.0006	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	4E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	732 [c]		732 [c]		734 [b]		734 [b]		734 [b]		734 [b]		735 [b, d]		736 [b, c]		736 [b, c]		737 [b, c]	
	Date Collected:	6/19/2012		9/7/2012		6/20/2012		9/7/2012		12/5/2012		3/21/2013		6/20/2012		6/2012		9/7/2012		6/29/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<8E-10 U	8E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	1.6E-9	1E-9	<8E-10 U	8E-10	2.5E-9	1E-9	<8E-10 U	8E-10	<9E-10 U	9E-10	<1E-9 U	1E-9	<9E-10 U	9E-10
Lead 210 MDC	µCi/mL	8E-10		-		8E-10		-		8E-10		-		8E-10		9E-10		-		9E-10	
Lead 210 precision (±)	µCi/mL	5E-10		-		5E-10		6E-10		5E-10		4E-10		5E-10		5E-10		-		5E-10	
Polonium 210	µCi/mL	<6E-10	6E-10	<1E-9 U	1E-9	7E-10	6E-10	<1E-9 U	1E-9	<1E-9 U	1E-9	<1E-9 U	1E-9	<7E-10 U	7E-10	<8E-10 U	8E-10	<1E-9 U	1E-9	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	6E-10		-		6E-10		-		1E-9		-		7E-10		8E-10		-		1E-9	
Polonium 210 precision (±)	µCi/mL	4E-10		-		7E-10		-		7E-10		-		4E-10		3E-10		-		7E-10	
Radium 226	µCi/mL	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<1.7E-10 U	1.7E-10	<2E-10 U	2E-10	<1.6E-10 U	1.6E-10	<1.9E-10 U	1.9E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.6E-10		-		1.6E-10		-		1.7E-10		-		1.6E-10		1.9E-10		-		2E-10	
Radium 226 precision (±)	µCi/mL	9E-11		-		6E-11		-		9E-11		-		1E-10		1.2E-10		-		1E-10	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	2E-10		-		1E-10		-		1E-10		-		2E-10		2E-10		-		2E-10	
Thorium 230 precision (±)	µCi/mL	7E-11		-		6E-11		-		6E-11		-		1E-10		7E-11		-		6E-11	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<9E-10 U	9E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	1E-9	1E-9	8E-10	6E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<8E-10 U	8E-10	<1E-9 U	1E-9	<7E-10 U	7E-10
Lead 210 MDC	µCi/mL	9E-10		-		8E-10		-		6E-10		-		8E-10		8E-10		-		7E-10	
Lead 210 precision (±)	µCi/mL	5E-10		-		5E-10		4E-10		4E-10		-		5E-10		5E-10		-		4E-10	
Polonium 210	µCi/mL	<2E-10 U	2E-10	<1E-9 U	1E-9	<3E-10 U	3E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<3E-10 U	3E-10	<4E-10 U	4E-10	<1E-9 U	1E-9	<4E-10 U	4E-10
Polonium 210 MDC	µCi/mL	2E-10		-		3E-10		-		5E-10		-		3E-10		4E-10		-		4E-10	
Polonium 210 precision (±)	µCi/mL	1E-10		-		2E-10		-		4E-10		-		1E-10		2E-10		-		2E-10	
Radium 226	µCi/mL	<1.2E-10 U	1.2E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.1E-10 U	1.1E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<6E-11 U	6E-11	<2E-10 U	2E-10	<6E-11 U	6E-11
Radium 226 MDC	µCi/mL	1.2E-10		-		1.3E-10		-		1.1E-10		-		1.3E-10		6E-11		-		6E-11	
Radium 226 precision (±)	µCi/mL	5E-11		-		6E-11		-		6E-11		-		5E-11		3E-11		-		3E-11	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	6E-11	4E-11	<2E-10 U	2E-10	5E-11	4E-11
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10		-		1E-10		4E-11		-		4E-11	
Thorium 230 precision (±)	µCi/mL	6E-11		-		8E-11		-		7E-11		-		4E-11		3E-11		-		3E-11	
METALS, DISSOLVED																					
Uranium	mg/L	0.0066	0.0003	0.0075	0.0003	0.0078	0.0003	0.0089	0.0003	0.009	0.0003	0.0069	0.0003	0.0063	0.0003	0.0081	0.0003	0.0069	0.0003	0.0086	0.0003
Uranium Activity	µCi/mL	4.5E-9	2E-10	5.1E-9	2E-10	5.2E-9	2E-10	6E-9	2E-10	6.1E-9	2E-10	4.7E-9	2E-10	4.2E-9	2E-10	5.5E-9	2E-10	4.7E-9	2E-10	5.8E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	0.001	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	6.5E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2.0E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	737 [b, c]		737 [b, c]		739		739		739		739		740 [c]		740 [c]		741		741	
	Date Collected:	9/28/2012		3/21/2013		6/20/2012		9/18/2012		11/27/2012		3/21/2013		6/20/2012		9/18/2012		3/31/2011		6/10/2011	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<1E-9 U	1E-9	1.5E-9	1E-9	<8E-10 U	8E-10	1.5E-9	1E-9	<8E-10 U	8E-10	3E-9	1E-9	<8E-10 U	8E-10	1.7E-9	1E-9	<8E-10 U	8E-10	<1.1E-9 U	1.1E-9
Lead 210 MDC	µCi/mL	-		-		8E-10		-		8E-10		-		8E-10		-		8E-10		1.1E-9	
Lead 210 precision (±)	µCi/mL	-		4E-10		5E-10		5E-10		5E-10		1E-9		5E-10		5E-10		5E-10		6E-10	
Polonium 210	µCi/mL	<1E-9 U	1E-9	<1.E-9	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	1.1E-9	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<5E-10 U	5E-10
Polonium 210 MDC	µCi/mL	-		-		8E-10		-		7E-10		-		6E-10		-		5E-10		5E-10	
Polonium 210 precision (±)	µCi/mL	-		-		4E-10		-		4E-10		4E-10		5E-10		-		4E-10		3E-10	
Radium 226	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<1.5E-10 U	1.5E-10	<2E-10 U	2E-10	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	2.9E-10	1E-10
Radium 226 MDC	µCi/mL	-		-		1.5E-10		-		1.6E-10		-		1.3E-10		-		2E-10		1E-10	
Radium 226 precision (±)	µCi/mL	-		-		1E-10		-		7E-11		-		9E-11		-		6E-11		1E-10	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	-		-		2E-10		-		2E-10		-		2E-10		-		2E-10		2E-10	
Thorium 230 precision (±)	µCi/mL	-		-		6E-11		-		6E-11		-		8E-11		-		8E-11		7E-10	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<1E-9 U	1E-9	<1E-9 U	1E-9	<8E-10 U	8E-10	1.2E-9	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<6E-10 U	6E-10
Lead 210 MDC	µCi/mL	-		-		8E-10		-		5E-10		-		8E-10		-		7E-10		6E-10	
Lead 210 precision (±)	µCi/mL	-		-		4E-10		5E-10		3E-10		-		5E-10		-		4E-10		4E-10	
Polonium 210	µCi/mL	<1E-9 U	1E-9	<1E-9 U	1E-9	<3E-10 U	3E-10	2.8E-9	1E-9	<1E-9 U	1E-9	<1E-9 U	1E-9	<2E-10 U	2E-10	1.2E-9	1E-9	<2E-10 U	2E-10	<2E-10 U	2E-10
Polonium 210 MDC	µCi/mL	-		-		3E-10		-		1E-9		-		2E-10		-		2E-10		2E-10	
Polonium 210 precision (±)	µCi/mL	-		-		2E-10		6E-10		5E-10		-		2E-10		5E-10		1E-10		1E-10	
Radium 226	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<1.2E-10 U	1.2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<1E-10 U	1E-10
Radium 226 MDC	µCi/mL	-		-		1.2E-10		-		1E-10		-		1.3E-10		-		1E-10		1E-10	
Radium 226 precision (±)	µCi/mL	-		-		5E-11		-		4E-11		-		6E-11		-		6E-11		5E-11	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10
Thorium 230 MDC	µCi/mL	-		-		1E-10		-		1E-10		-		1E-10		-		2E-10		1E-10	
Thorium 230 precision (±)	µCi/mL	-		-		5E-11		-		4E-11		-		6E-11		-		9E-11		7E-11	
METALS, DISSOLVED																					
Uranium	mg/L	0.0061	0.0003	0.0059	0.0003	0.0089	0.0003	0.0097	0.0003	0.0114	0.0003	0.0102	0.0003	0.013	0.0003	0.0191	0.0003	0.0058	0.0003	0.0081	0.0003
Uranium Activity	µCi/mL	4.1E-9	2E-10	4E-9	2E-10	6E-9	2E-10	6.6E-9	2E-10	7.7E-9	2E-10	6.9E-9	2E-10	8.8E-9	2E-10	1.29E-8	2E-10	3.9E-9	2E-10	5.5E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	0.001	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	6.5E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

Location ID:		741		741		742		742		742		742		743 [b]		743 [b]		743 [b]		743 [b]	
Date Collected:		9/22/2011		12/15/2011		6/20/2012		9/18/2012		11/27/2012		3/21/2013		6/18/2012		9/17/2012		11/26/2012		3/18/2013	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<7E-10	7E-10	<7E-10	7E-10	<7E-10 U	7E-10	2.2E-9	1E-9	<8E-10 U	8E-10	1.5E-9	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	7E-10		7E-10		7E-10		-		8E-10		-		8E-10		-		8E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		4E-10		5E-10		5E-10		5E-10		5E-10		5E-10		-		5E-10		-	
Polonium 210	µCi/mL	6E-10	5E-10	1.7E-9	1.3E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	1.6E-9	6E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	5E-10		1.3E-9		8E-10		-		8E-10		-		6E-10		-		7E-10		-	
Polonium 210 precision (±)	µCi/mL	5E-10		1.5E-9		3E-10		-		6E-10		-		1E-9		-		3E-10		-	
Radium 226	µCi/mL	2.4E-9	2E-10	5E-10	1E-10	<1.5E-10 U	1.5E-10	<2E-10 U	2E-10	<1.5E-10 U	1.5E-10	<2E-10 U	2E-10	4.2E-10	1.8E-10	<2E-10 U	2E-10	<1.5E-10 U	1.5E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	2E-10		1E-10		1.5E-10		-		1.5E-10		-		1.8E-10		-		1.5E-10		-	
Radium 226 precision (±)	µCi/mL	3E-10		1E-10		9E-11		-		1E-10		-		1.7E-10		-		8E-11		-	
Thorium 230	µCi/mL	<2E-10	2E-10	<1E-10	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	2E-10		1E-10		2E-10		-		2E-10		-		1E-10		-		2E-10		-	
Thorium 230 precision (±)	µCi/mL	6E-11		5E-11		6E-11		-		5E-11		-		5E-11		-		9E-11		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<6E-10	6E-10	<8E-10	8E-10	<8E-10 U	8E-10	1.5E-9	1E-9	<5E-10 U	5E-10	1.9E-9	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	6E-10		8E-10		8E-10		-		5E-10		-		6E-10		-		5E-10		-	
Lead 210 precision (±)	µCi/mL	3E-10		5E-10		5E-10		5E-10		3E-10		4E-10		4E-10		-		3E-10		-	
Polonium 210	µCi/mL	<2E-10	2E-10	<6E-10	6E-10	<2E-10 U	2E-10	<1E-9 U	1E-9	<1E-9 U	1E-9	<1E-9 U	1E-9	7E-10	3E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	2E-10		6E-10		2E-10		-		1E-9		-		3E-10		-		7E-10		-	
Polonium 210 precision (±)	µCi/mL	8E-11		2E-10		1E-10		-		4E-10		-		4E-10		-		3E-10		-	
Radium 226	µCi/mL	<1E-10	1E-10	<1E-10	1E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.2E-10 U	1.2E-10	<2E-10 U	2E-10	<1.4E-10	1.4E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1E-10		1E-10		1.3E-10		-		1.2E-10		-		1.4E-10		-		1E-10		-	
Radium 226 precision (±)	µCi/mL	3E-11		8E-11		5E-11		-		6E-11		-		5E-11		-		7E-11		-	
Thorium 230	µCi/mL	2E-10	1E-10	<1E-10	1E-10	<1E-10 U	1E-10	3E-10	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		1E-10		1E-10		-		1E-10		-		1E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	1E-10		5E-11		6E-11		1E-10		4E-11		-		5E-11		-		5E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0091	0.0003	0.0057	0.0003	0.0128	0.0003	0.0116	0.0003	0.0128	0.0003	0.0095	0.0003	0.0165	0.0003	0.0057	0.0003	0.0077	0.0003	0.0075	0.0003
Uranium Activity	µCi/mL	6.2E-9	2E-10	3.9E-9	2E-10	8.6E-9	2E-10	7.9E-9	2E-10	8.7E-9	2E-10	6.4E-9	2E-10	1.1E-8	2E-10	3.9E-9	2E-10	5.2E-9	2E-10	5.1E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

Location ID:		744		744		744		744		745 [c]	
Date Collected:		6/18/2012		9/17/2012		11/26/2012		3/18/2013		6/18/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED											
Lead 210	µCi/mL	<8E-10 U	8E-10	<1.E-9U	1E-9	<7E-10 U	7E-10	1.3E-9	1E-9	<8E-10 U	8E-10
Lead 210 MDC	µCi/mL	8E-10		-		7E-10		-		8E-10	
Lead 210 precision (±)	µCi/mL	5E-10		-		4E-10		4E-10		5E-10	
Polonium 210	µCi/mL	1E-9	5E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<4E-10 U	4E-10
Polonium 210 MDC	µCi/mL	5E-10		-		8E-10		-		4E-10	
Polonium 210 precision (±)	µCi/mL	6E-10		-		3E-10		-		4E-10	
Radium 226	µCi/mL	4.6E-10	2E-10	<2E-10 U	2E-10	1.9E-10	1.6E-10	<2E-10 U	2E-10	<2.4E-10 U	2.4E-10
Radium 226 MDC	µCi/mL	2E-10		-		1.6E-10		-		2.4E-10	
Radium 226 precision (±)	µCi/mL	1.9E-10		-		1.3-E10		-		1.5E-10	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10
Thorium 230 MDC	µCi/mL	2E-10		-		2E-10		-		1E-10	
Thorium 230 precision (±)	µCi/mL	9E-11		-		7E-11		-		5E-11	
RADIONUCLIDES-SUSPENDED											
Lead 210	µCi/mL	<6E-10 U	6E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<7E-10 U	7E-10
Lead 210 MDC	µCi/mL	6E-10		-		5E-10		-		7E-10	
Lead 210 precision (±)	µCi/mL	4E-10		-		3E-10		-		4E-10	
Polonium 210	µCi/mL	<2E-10 U	2E-10	<1E-9 U	1E-9	<9E-10 U	9E-10	<1E-9 U	1E-9	5E-10	3E-10
Polonium 210 MDC	µCi/mL	2E-10		-		9E-10		-		3E-10	
Polonium 210 precision (±)	µCi/mL	2E-10		-		3E-10		-		3E-10	
Radium 226	µCi/mL	<1.5E-10	1.5E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1.7E-10 U	1.7E-10
Radium 226 MDC	µCi/mL	1.5E-10		-		1E-10		-		1.7E-10	
Radium 226 precision (±)	µCi/mL	1E-10		-		7E-11		-		7E-11	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10	
Thorium 230 precision (±)	µCi/mL	4E-11		-		5E-11		-		4E-11	
METALS, DISSOLVED											
Uranium	mg/L	0.0043	0.0003	0.0038	0.0003	0.0034	0.0003	0.0028	0.0003	0.0072	0.0003
Uranium Activity	µCi/mL	2.9E-9	2E-10	2.6E-9	2E-10	2.3E-9	2E-10	1.9E-9	2E-10	4.8E-9	2E-10
METALS, SUSPENDED											
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Location ID:		745 [c]		745 [c]		745 [c]		746 [a]		746 [a]	
Date Collected:		9/17/2012		11/26/2012		3/18/2013		6/18/2012		9/18/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED											
Lead 210	µCi/mL	2.8E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	-		7E-10		-		8E-10		-	
Lead 210 precision (±)	µCi/mL	7E-10		4E-10		-		5E-10		-	
Polonium 210	µCi/mL	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	-		7E-10		-		7E-10		-	
Polonium 210 precision (±)	µCi/mL	-		3E-10		-		5E-10		-	
Radium 226	µCi/mL	<2E-10 U	2E-10	<1.6E-10	1.6E-10	<2E-10 U	2E-10	1.7E-10	1.7E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	-		1.6E-10		-		1.7E-10		-	
Radium 226 precision (±)	µCi/mL	-		7E-11		-		1E-10		-	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	-		2E-10		-		2E-10		-	
Thorium 230 precision (±)	µCi/mL	-		6E-11		-		8E-11		-	
RADIONUCLIDES-SUSPENDED											
Lead 210	µCi/mL	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	-		5E-10		-		6E-10		-	
Lead 210 precision (±)	µCi/mL	-		3E-10		-		4E-10		-	
Polonium 210	µCi/mL	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<2E-10 U	2E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	-		8E-10		-		2E-10		-	
Polonium 210 precision (±)	µCi/mL	-		3E-10		-		1E-10		-	
Radium 226	µCi/mL	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1.6E-10	1.6E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	-		1E-10		-		1.6E-10		-	
Radium 226 precision (±)	µCi/mL	-		7E-11		-		9E-11		-	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	-		1E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	-		5E-11		-		4E-11		-	
METALS, DISSOLVED											
Uranium	mg/L	0.0268	0.0003	0.0282	0.0003	0.0179	0.0003	0.0114	0.0003	0.0069	0.0003
Uranium Activity	µCi/mL	1.81E-8	2E-10	1.9E-8	2E-10	1.21E-8	2E-10	7.8E-9	2E-10	4.7E-9	2E-10
METALS, SUSPENDED											
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10 U	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

Location ID:		746 [a]		746 [a]		747		747		747		747		748 [a]		748 [a]		748 [a]		748 [a]	
Date Collected:		11/29/2012		3/18/2013		6/18/2012		9/17/2012		11/26/2012		3/18/2013		6/18/2012		9/17/2012		11/26/2012		3/21/2013	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<7E-10 U	7E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	1.6E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	1.3E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	7E-10		-		8E-10		-		7E-10		-		8E-10		-		7E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		-		5E-10		4E-10		4E-10		-		5E-10		4E-10		4E-10		-	
Polonium 210	µCi/mL	<1E-9 U	1E-9	<1E-9 U	1E-9	<4E-10 U	4E-10	<1E-9 U	1E-9	<1E-9 U	1E-9	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	1E-9		-		4E-10		-		1E-9		-		7E-10		-		8E-10		-	
Polonium 210 precision (±)	µCi/mL	4E-10		-		3E-10		-		4E-10		-		4E-10		-		3E-10		-	
Radium 226	µCi/mL	<1.5E-10	1.5E-10	<2E-10 U	2E-10	<1.7E-10	1.7E-10	<2E-10 U	2E-10	<1.4E-10	1.4E-10	<2E-10 U	2E-10	<1.7E-10 U	1.7E-10	<2E-10 U	2E-10	<1.5E-10 U	1.5E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.5E-10		-		1.7E-10		-		1.4E-10		-		1.7E-10		-		1.5E-10		-	
Radium 226 precision (±)	µCi/mL	6E-11		-		1.1E-10		-		7E-11		-		1.2E-10		-		9E-11		-	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	2E-10		-		2E-10		-		1E-10		-		2E-10		-		2E-10		-	
Thorium 230 precision (±)	µCi/mL	7E-11		-		7E-11		-		5E-11		-		7E-11		-		7E-11		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<6E-10 U	6E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	1.9E-9	1E-9
Lead 210 MDC	µCi/mL	6E-10		-		6E-10		-		5E-10		-		6E-10		-		5E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		-		4E-10		-		3E-10		-		4E-10		-		3E-10		4E-10	
Polonium 210	µCi/mL	<5E-10 U	5E-10	<1E-9 U	1E-9	<3E-10 U	3E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<2E-10 U	2E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	5E-10		-		3E-10		-		5E-10		-		2E-10		-		8E-10		-	
Polonium 210 precision (±)	µCi/mL	3E-10		-		1E-10		-		3E-10		-		1E-10		-		5E-10		-	
Radium 226	µCi/mL	<1.2E-10	1.2E-10	<2E-10 U	2E-10	<1.5E-10	1.5E-10	<2E-10 U	2E-10	<9E-11 U	9E-11	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.1E-10 U	1.1E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1E-10		-		1.5E-10		-		9E-11		-		1.3E-10		-		1.1E-10		-	
Radium 226 precision (±)	µCi/mL	7E-11		-		6E-11		-		5E-11		-		9E-11		-		5E-11		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10		-		1E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	6E-11		-		7E-11		-		6E-11		-		5E-11		-		5E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0075	0.0003	0.0073	0.0003	0.0134	0.0003	0.0078	0.0003	0.0061	0.0003	0.0047	0.0003	0.0082	0.0003	0.0051	0.0003	0.0043	0.0003	0.0042	0.0003
Uranium Activity	µCi/mL	5.1E-9	2E-10	4.9E-9	2E-10	9.1E-9	2E-10	5.3E-9	2E-10	4.2E-9	2E-10	3.2E-9	2E-10	5.6E-9	2E-10	3.5E-9	2E-10	2.9E-9	2E-10	2.8E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2.E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	750 [a]		750 [a]		750 [a]		750 [a]		752		752		752		752		753		753	
	Date Collected:	6/18/2012		9/17/2012		11/26/2012		3/18/2013		6/21/2012		9/7/2012		11/27/2012		3/21/2013		6/21/2012		9/7/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<7E-10 U	7E-10	2,1E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<9E-10 U	9E-10	1.5E-9	1E-9	<7E-10 U	7E-10	1.3E-9	1E-9	<9E-10 U	9E-10	1.3E-9	1E-9
Lead 210 MDC	µCi/mL	7E-10		-		7E-10		-		9E-10		-		7E-10		-		9E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		7E-10		4E-10		-		5E-10		5E-10		4E-10		5E-10		5E-10		4E-10	
Polonium 210	µCi/mL	<6E-10 U	6E-10	<1E-9 U	1E-9	<1E-9 U	1E-9	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<1E-9 U	1E-9	<1E-9 U	1E-9	<1E-9 U	1E-9	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	6E-10		-		1E-9		-		7E-10		-		1E-9		-		1E-9		-	
Polonium 210 precision (±)	µCi/mL	5E-10		-		7E-10		-		5E-10		-		6E-10		-		4E-10		-	
Radium 226	µCi/mL	<1.7E-10 U	1.7E-10	<2E-10 U	2E-10	<1.5E-10 U	1.5E-10	<2E-10 U	2E-10	2.9E-10	1.9E-10	<2E-10 U	2E-10	<1.5E-10 U	1.5E-10	<2E-10 U	2E-10	<1.9E-10 U	1.9E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.7E-10		-		1.5E-10		-		1.9E-10		-		1.5E-10		-		1.9E-10		-	
Radium 226 precision (±)	µCi/mL	8E-11		-		9E-11		-		1.6E-10		-		9E-11		-		8E-11		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		2E-10		-		1E-10		-		2E-10		-		2E-10		-	
Thorium 230 precision (±)	µCi/mL	9E-11		-		7E-11		-		6E-11		-		8E-11		-		1E-10		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<6E-10 U	6E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	1.4E-9	1E-9
Lead 210 MDC	µCi/mL	6E-10		-		5E-10		-		7E-10		-		6E-10		-		7E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		-		3E-10		-		4E-10		-		4E-10		-		4E-10		4E-10	
Polonium 210	µCi/mL	<3E-10 U	3E-10	<1E-9 U	1E-9	<9E-10 U	9E-10	<1E-9 U	1E-9	<4E-10 U	4E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<3E-10 U	3E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	3E-10		-		9E-10		-		4E-10		-		8E-10		-		3E-10		-	
Polonium 210 precision (±)	µCi/mL	1E-10		-		4E-10		-		1E-10		-		3E-10		-		1E-10		-	
Radium 226	µCi/mL	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.1E-10 U	1.1E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.2E-10 U	1.2E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.3E-10		-		1.1E-10		-		1.3E-10		-		1.2E-10		-		1.3E-10		-	
Radium 226 precision (±)	µCi/mL	6E-11		-		6E-11		-		8E-11		-		6E-11		-		7E-11		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10		-		1E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	5E-11		-		4E-11		-		7E-11		-		4E-11		-		7E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0054	0.0003	0.0059	0.0003	0.0058	0.0003	0.0066	0.0003	0.0096	0.0003	0.0087	0.0003	0.0084	0.0003	0.007	0.0003	0.0059	0.0003	0.0057	0.0003
Uranium Activity	µCi/mL	3.7E-9	2E-10	4E-9	2E-10	3.9E-9	2E-10	4.5E-9	2E-10	6.5E-9	2E-10	5.9E-9	2E-10	5.9E-9	2E-10	4.7E-9	2E-10	4E-9	2E-10	3.9E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10 U	2E-10	<2E-10	2E-10	<2E-10 U	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

Location ID:		753		753		754		754		754		754		755		755		755		755	
Date Collected:		11/27/2012		3/21/2013		6/21/2012		9/7/2012		11/27/2012		3/21/2013		6/21/2012		9/7/2012		11/28/2012		3/21/2013	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<7E-10 U	7E-10	1.3E-9	1E-9	<9E-10 U	9E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	1.8E-9	1E-9	<9E-10 U	9E-10	1.8E-9	1E-9	<7E-10 U	7E-10	1.8E-9	1E-9
Lead 210 MDC	µCi/mL	7E-10		-		9E-10		-		7E-10		-		9E-10		-		7E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		4E-10		5E-10		-		4E-10		7E-10		5E-10		5E-10		4E-10		6E-10	
Polonium 210	µCi/mL	<8E-10 U	8E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<1E-9 U	1E-09	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	8E-10		-		8E-10		-		8E-10		-		1E-9		-		8E-10		-	
Polonium 210 precision (±)	µCi/mL	4E-10		-		3E-10		-		4E-10		-		8E-10		-		3E-10		-	
Radium 226	µCi/mL	<1.8E-10	1.8E-10	<2E-10 U	2E-10	9.5E-9	1.9E-10	<2E-10 U	2E-10	<1.9E-10 U	1.9E-10	<2E-10 U	2E-10	2.4E-9	1.7E-10	<2E-10 U	2E-10	<1.5E-10 U	1.5E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.8E-10		-		1.9E-10		-		1.9E-09		-		1.7E-10		-		1.5E-10		-	
Radium 226 precision (±)	µCi/mL	9E-11		-		6.7E-10		-		1E-10		-		3E-10		-		8E-11		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		2E-10		-		1E-10		-		2E-10		-		2E-10		-	
Thorium 230 precision (±)	µCi/mL	4E-11		-		7E-11		-		6E-11		-		7E-11		-		1E-10		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	6E-10	6E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	6E-10	6E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	9E-10	6E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	6E-10		-		7E-10		-		6E-10		-		7E-10		-		6E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		-		4E-10		-		4E-10		-		4E-10		-		4E-10		-	
Polonium 210	µCi/mL	<6E-10 U	6E-10	<1E-9 U	1E-9	<3E-10 U	3E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<4E-10 U	4E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	6E-10		-		3E-10		-		6E-10		-		4E-10		-		6E-10		-	
Polonium 210 precision (±)	µCi/mL	3E-10		-		2E-10		-		2E-10		-		2E-10		-		3E-10		-	
Radium 226	µCi/mL	<1.2E-10 U	1E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.4E-10 U	1.4E-10	<2E-10 U	2E-10	<1.2E-10 U	1.2E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.2E-10		-		1.3E-10		-		1.3E-10		-		1.4E-10		-		1.2E-10		-	
Radium 226 precision (±)	µCi/mL	8E-11		-		7E-11		-		8E-11		-		8E-11		-		7E-11		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10		-		1E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	6E-11		-		9E-11		-		4E-11		-		7E-11		-		4E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0055	0.0003	0.0054	0.0003	0.0082	0.0003	0.0065	0.0003	0.0077	0.0003	0.0067	0.0003	0.0075	0.0003	0.0051	0.0003	0.0052	0.0003	0.0051	0.0003
Uranium Activity	µCi/mL	3.7E-9	2E-10	3.7E-9	2E-10	5.5E-9	2E-10	4.4E-9	2E-10	5.2E-9	2E-10	4.5E-9	2E-10	5.1E-9	2E-10	3.5E-9	2E-10	3.5E-9	2E-10	3.5E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10 U	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10 U	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	759 [d]		759 [d]		759 [d]		759 [d]		760 [a, c]		760 [a, c]		777		777		777		777	
	Date Collected:	3/31/2011		6/10/2011		9/22/2011		12/15/2011		11/28/2012		3/21/2013		6/20/2012		9/18/2012		11/27/2012		3/21/2013	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<8E-10 U	8E-10	<1.1E-9 U	1.1E-9	<8E-10 U	8E-10	<7E-10 U	7E-10	<7E-10 U	7E-10	1.2 E-9	1E-9	<8E-10 U	8E-10	3E-9	1E-9	<7E-10 U	7E-10	2.2E-9	1E-9
Lead 210 MDC	µCi/mL	8E-10		1.1E-9		8E-10		7E-10		7E-10		-		8E-10		-		7E-10		-	
Lead 210 precision (±)	µCi/mL	5E-10		7E-10		5E-10		4E-10		4E-10		4E-10		5E-10		6E-10		4E-10		7E-10	
Polonium 210	µCi/mL	<6E-10 U	6E-10	<5E-10 U	5E-10	<5E-10 U	5E-10	<6E-10 U	6E-10	<8E-10 U	8E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<1E-9 U	1E-9	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	6E-10		5E-10		5E-10		6E-10		8E-10		-		6E-10		-		1E-9		-	
Polonium 210 precision (±)	µCi/mL	2E-10		2E-10		4E-10		2E-10		3E-10		-		4E-10		-		4E-10		-	
Radium 226	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	7E-10	2E-10	1E-9	1E-10	<1.6E-10 U	1.6E-10	<2E-10 U	2E-10	<1.4E-10 U	1.4E-10	<2E-10 U	2E-10	<1.7E-10 U	1.7E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	2E-10		2E-10		2E-10		1E-10		1.6E-10		-		1.4E-10		-		1.7E-10		-	
Radium 226 precision (±)	µCi/mL	7E-11		1E-10		2E-10		2E-10		9E-11		-		8E-11		-		8E-11		-	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	2E-10		2E-10		2E-10		2E-10		1E-10		-		2E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	9E-11		7E-11		8E-11		7E-11		7E-11		-		9E-11		-		6E-11		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<7E-10 U	7E-10	<6E-10 U	6E-10	<6E-10 U	6E-10	<8E-10 U	8E-10	<6E-10 U	6E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	1.5E-9 B	1E-9	7E-10	6E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	7E-10		6E-10		6E-10		8E-10		6E-10		-		8E-10		-		6E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		4E-10		3E-10		5E-10		4E-10		-		5E-10		5E-10 B		4E-10		-	
Polonium 210	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<5E-10 U	5E-10	<7E-10 U	7E-10	<1E-9 U	1E-9	<2E-10 U	2E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	2E-10		2E-10		2E-10		5E-10		7E-10		-		2E-10		-		8E-10		-	
Polonium 210 precision (±)	µCi/mL	1E-10		1E-10		1E-10		2E-10		3E-10		-		1E-10		-		4E-10		-	
Radium 226	µCi/mL	<1E-10 U	1E-10	<1E-10 U	1E-10	<1E-10 U	1E-10	<1E-10 U	1E-10	<1.2E-10 U	1.2E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.2E-10 U	1.2-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1E-10		1E-10		1E-10		1E-10		1.2E-10		-		1.3E-10		-		1.2E-10		-	
Radium 226 precision (±)	µCi/mL	6E-11		6E-11		4E-11		4E-11		8E-11		-		6E-11		-		5E-11		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		1E-10		2E-10		1E-10		1E-10		-		1E-10		-		2E-10		-	
Thorium 230 precision (±)	µCi/mL	8E-11		5E-11		1E-10		6E-11		5E-11		-		4E-11		-		9E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0072	0.0003	0.0064	0.0003	0.0075	0.0003	0.0049	0.0003	0.0069	0.0003	0.0065	0.0003	0.0113	0.0003	0.0148	0.0003	0.0136	0.0003	0.0132	0.0003
Uranium Activity	µCi/mL	4.9E-9	2E-10	4.3E-9	2E-10	5.1E-9	2E-10	3.3E-9	2E-10	4.7E-9	2E-10	4.4E-9	2E-10	7.7E-9	2E-10	1E-8	2E-10	9.2E-9	2E-10	8.9E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	788		788		788		788		794 [b]		794 [b]		794 [b]		794 [b]		795 [b]		795 [b]	
	Date Collected:	6/22/2012		9/18/2012		12/5/2012		3/20/2013		6/19/2012		9/6/2012		12/5/2012		3/21/2013		6/19/2012		9/6/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<9E-10 U	9E-10	1.7E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	1.9E-9	1E-9	<7E-10 U	7E-10	<1E-9	1E-9	<9E-10 U	9E-10	1.2E-9	1E-9
Lead 210 MDC	µCi/mL	9E-10		-		7E-10		-		8E-10		-		7E-10		-		9E-10		-	
Lead 210 precision (±)	µCi/mL	5E-10		6E-10		4E-10		-		5E-10		6E-10		4E-10		-		5E-10		5E-10	
Polonium 210	µCi/mL	<6E-10 U	6E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<9E-10 U	9E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	6E-10		-		7E-10		-		5E-10		-		9E-10		-		6E-10		-	
Polonium 210 precision (±)	µCi/mL	5E-10		-		3E-10		-		3E-10		-		4E-10		-		3E-10		-	
Radium 226	µCi/mL	<1.9E-10	1.9E-10	<2E-10 U	2E-10	2.1E-10	1.8E-10	<2E-10 U	2E-10	<1.6E-10	1.6E-10	<2E-10 U	2E-10	<1.8E-10	1.8E-10	<2E-10 U	2E-10	<1.8E-10	1.8E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.9E-10		-		1.8E-10		-		1.6E-10		-		1.8E-10		-		1.8E-10		-	
Radium 226 precision (±)	µCi/mL	1.2E-10		-		1.4E-10		-		6E-11		-		1.1E-10		-		8E-11		-	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	2E-10		-		1E-10		-		2E-10		-		2E-10		-		2E-10		-	
Thorium 230 precision (±)	µCi/mL	8E-11		-		7E-11		-		7E-11		-		6E-11		-		8E-11		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<7E-10 U	7E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	7E-10	6E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	1.1E-9	1E-9
Lead 210 MDC	µCi/mL	7E-10		-		6E-10		-		6E-10		-		6E-10		-		6E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		-		4E-10		-		4E-10		-		4E-10		-		4E-10		5E-10	
Polonium 210	µCi/mL	<4E-10 U	4E-10	<1E-9 U	1E-9	<4E-10 U	4E-10	<1E-9 U	1E-9	<2E-10 U	2E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<3E-10 U	3E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	4E-10		-		4E-10		-		2E-10		-		5E-10		-		3E-10		-	
Polonium 210 precision (±)	µCi/mL	2E-10		-		2E-10		-		1E-10		-		4E-10		-		2E-10		-	
Radium 226	µCi/mL	<1.4E-10	1.4E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.4E-10		-		1E-10		-		1.3E-10		-		1E-10		-		1.3E-10		-	
Radium 226 precision (±)	µCi/mL	7E-11		-		6E-11		-		7E-11		-		5E-11		-		8E-11		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10		-		1E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	6E-11		-		6E-11		-		4E-11		-		6E-11		-		6E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0081	0.0003	0.0069	0.0003	0.0076	0.0003	0.0062	0.0003	0.0055	0.0003	0.0063	0.0003	0.0063	0.0003	0.006	0.0003	0.005	0.0003	0.0058	0.0003
Uranium Activity	µCi/mL	5.5E-9	2E-10	4.7E-9	2E-10	5.1E-9	2E-10	4.2E-9	2E-10	3.8E-9	2E-10	4.3E-9	2E-10	4.3E-9	2E-10	4.1E-9	2E-10	3.4E-9	2E-10	3.9E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2.0E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2.E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	795 [b]		795 [b]		799		799		799		799		802		802		802		802	
	Date Collected:	12/5/2012		3/21/2013		6/19/2012		9/18/2012		11/29/2012		3/20/2013		6/18/2012		9/18/2012		11/29/2012		3/18/2013	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<7E-10 U	7E-10	1E-9	1E-9	<8E-10 U	8E-10	1.2E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	1.1E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	7E-10		-		8E-10		-		7E-10		-		8E-10		-		7E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		4E-10		5E-10		8E-10		4E-10		-		5E-10		5E-10		4E-10		-	
Polonium 210	µCi/mL	<1E-9 U	1E-9	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<5E-10 U	5E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	1E-9		-		5E-10		-		8E-10		-		5E-10		-		8E-10		-	
Polonium 210 precision (±)	µCi/mL	4E-10		-		3E-10		-		3E-10		-		3E-10		-		4E-10		-	
Radium 226	µCi/mL	<1.9E-10	1.9E-10	<2E-10 U	2E-10	<1.8<1.8E-10 UE-10	1.8E-10	<2E-10 U	2E-10	<1.5E-10 U	1.5E-10	<2E-10 U	2E-10	<1.7E-10 U	1.7E-10	<2E-10 U	2E-10	<1.7E-10 U	1.7E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.9E-10		-		1.8E-10		-		1.5E-10		-		1.7E-10		-		1.7E-10		-	
Radium 226 precision (±)	µCi/mL	1.3E-10		-		1.2E-10		-		6E-11		-		8E-11		-		1E-10		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		2E-10		-		1E-10		-		2E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	6E-11		-		6E-11		-		4E-11		-		5E-11		-		7E-11		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	6E-10	6E-10	<1E-9 U	1E-9	<8E-10 U	8E-10	1.1E-9	1E-9	6E-10	6E-10	<1E-9 U	1E-9	<9E-10 U	9E-10	1.1E-9	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	6E-10		-		8E-10		-		6E-10		-		9E-10		-		6E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		-		5E-10		4E-10		4E-10		-		6E-10		4E-10		4E-10		-	
Polonium 210	µCi/mL	<5E-10 U	5E-10	<1E-9 U	1E-9	<2E-10 U	2E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	8E-10	4E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	5E-10		-		2E-10		-		7E-10		-		4E-10		-		7E-10		-	
Polonium 210 precision (±)	µCi/mL	2E-10		-		9E-11		-		3E-10		-		5E-10		-		3E-10		-	
Radium 226	µCi/mL	<1.1E-10	1.1E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.9E-10 U	1.9E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.1E-10		-		1.3E-10		-		1.3E-10		-		1.9E-10		-		1.3E-10		-	
Radium 226 precision (±)	µCi/mL	8E-11		-		5E-11		-		7E-11		-		1E-10		-		7E-11		-	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	2E-10	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	2E-10		-		1E-10		-		1E-10		-		2E-10		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	9E-11		-		6E-11		-		5E-11		-		6E-11		1E-10		4E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0062	0.0003	0.0062	0.0003	0.0063	0.0003	0.0079	0.0003	0.0086	0.0003	0.0076	0.0003	0.0045	0.0003	0.0046	0.0003	0.005	0.0003	0.0043	0.0003
Uranium Activity	µCi/mL	4.2E-9	2E-10	4.2E-9	2E-10	4.3E-9	2E-10	5.4E-9	2E-10	5.9E-9	2E-10	5.2E-9	2E-10	3E-9	2E-10	3.1E-9	2E-10	3.4E-9	2E-10	2.9E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2.E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	811 [a]		811 [a]		815		815		815		815		821 [b]		821 [b]		821 [b]		821 [b]	
	Date Collected:	11/29/2012		3/18/2013		6/21/2012		9/18/2012		11/29/2012		3/21/2013		6/21/2012		9/18/2012		11/29/2012		3/21/2013	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<7E-10 U	7E-10	<1E-9 U	1E-9	<9E-10 U	9E-10	2.3E-9	1E-9	<7E-10 U	7E-10	1.2E-9	1E-9	<9E-10 U	9E-10	1.4E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	7E-10		-		9E-10		-		7E-10		-		9E-10		-		7E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		-		5E-10		5E-11		4E-10		4E-10		5E-10		5E-10		4E-10		-	
Polonium 210	µCi/mL	<7E-10 U	7E-10	<1E-9 U	1E-9	<1E-9 U	1E-9	2.9E-9	1E-9	<8E-10 U	8E-10	<1E-9 U	1E-9	<1E-9 U	1E-9	1E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	7E-10		-		1E-9		-		8E-10		-		1E-9		-		7E-10		-	
Polonium 210 precision (±)	µCi/mL	3E-10		-		7E-10		1.1E-9		3E-10		-		9E-10		7E-10		4E-10		-	
Radium 226	µCi/mL	<1.7E-10 U	1.7E-10	<2E-10 U	2E-10	<1.7E-10 U	1.7E-10	<2E-10 U	2E-10	<1.4E-10 U	1.4E-10	<2E-10 U	2E-10	<1.7E-10 U	1.7E-10	<2E-10 U	2E-10	<1.5E-10 U	1.5E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.7E-10		-		1.7E-10		-		1.4E-10		-		1.7E-10		-		2E-10		-	
Radium 226 precision (±)	µCi/mL	8E-11		-		9E-11		-		7E-11		-		8E-11		-		8E-11		-	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	1E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<2E-10 U	2E-10	<8E-11 U	8E-11	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	2E-10		-		2E-10		-		2E-10		-		2E-10		-		8E-11		-	
Thorium 230 precision (±)	µCi/mL	9E-11		-		6E-11		-		6E-11		-		6E-11		-		5E-11		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<7E-10 U	7E-10	2.5E-9	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<6E-10 U	6E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	7E-10		-		7E-10		-		6E-10		-		7E-10		-		6E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		5E-10		4E-10		-		4E-10		-		4E-10		-		4E-10		-	
Polonium 210	µCi/mL	<6E-10 U	6E-10	1.5E-9	1E-9	<4E-10 U	4E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9	<4E-10 U	4E-10	<1E-9 U	1E-9	<7E-10 U	7E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	6E-10		-		4E-10		-		7E-10		-		4E-10		-		7E-10		-	
Polonium 210 precision (±)	µCi/mL	3E-10		1E-9		2E-10		-		3E-10		-		2E-10		-		3E-10		-	
Radium 226	µCi/mL	<1.4E-10 U	1.4E-10	<2E-10 U	2E-10	<1.4E-10 U	1.4E-10	<2E-10 U	2E-10	<1.2E-10 U	1.2E-10	<2E-10 U	2E-10	<1.3E-10 U	1.3E-10	<2E-10 U	2E-10	<1.2E-10 U	1.2E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.4E-10		-		1.4E-10		-		1.2E-10		-		1.3E-10		-		1.2E-10		-	
Radium 226 precision (±)	µCi/mL	5E-11		-		8E-11		-		7E-11		-		5E-11		-		7E-11		-	
Thorium 230	µCi/mL	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10	<9E-11 U	9E-11	<2E-10 U	2E-10	<1E-10 U	1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10		-		9E-11		-		1E-10		-	
Thorium 230 precision (±)	µCi/mL	5E-11		-		6E-11		-		3E-11		-		3E-11		-		4E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0071	0.0003	0.0059	0.0003	0.0058	0.0003	0.0046	0.0003	0.0055	0.0003	0.0052	0.0003	0.0057	0.0003	0.0053	0.0003	0.0060	0.0003	0.0057	0.0003
Uranium Activity	µCi/mL	4.8E-9	2E-10	4E-9	2E-10	3.9E-9	2E-10	3.1E-9	2E-10	3.7E-9	2E-10	3.5E-9	2E-10	3.9E-9	2E-10	3.6E-9	2E-10	4.1E-9	2E-10	3.9E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	0.0004	0.0003	0.0004	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	2.5E-10	2E-10	3E-10	2E-10	<2E-10 U	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-8. Radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	845 [a]		845 [a]	
	Date Collected:	11/26/2012		3/21/2013	
Analyte	Units	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED					
Lead 210	µCi/mL	<7E-10 U	7E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	7E-10		-	
Lead 210 precision (±)	µCi/mL	4E-10		-	
Polonium 210	µCi/mL	<1E-9 U	1E-9	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	1E-9		-	
Polonium 210 precision (±)	µCi/mL	4E-10		-	
Radium 226	µCi/mL	<1.8E-10	1.8E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.8E-10		-	
Radium 226 precision (±)	µCi/mL	8E-11		-	
Thorium 230	µCi/mL	<2E-10 U	2E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	2E-10		-	
Thorium 230 precision (±)	µCi/mL	6E-11		-	
RADIONUCLIDES-SUSPENDED					
Lead 210	µCi/mL	<5E-10 U	5E-10	<1E-9 U	1E-9
Lead 210 MDC	µCi/mL	5E-10		-	
Lead 210 precision (±)	µCi/mL	3E-10		-	
Polonium 210	µCi/mL	<6E-10 U	6E-10	<1E-9 U	1E-9
Polonium 210 MDC	µCi/mL	6E-10		-	
Polonium 210 precision (±)	µCi/mL	3E-10		-	
Radium 226	µCi/mL	<1.1E-10	1.1E-10	<2E-10 U	2E-10
Radium 226 MDC	µCi/mL	1.1E-10		-	
Radium 226 precision (±)	µCi/mL	6E-11		-	
Thorium 230	µCi/mL	<1E-10 U	1.1E-10	<2E-10 U	2E-10
Thorium 230 MDC	µCi/mL	1E-10		-	
Thorium 230 precision (±)	µCi/mL	6E-11		-	
METALS, DISSOLVED					
Uranium	mg/L	0.00565	0.0003	0.0056	0.0003
Uranium Activity	µCi/mL	3.8E-9	2E-10	3.8E-9	2E-10
METALS, SUSPENDED					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10

Notes:
RL - Analyte reporting limit.
U - Not detected at minimum detectable concentration
B- Analyte detected in the associated method blank
µCi/mL - microcuries per milliliter
mg/L - milligrams per liter
[a] Discussions with land owners regarding known completion depths of private water wells in the area suggest that these wells are completed within the Arikaree Formation or the Brule Formation or a combination of both.
[b] Information provided by private well owner and nearby well data indicate that one or more aquifer is used, but cannot be specifically determined. Assigned formation based on available information.
[c] Wells are not active year-around. Wells are used seasonally and sampled when active, resulting in irregular sampling events.
[d] Well is inoperable, resulting in partial sampling events.
[e] CBR driller water supply.

Table 2.9-9. Non-radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review

	Location ID:	703		703		703		703		705		705		714		719		723		723	
	Date Collected:	3/31/2011		6/10/2011		9/22/2011		12/15/2011		3/24/2011		9/19/2012		9/18/2012		9/18/2012		3/31/2011		6/10/2011	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	158	1	160	1	148	1	144	1	153	1	167	5	148	5	157	5	156	1	159	1
Bicarbonate as HCO3	mg/L	193	1	195	1	181	1	176	1	187	1	199	5	181	5	188	5	191	1	194	1
Carbonate as CO3	mg/L	<1	1	<1	1	<1	1	<1	1	<1	1	<5	5	<5	5	<5	5	<1	1	<1	1
Chloride	mg/L	3	1	3	1	3	1	3	1	3	1	3	1	9	1	<1	1	2	1	3	1
Fluoride	mg/L	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.6	0.1	0.4	0.1	0.4	0.1	0.4	0.1	0.6	0.1	0.7	0.1
Magnesium	mg/L	8	1	8	1	8	1	8	1	8	1	8	1	8	1	8	1	8	1	9	1
Nitrogen Ammonia as N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	1.6	0.1	1.7	0.1	1.7	0.1	1.7	0.1	1.4	0.1	1.7	0.1	7	0.1	1.3	0.1	0.8	0.1	0.9	0.1
Potassium	mg/L	3	1	3	1	3	1	3	1	4	1	4	1	4	1	3	1	4	1	3	1
Silica	mg/L	69.7	0.2	64.9	0.2	68.5	0.2	65.7	0.2	70.6	0.2	60	1	61	1	67	1	80.8	0.2	77.3	0.2
Sodium	mg/L	16	1	15	1	13	1	16	1	19	1	21	1	17	1	20	1	20	1	17	1
Sulfate	mg/L	7	1	7	1	7	1	7	1	9	1	8	1	9	1	6	1	9	1	8	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	umhos/cm	317	1	311	1	315	1	325	1	307	1	315	1	338	1	299	1	310	1	304	1
pH	s.u.	7.78	0.01	7.81	0.01	7.99	0.01	7.79	0.01	7.94	0.01	8.4	0.1	8.4	0.1	8.4	0.1	7.76	0.01	7.77	0.01
Solids Total Dissolved TDS @ 180 C	mg/L	238	10	230	10	231	10	208	10	216	10	250	10	260	10	220	10	228	10	240	10
METALS, DISSOLVED																					
Aluminum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Arsenic	mg/L	0.004	0.001	0.004	0.001	0.004	0.001	0.004	0.001	0.004	0.001	0.001	0.001	0.0003	0.001	0.002	0.001	0.006	0.001	0.007	0.001
Barium	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	0.1	0.1	0.1	0.1	0.1
Boron	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	41	1	42	1	41	1	42	1	33	1	35	1	43	1	32	1	33	1	38	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.05	0.01	<0.01	0.01
Iron	mg/L	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	0.06	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03
Lead	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	0.002	0.001	<0.001	0.001
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.02	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	0.002	0.001	0.002	0.001
Vanadium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.02	<0.1	0.02	<0.1	0.02	<0.1	0.1	<0.1	0.1
Zinc	mg/L	0.04	0.01	0.05	0.01	0.07	0.01	0.11	0.01	0.08	0.01	0.05	0.01	<0.01	0.01	0.01	0.01	0.21	0.01	0.03	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	-1.31		-0.711		0.341		3.88		-3.67		4.13		3.51		2.1		-2.04		-0.463	
Anions	meq/L	3.53		3.58		3.33		3.25		3.46		3.74		3.9		3.38		3.47		3.53	
Cations	meq/L	3.44		3.53		3.36		3.51		3.22		3.44		3.63		3.24		3.33		3.5	
Solids Total Dissolved Calculated	mg/L	268		265		259		173		268		250		870		240		277		277	

Notes:
RL - Analyte reporting limit

Table 2.9-9. Non-radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	723		723		725		725		725		725		727		727		727		727	
	Date Collected:	9/22/2011		12/20/2011		3/31/2011		6/15/2011		9/29/2011		12/16/2011		3/24/2011		6/15/2011		9/22/2011		12/15/2011	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	154	1	149	1	149	1	149	1	156	1	141	1	160	1	158	1	150	1	146	1
Bicarbonate as HCO3	mg/L	187	1	182	1	181	1	182	1	182	1	172	1	195	1	193	1	182	1	178	1
Carbonate as CO3	mg/L	<1	1	<1	1	<1	1	<1	1	4	1	<1	1	<1	1	<1	1	<1	1	<1	1
Chloride	mg/L	3	1	2	1	2	1	3	1	3	1	2	1	5	1	5	1	5	1	5	1
Fluoride	mg/L	0.7	0.1	0.6	0.1	0.7	0.1	0.8	0.1	0.7	0.1	0.7	0.1	0.4	0.1	0.5	0.1	0.5	0.1	0.5	0.1
Magnesium	mg/L	8	1	9	1	6	1	7	1	7	1	6	1	12	1	13	1	13	1	13	1
Nitrogen Ammonia as N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	0.8	0.1	0.7	0.1	0.6	0.1	0.7	0.1	0.8	0.1	0.7	0.1	1.4	0.1	1.3	0.1	1.4	0.1	1.6	0.1
Potassium	mg/L	3	1	3	1	5	1	4	1	4	1	4	1	4	1	4	1	4	1	4	1
Silica	mg/L	78.3	0.2	75.6	0.2	64.4	0.2	72.2	0.2	72.0	0.2	68.4	0.2	77.8	0.2	84.5	0.2	81.8	0.2	83	1
Sodium	mg/L	17	1	22	1	33	1	26	1	25	1	31	1	19	1	20	1	17	1	19	1
Sulfate	mg/L	9	1	9	1	19	1	11	1	13	1	16	1	9	1	9	1	9	1	8	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	umhos/cm	308	1	306	1	313	1	296	1	309	1	241	1	325	1	312	1	325	1	344	1
pH	s.u.	7.99	0.01	7.72	0.01	7.95	0.01	8.15	0.01	8.00	0.01	7.95	0.01	8.05	0.01	8.19	0.01	8.01	0.01	7.73	0.01
Solids Total Dissolved TDS @ 180 C	mg/L	235	10	215	10	230	10	234	10	248	10	234	10	290	10	245	10	244	10	229	10
METALS, DISSOLVED																					
Aluminum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Arsenic	mg/L	0.007	0.001	0.006	0.001	0.003	0.001	0.006	0.001	0.005	0.001	0.004	0.001	0.002	0.001	0.003	0.001	0.003	0.001	0.002	0.001
Barium	mg/L	0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	0.1
Boron	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	34	1	34	1	30	1	29	1	30	1	33	1	30	1	32	1	31	1	34	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	0.04	0.01	0.06	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Iron	mg/L	<0.03	0.03	<0.03	0.03	0.08	0.03	0.06	0.03	0.04	0.03	0.06	0.03	<0.03	0.03	0.05	0.03	<0.03	0.03	0.03	0.03
Lead	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.002	0.001	0.001	0.001	<0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.002	0.001
Vanadium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<.1	0.1	<0.1	0.1
Zinc	mg/L	0.1	0.01	0.19	0.01	0.32	0.01	0.29	0.01	0.18	0.01	0.24	0.01	0.28	0.01	0.25	0.01	0.3	0.01	0.49	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	-3.11		1.91		-0.0053		-2.8		-5.17		4.47		-2.51		0.0438		0.00487		5.25	
Anions	meq/L	3.41		3.31		3.5		3.42		3.56		3.3		3.65		3.61		3.44		3.37	
Cations	meq/L	3.21		3.44		3.5		3.23		3.21		3.61		3.47		3.61		3.44		3.74	
Solids Total Dissolved Calculated	mg/L	269		172		268		174		270		181		290		183		279		179	

Notes:
RL - Analyte reporting limit

Table 2.9-9. Non-radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	731		739		740		741		741		741		741		742		745		745	
	Date Collected:	9/18/2012		9/18/2012		9/18/2012		3/31/2011		6/10/2011		9/22/2011		12/15/2011		9/18/2012		3/31/2011		6/10/2011	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	151	5	223	5	228	5	159	1	199	1	179	1	173	1	244	5	185	1	175	1
Bicarbonate as HCO3	mg/L	180	5	269	5	272	5	194	1	243	1	218	1	211	1	293	5	226	1	209	1
Carbonate as CO3	mg/L	<5	5	<5	5	<5	5	<1	1	<1	1	<1	1	<1	1	<5	5	<1	1	2	1
Chloride	mg/L	3	1	4	1	7	1	4	1	5	1	5	1	5	1	8	1	4	1	3	1
Fluoride	mg/L	0.4	0.1	0.4	0.1	0.5	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.4	0.1	0.4	0.1
Magnesium	mg/L	8	1	10	1	11	1	7	1	9	1	8	1	9	1	12	1	11	1	10	1
Nitrogen Ammonia as N	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.1	0.1	<0.05	0.05	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	1.9	0.1	8.7	0.1	1.6	0.1	1.8	0.1	3.3	0.1	3.2	0.2	3.1	0.1	0.8	0.1	6.9	0.5	3.9	0.2
Potassium	mg/L	3	1	7	1	9	1	5	1	5	1	5	1	5	1	13	1	3	1	2	1
Silica	mg/L	67	1	53	1	53	1	70	0.2	65.1	0.2	66.2	0.2	64.4	0.2	40	1	72.6	0.2	70.1	0.2
Sodium	mg/L	19	1	23	1	31	1	19	1	26	1	22	1	26	1	28	1	9	1	8	1
Sulfate	mg/L	8	1	12	1	44	1	11	1	13	1	13	1	12	1	24	1	19	1	11	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	umhos/cm	292	1	476	1	519	1	324	1	413	1	403	1	327	1	507	1	432	1	356	1
pH	s.u.	8.4	0.1	8.3	0.1	8.3	0.1	7.72	0.01	7.72	0.01	7.99	0.01	7.86	0.01	8.3	0.1	7.64	0.01	7.78	0.01
Solids Total Dissolved TDS @ 180 C	mg/L	230	10	320	10	370	10	244	10	289	10	277	10	259	10	330	10	334	10	280	10
METALS, DISSOLVED																					
Aluminum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<.1	0.1	<0.1	0.1	<.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Arsenic	mg/L	0.003	0.001	0.005	0.001	0.008	0.001	0.005	0.001	0.006	0.001	0.006	0.001	0.006	0.001	0.01	0.001	0.003	0.001	0.003	0.001
Barium	mg/L	0.1	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	<0.1	0.1	<0.1	0.1
Boron	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<.1	0.1	<0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	30	1	61	1	62	1	38	1	52	1	50	1	49	1	59	1	65	1	57	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Iron	mg/L	<0.03	0.03	<0.03	0.03	<0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	<0.03	0.03	<0.5	0.05	<0.03	0.03	<0.03	0.03
Lead	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.05	0.001	0.001	<0.001	0.001
Manganese	mg/L	<0.01	0.01	<0.01	0.01	0.08	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.14	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	0.002	0.001	0.002	0.001	0.002	0.001	0.002	0.001	<0.001	0.001	0.002	0.001	0.002	0.001
Vanadium	mg/L	<0.1	0.02	<0.1	0.02	<0.1	0.02	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.02	<0.1	0.1	<0.1	0.1
Zinc	mg/L	0.23	0.01	0.01	0.01	<0.01	0.01	0.03	0.01	0.02	0.01	0.03	0.01	0.02	0.01	<0.01	0.01	0.43	0.01	0.14	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	4.44		4.42		2.69		-2.98		-0.33		0.0941		3.69		2.48		-0.785		-0.713	
Anions	meq/L	3.41		5.45		5.82		3.67		4.67		4.24		4.1		5.68		4.7		4.13	
Cations	meq/L	3.12		4.99		5.51		3.46		4.64		4.25		4.42		5.41		4.63		4.07	
Solids Total Dissolved Calculated	mg/L	240		340		360		277		329		308		224		330		344		303	

Notes:
RL - Analyte reporting limit

Table 2.9-9. Non-radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	745		745		746		747		759		759		759		759		777		788	
	Date Collected:	9/22/2011		12/15/2011		9/18/2012		3/25/2011		3/31/2011		6/10/2011		9/22/2011		12/15/2011		9/18/2012		3/24/2011	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	172	1	164	1	155	5	131	1	163	1	153	1	144	1	140	1	302	5	154	1
Bicarbonate as HCO3	mg/L	209	1	200	1	184	5	160	1	199	1	187	1	175	1	170	1	369	5	187	1
Carbonate as CO3	mg/L	<1	1	<1	1	<5	5	<1	1	<1	1	<1	1	<1	1	<1	1	<5	5	<1	1
Chloride	mg/L	3	1	4	1	2	1	3	1	2	1	2	1	2	1	2	1	4	1	3	1
Fluoride	mg/L	0.4	0.1	0.4	0.1	0.5	0.1	1	0.1	0.6	0.1	0.5	0.1	0.6	0.1	0.6	0.1	0.4	0.1	0.4	0.1
Magnesium	mg/L	11	1	11	1	12	1	7	1	3	1	6	1	6	1	6	1	10	1	9	1
Nitrogen Ammonia as N	mg/L	<0.05	0.05	<0.05	0.05	<0.1	0.1	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.1	0.1	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	6.5	0.5	5	0.1	1.1	0.1	1	0.1	0.8	0.1	0.8	0.1	0.8	0.1	0.8	0.1	3	0.1	2.2	0.1
Potassium	mg/L	2	1	2	1	2	1	3	1	6	1	5	1	5	1	5	1	7	1	4	1
Silica	mg/L	70.9	0.2	67.2	0.2	75	1	85.5	0.2	74.9	0.2	69.1	0.2	75.3	0.2	71.9	0.2	53	1	69.2	0.2
Sodium	mg/L	8	1	8	1	10	1	13	1	49	1	25	1	23	1	25	1	38	1	19	1
Sulfate	mg/L	16	1	16	1	3	1	5	1	15	1	8	1	8	1	7	1	15	1	7	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	umhos/cm	419	1	327	1	278	1	255	1	323	1	294	1	299	1	307	1	578	1	307	1
pH	s.u.	7.94	0.01	7.79	0.01	8.4	0.1	8.07	0.01	7.7	0.01	7.97	0.01	8.05	0.01	7.76	0.01	8.2	0.1	7.98	0.01
Solids Total Dissolved TDS @ 180 C	mg/L	315	10	292	10	220	10	202	10	236	10	212	10	217	10	203	10	400	10	231	10
METALS, DISSOLVED																					
Aluminum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Arsenic	mg/L	0.003	0.001	0.003	0.001	0.003	0.001	0.005	0.001	0.006	0.001	0.004	0.001	0.004	0.001	0.003	0.001	0.006	0.001	0.003	0.001
Barium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1
Boron	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	64	1	61	1	33	1	31	1	21	1	31	1	31	1	32	1	73	1	34	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.1	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Iron	mg/L	<0.03	0.03	<0.03	0.03	0.15	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03
Lead	mg/L	0.001	0.001	0.002	0.001	<0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.002	0.001	0.002	0.001	<0.001	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	0.001	0.001	0.001
Vanadium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.02	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.02	<0.1	0.1
Zinc	mg/L	0.51	0.01	0.72	0.01	0.03	0.01	0.07	0.01	0.01	0.01	0.01	0.01	0.04	0.01	0.1	0.01	0.03	0.01	0.07	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	2.15		3.13		3.59		-3.49		-1.48		-1.77		0.123		4.27		3.2		-1.8	
Anions	meq/L	4.35		4.1		3.31		2.94		3.7		3.35		3.17		3.08		6.71		3.48	
Cations	meq/L	4.54		4.36		3.08		2.75		3.59		3.24		3.18		3.35		6.29		3.36	
Solids Total Dissolved Calculated	mg/L	327		223		230		255		292		262		260		166		400		275	

Notes:
RL - Analyte reporting limit

Table 2.9-9. Non-radiological Analyses for Private Water Supply Wells in Marsland Expansion Area of Review (Cont.)

	Location ID:	788		799		802		809		810		811		815		821		845	
	Date Collected:	9/18/2012		9/18/2012		9/18/2012		9/18/2012		9/18/2012		9/18/2012		9/18/2012		9/18/2012		9/18/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																			
Alkalinity Total as CaCO3	mg/L	148	5	173	5	161	5	170	5	171	5	165	5	168	5	149	5	158	5
Bicarbonate as HCO3	mg/L	480	5	199	5	190	5	198	5	201	5	195	5	198	5	175	5	187	5
Carbonate as CO3	mg/L	<5	5	6	5	<5	5	<5	5	<5	5	<5	5	<5	5	<5	5	<5	5
Chloride	mg/L	3	1	3	1	3	1	3	1	4	1	2	1	4	1	4	1	2	1
Fluoride	mg/L	0.4	0.1	0.4	0.1	0.5	0.1	0.8	0.1	0.9	0.1	0.7	0.1	0.04	0.1	0.5	0.1	0.4	0.1
Magnesium	mg/L	9	1	10	1	8	1	9	1	9	1	10	1	8	1	6	1	7	1
Nitrogen Ammonia as N	mg/L	0.2	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nitrogen Nitrate+Nitrite as N	mg/L	3.7	0.1	0.9	0.1	2.7	0.1	0.8	0.1	0.9	0.1	0.5	0.1	5.5	0.1	2.4	0.1	1.4	0.1
Potassium	mg/L	4	1	3	1	2	1	5	1	5	1	5	1	3	1	6	1	4	1
Silica	mg/L	62	1	63	1	61	1	62	1	63	1	54	1	58	1	62	1	60	1
Sodium	mg/L	19	1	8	1	8	1	17	1	18	1	8	1	16	1	30	1	18	1
Sulfate	mg/L	6	1	5	1	3	1	4	1	6	1	3	1	7	1	17	1	7	1
PHYSICAL PROPERTIES																			
Conductivity @ 25 C	µmhos/cm	305	1	314	1	298	1	313	1	314	1	289	1	335	1	321	1	302	1
pH	s.u.	8.4	0.1	8.5	0.1	8.4	0.1	8.4	0.1	8.4	0.1	8.4	0.1	8.4	0.1	8.4	0.1	8.4	0.1
Solids Total Dissolved TDS @ 180 C	mg/L	305	10	240	10	220	10	240	10	240	10	220	10	260	10	250	10	250	10
METALS, DISSOLVED																			
Aluminum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Arsenic	mg/L	0.002	0.001	0.004	0.001	0.003	0.001	0.006	0.001	0.008	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001
Barium	mg/L	0.2	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Boron	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	32	1	45	1	45	1	37	1	37	1	39	1	45	1	29	1	35	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Iron	mg/L	0.07	0.03	0.04	0.03	0.09	0.03	0.07	0.03	<0.03	0.03	0.04	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03
Lead	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Vanadium	mg/L	<0.1	0.02	<0.1	0.02	<0.1	0.02	<0.1	0.02	<0.1	0.02	<0.1	0.02	<0.1	0.02	<0.1	0.02	<0.1	0.02
Zinc	mg/L	0.11	0.01	0.06	0.01	0.06	0.01	0.3	0.01	0.18	0.01	0.29	0.01	0.29	0.01	0.29	0.01	0.29	0.01
DATA QUALITY																			
A/C Balance (± 5)	%	3.4		3.66		4.27		3.1		3.92		4.17		4.87		3.1		3.57	
Anions	meq/L	3.46		3.74		3.58		3.67		3.76		3.48		4.02		3.64		3.47	
Cations	meq/L	3.23		3.47		3.29		3.45		3.48		3.2		3.65		3.42		3.23	
Solids Total Dissolved Calculated	mg/L	240		250		220		240		250		220		270		260		230	

Notes:
RL - Analyte reporting limit

Table 2.9-10. Radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014

	Location ID:	BOW 2010-1		BOW 2010-1		BOW 2010-1		BOW 2010-1		BOW 2010-2		BOW 2010-2		BOW 2010-2		BOW 2010-2		BOW 2010-3		BOW 2010-3	
	Date Collected:	12/10/2013		2/25/2014		6/16/2014		9/16/2014		12/10/2013		2/25/2014		6/16/2014		9/16/2014		12/10/2013		2/25/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	1.8E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	NA		5E-10		7E-10		NA		NA		4E-10		3E-10		NA		NA		4E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-09	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	NA		1E-10		2E-10		NA		NA		2E-10		1E-10		NA		NA		2E-10	
Radium 226	µCi/mL	5E-10	2E-10	3E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	3E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	1E-10		1E-10		1E-10		NA		NA		1E-10		1E-10		1E-10		NA		4E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	NA		2E-11		1E-10		NA		NA		1E-10		1E-10		NA		NA		3E-11	
Thorium 230 Tracer (30-120)	µCi/mL	120		80		79		80		100		94		87		74		110		97	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<1E-9	1E-9	1.1E-9	1E-19	1.3E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	NA		5E-10		4E-10		NA		NA		5E-10		4E-10		NA		NA		5E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-09	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-09	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	NA		2E-10		2E-10		NA		NA		2E-10		1E-10		NA		NA		2E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	NA		4E-11		0.0		NA		NA		1E-10		0.0		NA		NA		2E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	4E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	NA		4E-11		4E-11		NA		NA		4E-11		2E-11	NA	2E-10		NA		3E-11	
Thorium 230 Tracer (30-120)	µCi/mL	81		92		78		73		90		96		95	74	74		90		100	
METALS, DISSOLVED																					
Uranium	mg/L	0.0004	0.0003	0.0004	0.0003	<0.0003	0.0003	<0.0003	0.0003	0.0016	0.0003	0.0014	0.0003	0.0018	0.0003	0.0017	0.0003	0.0023	0.0003	0.0024	0.0003
Uranium Activity	µCi/mL	3E-10	2E-10	3E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	1.1E-9	2E-10	9E-10	2E-10	1.2E-9	2E-10	1.2E-9	2E-10	1.6E-9	2E-10	1.6E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
µCi/mL = microcuries per milliliter
mg/L = milligrams per liter
RL - Analyte reporting limit.

Table 2.9-10. Radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	BOW 2010-3		BOW 2010-3		BOW 2010-4A		BOW 2010-4A		BOW 2010-4A		BOW 2010-4A		BOW 2010-5		BOW 2010-5		BOW 2010-5		BOW 2010-5	
	Date Collected:	6/16/2014		9/16/2014		12/10/2013		2/25/2014		6/16/2014		9/17/2014		12/16/2013		2/26/2014		6/17/2014		9/17/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1.1E-9	1E-9
Lead 210 precision (±)	µCi/mL	4E-10		NA		NA		4E-10		3E-10		5E-10		NA		4E-10		4E-10		5E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-10	1E-10	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	4E-9	1E-9
Polonium 210 precision (±)	µCi/mL	2E-10		NA		NA		2E-10		2E-10		2E-10		NA		2E-10		1E-10		9E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	1E-9	2E-10	8E-10	2E-10	5E-10	2E-10	5E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	3E-11		NA		1E-10		1E-10		1E-10		2E-10		NA		4E-11		0.0		4E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	1E-10		NA		NA		5E-11		2E-11		1E-10		NA		3E-11		0.0		2E-11	
Thorium 230 Tracer (30-120)	µCi/mL	81		89		120		98		79		79		90		77		85		95	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/L	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1E-9	1E-9	<1E-9	1E-9	1.1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1.5E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/L	4E-10		NA		NA		5E-10		4E-10		5E-10		NA		4E-10		6E-10		5E-10	
Polonium 210	µCi/L	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/L	2E-10		NA		NA		2E-10		2E-10		2E-10		NA		2E-10		1E-10		2E-10	
Radium 226	µCi/L	<2E-10	2E-10	<2E-10	2E-10	9E-10	2E-10	3E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/L	0.0		NA		1E-10		0.0		0.0		1E-10		NA		2E-11		0.0		3E-11	
Thorium 230	µCi/L	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/L	2E-11		NA		NA		1E-10		4E-11		5E-11		NA		3E-11		0.0		1E-10	
Thorium 230 Tracer (30-120)	µCi/L	95		77		80		74		94		41		82		89		83		61	
METALS, DISSOLVED																					
Uranium	mg/L	0.0032	0.0003	0.0035	0.0003	0.0008	0.0003	0.0014	0.0003	0.0017	0.0003	0.0016	0.0003	0.0067	0.0003	0.0076	0.0003	0.0070	0.0003	0.0070	0.0003
Uranium Activity	µCi/mL	2.2E-9	2E-01	2.4E-9	2E-10	5E-9	2E-10	9E-9	2E-10	1.2E-9	2E-10	1.1E-9	1E-10	4.5E-9	2E-10	5.2-9	2E-01	4.7E-9	2E-10	4.7E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
µCi/mL = microcuries per milliliter
mg/L = milligrams per Liter
RL - Analyte reporting limit.

Table 2.9-10. Radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	BOW 2010-6		BOW 2010-6		BOW 2010-6		BOW 2010-6		BOW 2010-7		BOW 2010-7		BOW 2010-7		BOW 2010-7		BOW 2010-8		BOW 2010-8	
	Date Collected:	12/16/2013		2/26/2014		6/19/2014		9/17/2014		12/16/2013		2/25/2014		6/16/2014		9/16/2014		12/10/2013		2/26/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/L	<1E-9	1E-9	1.2E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/L	NA		4E-10		NA		5E-10		NA		4E-10		4E-10		NA		NA		4E-10	
Polonium 210	µCi/L	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/L	NA		2E-10		NA		1E-10		NA		2E-10		3E-10		NA		NA		2E-10	
Radium 226	µCi/L	3E-10	2E-10	8E-10	2E-10	2E-10	2E-10	<2E-10	2E-10	5E-10	2E-10	4E-10	2E-10	4E-10	2E-10	4E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/L	1E-10		1E-10		0.0		5E-11		0.1		1E-10		1E-10		1E-10		NA		3E-11	
Thorium 230	µCi/L	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/L	NA		2E-11		NA		0.0		NA		1E-10		2E-11		NA		NA		3E-11	
Thorium 230 Tracer (30-120)	µCi/L	85		99		90		84		77		85		88		78		89		87	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/L	<1E-9	1E-9	<1E-9	1E-9	1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1.1E-9	1E-9	<1E-9	1E-9	1.5E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/L	NA		4E-10		4E-10		4E-10		NA		5E-10		4E-10		6E-10		NA		4E-10	
Polonium 210	µCi/L	<1E-9	1E-09	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/L	NA		3E-10		NA		2E-10		NA		2E-10		2E-10		NA		NA		2E-10	
Radium 226	µCi/L	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/L	NA		3E-11		NA		3E-11		1E-10		4E-11		0.0		NA		NA		2E-11	
Thorium 230	µCi/L	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/L	NA		4E-11		NA		1E-10		NA		2E-11		2E-11		NA		NA		3E-11	
Thorium 230 Tracer (30-120)	µCi/L	81		100		91		76		87		89		86		76		110		92	
METALS, DISSOLVED																					
Uranium	mg/L	0.0049	0.0003	0.0056	0.0003	0.0047	0.0003	0.0052	0.0003	0.0035	0.0003	0.0041	0.0003	0.0048	0.0003	0.0049	0.0003	0.0034	0.0003	0.0041	0.0003
Uranium Activity	µCi/mL	3.3E-9	2E-10	3.8E-9	2E-10	3.2E-9	2E-10	3.5E-9	2E-10	2.4E-9	2E-10	2.8E-9	2E-10	3.3E-9	2E-10	3.3E-9	2E-10	2.3E-9	2E-10	2.8E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
µCi/mL = microcuries per milliliter
mg/L = milligrams per Liter
RL - Analyte reporting limit.

Table 2.9-10. Radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	BOW 2010-8		BOW 2010-8		BOW 9		BOW 9		BOW 9		BOW 9		BOW 10		BOW 10		BOW 10		BOW 10	
	Date Collected:	6/16/2014		9/16/2014		11/8/2013		2/26/2014		6/16/2014		9/17/2014		11/8/2013		2/25/2014		6/16/2014		9/17/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1.4	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	3E-10		NA		NA		4E-10		3E-10		4E-10		NA		5E-10		3E-10		5E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	2E-10		NA		NA		2E-10		2E-10		2E-10		NA		2E-10		2E-10		1E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	3E-11		NA		NA		4E-11		0.0		4E-11		NA		3E-11		0.0		4E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	1E-10		NA		NA		0.0		3E-11		4E-11		NA		5E-11		3E-11		4E-11	
Thorium 230 Tracer (30-120)	µCi/mL	92		64		67		94		82		89		55		82		81		70	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<1E-9	1E-9	2.9E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1.6E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	4E-10		7E-10		NA		4E-10		4E-10		5E-10		NA		5E-10		6E-10		4E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	2E-10		NA		NA		2E-10		1E-10		3E-10		NA		2E-10		1E-10		2E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	0.0		NA		NA		3E-11		0.0		1E-10		NA		3E-11		0.0		5E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	2E-11		NA		NA		1E-10		3E-11		1E-10		NA		5E-11		3E-11		1E-10	
Thorium 230 Tracer (30-120)	µCi/mL	87		80		71		99		92		87		60		94		93		51	
METALS, DISSOLVED																					
Uranium	mg/L	0.0043	0.0003	0.0042	0.0003	0.0073	0.0003	0.0081	0.0003	0.0076	0.0003	0.0080	0.0003	0.0075	0.0003	0.0074	0.0003	0.0073	0.0003	0.0071	0.0003
Uranium Activity	µCi/mL	2.9E-9	2E-10	2.8E-9	2E-10	4.9E-9	2E-10	5.5E-09	2E-10	5.2E-9	2E-10	5.4E-9	2E-10	5.1E-9	2E-10	5E-9	2E-10	4.9E-9	2E-10	4.8E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
µCi/mL = microcuries per milliliter
mg/L = milligrams per Liter
RL - Analyte reporting limit.

Table 2.9-10. Radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	BOW 11		BOW 11		BOW 11		BOW 11	
	Date Collected:	11/8/2013		2/26/2014		6/17/2014		9/17/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED									
Lead 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	NA		4E-10		3E-10		5E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	NA		2E-10		2E-10		3E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	NA		5E-11		0.0		4E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	NA		4E-11		0.0		1E-10	
Thorium 230 Tracer (30-120)	µCi/mL	65		95		82		54	
RADIONUCLIDES-SUSPENDED									
Lead 210	µCi/mL	2.5E-9	1E-9	<1E-9	1E-9	1.3E-9	1E-9	1.5E-9	1E-9
Lead 210 precision (±)	µCi/mL	1.3E-10		4E-10		4E-10		5E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	NA		3E-10		2E-10		2E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	NA		2E-11		0.0		3E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	NA		3E-11		4E-11		1E-10	
Thorium 230 Tracer (30-120)	µCi/mL	70		91		92		73	
METALS, DISSOLVED									
Uranium	mg/L	0.0053	0.0003	0.0050	0.0003	0.0051	0.0003	0.0051	0.0003
Uranium Activity	µCi/mL	3.6E-9	2E-10	3.4E-9	2E-10	3.5E-9	2E-10	3.5E-9	2E-10
METALS, SUSPENDED									
Uranium	mg/L	0.0007	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	5E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
µCi/mL = microcuries per milliliter
mg/L = milligrams per Liter
RL - Analyte reporting limit.

Table 2.9-11. Non-radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014

	Location ID:	BOW 2010-1		BOW 2010-1		BOW 2010-1		BOW 2010-1		BOW 2010-2		BOW 2010-2		BOW 2010-2		BOW 2010-2		BOW 2010-3		BOW 2010-3	
	Date Collected:	12/10/2013		2/25/2014		6/16/2014		9/16/2014		12/10/2013		2/25/2014		6/16/2014		9/16/2014		12/10/2013		2/25/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	308	5	268	5	252	5	236	5	255	5	243	5	224	5	201	5	97	5	109	5
Bicarbonate as HCO3	mg/L	<1	1	<1	1	<1	1	<1	1	<1	1	<1	1	<1	1	<1	1	72	1	94	1
Carbonate as CO3	mg/L	69	1	70	1	64	1	62	1	112	1	113	1	117	1	116	1	23	1	19	1
Chloride	mg/L	502	1	435	1	326	1	326	1	339	1	251	1	182	1	136	1	37	1	36	1
Fluoride	mg/L	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.7	0.1	0.6	0.1
Magnesium	mg/L	<1	1	<1	1	<1	1	<1	1	<1	1	<1	1	<1	1	<1	1	<1	1	<1	1
Nitrogen Ammonia as N	mg/L	<0.05	0.05	0.30	0.05	0.11	0.05	0.35	0.05	<0.05	0.05	0.10	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	0.5	0.1	0.6	0.1	1.0	0.1	0.9	0.1	0.6	0.1	0.8	0.1	1.0	0.1	1	0.1	0.2	0.1	<0.1	0.1
Potassium	mg/L	38	1	31	1	27	1	23	1	35	1	27	1	23	1	18	1	8	1	8	1
Silica	mg/L	183	1	180	1	178	1	174	1	126	1	122	1	108	1	100	1	68	1	71	1
Sodium	mg/L	409	1	358	1	326	1	288	1	300	1	253	1	211	1	168	1	79	1	86	1
Sulfate	mg/L	62	1	43	1	43	1	37	1	33	1	33	1	34	1	28	1	52	1	59	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	µmhos/cm	10.7	0.1	10.7	0.1	10.8	0.1	10.7	0.1	10.4	0.1	10.4	0.1	10.3	0.1	10.2	0.1	9.2	0.1	9.1	0.1
pH	s.u.	2300	1	2030	1	1650	1	1520	1	1730	1	1370	1	1060	1	891	1	486	1	468	1
Solids Total Dissolved TDS @ 180 C	mg/L	1280	10	1190	10	1070	10	1030	10	970	10	850	10	700	10	620	10	340	10	340	10
Nitrogen, Nitrite as N	mg/L	0.1	0.1 L	0.2	0.1 L	0.3	0.1 L	0.4	0.1	<0.1	0.1 L	0.1	0.1 L	<0.1	0.1 L	<0.1	0.1	<0.1	0.1 L	<0.1	0.1 L
METALS, DISSOLVED																					
Aluminum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.05	0.05	<0.1	0.1	<0.1	0.1
Arsenic	mg/L	0.007	0.001	0.007	0.001	0.008	0.001	0.009	0.001	0.006	0.001	0.006	0.001	0.006	0.001	0.006	0.001	0.010	0.001	0.010	0.001
Barium	mg/L	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Boron	mg/L	<0.1	0.1	<0.1	0.1	0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	31	1	29	1	23	1	19	1	20	1	17	1	12	1	8	1	4	1	5	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Iron	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Lead	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.01	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.008	0.001	0.008	0.001	0.009	0.001	0.012	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.004	0.001	0.004	0.001
Vanadium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Zinc	mg/L	0.07	0.01	0.11	0.01	0.09	0.01	0.1	0.01	0.11	0.01	0.20	0.01	0.23	0.01	0.11	0.01	<0.01	0.01	<0.01	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	3.22	0.01	2.10	0.01	2.53	0.01	2.33	0.01	1.60	0.01	0.70	0.01	0.42	0.01	2.53	0.01	3.27	0.01	3.29	0.01
Anions	meq/L	21.67	0.01	18.58	0.01	15.22	0.01	14.77	0.01	15.42	0.01	12.70	0.01	10.43	0.01	8.56	0.01	4.12	0.01	4.44	0.01
Cations	meq/L	20.32	0.01	17.82	0.01	16.01	0.01	14.1	0.01	14.93	0.01	12.52	0.01	10.35	0.01	8.14	0.01	3.86	0.01	4.16	0.01
Solids Total Dissolved Calculated		1410	10	1240	10	1080	10	1010	10	1010	10	850	10	710	10	580	10	310	10	330	10
Calculated TDS/TDS Ratio	mg/L	0.91	0.01	0.96	0.01	0.99	0.01	1.02	0.01	0.96	0.01	1.00	0.01	0.99	0.01	1.07	0.01	1.10	0.01	1.03	0.01

Notes:
mg/L = milligrams per Liter
µmhos/cm = micromhos per centimeter
s.u. = standard unit
meq/L = milliequivalents per Liter
RL = Analyte Reporting Limit
L = Analyzed by a contract laboratory

Table 2.9-11. Non-radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	BOW 2010-3		BOW 2010-3		BOW 2010-4A		BOW 2010-4A		BOW 2010-4A		BOW 2010-4A		BOW 2010-5		BOW 2010-5		BOW 2010-5		BOW 2010-5	
	Date Collected:	6/16/2014		9/16/2014		12/10/2013		2/25/2014		6/16/2014		9/16/2014		12/16/2013		2/26/2014		6/17/2014		9/17/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	117	5	123	1	38	5	56	5	58	5	63	5	150	5	151	5	148	5	147	5
Bicarbonate as HCO3	mg/L	104	1	112	1	46	1	68	1	70	1	73	1	184	5	181	1	177	1	169	1
Carbonate as CO3	mg/L	19	1	19	1	<1	1	<1	1	<1	1	2	1	<1	1	1	1	2	1	5	1
Chloride	mg/L	23	1	23	1	367	1	293	1	300	1	267	1	3	1	3	1	4	1	2	1
Fluoride	mg/L	0.6	0.1	0.6	0.1	0.4	0.1	0.4	0.1	0.4	0.1	0.4	0.1	1.8	0.1	0.6	0.1	0.5	0.1	0.6	0.1
Magnesium	mg/L	<1	1	<1	1	2	1	2	1	2	1	2	1	7	1	7	1	7	1	7	1
Nitrogen Ammonia as N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	0.4	0.1	0.5	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.8	0.1	0.9	0.1	0.9	0.1	0.9	0.1
Potassium	mg/L	9	1	8	1	23	1	18	1	18	1	17	1	4	1	4	1	5	1	4	1
Silica	mg/L	77	1	77	1	26	1	35	1	39	1	37	1	66	1	68	1	69	1	67	1
Sodium	mg/L	91	1	84	1	210	1	188	1	188	1	177	1	22	1	22	1	24	1	22	1
Sulfate	mg/L	52	1	54	1	40	1	43	1	39	1	41	1	7	1	8	1	7	1	7	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	µmhos/cm	9.1	0.1	9	0.1	8.1	0.1	8.3	0.1	8.3	0.1	8.4	0.1	8.2	0.1	8.3	0.1	8.3	0.1	8.4	0.1
pH	s.u.	450	1	468	1	1420	1	1160	1	1110	1	1070	1	327	1	314	1	299	1	315	5
Solids Total Dissolved TDS @ 180 C	mg/L	340	10	360	10	730	10	640	10	630	10	610	10	200	10	240	10	250	10	250	10
Nitrogen, Nitrite as N	mg/L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L
METALS, DISSOLVED																					
Aluminum	mg/L	<0.1	0.1	<0.05	0.05	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05
Arsenic	mg/L	0.012	0.001	0.011	0.001	0.003	0.001	0.005	0.001	0.006	0.001	0.005	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001
Barium	mg/L	<0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Boron	mg/L	0.1	0.1	0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	4	1	4	1	33	1	24	1	25	1	22	1	29	1	30	1	28	1	28	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.02	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Iron	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0,05
Lead	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	0.003	0.001	0.003	0.001	0.002	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.005	0.001	0.004	0.001	0.003	0.001	0.002	0.001	0.004	0.001	0.004	0.001	0.001	0.001	<0.001	0.001	0.001	0.001	<0.001	0.001
Vanadium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Zinc	mg/L	<0.01	0.01	<0.02	0.02	0.39	0.01	1.90	0.01	1.35	0.01	0.63	0.01	0.12	0.01	0.13	0.01	0.13	0.01	0.12	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	3.23	0.01	2.86	0.01	1.96	0.01	1.53	0.01	2.03	0.01	1.49	0.01	4.59	0.01	316	0.01	3.02	0.01	2.75	0.01
Anions	meq/L	4.1	0.01	4.3	0.01	11.97	0.01	10.26	0.01	10.44	0.01	9.66	0.01	3.38	0.01	3.34	0.01	3.30	0.01	3.25	0.01
Cations	meq/L	4.38	0.01	4.06	0.01	11.51	0.01	9.95	0.01	10.03	0.01	9.37	0.01	3.08	0.01	3.14	0.01	3.10	0.01	3.08	0.01
Solids Total Dissolved Calculated		330	10	330	10	720	10	640	10	650	10	600	10	230	10	240	10	240	10	230	10
Calculated TDS/TDS Ratio	mg/L	1.03	0.01	1.09	0.01	1.00	0.01	1.00	0.01	0.97	0.01	1.02	0.01	0.87	0.01	1.00	0.01	1.04	0.01	1.09	0.01

Notes:
mg/L = milligrams per Liter
µmhos/cm = micromhos per centimeter
s.u. = standard unit
meq/L = milliequivalents per Liter
RL = Analyte Reporting Limit
L = Analyzed by a contract laboratory

Table 2.9-11. Non-radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	BOW 2010-6		BOW 2010-6		BOW 2010-6		BOW 2010-6		BOW 2010-7		BOW 2010-7		BOW 2010-7		BOW 2010-7		BOW 2010-8		BOW 2010-8	
	Date Collected:	12/16/2013		2/26/2014		6/19/2014		9/17/2014		12/16/2013		2/25/2014		6/16/2014		9/16/2014		12/10/2013		2/26/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	137	5	139	5	129	5	140	5	176	5	183	5	184	5	179	5	160	5	175	5
Bicarbonate as HCO3	mg/L	153	5	162	1	148	1	158	1	184	5	203	1	205	1	199	1	130	1	153	1
Carbonate as CO3	mg/L	7	1	4	1	4	1	6	1	15	1	10	1	10	1	9	1	32	1	30	1
Chloride	mg/L	13	1	11	1	7	1	5	1	24	1	16	1	12	1	14	1	8	1	5	1
Fluoride	mg/L	0.7	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.7	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.7	0.1	0.6	0.1
Magnesium	mg/L	6	1	6	1	5	1	6	1	<1	1	<1	1	<1	1	<1	1	<1	1	<1	1
Nitrogen Ammonia as N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	0.9	0.1	0.9	0.1	1.0	0.1	1	0.1	0.7	0.1	0.9	0.1	1.0	0.1	0.9	0.1	0.7	0.1	0.9	0.1
Potassium	mg/L	5	1	5	1	5	1	5	1	10	1	10	1	10	1	9	1	9	1	8	1
Silica	mg/L	60	1	60	1	61	1	61	1	67	1	68	1	73	1	71	1	78	1	77	1
Sodium	mg/L	26	1	25	1	21	1	20	1	97	1	98	1	106	1	97	1	76	1	81	1
Sulfate	mg/L	10	1	11	1	10	1	9	1	46	1	50	1	43	1	45	1	28	1	27	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	µmhos/cm	8.5	0.1	8.4	0.1	8.5	0.1	8.4	0.1	8.7	0.1	8.6	0.1	8.7	0.1	8.6	0.1	9.2	0.1	9.1	0.1
pH	s.u.	348	1	330	1	289	1	312	1	558	1	513	1	502	1	529	1	419	1	423	1
Solids Total Dissolved TDS @ 180 C	mg/L	250	10	260	10	220	10	240	10	360	10	370	10	370	10	390	10	280	10	340	10
Nitrogen, Nitrite as N	mg/L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1	<0.1	0.1 L	<0.1	0.1 L
METALS, DISSOLVED																					
Aluminum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05	<0.1	0.1	<0.1	0.1
Arsenic	mg/L	0.004	0.001	0.004	0.001	0.004	0.001	0.005	0.001	0.026	0.001	0.024	0.001	0.028	0.001	0.028	0.001	0.008	0.001	0.008	0.001
Barium	mg/L	<0.1	0.1	0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Boron	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	29	1	31	1	26	1	30	1	8	1	9	1	8	1	8	1	4	1	5	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Iron	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Lead	mg/L	<0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0/1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.001	0.001	<0.001	0.001	0.001	0.001	0.001	0.001	0.139	0.001	0.143	0.001	0.197	0.001	0.153	0.001	0.001	0.001	<0.001	0.001
Vanadium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Zinc	mg/L	0.03	0.01	0.43	0.01	0.02	0.01	0.06	0.01	0.03	0.01	0.09	0.01	0.01	0.01	<0.01	0.01	0.05	0.01	0.05	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	3.52	0.01	2.61	0.01	4.79	0.01	3.05	0.01	3.51	0.01	3.23	0.01	2.23	0.01	1.66	0.01	3.95	0.01	4.55	0.01
Anions	meq/L	3.41	0.01	3.42	0.01	3.07	0.01	3.22	0.01	5.22	0.01	5.27	0.01	5.02	0.01	4.99	0.01	4.07	0.01	4.29	0.01
Cations	meq/L	3.18	0.01	3.25	0.01	2.79	0.01	3.02	0.01	4.86	0.01	4.94	0.01	5.25	0.01	4.83	0.01	3.76	0.01	3.92	0.01
Solids Total Dissolved Calculated		240	10	240	10	220	10	230	10	360	10	370	10	370	10	360	10	300	10	310	10
Calculated TDS/TDS Ratio	mg/L	1.04	0.01	1.08	0.01	1.00	0.01	1.04	0.01	1.00	0.01	1.00	0.01	1.00	0.01	1.08	0.01	0.93	0.01	1.10	0.01

Notes:
mg/L = milligrams per Liter
µmhos/cm = micromhos per centimeter
s.u. = standard unit
meq/L = milliequivalents per Liter
RL = Analyte Reporting Limit
L = Analyzed by a contract laboratory

Table 2.9-11. Non-radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	BOW 2010-8		BOW 2010-8		BOW 9		BOW 9		BOW 9		BOW 9		BOW 10		BOW 10		BOW 10		BOW 10	
	Date Collected:	6/16/2014		9/16/2014		11/8/2013		2/26/2014		6/16/2014		9/17/2014		11/8/2013		2/25/2014		6/16/2014		9/17/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	172	5	168	5	155	5	160	5	166	5	154	5	147	5	171	5	153	5	146	5
Bicarbonate as HCO3	mg/L	136	1	145	1	176	5	187	1	196	1	175	1	172	5	205	1	185	1	166	1
Carbonate as CO3	mg/L	37	1	30	1	6	1	4	1	3	1	6	1	4	1	1	1	1	1	6	1
Chloride	mg/L	4	1	4	1	10	1	7	1	5	1	5	1	11	1	8	1	6	1	4	1
Fluoride	mg/L	0.5	0.1	0.6	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.4	0.1	0.6	0.1
Magnesium	mg/L	<1	1	<1	1	8	1	9	1	9	1	9	1	9	1	10	1	10	1	9	1
Nitrogen Ammonia as N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	0.9	0.1	0.8	0.1	1.1	0.1	1.0	0.1	1.2	0.1	1.1	0.1	1.4	0.1	1.4	0.1	1.4	0.1	1.4	0.1
Potassium	mg/L	9	1	8	1	4	1	4	1	4	1	4	1	4	1	4	1	4	1	3	1
Silica	mg/L	81	1	81	1	66	1	67	1	71	1	66	1	66	1	68	1	72	1	66	1
Sodium	mg/L	87	1	79	1	28	1	20	1	20	1	19	1	26	1	27	1	22	1	21	1
Sulfate	mg/L	22	1	24	1	9	1	7	1	7	1	7	1	10	1	8	1	7	1	11	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	µmhos/cm	9.3	0.1	9.2	0.1	8.5	0.1	8.4	0.1	8.4	0.1	8.4	0.1	8.4	0.1	8.4	0.1	8.3	0.1	8.4	0.1
pH	s.u.	396	1	414	1	346	1	344	1	323	1	337	1	346	1	329	1	328	1	333	1
Solids Total Dissolved TDS @ 180 C	mg/L	320	10	330	10	230	10	270	10	250	10	260	10	230	10	250	10	250	10	260	10
Nitrogen, Nitrite as N	mg/L	<0.1	0.1 L	<0.1	0.1	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1
METALS, DISSOLVED																					
Aluminum	mg/L	<0.1	0.1	<0.05	0.05	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05
Arsenic	mg/L	0.007	0.001	0.007	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001
Barium	mg/L	<0.1	0.1	<0/1	0.1	<0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Boron	mg/L	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	5	1	5	1	30	1	34	1	35	1	32	1	29	1	31	1	32	1	29	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.005	0.005
Copper	mg/L	<0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Iron	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Lead	mg/L	<0.001	0.001	<0.001	0.001	<0.005	0.005	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.005	0.005	<0.001	0.001	<0.001	0.001	<0.001	0.001
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.001	0.001	0.001	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.003	0.001	0.002	0.001	0.001	0.001
Vanadium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Zinc	mg/L	0.05	0.01	0.04	0.01	0.03	0.01	<0.01	0.01	<0.01	0.01	0.01	0.01	0.02	0.01	0.04	0.01	<0.01	0.01	<0.01	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	1.70	0.01	2.72	0.01	2.59	0.01	3.59	0.01	3.03	0.01	3.65	0.01	1.89	0.01	3.51	0.01	0.60	0.01	2.8	0.01
Anions	meq/L	4.11	0.01	4.06	0.01	3.66	0.01	3.65	0.01	3.70	0.01	3.46	0.01	3.57	0.01	3.91	0.01	3.52	0.01	3.39	0.01
Cations	meq/L	4.25	0.01	3.85	0.01	3.48	0.01	3.40	0.01	3.48	0.01	3.22	0.01	3.44	0.01	3.65	0.01	3.48	0.01	3.2	0.01
Solids Total Dissolved Calculated		320	10	300	10	250	10	250	10	260	10	240	10	250	10	260	10	250	10	240	10
Calculated TDS/TDS Ratio	mg/L	1.00	0.01	1.1	0.01	0.92	0.01	1.08	0.01	0.96	0.01	1.08	0.01	0.92	0.01	0.96	0.01	1.00	0.01	1.08	0.01

Notes:
mg/L = milligrams per Liter
µmhos/cm = micromhos per centimeter
s.u. = standard unit
meq/L = milliequivalents per Liter
RL = Analyte Reporting Limit
L = Analyzed by a contract laboratory

Table 2.9-11. Non-radiological Analytical Results for Brule Formation Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	BOW 11		BOW 11		BOW 11		BOW 11	
	Date Collected:	11/8/2013		2/26/2014		6/17/2014		9/17/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS									
Alkalinity Total as CaCO3	mg/L	144	5	148	5	147	5	153	5
Bicarbonate as HCO3	mg/L	170	5	178	1	177	1	178	1
Carbonate as CO3	mg/L	3	1	1	1	1	1	4	1
Chloride	mg/L	5	1	5	1	4	1	5	1
Fluoride	mg/L	0.6	0.1	0.6	0.1	0.6	0.1	0.5	0.1
Magnesium	mg/L	7	1	7	1	7	1	7	1
Nitrogen Ammonia as N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	1.5	0.1	1.5	0.1	1.5	0.1	1.6	0.1
Potassium	mg/L	4	1	5	1	5	1	5	1
Silica	mg/L	59	1	61	1	61	1	59	1
Sodium	mg/L	19	1	20	1	18	1	19	1
Sulfate	mg/L	11	1	11	1	11	1	7	1
PHYSICAL PROPERTIES									
Conductivity @ 25 C	µmhos/cm	8.4	0.1	8.4	0.1	8.3	0.1	8.4	0.1
pH	s.u.	325	1	330	1	309	1	336	1
Solids Total Dissolved TDS @ 180 C	mg/L	250	10	260	10	240	10	260	10
Nitrogen, Nitrite as N	mg/L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1
METALS, DISSOLVED									
Aluminum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05
Arsenic	mg/L	0.005	0.001	0.005	0.001	0.005	0.001	0.005	0.001
Barium	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Boron	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	34	1	35	1	35	1	34	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Iron	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Lead	mg/L	<0.005	0.005	<0.001	0.001	<0.001	0.001	<0.001	0.001
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.002	0.001	<0.001	0.001	0.002	0.001	0.002	0.001
Vanadium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Zinc	mg/L	<0.01	0.01	0.02	0.01	<0.01	0.01	<0.01	0.01
DATA QUALITY									
A/C Balance (± 5)	%	2.90	0.01	2.09	0.01	3.00	0.01	4.18	0.01
Anions	meq/L	3.38	0.01	3.45	0.01	3.41	0.01	3.47	0.01
Cations	meq/L	3.19	0.01	3.31	0.01	3.21	0.01	3.19	0.01
Solids Total Dissolved Calculated		230	10	240	10	240	10	230	10
Calculated TDS/TDS Ratio	mg/L	1.09	0.01	1.08	0.01	1.00	0.01	1.13	0.01

Notes:
mg/L = milligrams per Liter
µmhos/cm = micromhos per centimeter
s.u. = standard unit
meq/L = milliequivalents per Liter
RL = Analyte Reporting Limit
L = Analyzed by a contract laboratory

Table 2.9-12. Radiological Analytical Results for Arikaree Monitoring Well Quarterly Sampling 2013-2014

Location ID:		AOW-3		AOW-3		AOW-3		AOW-3		AOW-4		AOW-4		AOW-4		AOW-4		AOW-5		AOW-5	
Date Collected:		11/8/2013		2/25/2014		6/16/2014		9/16/2014		11/8/2013		2/25/2014		6/16/2014		9/17/2014		11/8/2013		2/26/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	NA		4E-10		3E-10		NA		NA		4E-10		3E-9		4E-10		NA		4E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	NA		2E-10		2E-10		NA		NA		2E-10		2E-10		1E-10		NA		2E-10	
Radium 226	µCi/mL	<2E-10	2E-10	2E-10	2E-10	3E-10	2E-10	4E-10	2E-10	<2E-10	2E-10	2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	NA		1E-10		1E-10		1E-10		NA		1E-10		1E-10		4E-11		NA		3E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	NA		1E-10		0.0		NA		NA		1E-10		4E-11		4E-11		NA		1E-10	
Thorium 230 Tracer (30-120)	µCi/mL	66		87		100		76		61		100		91		86		57		100	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1.1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1.2E-9	1E-9	1.3E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	NA		5E-10		4E-10		6E-10		NA		4E-10		4E-10		6E-10		NA		4E-10	
Polonium 210	µCi/mL	2E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1.2E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1.1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	7E-10		2E-10		2E-10		5E-10		NA		2E-10		1E-10		5E-10		NA		2E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	6E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	3E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	NA		4E-11		0.0		1E-10		NA		3E-11		0.0		1E-10		NA		3E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	NA		3E-11		3E-11		NA		NA		4E-11		1E-10		1E-10		NA		3E-11	
Thorium 230 Tracer (30-120)	µCi/mL	68		100		90		99		64		98		96		78		68		100	
METALS, DISSOLVED																					
Uranium	mg/L	0.0087	0.0003	0.0068	0.0003	0.0052	0.0003	0.0041	0.0003	0.0052	0.0003	0.0041	0.0003	0.0051	0.0003	0.0044	0.0003	0.0077	0.0003	0.0077	0.0003
Uranium Activity	µCi/mL	5.9E-9	2E-10	4.6E-9	2E-10	3.5E-9	2E-10	2.8E-9	2E-10	3.5E-9	2E-10	2.8E-9	2E-10	3.5E-9	2E-10	3E-9	2E-10	5.2E-9	2E-10	5.2E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	0.0004	0.0003	0.0006	0.0003	<0.0003	0.0003	0.0004	0.0003	0.0017	0.0003	<0.0003	0.0003	<0.0003	0.0003	0.0004	0.0003	0.0004	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	3E-10	2E-10	4E-10	2E-10	<2E-10	2E-10	3E-10	2E-10	1.2E-9	2E-10	<2E-10	2E-10	<2E-10	2E-10	3E-10	2E-10	3E-10	2E-10	<2E-10	2E-10

Notes:
µCi/mL = microcuries per milliliter
mg/L = milligrams per Liter
RL - Analyte reporting limit
AOW-1 & AOW-7; Do not produce sufficient water volume to produce sample
AOW-2 - Not drilled

Table 2.9-12. Radiological Analytical Results for Arikaree Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	AOW-5		AOW-5		AOW-6		AOW-6		AOW-6		AOW-6		AOW-8		AOW-8		AOW-8		AOW-8	
	Date Collected:	6/17/2014		9/17/2014		11/8/2013		2/26/2014		6/17/2014		9/17/2014		11/8/2013		2/26/2014		6/16/2014		9/16/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	1.3E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1.3E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	4E-10		4E-10		NA		4E-10		0.3		4E-10		4E-10		4E-10		3E-10		NA	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	1E-10		1E-10		NA		1E-10		2E-10		2E-10		NA		2E-10		2E-10		NA	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	0.0		5E-11		NA		4E-11		0.0		3E-11		NA		4E-11		0.0		NA	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	2E-11		1E-10		NA		0.0		0.03		0.0		NA		5E-11		2E-11		NA	
Thorium 230 Tracer (30-120)	µCi/mL	95		86		63		94		87		75		63		71		89		69	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	2E-9	1E-9	1.4E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1.1E-9	1E-9	3.1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	6E-10		6E-10		NA		4E-10		7E-10		7E-10		NA		4E-10		4E-10		NA	
Polonium 210	µCi/mL	<1E-9	1E-9	1.9E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	1E-10		6E-10		NA		2E-10		2E-10		4E-10		NA		2E-10		2E-10		NA	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	0.0		4E-11		NA		2E-11		0.0		4E-11		NA		3E-11		0.0		NA	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	4E-11		2E-11		NA		2E-11		2E-11		5E-11		NA		1E-10		2E-11		2E-10	
Thorium 230 Tracer (30-120)	µCi/mL	91		93		69		96		79		70		74		110		96		32	
METALS, DISSOLVED																					
Uranium	mg/L	0.0072	0.0003	0.0071	0.0003	0.0069	0.0003	0.0070	0.0003	0.0062	0.0003	0.0062	0.0003	0.0039	0.0003	0.0041	0.0003	0.0039	0.0003	0.0038	0.0003
Uranium Activity	µCi/mL	4.9E-9	2E-10	4.8E-9	2E-10	4.7E-9	2E-10	4.7E-9	2E-10	4.2E-9	2E-10	4.2E-9	2E-10	2.6E-9	2E-10	2.8E-9	2E-10	2.6E-9	2E-10	2.6E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	0.0009	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	0.0004	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	6E-9	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	3E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
µCi/mL = microcuries per milliliter
mg/L = milligrams per Liter
RL - Analyte reporting limit
AOW-1 & AOW-7; Do not produce sufficient water volume to produce sample
AOW-2 - Not drilled

Table 2.9-12. Radiological Analytical Results for Arikaree Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	AOW-9		AOW-9		AOW-9		AOW-9		AOW-10		AOW-10		AOW-10		AOW-10		AOW-11		AOW-11	
	Date Collected:	11/8/2013		2/26/2014		6/17/2014		9/17/2014		11/8/2013		2/25/2014		6/16/2014		9/17/2014		11/8/2013		2/26/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<1E-9	1E-9	1E-9	1E-9	1.4E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1.2E-9	1E-9	<1E-9	1E-9	1.1E-9	1E-9
Lead 210 precision (±)	µCi/mL	NA		7E-10		6E-10		5E-10		NA		4E-10		3E-10		5E-10		NA		4E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	NA		2E-10		1E-10		3E-10		NA		1E-10		1E-10		2E-10		NA		1E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	NA		3E-11		0.0		4E-11		NA		4E-11		3E-11		4E-11		NA		3E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	NA		3E-11		3E-11		0		NA		5E-11		0.0		1E-10		NA		3E-11	
Thorium 230 Tracer (30-120)	µCi/mL	71		100		82		82		74		85		75		88		76		88	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	4.8E-9	1E-9	<1E-9	1E-9	1.1E-9	1E-9	<1E-9	1E-9	4.1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	NA		6E-10		4E-10		8E-10		NA		5E-10		4E-10		7E-10		NA		4E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	1.3E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	NA		2E-10		2E-10		6E-10		NA		3E-10		2E-10		4E-10		NA		1E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	3E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	NA		4E-11		0.0		1E-10		NA		3E-11		0.0		4E-11		NA		2E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	NA		1E-10		1E-10		1E-10		NA		4E-11		1E-10		1E-10		NA		4E-11	
Thorium 230 Tracer (30-120)	µCi/mL	71		110		93		80		72		96		95		84		74		110	
METALS, DISSOLVED																					
Uranium	mg/L	0.0083	0.0003	0.0074	0.0003	0.0077	0.0003	0.0077	0.0003	0.0069	0.0003	0.0069	0.0003	0.0069	0.0003	0.0068	0.0003	0.0067	0.0003	0.0064	0.0003
Uranium Activity	µCi/mL	5.6E-9	2E-10	5E-9	2E-10	5.2E-9	2E-10	5.2E-9	1E-10	4.7E-9	2E-10	4.7E-9	2E-10	4.7E-9	2E-10	4.6E-9	2E-10	4.5E-9	2E-10	4.3E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	0.0004	0.0003	0.0003	0.0003	<0.0003	0.0003	0.0008	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	3E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	5E-9	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
µCi/mL = microcuries per milliliter
mg/L = milligrams per Liter
RL - Analyte reporting limit
AOW-1 & AOW-7; Do not produce sufficient water volume to produce sample
AOW-2 - Not drilled

Table 2.9-12. Radiological Analytical Results for Arikaree Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	AOW-11		AOW-11	
	Date Collected:	6/17/2014		9/17/2014	
Analyte	Units	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED					
Lead 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	3E-10		5E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	1E-10		2E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	0.0		5E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	0.0		2E-11	
Thorium 230 Tracer (30-120)	µCi/mL	75	76	85	
RADIONUCLIDES-SUSPENDED					
Lead 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	4E-10		5E-10	
Polonium 210	µCi/mL	<1E-9	1E-9	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	0.1		1E-10	
Radium 226	µCi/mL	<2E-10	2E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	0.0		4E-11	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	4E-11		1E-10	
Thorium 230 Tracer (30-120)	µCi/mL	95	74	81	
METALS, DISSOLVED					
Uranium	mg/L	0.0065	0.0067	0.0067	0.0003
Uranium Activity	µCi/mL	4.4E-9	2E-10	4.5E-9	2E-10
METALS, SUSPENDED					
Uranium	mg/L	<0.0003	<0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10

Notes:
µCi/mL = microcuries per milliliter
mg/L = milligrams per Liter
RL - Analyte reporting limit
AOW-1 & AOW-7; Do not produce sufficient water volume to produce sample
AOW-2 - Not drilled

Table 2.9-13. Non-radiological Analytical Results for Arikaree Monitoring Well Quarterly Sampling 2013-2014

Location ID:		AOW-3		AOW-3		AOW-3		AOW-3		AOW-4		AOW-4		AOW-4		AOW-4		AOW-5		AOW-5	
Date Collected:		11/8/2013		2/25/2014		6/16/2014		9/16/2014		11/8/2013		2/25/2014		6/16/2014		9/17/2014		11/8/2013		2/26/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	188	5	185	5	181	5	169	5	148	5	148	5	150	5	145	5	149	5	154	5
Bicarbonate as HCO3	mg/L	220	5	219	1	221	1	206	1	170	5	174	1	179	1	173	1	174	5	188	1
Carbonate as CO3	mg/L	4	1	3	1	<1	1	<1	1	5	1	3	1	2	1	2	1	4	1	<1	1
Chloride	mg/L	1	1	2	1	1	1	2	1	7	1	5	1	4	1	4	1	2	1	3	1
Fluoride	mg/L	0.7	0.1	0.7	0.1	0.7	0.1	0.5	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.5	0.1	0.5	0.1
Magnesium	mg/L	18	1	17	1	16	1	14	1	7	1	6	1	7	1	6	1	8	1	8	1
Nitrogen Ammonia as N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	1.9	0.1	2.0	0.1	1.4	0.1	1	0.3	0.8	0.1	0.8	0.1	0.9	0.1	0.5	0.1	1.2	0.1	1.1	0.1
Potassium	mg/L	2	1	2	1	3	1	2	1	4	1	4	1	4	1	4	1	4	1	4	1
Silica	mg/L	76	1	73	1	77	1	64	1	60	1	63	1	66	1	60	1	64	1	67	1
Sodium	mg/L	13	1	14	1	12	1	13	1	19	1	26	1	17	1	18	1	19	1	18	1
Sulfate	mg/L	4	1	4	1	4	1	4	1	9	1	9	1	8	1	8	1	7	1	7	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	µmhos/cm	8.4	0.1	8.4	0.1	8.3	0.1	8.3	0.1	8.5	0.1	8.4	0.1	8.4	0.1	8.5	0.1	8.4	0.1	8.3	0.1
pH	s.u.	370	1	360	1	347	1	348	1	324	1	316	1	310	1	308	1	313	1	319	1
Solids Total Dissolved TDS @ 180 C	mg/L	280	10	240	10	280	10	300	10	230	10	240	10	240	10	240	10	220	10	250	10
Nitrogen, Nitrite as N	mg/L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L
METALS, DISSOLVED																					
Aluminum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05	<0.1	0.1	<0.1	0.1
Arsenic	mg/L	0.0003	0.001	0.003	0.001	0.003	0.001	0.002	0.001	0.005	0.001	0.004	0.001	0.004	0.001	0.005	0.001	0.003	0.001	0.003	0.001
Barium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	0.1	0.1
Boron	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	37	1	37	1	36	1	34	1	35	1	36	1	38	1	35	1	31	1	33	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	0.03	0.01	0.01	0.01	0.02	0.01	0.01	0.01	<0.01	0.01	0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Iron	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Lead	mg/L	<0.005	0.005	0.002	0.001	0.002	0.001	0.002	0.001	<0.005	0.005	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.005	0.005	<0.001	0.001
Manganese	mg/L	<0.01	0.01	<0.01	0.01	0.01	0.01	0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.001	0.001	0.002	0.001	<0.001	0.001	<0.001	0.001	0.002	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.002	0.001	<0.001	0.001
Vanadium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Zinc	mg/L	1.97	0.01	1.08	0.01	2.15	0.01	1.38	0.01	0.23	0.01	0.29	0.01	0.31	0.01	0.23	0.01	0.11	0.01	0.10	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	1.80	0.01	1.15	0.01	2.33	0.01	1.36	0.01	2.56	0.01	3.04	0.01	0.40	0.01	1.64	0.01	2.21	0.01	2.83	0.01
Anions	meq/L	4.04	0.01	4.01	0.01	3.88	0.01	3.61	0.01	3.41	0.01	3.37	0.01	3.35	0.01	3.27	0.01	3.30	0.01	3.40	0.01
Cations	meq/L	3.89	0.01	3.92	0.01	3.70	0.01	3.51	0.01	3.24	0.01	3.58	0.01	3.32	0.01	3.16	0.01	3.16	0.01	3.22	0.01
Solids Total Dissolved Calculated		270	10	270	10	260	10	240	10	230	10	240	10	240	10	230	10	230	10	240	10
Calculated TDS/TDS Ratio	mg/L	1.04	0.01	0.89	0.01	1.08	0.01	1.25	0.01	1.00	0.01	1.00	0.01	1.00	0.01	1.04	0.01	0.96	0.01	1.04	0.01

Notes:
mg/L = milligrams per Liter
µmhos/cm = micromhos per centimeter
s.u. = standard unit
meq/L = milliequivalents per Liter
RL = Analyte Reporting Limit
L = Analyzed by a contract laboratory
AOW-1 & AOW-7; Do not produce sufficient water volume to produce sample
AOW-2 - Not drilled

Table 2.9-13. Non-radiological Analytical Results for Arikaree Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	AOW-5		AOW-5		AOW-6		AOW-6		AOW-6		AOW-6		AOW-8		AOW-8		AOW-8		AOW-8	
	Date Collected:	6/17/2014		9/15/2014		11/8/2013		2/26/2014		6/17/2014		9/17/2014		11/8/2013		2/26/2014		6/16/2014		9/16/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	153	5	147	5	163	5	163	5	159	5	162	5	133	5	138	5	131	5	136	5
Bicarbonate as HCO3	mg/L	183	1	179	1	193	5	199	1	193	1	185	1	155	5	169	1	160	1	163	1
Carbonate as CO3	mg/L	2	1	<1	1	3	1	<1	1	<1	1	6	1	3	1	<1	1	<1	1	2	1
Chloride	mg/L	2	1	2	1	8	1	5	1	4	1	4	1	8	1	5	1	1	1	<1	1
Fluoride	mg/L	0.5	0.1	0.5	0.1	0.6	0.1	0.6	0.1	0.5	0.1	0.6	0.1	0.4	0.1	0.4	0.1	0.4	0.1	0.4	0.1
Magnesium	mg/L	8	1	8	1	8	1	8	1	7	1	8	1	12	1	11	1	11	1	10	1
Nitrogen Ammonia as N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	1.2	0.1	1.2	0.1	2.6	0.1	2.3	0.1	2.4	0.1	2.5	0.1	1.2	0.1	1.6	0.1	0.9	0.1	1.4	0.1
Potassium	mg/L	4	1	4	1	5	1	5	1	5	1	5	1	1	1	1	1	1	1	1	1
Silica	mg/L	67	1	64	1	57	1	60	1	59	1	57	1	72	1	74	1	77	1	78	1
Sodium	mg/L	18	1	20	1	20	1	19	1	18	1	18	1	6	1	6	1	6	1	6	1
Sulfate	mg/L	7	1	7	1	12	1	11	1	10	1	10	1	3	1	3	1	1	1	2	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	µmhos/cm	8.3	0.1	8.4	0.1	8.4	0.1	8.3	0.1	8.3	0.1	8.4	0.1	8.4	0.1	8.3	0.1	8.3	0.1	8.3	0.1
pH	s.u.	300	1	312	1	377	1	362	1	341	1	360	1	287	1	288	1	248	1	281	1
Solids Total Dissolved TDS @ 180 C	mg/L	250	10	240	10	260	10	280	10	260	10	260	10	220	10	240	10	220	10	270	10
Nitrogen, Nitrite as N	mg/L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L
METALS, DISSOLVED																					
Aluminum	mg/L	<0.1	0.1	<0.05	0.05	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05
Arsenic	mg/L	0.003	0.001	0.003	0.001	0.005	0.001	0.005	0.001	0.005	0.001	0.005	0.001	0.002	0.001	0.002	0.001	0.002	0.001	0.001	0.001
Barium	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Boron	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	32	1	32	1	42	1	42	1	40	1	40	1	33	1	33	1	34	1	32	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Iron	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Lead	mg/L	<0.001	0.001	<0.001	0.001	<0.005	0.005	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.005	0.005	<0.001	0.001	<0.001	0.001	<0.001	0.001
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	<0.001	0.001	0.001	0.001	0.002	0.001	<0.001	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Vanadium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Zinc	mg/L	0.10	0.01	0.1	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.19	0.01	0.20	0.01	0.28	0.01	0.21	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	3.61	0.01	0.32	0.01	2.62	0.01	2.64	0.01	2.37	0.01	3.12	0.01	1.95	0.01	3.74	0.01	2.53	0.01	2.12	0.01
Anions	meq/L	3.36	0.01	3.25	0.01	3.93	0.01	3.82	0.01	3.70	0.01	3.77	0.01	3.03	0.01	3.09	0.01	2.76	0.01	2.88	0.01
Cations	meq/L	3.13	0.01	3.23	0.01	3.73	0.01	3.62	0.01	3.53	0.01	3.54	0.01	2.91	0.01	2.86	0.01	2.91	0.01	2.76	0.01
Solids Total Dissolved Calculated		230	10	230	10	260	10	260	10	250	10	250	10	220	10	220	10	210	10	220	10
Calculated TDS/TDS Ratio	mg/L	1.09	0.01	1.04	0.01	1.00	0.01	1.08	0.01	1.04	0.01	1.04	0.01	1.00	0.01	1.09	0.01	1.05	0.01	1.23	0.01

Notes:
mg/L = milligrams per Liter
µmhos/cm = micromhos per centimeter
s.u. = standard unit
meq/L = milliequivalents per Liter
RL = Analyte Reporting Limit
L = Analyzed by a contract laboratory
AOW-1 & AOW-7; Do not produce sufficient water volume to produce sample
AOW-2 - Not drilled

Table 2.9-13. Non-radiological Analytical Results for Arikaree Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	AOW-9		AOW-9		AOW-9		AOW-9		AOW-10		AOW-10		AOW-10		AOW-10		AOW-11		AOW-11	
	Date Collected:	11/8/2013		2/26/2014		6/17/2014		9/17/2014		11/8/2013		2/25/2014		6/16/2014		9/17/2014		11/8/2013		2/26/2014	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	153	5	160	5	161	5	154	6	150	5	156	5	154	5	154	5	166	5	171	5
Bicarbonate as HCO3	mg/L	178	5	194	1	194	1	179	1	182	5	186	1	186	1	177	1	195	5	207	1
Carbonate as CO3	mg/L	4	1	<1	1	<1	1	4	1	<1	1	2	1	<1	1	6	1	4	1	1	1
Chloride	mg/L	4	1	4	1	4	1	4	1	4	1	6	1	3	1	6	1	10	1	7	1
Fluoride	mg/L	0.5	0.1	0.5	0.1	0.4	0.1	0.5	0.1	0.5	0.1	0.5	0.1	0.4	0.1	3	1	0.6	0.1	0.5	0.1
Magnesium	mg/L	8	1	8	1	8	1	8	1	9	1	9	1	9	1	9	1	9	1	8	1
Nitrogen Ammonia as N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	1.2	0.1	1.3	0.1	1.4	0.1	1.3	0.1	2.1	0.1	2.1	0.1	2.4	0.1	2.3	0.1	3.6	0.1	3.1	0.1
Potassium	mg/L	4	1	4	1	4	1	4	1	3	1	3	1	4	1	4	1	5	1	4	1
Silica	mg/L	64	1	67	1	65	1	64	1	63	1	65	1	68	1	63	1	57	1	59	1
Sodium	mg/L	19	1	18	1	18	1	18	1	21	1	24	1	20	1	20	1	18	1	16	1
Sulfate	mg/L	8	1	8	1	8	1	7	1	8	1	8	1	6	1	7	1	10	1	9	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	µmhos/cm	8.4	0.1	8.3	0.1	8.3	0.1	8.4	0.1	8.4	0.1	8.3	0.1	8.3	0.1	8.4	0.1	8.4	0.1	8.3	0.1
pH	s.u.	325	1	333	1	327	1	331	1	328	1	332	1	324	1	295	1	398	1	379	1
Solids Total Dissolved TDS @ 180 C	mg/L	220	10	270	10	260	10	250	10	230	10	240	10	260	10	270	10	260	10	290	10
Nitrogen, Nitrite as N	mg/L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1 L	<0.1	0.1	<0.1	0.1 L	<0.1	0.1 L
METALS, DISSOLVED																					
Aluminum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.05	0.05	<0.1	0.1	<0.1	0.1
Arsenic	mg/L	0.003	0.001	0.002	0.001	0.002	0.001	0.003	0.001	0.002	0.001	0.002	0.001	0.002	0.001	0.003	0.001	0.004	0.001	0.004	0.001
Barium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Boron	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	34	1	35	1	36	1	34	1	32	1	34	1	34	1	32	1	48	1	46	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Iron	mg/L	0.06	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Lead	mg/L	<0.005	0.005	<0.001	0.001	<0.001	0.001	0.002	0.001	<0.005	0.005	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.005	0.005	<0.001	0.001
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.002	0.001	<0.001	0.001	0.002	0.001	0.001	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.002	0.001	<0.001	0.001
Vanadium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Zinc	mg/L	0.22	0.01	0.31	0.01	0.40	0.01	0.42	0.01	0.21	0.01	0.23	0.01	0.26	0.01	0.26	0.01	<0.01	0.01	<0.01	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	2.25	0.01	4.65	0.01	4.11	0.01	3.14	0.01	1.92	0.01	<0.01	0.01	0.92	0.01	3.72	0.01	1.23	0.01	4.15	0.01
Anions	meq/L	3.44	0.01	3.58	0.01	3.61	0.01	3.46	0.01	3.46	0.01	3.61	0.01	3.51	0.01	3.52	0.01	4.09	0.01	4.05	0.01
Cations	meq/L	3.29	0.01	3.26	0.01	3.33	0.01	3.25	0.01	3.33	0.01	3.61	0.01	3.44	0.01	3.26	0.01	3.99	0.01	3.72	0.01
Solids Total Dissolved Calculated		240	10	240	10	250	10	240	10	240	10	250	10	250	10	240	10	270	10	270	10
Calculated TDS/TDS Ratio	mg/L	0.92	0.01	1.12	0.01	1.04	0.01	1.04	0.01	0.96	0.01	0.96	0.01	1.04	0.01	1.12	0.01	0.96	0.01	1.07	0.01

Notes:
mg/L = milligrams per Liter
µmhos/cm = micromhos per centimeter
s.u. = standard unit
meq/L = milliequivalents per Liter
RL = Analyte Reporting Limit
L = Analyzed by a contract laboratory
AOW-1 & AOW-7; Do not produce sufficient water volume to produce sample
AOW-2 - Not drilled

Table 2.9-13. Non-radiological Analytical Results for Arikaree Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	AOW-11		AOW-11	
	Date Collected:	6/17/2014		9/17/2014	
Analyte	Units	RESULT	RL	RESULT	RL
MAJOR IONS					
Alkalinity Total as CaCO3	mg/L	167	5	165	5
Bicarbonate as HCO3	mg/L	201	1	194	1
Carbonate as CO3	mg/L	1	1	4	1
Chloride	mg/L	7	1	4	1
Fluoride	mg/L	0.5	0.1	0.5	0.1
Magnesium	mg/L	8	1	8	1
Nitrogen Ammonia as N	mg/L	<0.05	0.05	<0.05	0.05
Nitrogen Nitrate+Nitrite as N	mg/L	3.3	0.1	3.2	0.1
Potassium	mg/L	5	1	5	1
Silica	mg/L	59	1	58	1
Sodium	mg/L	16	1	15	1
Sulfate	mg/L	9	1	9	1
PHYSICAL PROPERTIES					
Conductivity @ 25 C	µmhos/cm	8.3	0.1	8.4	0.1
pH	s.u.	366	1	338	1
Solids Total Dissolved TDS @ 180 C	mg/L	280	10	290	1
Nitrogen, Nitrite as N	mg/L	<0.1	0.1 L	<0.1	0.1
METALS, DISSOLVED					
Aluminum	mg/L	<0.1	0.1	<0.05	0.05
Arsenic	mg/L	0.004	0.001	0.004	0.001
Barium	mg/L	0.1	0.1	0.1	0.1
Boron	mg/L	<0.1	0.1	<0.1	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005
Calcium	mg/L	46	1	44	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.01
Iron	mg/L	<0.05	0.05	<0.05	0.05
Lead	mg/L	<0.001	0.001	<0.001	0.001
Manganese	mg/L	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.001	0.001	0.002	0.001
Vanadium	mg/L	<0.1	0.1	<0.1	0.1
Zinc	mg/L	<0.01	0.01	<0.01	0.01
DATA QUALITY					
A/C Balance (± 5)	%	2.30	0.01	2.6	0.01
Anions	meq/L	3.99	0.01	3.86	0.01
Cations	meq/L	3.81	0.01	3.66	0.01
Solids Total Dissolved Calculated		270	10	260	10
Calculated TDS/TDS Ratio	mg/L	1.04	0.01	1.12	0.01

Notes:
mg/L = milligrams per Liter
µmhos/cm = micromhos per centimeter
s.u. = standard unit
meq/L = milliequivalents per Liter
RL = Analyte Reporting Limit
L = Analyzed by a contract laboratory
AOW-1 & AOW-7; Do not produce sufficient water volume to produce sample
AOW-2 - Not drilled

Table 2.9-14. Radiological Analytical Results for Chadron Monitoring Well Quarterly Sampling 2013-2014

	Location ID:	Monitor 1		Monitor 1		Monitor 1		Monitor 1		Monitor 2		Monitor 2		Monitor 2		Monitor 2		CPW-2010-1		CPW-2010-1	
	Date Collected:	11/7/2011		2/13/2012		6/4/2012		8/20/2012		11/7/2011		2/13/2012		6/4/2012		8/20/2012		11/7/2011		2/13/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	1.35E-7	8E-10	1.1E-8	1E-9	3.96E-8	1.1E-9	1.97E-8	1E-9	9E-10	8E-10	<1E-9	1E-9	<8E-10	8E-10	2.8E-9	1E-9	1.53E-8	1.3E-9	3.6E-9	1E-9
Lead 210 precision (±)	µCi/mL	1.1E-9		9E-10		1.2E-9		1.1E-09		5E-10		NA		5E-10		5E-10		9E-10		5E-10	
Lead 210 MDC	µCi/mL	8E-10		-		1.1E-9		-		8E-10		-		8E-10		-		1.3E-9		-	
Polonium 210	µCi/mL	1.7E-8	9E-10	<1E-9	1E-9	4.9E-9	6E-10	1E-9	1E-9	3.3E-9	9E-10	<1E-9	1E-9	<5E-10	5E-10	<1E-9	1E-9	6.6E-9	6E-10	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	5.7E-9		NA		1.8E-9		8E-10		1.7E-9		NA		3E-10		NA		2.2E9		NA	
Polonium 210 MDC	µCi/mL	9E-10		-		6E-10		-		9E-10		-		5E-10		-		6E-10		-	
Radium 226	µCi/mL	1.5E-8	1E-10	1.23E-8	2E-10	1.7E-8	1.7E-10	1.29E-8	2E-10	1.7E-9	1E-10	<1.2E-9	2E-10	1.E-9	1.6E-10	1.9E-9	2E-10	2.3E-08	1E-10	2.75E-8	2E-10
Radium 226 precision (±)	µCi/mL	7E-10		4E-10		8.3E-10		5E-10		3E-10		1E-10		2.8E-10		1E-10		8E-10		6E-10	
Radium 226 MDC	µCi/mL	1E-10		-		1.7E-10		-		1E-10		-		1.6E-10		-		1E-10		-	
Thorium 230	µCi/mL	6E-10	2E-10	<2E-10	2E-10	4E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	2E-10		NA		2E-10		NA		9E-11		NA		7E-11		NA		9E-11		NA	
Thorium 230 MDC	µCi/mL	2E-10		-		2E-10		-		2E-10		-		2E-10		-		2E-10		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	6.5E-8	1.1E-9	6.12E-8	1E-9	4.49E-8	8E-10	5.3E-8	1E-9	1.2E-9	9E-10	1.1E-9	1E-9	<8E-10	8E-10	1.2E-9	1E-9	1.5E-9	9E-10	5.6E-9	1E-9
Lead 210 precision (±)	µCi/mL	1.4E-9		2.1E-9		1E-9		1.5E-9		6E-10		5E-10		5E-10		3E-10		6E-10		6E-10	
Lead 210 MDC	µCi/mL	1.1E-9		-		8E-10		-		9E-10		-		8E-10		-		9E-10		-	
Polonium 210	µCi/mL	2.3E-8	2E-10	8.8E-9	1E-9	1.48E-8	6E-10	2.5E-9	1E-9	3E-10	3E-10	<1E-9	1E-9	<3E-10	3E-10	<1E-9	1E-9	8E-10	2E-10	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	5.2E-9		1E-9		5.4E-9		8E-10		2E-10		NA		3E-10		NA		4E-10		NA	
Polonium 210 MDC	µCi/mL	2E-10		-		6E-10		-		3E-10		-		3E-10		-		2E-10		-	
Radium 226	µCi/mL	1.8E-8	1E-10	8.8E-9	2E-10	1.7E-8	1.2E-10	7.8E-9	1E-10	9E-10	1E-10	5E-10	2E-10	3.2E-10	1.3E-10	3E-10	1E-10	1.6E-9	1E-10	1.7E-9	1E-10
Radium 226 precision (±)	µCi/mL	6E-10		5E-10		7.2E-10		3E-10		1E-10		1E-10		1.3E-10		1E-10		2E-10		2E-10	
Radium 226 MDC	µCi/mL	1E-10		-		1.2E-10		-		1E-10		-		1.3E-10		-		1E-10		-	
Thorium 230	µCi/mL	1E-8	1E-10	4.3E-9	2E-10	1.01E-8	1E-10	3E-9	2E-10	2E-10	1E-10	<2E-10	2E-10	<1E-10	1.0E-10	<2E-10	2E-10	<1E-10	1E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	1.2E-9		6E-10		1.5E-9		5E-10		1E-10		NA		9E-11		NA		6E-11		NA	
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10		-		1E-10		-		1E-10		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0060	0.0003	0.0064	0.0003	0.0062	0.0003	0.0073	0.0003	0.0023	0.0003	0.0034	0.0003	0.0021	0.0003	0.0017	0.0003	0.0142	0.0003	0.0091	0.0003
Uranium Activity	µCi/mL	4E-9	2E-10	4.3E-10	2E-10	4.2E-9	2E-10	4.9E-10	2E-10	1.6E-9	2E-10	2.3E-10	2E-10	1.4E-9	2E-10	1.2E-10	2E-10	9.6E-9	2E-10	6.2E-9	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	0.0403	0.0003	0.0008	0.0003	0.0295	0.0003	0.0092	0.0003	0.0010	0.0003	<0.0003	0.0003	0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	2.7E-8	2E-10	5E-10	2E-10	2E-8	2E-10	6.9E-10	2E-10	6.9E-10	2E-10	<2E-10	2E-10	2.1E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
µCi/mL = microcuries per milliliter
mg/L = milligrams per Liter
MDC - minimum detectable concentration
LLD - lower limit of detection
RL - Analyte reporting limit

Table 2.9-14. Radiological Analytical Results for Chadron Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	CPW-2010-1		CPW-2010-1		Monitor 4A		Monitor 4A		Monitor 4A		Monitor 4A		Monitor 5		Monitor 5		Monitor 5		Monitor 5	
	Date Collected:	6/4/2012		8/20/2012		11/7/2011		2/13/2012		6/4/2012		8/20/2012		11/7/2011		2/13/2012		6/4/2012		8/20/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	4.9E-9	1.1E-09	5.8E-9	1E-9	1.13E-6	1.3E-09	5.91E-7	1E-9	6.04E-7	1.1E-9	5.4E-07	1E-9	<8E-10	8E-10	<1E-9	1E-9	<8E-10	8E-10	1.6E-9	1E-9
Lead 210 precision (±)	µCi/mL	7E-10		6E-10		4.6E-9		5.3E-9		4.1E-9		5.4E-09		5E-10		NA		5E-10		4E-10	
Lead 210 MDC	µCi/mL	1.1E-10		-		1.3E-9		-		1.1E-9		-		8E-10		-		8E-10		-	
Polonium 210	µCi/mL	<5E-10	5E-10	<1E-9	1E-9	1.65E-7	1.2E-09	6.26E-8	1E-9	1.04E-7	5E-10	1E-07	1E-9	<7E-10	7E-10	<1E-9	1E-9	<5E-10	5E-10	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	3E-10		NA		5.4E-8		3.2E-9		2.11E-8		4.3E-09		5E-10		NA		3E-10		NA	
Polonium 210 MDC	µCi/mL	5E-10		-		1.2E-9		-		5E-10		-		7E-10		-		5E-10		-	
Radium 226	µCi/mL	2.4E-8	1.7E-10	1.43E-8	2E-10	2.62E-7	2.0E-10	3.2E-7	2E-10	3.9E-7	1.7E-10	3.48E-07	2E-10	3.5E-9	1E-10	9E-10	2E-10	3.4E-9	1.7E-10	5.5E-10	2E-10
Radium 226 precision (±)	µCi/mL	9.8E-10		4E-10		3E-9		2.2E-9		4E-09		2.3E-09		3E-10		1E-10		3.9E-10		3E-10	
Radium 226 MDC	µCi/mL	1.7E-10		-		1E-10		-		1.7E-10		-		1E-10		-		1.7E-10		-	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2.0E-10	7E-11	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	8E-11		NA		1E-10		2E-10		9E-09		NA		1E-10		NA		8E-11		NA	
Thorium 230 MDC	µCi/mL	2E-10		-		2E-10		-		2E-10		-		2E-10		-		2E-10		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	2.3E-9	9E-10	6.4E-9	1E-9	2.2E-8	9E-10	4.97E-8	1E-9	1.76E-8	8E-10	6.04E-08	1E-9	<9E-10	9E-10	<1E-9	1E-9	<8E-10	8E-10	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	6E-10		7E-10		9E-10		1.5E-9		7E-10		2.20E-09		6E-10		NA		4E-10		NA	
Lead 210 MDC	µCi/mL	9E-10		-		9E-10		-		8E-10		-		9E-10		-		8E-10		-	
Polonium 210	µCi/mL	3E-10	3E-10	<1E-9	1E-9	6.2E-9	2E-10	3.97E-8	1E-9	4.5E-9	3E-10	1.72E-8	1E-9	<2E-10	2E-10	<1E-9	1E-9	<3E-10	3E-10	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	3E-10		NA		1.4E-9		2.6E-9		1.6E-9		1.5E-9		1E-10		NA		2E-10		NA	
Polonium 210 MDC	µCi/mL	3E-10		-		2E-10		-		3E-10		-		2E-10		-		3E-10		-	
Radium 226	µCi/mL	2.2E-9	1.2E-10	3.5E-9	1E-10	9E-10	1E-10	5E-10	2E-10	3.2E-10	1.1E-10	3E-10	1E-10	<1E-10	1E-10	<2E-10	2E-10	<1.3E-10	1.3E-10	<1E-10	1E-10
Radium 226 precision (±)	µCi/mL	2.6E-10		2E-10		1E-10		1E-10		1.1E-10		1E-10		5E-11		NA		7E-9		NA	
Radium 226 MDC	µCi/mL	1.2E-10		-		1E-10		-		1.1E-10		-		1E-10		-		1.3E-10		-	
Thorium 230	µCi/mL	<1E-10	1E-10	<2E-10	2E-10	3E-10	1E-10	<2E-10	2E-10	4E-10	1E-10	<2E-10	2E-10	<1E-10	1E-10	<2E-10	2E-10	<9E-11	9E-11	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	6E-11		NA		1E-10		NA		1E-10		NA		6E-11		NA		7E-11		NA	
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10		-		1E-10		-		9E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0090	0.0003	0.0037	0.0003	0.0771	0.0003	0.0457	0.0003	0.0475	0.0003	0.0346	0.0003	0.0007	0.0003	<0.0003	0.0003	0.0006	0.0003	0.0004	0.0003
Uranium Activity	µCi/mL	6.1E-9	2E-10	2.5E-9	2E-10	5.2E-8	2E-10	3.09E-8	2E-10	3.2E-8	2E-10	2.34E-8	2E-10	4.6E-10	2E-10	<2E-10	2E-10	3.9E-10	2E-10	3E-10	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	0.0008	0.0003	<0.0003	0.0003	0.0005	0.0003	0.0004	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	0.0004	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	5.6E-10	2E-10	<2E-10	2E-10	3.6E-10	2E-10	3E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	3E-10	2E-10

Notes:
µCi/mL = microcuries per milliliter
mg/L = milligrams per Liter
MDC - minimum detectable concentration
LLD - lower limit of detection
RL - Analyte reporting limit

Table 2.9-14. Radiological Analytical Results for Chadron Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	Monitor 6		Monitor 6		Monitor 6		Monitor 6		Monitor 7		Monitor 7		Monitor 7		Monitor 7		Monitor 8		Monitor 8	
	Date Collected:	11/7/2011		2/13/2012		6/4/2012		8/20/2012		11/7/2011		2/13/2012		6/4/2012		8/20/2012		11/7/2011		2/13/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<2.2E-9	1.3E-9	1.6E-9	1E-9	<8E-10	8E-10	1.5E-9	1E-9	<8E-10	8E-10	<1E-9	1E-9	<8E-10	8E-10	<1E-9	1.00E-09	<8E-10	8E-10	1.1E-9	1E-9
Lead 210 precision (±)	µCi/mL	<8E-10		4E-10		5E-10		4E-10		5E-10		NA		5E-10		NA		5E-10		4E-10	
Lead 210 MDC	µCi/mL	1.3E-09		-		8E-10		-		8E-10		-		8E-10		-		8E-10		-	
Polonium 210	µCi/mL	9E-10	8E-10	<1E-9	1E-9	<9E-10	9.0E-10	<1E-9	1E-9	<7E-10	7E-10	<1E-9	1E-9	1.6E-09	6E-10	<1E-9	1.00E-09	1E-9	5E-10	<E-9	1E-9
Polonium 210 precision (±)	µCi/mL	9E-10		NA		4E-10		NA		4E-10		NA		9E-10		NA		7E-10		NA	
Polonium 210 MDC	µCi/mL	8E-10		-		9E-10		-		7E-10		-		6E-10		-		5E-10		-	
Radium 226	µCi/mL	1.9E-9	1E-10	1.8E-9	2E-10	9E-9	1.7E-10	2.7E-9	2E-10	9E-10	1E-10	3E-10	2E-10	5.3E-10	1.7E-10	9E-10	2.00E-10	2.3E-9	1E-10	4E-10	2E-10
Radium 226 precision (±)	µCi/mL	3E-10		2E-10		6.1E-10		2E-10		2E-10		1E-10		1.7E-10		1E-10		3E-10		1E-10	
Radium 226 MDC	µCi/mL	1E-10		-		1.7E-10		-		1E-10		-		1.7E-10		-		1E-10		-	
Thorium 230	µCi/mL	<2E-10	2E-10	4E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2.00E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	9E-11		2E-10		9E-11		NA		1E-10		NA		6E-11		NA		1E-10		NA	
Thorium 230 MDC	µCi/mL	2E-10		-		2E-10		-		2E-10		-		2E-10		-		2E-10		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<9E-10	9E-10	1.4E-9	1E-9	<8E-10	8E-10	<1E-9	1E-9	<9E-10	9E-10	1.2E-9	1E-9	<8E-10	8E-10	1.5E-9	1E-9	<9E-10	9E-10	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	6E-10		4E-10		4E-10		NA		5E-10		4E-10		5E-10		4E-10		5E-10		NA	
Lead 210 MDC	µCi/mL	9E-10		-		8E-10		-		9E-10		-		8E-10		-		9E-10		-	
Polonium 210	µCi/mL	<2E-10	2E-10	<1E-9	1E-9	<5E-10	5E-10	<1E-9	1E-9	<2E-10	2E-10	<1E-9	1E-9	<3E-10	3E-10	<1E-9	1E-9	2E-10	2E-10	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	2E-10		NA		2E-10		NA		2E-10		NA		2E-10		NA		2E-10		NA	
Polonium 210 MDC	µCi/mL	2E-10		-		5E-10		-		2E-10		-		3E-10		-		2E-10		-	
Radium 226	µCi/mL	<1E-10	1E-10	<2E-10	2E-10	<1.2E-10	1.2E-10	<1E-10	1E-10	<1E-10	1E-10	<2E-10	2E-10	<1.3E-10	1.3E-10	<1E-10	1E-10	2E-10	1E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	3E-11		NA		9E-11		NA		5E-11		NA		8E-11		NA		7E-11		NA	
Radium 226 MDC	µCi/mL	1E-10		-		1.2E-10		-		1E-10		-		1.3E-10		-		1E-10		-	
Thorium 230	µCi/mL	<1E-10	1E-10	<2E-10	2E-10	<1E-10	1E-10	<2E-10	2E-10	<1E-10	1E-10	<2E-10	2E-10	<1E-10	1E-10	<2E-10	2E-10	<1E-10	1E-10	1E-10	2E-10
Thorium 230 precision (±)	µCi/mL	7E-11		NA		8E-11		NA		5E-11		NA		9E-11		NA		6E-11		1E-10	
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10		-		1E-10		-		1E-10		-	
METALS, DISSOLVED																					
Uranium	mg/L	0.0014	0.0003	0.0011	0.0003	0.0011	0.0003	0.0011	0.0003	0.0005	0.0003	0.0004	0.0003	<0.0003	0.0003	<0.0003	0.0003	0.0006	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	9.5E-10	2E-10	7E-10	2E-10	7.3E-10	2E-10	7E-10	2E-10	3.10E-10	2E-10	3E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	4.1E-10	2E-10	<2E-10	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
µCi/mL = microcuries per milliliter
mg/L = milligrams per Liter
MDC - minimum detectable concentration
LLD - lower limit of detection
RL - Analyte reporting limit

Table 2.9-14. Radiological Analytical Results for Chadron Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	Monitor 8		Monitor 8		Monitor 9		Monitor 9		Monitor 9		Monitor 9		Monitor 10		Monitor 10		Monitor 10		Monitor 10	
	Date Collected:	6/4/2012		8/20/2012		11/7/2011		2/13/2012		6/4/2012		8/20/2012		11/7/2011		2/13/2012		6/4/2012		8/20/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED																					
Lead 210	µCi/mL	<8E-10	8E-10	1.2E-9	1E-9	1.3E-9	1.3E-9	1.9E-9	1E-9	<8E-10	8E-10	2.9E-9	1E-9	<8E-10	8E-10	<1E-9	1E-9	<8E-10	8E-10	<1E-9	1E-9
Lead 210 precision (±)	µCi/mL	5E-10		4E-10		8E-10		4E-10		5E-10		5E-10		5E-10		NA		5E-10		NA	
Lead 210 MDC	µCi/mL	8E-10		-		1.3E-9		-		8E-10		-		8E-10		-		8E-10		-	
Polonium 210	µCi/mL	<7E-10	7E-10	<1E-9	1E-9	9E-10	7E-10	<1E-9	1E-9	8E-10	5E-10	<1E-9	1E-9	<6E-10	6E-10	<1E-9	1E-9	2.1E-9	5E-10	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	4E-10		NA		7E-10		NA		6E-10		NA		3E-10		NA		1E-9		NA	
Polonium 210 MDC	µCi/mL	7E-10		-		7E-10		-		5E-10		-		6E-10		-		5E-10		-	
Radium 226	µCi/mL	2.1E-09	1.7E-10	5E-10	2E-10	3E-10	1E-10	3E-10	2E-10	1.5E-9	1.7E-10	8E-10	2E-10	8E-10	1E-10	5E-10	2E-10	6.6E-9	1.7E-10	6E-10	2E-10
Radium 226 precision (±)	µCi/mL	3.1E-10		1E-10		1E-10		1E-10		2.6E-10		1E-10		2E-10		1E-10		5.3E-10		1E-10	
Radium 226 MDC	µCi/mL	1.7E-10		-		1E-10		-		1.7E-10		-		1E-10		-		1.7E-10		-	
Thorium 230	µCi/mL	<1E-10	1E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	5E-11		NA		9E-11		NA		7E-11		NA		9E-11		NA		7E-11		NA	
Thorium 230 MDC	µCi/mL	1E-10		-		2E-10		-		2E-10		-	1E-9	2E-10		-		2E-10		-	
RADIONUCLIDES-SUSPENDED																					
Lead 210	µCi/mL	<8E-10	8E-10	1.2E-9	1E-9	<9E-10	9E-10	1.4E-9	1E-9	<7E-10	7E-10	1.43E-8	1E-9	<9E-10	9E-10	<1E-9	1E-9	<8E-10	8E-10	3E-9	1E-9
Lead 210 precision (±)	µCi/mL	5E-10		4E-10		6E-10		4E-10		5E-10		1E-9		6E-10		NA		5E-10		6E-10	
Lead 210 MDC	µCi/mL	8E-10		-		9E-10		-		7E-10		-		9E-10		-		6E-10		-	
Polonium 210	µCi/mL	<4E-10	4E-10	<1E-9	1E-9	<3E-10	3E-10	<1E-9	1E-9	<3E-10	3E-10	<1E-9	1E-9	<2E-10	2E-10	<1E-9	1E-9	<4E-10	4E-10	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	3E-10		NA		2E-10		NA		2E-10		NA		1E-10		NA		2E-10		NA	
Polonium 210 MDC	µCi/mL	4E-10		-		3E-10		-		3E-10		-		2E-10		-		4E-10		-	
Radium 226	µCi/mL	<1.3E-10	1.3E-10	<2E-10	2E-10	<1E-10	1E-10	<2E-10	2E-10	<1.1E-10	1.1E-10	<2E-10	2E-10	<1E-10	1E-9	2E-10	2E-10	1.1E-10	1.1E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	9E-11		NA		4E-11		NA		7E-11		NA		3E-11		NA		8E-11		NA	
Radium 226 MDC	µCi/mL	1.3E-10		-		1E-10		-		1.1E-10		-		1E-10		-		1.1E-10		-	
Thorium 230	µCi/mL	<1E-10	1E-10	3E-10	2E-10	<1E-10	1E-10	1E-10	2E-10	<1E-10	1E-10	<2E-10	2E-10	<1E-10	1E-10	<2E-10	2E-10	2E-10	8E-11	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	5E-11		2E-10		6E-11		NA		7E-11		NA		4E-11		NA		1E-10		NA	
Thorium 230 MDC	µCi/mL	1E-10		-		1E-10		-		1E-10		-		1E-10		-		8E-11		-	
METALS, DISSOLVED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	0.0040	0.0003	0.0022	0.0003	0.0021	0.0003	0.0015	0.0003	0.0005	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	2.7E-9	2E-10	1.5E-9	2E-10	1.4E-9	2E-10	1E-10	2E-10	3.4E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
METALS, SUSPENDED																					
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
µCi/mL = microcuries per milliliter
mg/L = milligrams per Liter
MDC - minimum detectable concentration
LLD - lower limit of detection
RL - Analyte reporting limit

Table 2.9-14. Radiological Analytical Results for Chadron Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	Monitor 11		Monitor 11		Monitor 11		Monitor 11	
	Date Collected:	11/7/2011		2/13/2012		6/4/2012		8/20/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
RADIONUCLIDES-DISSOLVED									
Lead 210	µCi/mL	<8E-10	8E-10	<1E-9	1E-9	<8E-10	8E-10	1.3E-9	1E-9
Lead 210 precision (±)	µCi/mL	5E-10		NA		5E-10		4E-10	
Lead 210 MDC	µCi/mL	8E-10		-		8E-10		-	
Polonium 210	µCi/mL	<7E-10	7E-10	<1E-9	1E-9	<5E-10	5E-10	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	4E-10		NA		3E-10		NA	
Polonium 210 MDC	µCi/mL	7E-10		-		5E-10		-	
Radium 226	µCi/mL	4E-10	1E-10	2E-10	2E-10	2.4E-9	1.7E-10	4E-10	2E-10
Radium 226 precision (±)	µCi/mL	1E-10		1E-10		3.2E-10		1E-10	
Radium 226 MDC	µCi/mL	1E-10		-		1.7E-10		-	
Thorium 230	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	9E-11		NA		6E-11		NA	
Thorium 230 MDC	µCi/mL	2E-10		-		2E-10		-	
RADIONUCLIDES-SUSPENDED									
Lead 210	µCi/mL	<9E-10	9E-10	<1E-9	1E-9	<8E-10	8E-10	1.55E-8	1E-09
Lead 210 precision (±)	µCi/mL	5E-10		NA		5E-10		1E-9	
Lead 210 MDC	µCi/mL	9E-10		-		8E-10		-	
Polonium 210	µCi/mL	<2E-10	2E-10	<1E-9	1E-9	<4E-10	4E-10	<1E-9	1E-9
Polonium 210 precision (±)	µCi/mL	1E-10		NA		1E-10		NA	
Polonium 210 MDC	µCi/mL	2E-10		-		4E-10		-	
Radium 226	µCi/mL	<1E-10	1E-10	<2E-10	2E-10	<1.2E-10	1E-10	<2E-10	2E-10
Radium 226 precision (±)	µCi/mL	4E-11		NA		7E-11		NA	
Radium 226 MDC	µCi/mL	1E-10		-		1.2E-10		-	
Thorium 230	µCi/mL	<1E-10	1E-10	<2E-10	2E-10	<9E-11	9E-11	<2E-10	2E-10
Thorium 230 precision (±)	µCi/mL	5E-11		NA		6E-11		NA	
Thorium 230 MDC	µCi/mL	1E-10		-		9E-11		-	
METALS, DISSOLVED									
Uranium	mg/L	0.0014	0.0003	0.0008	0.0003	0.0007	0.0003	0.0005	0.0003
Uranium Activity	µCi/mL	9.3E-10	2E-10	5E-10	2E-10	4.8E-10	2E-10	3E-10	2E-10
METALS, SUSPENDED									
Uranium	mg/L	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003	<0.0003	0.0003
Uranium Activity	µCi/mL	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10	<2E-10	2E-10

Notes:
µCi/mL = microcuries per milliliter
mg/L = milligrams per Liter
MDC - minimum detectable concentration
LLD - lower limit of detection
RL - Analyte reporting limit

Table 2.9-15. Non-radiological Analytical Results for Chadron Monitoring Well Quarterly Sampling 2013-2014

	Location ID:	Monitor 1		Monitor 1		Monitor 1		Monitor 1		Monitor 2		Monitor 2		Monitor 2		Monitor 2		CPW-2010-1		CPW-2010-1	
	Date Collected:	11/7/2011		2/13/2012		6/4/2012		8/20/2012		11/7/2011[a]		2/13/2012		6/4/2012		8/20/2012		11/7/2011		2/13/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	288	1	398	5	411	5	416	5	374	1	394	5	398	5	410	5	288	1	281	5
Bicarbonate as HCO3	mg/L	193	1	486	5	488	5	475	5	439	1	480	5	475	5	471	5	193	1	286	5
Carbonate as CO3	mg/L	78	1	<5	5	7	5	16	5	9	1	<5	5	5	5	14	5	78	1	28	5
Chloride	mg/L	605	4	180	1	170	1	177	1	176	1	168	1	161	1	166	1	605	4	563	1
Fluoride	mg/L	0.9	0.1	0.6	0.1	0.6	0.1	0.5	0.1	0.5	0.1	0.6	0.1	0.6	0.1	0.5	0.1	0.9	0.1	0.8	0.1
Magnesium	mg/L	<1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	<1	1	<1	1
Nitrogen Ammonia as N	mg/L	0.7	0.05	0.3	0.1	0.22	0.05	0.1	0.1	0.27	0.05	0.2	0.1	0.24	0.05	0.1	0.1	0.7	0.05	0.5	0.1
Nitrogen Nitrate+Nitrite as N	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Potassium	mg/L	35	1	11	1	8	1	11	1	8	1	12	1	8	1	11	1	35	1	40	1
Silica	mg/L	20.7	0.2	14	1	15.2	0.2	15	1	15.6	0.2	15	1	17.2	0.2	16	1	20.7	0.2	17	1
Sodium	mg/L	514	2	330	1	307	1	349	1	299	1	322	1	298	1	337	1	514	2	488	1
Sulfate	mg/L	80	8	48	1	60	4	49	1	57	1	47	1	56	4	46	1	80	8	76	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	µmhos/cm	2740	1	1490	1	1410	1	1350	1	1410	1	1450	1	1380	1	1340	1	2740	1	2360	1
pH	s.u.	9.62	0.01	8.3	0.01	8.29	0.01	8.6	0.1	8.32	0.01	8.3	0.01	8.29	0.01	8.6	0.1	9.62	0.01	9	0.1
Solids Total Dissolved TDS @ 180 C	mg/L	1400	10	830	10	853	10	840	10	791	10	830	10	818	10	850	10	1400	10	1260	10
METALS, DISSOLVED																					
Aluminum	mg/L	0.3	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	0.3	0.1	<0.1	0.1
Arsenic	mg/L	0.001	0.001	0.001	0.001	0.002	0.001	0.002	0.001	0.003	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Barium	mg/L	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	0.1
Boron	mg/L	1.2	0.1	1.4	0.1	1.4	0.1	1.6	0.1	1.3	0.1	1.4	0.1	1.5	0.1	1.5	0.1	1.2	0.1	1.5	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	10	1	4	1	5	1	5	1	4	1	5	1	5	1	5	1	10	1	10	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.1	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.1	<0.01	0.01	<0.01	0.1
Iron	mg/L	0.04	0.03	<0.05	0.05	0.03	0.03	<0.05	0.05	0.05	0.03	0.05	0.05	<0.05	0.03	<0.05	0.05	0.04	0.03	<0.05	0.05
Lead	mg/L	<0.001	0.001	<0.001	0.05	0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.006	0.001	0.002	0.001	0.002	0.001	<0.001	0.001	0.003	0.001	<0.001	0.001	0.002	0.001	<0.001	0.001	0.006	0.001	<0.001	0.001
Vanadium	mg/L	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02	0.1	0.1	0.05	0.02
Zinc	mg/L	<0.01	0.01	<0.01	0.01	0.03	0.01	<0.01	0.01	0.02	0.01	0.03	0.01	0.5	0.01	0.09	0.01	<0.01	0.01	0.09	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	-1.57		3.04		-1.19		4.77		-0.51		3.49		-0.691		4.81		-1.57		0.8	
Anions	meq/L	24.6		14.08		14.3		14.34		13.7		13.61		13.7		13.85		24.6		23.12	
Cations	meq/L	23.8		14.96		13.9		15.78		13.5		14.6		13.6		15.26		23.8		22.75	
Solids Total Dissolved Calculated	mg/L	1450		830		800		860		789		810		770		830		1450		1360	

Notes:
µmhos/cm - micromhos per centimeter
mg/L = milligrams per liter
meq/L = milliequivalent per liter
RL = analyte reporting limit
s.u. = standard unit
[a] A different lab was use for 11/7/2011 bicarbonate analyses than for the other analytical dates (RL of 1 vs RL of 5 mg/L).

Table 2.9-15. Non-radiological Analytical Results for Chadron Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	CPW-2010-1		CPW-2010-1		Monitor 4A		Monitor 4A		Monitor 4A		Monitor 4A		Monitor 5		Monitor 5		Monitor 5		Monitor 5	
	Date Collected:	6/4/2013		8/20/2012		11/7/2011		2/13/2012		6/4/2012		8/20/2012		11/7/2011		2/13/2012		6/4/2012		8/20/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	281	5	298	5	323	1	358	5	360	5	390	5	248	1	260	5	260	5	266	5
Bicarbonate as HCO3	mg/L	306	5	311	5	342	1	414	5	405	5	432	5	140	1	214	5	234	5	230	5
Carbonate as CO3	mg/L	18	5	26	5	25	1	11	5	17	5	22	5	80	1	51	5	43	5	47	5
Chloride	mg/L	368	5	327	1	258	2	226	1	209	1	196	1	320	2	280	1	254	1	233	1
Fluoride	mg/L	0.8	0.1	0.6	0.1	0.8	0.1	0.7	0.1	0.8	0.1	0.6	0.1	0.7	0.1	0.6	0.1	0.7	0.1	0.5	0.1
Magnesium	mg/L	<1	1	<1	1	<1	1	<1	1	1	1	<1	1	1	1	1	1	2	1	1	1
Nitrogen Ammonia as N	mg/L	0.49	0.05	0.4	0.1	0.36	0.05	0.3	0.1	0.33	0.05	0.1	0.1	0.54	0.05	0.2	0.1	0.41	0.05	0.2	0.1
Nitrogen Nitrate+Nitrite as N	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Potassium	mg/L	21	1	23	1	18	1	23	1	16	1	19	1	31	1	36	1	27	1	29	1
Silica	mg/L	17.8	0.2	15	1	15.3	0.2	14	1	18.1	0.2	17	1	25	0.2	23	1	22.9	0.2	20	1
Sodium	mg/L	393	1	399	1	365	1	367	1	340	1	357	1	438	1	454	1	421	1	429	1
Sulfate	mg/L	88	4	73	1	113	2	103	1	115	4	95	1	312	4	269	1	308	4	275	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	µmhos/cm	1890	1	1740	1	1750	1	1710	1	1580	1	1510	1	2260	1	2220	1	2010	1	1880	1
pH	s.u.	8.98	0.01	8.9	0.1	8.91	0.01	8.6	0.01	8.78	0.01	8.7	0.1	9.72	0.01	9.3	0.01	9.48	0.01	9.3	0.1
Solids Total Dissolved TDS @ 180 C	mg/L	1090	10	1070	10	958	10	940	10	951	10	930	10	1290	10	1220	10	1270	10	1190	10
METALS, DISSOLVED																					
Aluminum	mg/L	0.3	0.1	0.2	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.3	0.1	0.2	0.1	0.1	0.1	<0.1	0.1
Arsenic	mg/L	<0.001	0.001	<0.001	0.001	0.005	0.001	0.002	0.001	0.003	0.001	0.002	0.001	0.002	0.001	<0.001	0.001	0.002	0.001	<0.001	0.001
Barium	mg/L	0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Boron	mg/L	1.4	0.1	1.3	0.1	1.3	0.1	1.6	0.1	1.4	0.1	1.5	0.1	1.1	0.1	1.2	0.1	1.3	0.1	1.3	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	19	1	14	1	3	1	4	1	5	1	4	1	4	1	5	1	7	1	5	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.1	<0.01	0.1	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.1	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.1
Iron	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.03	<0.05	0.05	<0.05	0.03	<0.05	0.05	0.04	0.03	<0.05	0.05	<0.05	0.03	<0.05	0.05
Lead	mg/L	<0.001	0.05	<0.001	0.05	<0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.002	0.001	0.008	0.001	0.003	0.001	0.024	0.001	0.002	0.001	<0.001	0.001	0.005	0.001	0.068	0.001	0.003	0.001	0.006	0.001
Vanadium	mg/L	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02
Zinc	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.02	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	2.28		4.63		1.32		3.17		0.175		2.72		-8.37		4.76		1.17		4.62	
Anions	meq/L	17.9		16.99		16.1		15.71		15.5		15.34		20.6		19.11		19.1		17.99	
Cations	meq/L	18.7		18.64		16.6		16.74		15.6		16.2		20.2		21.03		19.6		19.73	
Solids Total Dissolved Calculated	mg/L	1100		1030		971		950		900		920		1290		1220		1200		1150	

Notes:
µmhos/cm - micromhos per centimeter
mg/L = milligrams per liter
meq/L = milliequivalent per liter
RL = analyte reporting limit
s.u. = standard unit
[a] A different lab was use for 11/7/2011 bicarbonate analyses than for the other analytical dates (RL of 1 vs RL of 5 mg/L).

Table 2.9-15. Non-radiological Analytical Results for Chadron Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	Monitor 6		Monitor 6		Monitor 6		Monitor 6		Monitor 7		Monitor 7		Monitor 7		Monitor 7		Monitor 8		Monitor 8	
	Date Collected:	11/7/2011		2/13/2012		6/4/2012		8/20/2012		11/7/2011		2/13/2012		6/4/2012		8/20/2012		11/7/2011		2/13/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	271	1	292	5	260	5	322	5	245	1	283	5	301	5	311	5	253	1	274	5
Bicarbonate as HCO3	mg/L	280	1	334	5	234	5	345	5	264	1	321	5	338	5	339	5	267	1	918	5
Carbonate as CO3	mg/L	25	1	11	5	43	5	23	5	17	1	12	5	14	5	20	5	20	1	5	5
Chloride	mg/L	398	4	361	1	254	1	304	1	241	1	216	1	188	1	192	1	250	2	197	1
Fluoride	mg/L	0.8	0.1	0.8	0.1	0.7	0.1	0.6	0.1	0.8	0.1	0.8	0.1	0.8	0.1	0.6	0.1	0.7	0.1	0.7	0.1
Magnesium	mg/L	<1	1	<1	1	2	1	1	1	2	1	2	1	2	1	2	1	2	1	2	1
Nitrogen Ammonia as N	mg/L	0.53	0.05	0.4	0.1	0.41	0.05	0.3	0.1	0.33	0.05	0.2	0.1	0.29	0.05	0.1	0.1	0.39	0.05	0.3	0.1
Nitrogen Nitrate+Nitrite as N	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Potassium	mg/L	22	1	25	1	27	1	23	1	16	1	21	1	15	1	18	1	20	1	24	1
Silica	mg/L	15.5	0.2	15	1	22.9	0.2	16	1	15.8	0.2	16	1	18.5	0.2	16	1	18.9	0.2	16	1
Sodium	mg/L	377	1	381	1	421	1	378	1	410	1	422	1	386	1	423	1	445	1	441	1
Sulfate	mg/L	53	1	45	1	308	4	46	1	305	2	266	1	306	4	278	1	388	2	349	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	µmhos/cm	1950	1	1920	1	2010	1	1660	1	1960	1	1970	1	1810	1	1730	1	2180	1	2090	1
pH	s.u.	8.82	0.01	8.6	0.01	9.48	0.01	8.8	0.1	8.86	0.01	8.6	0.01	8.76	0.01	8.8	0.1	8.91	0.01	8.5	0.01
Solids Total Dissolved TDS @ 180 C	mg/L	1040	10	1000	10	1270	10	970	10	1110	10	1130	10	1130	10	1080	10	1260	10	1190	10
METALS, DISSOLVED																					
Aluminum	mg/L	0.1	0.1	0.2	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Arsenic	mg/L	0.002	0.001	<0.001	0.001	0.002	0.001	<0.001	0.001	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	<0.001	0.001
Barium	mg/L	0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Boron	mg/L	1.2	0.1	1.2	0.1	1.3	0.1	1.4	0.1	1.3	0.1	1.4	0.1	1.5	0.1	1.4	0.1	1.2	0.1	1.2	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	13	1	5	1	7	1	9	1	6	1	7	1	10	1	8	1	12	1	10	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.1	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.1	<0.01	0.01	<0.01	0.01
Iron	mg/L	<0.05	0.03	<0.05	0.05	<0.05	0.03	<0.05	0.05	<0.05	0.03	<0.05	0.05	<0.05	0.03	<0.05	0.05	<0.05	0.03	<0.05	0.05
Lead	mg/L	<0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.004	0.001	0.068	0.001	0.003	0.001	0.001	0.001	0.004	0.001	0.011	0.001	0.002	0.001	<0.001	0.001	0.003	0.001	0.012	0.001
Vanadium	mg/L	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02
Zinc	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.01	0.01	0.04	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	0.32		2.56		1.17		4.62		1.67		4.86		0.403		4.57		0.971		4.86	
Anions	meq/L	17.8		17.01		19.1		16		18.1		17.59		17.7		17.72		20.2		18.6	
Cations	meq/L	17.7		17.9		19.6		17.55		18.7		19.39		17.9		19.42		20.6		20.51	
Solids Total Dissolved Calculated	mg/L	1050		1020		1200		970		1150		1120		1100		1120		1290		1200	

Notes:
µmhos/cm - micromhos per centimeter
mg/L = milligrams per liter
meq/L = milliequivalent per liter
RL = analyte reporting limit
s.u. = standard unit
[a] A different lab was use for 11/7/2011 bicarbonate analyses than for the other analytical dates (RL of 1 vs RL of 5 mg/L).

Table 2.9-15. Non-radiological Analytical Results for Chadron Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	Monitor 8		Monitor 8		Monitor 9		Monitor 9		Monitor 9		Monitor 9		Monitor 10		Monitor 10		Monitor 10		Monitor 10	
	Date Collected:	6/4/2012		8/20/2012		11/7/2011		2/13/2012		6/4/2012		8/20/2012		11/7/2011		2/13/2012		6/4/2012		8/20/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS																					
Alkalinity Total as CaCO3	mg/L	282	5	296	5	307	1	336	5	343	5	356	5	274	1	307	5	314	5	361	5
Bicarbonate as HCO3	mg/L	323	5	336	5	297	1	381	5	387	5	390	5	301	1	363	5	360	5	412	5
Carbonate as CO3	mg/L	10	5	13	5	38	1	14	5	16	5	22	5	16	1	6	5	11	5	14	5
Chloride	mg/L	177	1	169	1	269	2	252	1	232	1	224	1	151	1	143	1	141	1	137	1
Fluoride	mg/L	0.7	0.1	0.5	0.1	0.8	0.1	0.8	0.1	0.8	0.1	0.6	0.1	0.8	0.1	0.7	0.1	0.8	0.1	0.6	0.1
Magnesium	mg/L	3	1	3	1	<1	1	<1	1	<1	1	<1	1	1	1	2	1	<1	1	2	1
Nitrogen Ammonia as N	mg/L	0.32	0.05	0.1	0.1	0.33	0.05	0.3	0.1	0.34	0.05	0.2	0.1	0.37	0.05	0.4	0.1	0.38	0.05	0.2	0.1
Nitrogen Nitrate+Nitrite as N	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Potassium	mg/L	17	1	23	1	15	1	19	1	14	1	18	1	11	1	15	1	11	1	16	1
Silica	mg/L	18.5	0.2	15	1	14.9	0.2	15	1	17.3	0.2	15	1	17.2	0.2	16	1	18	0.2	16	1
Sodium	mg/L	425	1	430	1	344	1	362	1	341	1	361	1	386	1	405	1	392	1	425	1
Sulfate	mg/L	388	4	362	1	91	2	78	1	95	4	79	1	347	2	307	1	347	4	300	1
PHYSICAL PROPERTIES																					
Conductivity @ 25 C	µmhos/cm	1950	1	1830	1	1700	1	1690	1	1570	1	1500	1	1810	1	1880	1	1770	1	1710	1
pH	s.u.	8.65	0.01	8.6	0.1	8.91	0.01	8.7	0.01	8.75	0.01	8.8	0.1	8.66	0.01	8.4	0.01	8.54	0.01	8.6	0.1
Solids Total Dissolved TDS @ 180 C	mg/L	1220	10	1250	10	946	10	890	10	910	10	1180	10	1080	10	1090	10	1120	10	1180	10
METALS, DISSOLVED																					
Aluminum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Arsenic	mg/L	0.001	0.001	<0.001	0.001	0.002	0.001	<0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	<0.001	0.001	0.001	0.001	<0.001	0.001
Barium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Boron	mg/L	1.4	0.1	1.3	0.1	1.1	0.1	1.2	0.1	1.3	0.1	1.4	0.1	1.3	0.1	1.3	0.1	1.4	0.1	1.5	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	12	1	10	1	2	1	10	1	4	1	3	1	6	1	7	1	8	1	7	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.1	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.1	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.1
Iron	mg/L	<0.05	0.03	<0.05	0.05	<0.05	0.03	<0.05	0.05	<0.05	0.03	<0.05	0.05	<0.05	0.03	<0.05	0.05	<0.05	0.03	<0.05	0.05
Lead	mg/L	<0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.002	0.001	<0.001	0.001	0.004	0.001	0.011	0.001	0.003	0.001	<0.001	0.001	0.003	0.001	<0.001	0.001	0.001	0.001	<0.001	0.001
Vanadium	mg/L	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02
Zinc	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.03	0.01	0.02	0.01	0.04	0.01
DATA QUALITY																					
A/C Balance (± 5)	%	2.74		4.72		-0.463		2.77		0.0047		3.85		1.52		4.67		1.4		4.96	
Anions	meq/L	18.7		18.23		15.7		15.51		15.5		15.1		17		16.87		17.5		17.61	
Cations	meq/L	19.8		20.04		15.5		16.4		15.5		16.31		17.5		18.53		18		19.45	
Solids Total Dissolved Calculated	mg/L	1200		1190		925		930		890		910		1090		1080		1100		1120	

Notes:
µmhos/cm - micromhos per centimeter
mg/L = milligrams per liter
meq/L = milliequivalent per liter
RL = analyte reporting limit
s.u. = standard unit
[a] A different lab was use for 11/7/2011 bicarbonate analyses than for the other analytical dates (RL of 1 vs RL of 5 mg/L).

Table 2.9-15. Non-radiological Analytical Results for Chadron Monitoring Well Quarterly Sampling 2013-2014 (Cont.)

	Location ID:	Monitor 11		Monitor 11		Monitor 11		Monitor 11	
	Date Collected:	11/7/2011		2/13/2012		6/4/2012		8/20/2012	
Analyte	Units	RESULT	RL	RESULT	RL	RESULT	RL	RESULT	RL
MAJOR IONS									
Alkalinity Total as CaCO3	mg/L	323	1	352	5	365	5	369	5
Bicarbonate as HCO3	mg/L	330	1	393	5	403	5	394	5
Carbonate as CO3	mg/L	32	1	18	5	21	5	28	5
Chloride	mg/L	370	4	318	1	292	2	270	1
Fluoride	mg/L	0.7	0.1	0.8	0.1	0.7	0.1	0.6	0.1
Magnesium	mg/L	1	1	1	1	2	1	1	1
Nitrogen Ammonia as N	mg/L	0.37	0.05	0.3	0.1	0.32	0.05	0.2	0.1
Nitrogen Nitrate+Nitrite as N	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Potassium	mg/L	21	1	28	1	21	1	26	1
Silica	mg/L	12.4	0.2	13	1	14.7	0.2	13	1
Sodium	mg/L	425	1	439	1	403	1	414	1
Sulfate	mg/L	124	2	107	1	131	4	110	1
PHYSICAL PROPERTIES									
Conductivity @ 25 C	µmhos/cm	2120	1	2060	1	1890	1	1760	1
pH	s.u.	8.99	0.01	8.7	0.01	8.85	0.01	8.8	0.1
Solids Total Dissolved TDS @ 180 C	mg/L	1160	10	1110	10	1130	10	1120	10
METALS, DISSOLVED									
Aluminum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Arsenic	mg/L	0.003	0.001	0.002	0.001	0.003	0.001	0.001	0.001
Barium	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Boron	mg/L	1.2	0.1	1.3	0.1	1.4	0.1	1.4	0.1
Cadmium	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
Calcium	mg/L	5	1	6	1	8	1	6	1
Chromium	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Copper	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.1
Iron	mg/L	<0.05	0.03	<0.05	0.05	<0.05	0.03	<0.05	0.05
Lead	mg/L	<0.001	0.001	<0.001	0.05	<0.001	0.001	<0.001	0.05
Manganese	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
Mercury	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
Molybdenum	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
Nickel	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
Selenium	mg/L	0.0005	0.001	0.022	0.001	0.002	0.001	<0.001	0.001
Vanadium	mg/L	<0.1	0.1	<0.02	0.02	<0.1	0.1	<0.02	0.02
Zinc	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
DATA QUALITY									
A/C Balance (± 5)	%	-0.277		4.45		0.897		4.88	
Anions	meq/L	19.5		18.5		18.3		17.31	
Cations	meq/L	19.4		20.22		18.6		19.09	
Solids Total Dissolved Calculated	mg/L	1160		1120		1100		1060	

Notes:
µmhos/cm - micromhos per centimeter
mg/L = milligrams per liter
meq/L = milliequivalent per liter
RL = analyte reporting limit
s.u. = standard unit
[a] A different lab was use for 11/7/2011 bicarbonate analyses than for the other analytical dates (RL of 1 vs RL of 5 mg/L).

Table 2.9-16. Summary of Water Quality for the Marsland Expansion Area and Vicinity (2011-2014)

Constituent	Units	Active Private Wells[a]		MEA Wells					
		Arikaree Group and Brule Formations		Arikaree Formation [b]		Brule Formation [c]		Basal Sandstone of Chadron Formation [d]	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
Calcium	mg/l	21-73	38.9	31 - 48	36.5	4 - 35	21.7	2 - 19	7.14
Magnesium[e]	mg/l	3 - 13	8.8	6 - 18	9.3	<1 - 10	3.84	<1 U - 3	1.17
Sodium	mg/l	8 - 49	19.8	6 - 26	16.5	18 - 408	104	298 - 514	394
Potassium	mg/l	2 -13	4.2	1 - 5	3.6	3 - 38	11.16	8 - 40	20.2
Bicarbonate as HCO_3	mg/l	160 - 480	201.9	155 - 221	186.7	<1 - 205	26.2	140 - 918	357
Sulfate	mg/l	3 - 44	10.2	1 - 12	7.1	7 - 62	26.2	45 - 388	172
Chloride	mg/l	2 - 9	3.5	0.5 - 10	4.2	2 - 502	92.1	137 - 605	259
Conductivity @ 25 °C	µmhos/cm	241 - 578	329.9	248 - 398	330.8	289 - 2300	669	1340 - 2740	1835
Total Dissolved Solids @ 180 C	mg/l	202 - 400	250.2	220 - 300	254.4	200 - 1280	440	791 - 1400	1076
Total Dissolved Solids Calculated	mg/l	166 - 870	270.7	210 - 270	244.4	220 - 1410	439	770 - 1450	1063
pH	s.u.	7.64 - 8.5	8.1	8.3 - 8.5	8.4	8.1 - 10.8	8.9	8.29 - 9.72	8.81
Cations	meq/l	2.75 - 6.29	3.6	2.76 - 3.99	3.4	1.92 - 20.32	6.14	13.5 - 23.8	18.2
Anions	meq/l	2.94 - 6.71	3.7	2.76 - 4.09	3.5	3.07 - 21.67	6.42	13.6 - 24.6	17.4
Uranium, Suspended[e]	mg/l	<0.0003 U - 0.001[f]	0.0002	<0.0003-0.0017	0.0003	<0.0003 U - 0.0007	0.0002	<0.0003 U - 0.0295	0.0011
Uranium, Dissolved[e]	mg/l	0.0028 - 0.0282	0.0071	0.0038-0.0087	0.0062	0.0003 - 0.0282	0.007	<0.0003 U - 0.0771	0.0068
Radium-226, Dissolved[e]	µCi/ml	<1.3E-10 - 9.5E-9[g]	2.3E-10	<2E-10 - 4E-10	1.22E-10	<2E-10 - 1E-9	2.25E-10	2E-10 - 3.48E-7	1.91E-08
Radium-226, Suspended[e]	µCi/ml	3E-11 - 2E-10[h]	8.5E-11	<2E-10 - 6E-10	1.28E-10	<2E-10 - 9E-10	1.27E-10	<1E-10 - 9E-10	1.86E-10
Uranium Activity, Dissolved[e]	µCi/ml	3.8E-10 - 3.9E-9	2.14E-09	2.6E-9 - 5.9E-9	4.23E-09	<2E-10 - 9E-9	3.17E-09	<2.E-10 - 9.5	3.47E-10
Uranium Activity, Suspended[e]	µCi/ml	<2.E-10 - 6.5E-10[i]	1E-10	<2E-10-6E-10	3.44E-10	<2E-10 - 5E-10	1.9E - 10	<2.E-10 - 6E-10	1E-10

Notes:
[a] Active private water supply wells within 2k (700, 702, 703, 704, 705, 706, 707, 714, 715, 716, 719, 720, 721, 722, 723, 725, 727, 728, 730, 731, 732, 734, 735, 736, 737, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 750, 752, 753, 754, 755, 759, 760, 777, 788, 794, 795, 799, 802, 809, 810, 811, 815, 821, 836, 841, 845) (March 2011 - March 2013)."
[b] 8 CBR MEA Arikaree monitor wells (AOW-3, AOW-4, AOW-5, AOW-6, AOW-8, AOW-9, AOW-10, AOW-11) (November 2013 - September 2014)
[c] 11 CBR MEA Brule monitor wells (BOW-2010-1, BOW-2010-2, BOW-2010-3, BOW-2010-4A, BOW-2010-5, BOW-2010-6, BOW-2010-7, BOW-2010-8, BOW-9, BOW-10, BOW-11) (December 2013 - September 2014).
[d] 11 CBR MEA Basal Chadron monitor wells (Monitor-1, Monitor-2, Monitor-4A, Monitor-5, Monitor-6, Monitor-7, Monitor-8, Monitor-9, Monitor-10, Monitor-11, CPW-2010-1) (November 2011 - August 2012).
[e] Values less than detection limits reduced by one-half in order to provide a conservative estimate.
[f] 198 of 202 sample analyses were less than RL 0.0003 mg/L
[g] 184 of 202 sample analyses were less than RLs ranging from <1.3E-10 to 2.4E-10 µCi/mL
[h] 200 of 202 sample analyses were less than RLs ranging from <9E-11 to 2E-10 µCi/mL, with 96 being less than 2E-10 µCi/mL
[i] 197 of 202 sample analyses were less than RL of 2E-10 µCi/mL

Table 2.9-17. Summary of NDEQ Non-Radiological Water Quality Data for Niobrara River Above Box Butte Reservoir 2003 – 2011

Constituent	Unit	Average Value	Minimum Value	Maximum Value	Total Observations	Number of Values Less Than RL	RL
Major Ions							
Calcium, Dissolved	mg/L	49.95	42.82	58.2	36	0	0.15
Chloride	mg/L	4.83	3.46	7.35	131	0	1.0
Magnesium, Dissolved	mg/L	8.92	<0.15	11.54	35	1	0.15
Nitrogen, Total Ammonia as N	mg/L	0.06	<0.05 [a]	1.05	150	90	0.05
Nitrogen, Total (Nitrate + Nitrite as N)	mg/L	0.85	0.16	1.58	146	0	0.05
Nitrogen as N, Total Kjeldahl	mg/L	0.44	0.5 [a]	2.17	151	100	0.5
Phosphorus, Total	mg/L	0.05	<0.04 [a]	0.71	152	78	0.04
Sodium, Dissolved	mg/L	25.5	21.4	40.6	35	0	0.15
Physical Properties							
Alkalinity	mg/L	184	162	212	13	--	--
Dissolved Oxygen	mg/L	8.85	3.34	12.9	139	--	--
Chemical Oxygen Demand (COD)	mg/L	7.9	<12 [a]	20.3	12	9	12
pH	s.u.	8.09	7.1	9.92	211	--	--
Specific Conductance	µmhos/cm	386	100	539	151	--	--
Suspended Solids, Total (TSS)	mg/L	24.7	<5 [a]	297	150	14	5.0
Temperature	°C	11.13	-0.26	29.0	142	--	--
Turbidity, Field	NTU	27.7	0.2	233	139	--	--
Metals, Dissolved							
Arsenic, Dissolved [b]	µg/L	5.93	<10 [a]	7.33	39	29	10
Cadmium, Dissolved	µg/L	<1	<1	<1	16	16	1
Chromium, Dissolved	µg/L	<10	<10	<10	16	16	10
Copper, Dissolved	µg/L	<10	<10	<10	16	16	10
Lead, Dissolved	µg/L	<5	<5	<5	16	16	5
Mercury, Dissolved as Hg	µg/L	<1	<1	<1	16	16	1
Nickel, Dissolved	µg/L	<10	<10	<10	16	16	10
Selenium, Total	µg/L	<5	<5	<5	39	39	5
Silver, Dissolved	µg/L	<1	<1	<1	16	16	1
Zinc, Dissolved	µg/L	<10	<10	<10	16	16	10
Stream Flow							
Gage Height	inches	3.5	2.3	10.7	144	--	--
Stream Discharge	cfs	36.3	0.35	201.6	142	--	

Source: Ihrie 2013
[a] Value of one-half of Less Than Reporting Limit used for calculating average values.
[b] Arsenic values were below the RL of 10 ug/L for 2002 – 2007, with detected values for years 2008 through 2011.

Table 2.9-18. Summary of NDEQ Water Quality for Niobrara River Below Box Butte Reservoir 2008

Parameter	Minimum	Maximum
	mg/L	
Chloride	3.28	5.66
Nitrogen, Total Ammonia as N[a]	<0.05	0.16
Nitrogen, Total (Nitrate + Nitrite as N)[b]	<0.05	0.93
Nitrogen as N, Total Kjeldahl	<0.05	0.73
Phosphorus, Total[c]	<0.04	0.05
Suspended Solids, Total (TSS)[d]	<5.0	27.5

[a] 15 of 17 measurements <0.05 mg/L
[b] 14 of 17 measurements <0.05 mg/L
[c] 15 of 17 measurements below <0.04 mg/L
[d] 15 of 16 measurements below 8.0 mg/L
mg/L = milligrams per liter

Table 2.9-19. Summary of Radiological Baseline Data for Niobrara River Near Marsland Expansion Area Collected by Crow Butte

Analyte	Concentration (µCi/mL) [a]		Non-Detection Frequency [b]	Non-Detection Value [c]	
	Minimum	Maximum		Minimum	Maximum
NIOBRARA RIVER UPGRADIENT SAMPLING POINT N-1					
Dissolved Radiological Analytes					
Lead 210	<1E-9	2E-9	8/12	<1E-9	<1E-9
Polonium 210	<1E-9	<1E-9	12/12	<1E-9	<1E-9
Radium 226	<2E-10	5E-10	11/12	<2E-10	<2E-10
Thorium 230	<2E-10	<2E-10	12/12	<2E-10	<2E-10
Uranium Activity (µCi/ml)	8.8E-9	2.4E-9	0/12	N/A	N/A
Uranium (mg/l)	0.0035	0.0130	0/24	N/A	N/A
Suspended Radiological Analytes					
Lead 210	<1E-9	1.1E-9	11/12	<1E-9	<1E-9
Polonium 210	<1E-9	<1E-9	12/12	<1E-9	<1E-9
Radium 226	<2E-10	3E-10	10/12	<2E-10	<2E-10
Thorium 230	<2E-10	<2E-10	12/12	<2E-10	<2E-10
Uranium Activity (µCi/ml)	<2E-10	<2E-10	12/12	<2E-10	<2E-10
Uranium (mg/l)	<0.0003	0.0051	11/12	<0.0003	<0.0003
NIOBRARA RIVER DOWNGRADIENT SAMPLING POINT N-2					
Dissolved Radiological Analytes					
Lead 210	<1E-9	2.1E-9	9/12	<1E-9	<1E-9
Polonium 210	<1E-9	3E-9	11/12	<1E-9	<1E-9
Radium 226	<2E-10	5E-10	8/12	<2E-10	<2E-10
Thorium 230	<2E-10	<2E-10	12/12	<2E-10	<2E-10
Uranium Activity (µCi/ml)	1.2E-9	6.8E-9	0/12	N/A	N/A
Uranium (mg/l)	0.0018	0.0100	0/12	N/A	N/A
Suspended Radiological Analytes					
Lead 210	<1E-9	1.6E-9	11/12	<1E-9	<1E-9
Polonium 210	<1E-9	<1E-9	12/12	<1E-9	<1E-9
Radium 226	<2E-10	4E-10	11/12	<2E-10	<2E-10
Thorium 230	<2E-10	<2E-10	12/12	<2E-10	<2E-10
Uranium Activity (µCi/ml)	<2E-10	8E-10	10/12	<2E-10	<2E-10
Uranium (mg/l)	<0.0003	0.0012	10/12	<0.0003	<0.0003

[a] Unless noted otherwise.
[b] Number of samples with values less than the Non-Detection Limit; 5/6 = five of six samples with values below the detection limit.
[c] The minimum and maximum non-detection values for all samples during that testing period.
µCi/mL - microcuries per milliliter
mg/l - milligrams per liter

Table 2.9-20. Marsland Expansion Area Vegetation Seasonal Radiological Laboratory Analysis

Location ID:		Marsland West						NRC LLD [a]
Date Collected:		6/26/2013		7/19/2013		9/13/2013		µCi/kg (wet)
	UNITS	RESULTS	RL	RESULTS	RL	RESULTS	RL	
RADIONUCLIDES								
Lead 210	µCi/kg	4.6E-05	4.6E-06	1.0E-04	8.2E-06	1.5E-04	3.3E-06	1E-06
Lead 210 precision (±)	µCi/kg	4.0E-06		8.0E-06		4.6E-06		
Lead 210 MDC	µCi/kg	4.6E-06		8.2E-06		3.3E-06		
Polonium 210	µCi/kg	4.6E-06	4.4E-06	2.9E-05	2.5E-06	5.9E-05	2.8E-06	1E-06
Polonium 210 precision (±)	µCi/kg	4.2E-06		7.0E-06		1.0E-05		
Polonium MDC	µCi/kg	4.4E-06		2.5E-06		2.8E-06		
Radium 226	µCi/kg	1.1E-06	1.0E-06	2.7E-06	1.7E-07	4.7E-06	3.1E-07	5E-08
Radium 226 precision (±)	µCi/kg	6.7E-07		3.0E-07		5.0E-07		
Radium MDC	µCi/kg	1.0E-06		1.7E-07		3.1E-07		
Thorium 230	µCi/kg	4.6E-06	2.2E-06	3.6E-06	1.8E-06	9.3E-06	1.6E-06	2E-07
Thorium 230 precision (±)	µCi/kg	2.1E-06		1.6E-06		2.4E-06		
Thorium MDC	µCi/kg	2.2E-06		1.8E-06		1.6E-06		
METALS								
Uranium	mg/kg	0.63 D	0.0031	0.0093	0.00073	0.08	0.02	
Uranium Activity	µCi/kg	4.2E-04 D	2.1E-06	6.3E-06	4.9E-07	5.0E-05	1.0E-05	2E-07

Location ID:		Marsland Middle					
Date Collected:		6/26/2013		7/19/2013		9/13/2013	
	UNITS	RESULTS	RL	RESULTS	RL	RESULTS	RL
RADIONUCLIDES							
Lead 210	µCi/kg	1.2E-04	5.0E-06	1.1E-05	4.5E-06	9.8E-05	2.8E-06
Lead 210 precision (±)	µCi/kg	6.2E-06		3.1E-06		3.5E-06	
Lead 210 MDC	µCi/kg	5.0E-06		4.5E-06		2.8E-06	
Polonium 210	µCi/kg	2.4E-05	3.1E-06	2.1E-06	1.2E-06	3.5E-05	2.4E-06
Polonium 210 precision (±)	µCi/kg	8.6E-06		1.4E-06		6.7E-06	
Polonium MDC	µCi/kg	3.1E-06		1.2E-06		2.4E-06	
Radium 226	µCi/kg	9.1E-06	9.6E-07	4.0E-07	8.0E-08	2.8E-06	2.5E-07
Radium 226 precision (±)	µCi/kg	1.0E-06		8.9E-08		3.6E-07	
Radium MDC	µCi/kg	9.6E-07		8.0E-08		2.5E-07	
Thorium 230	µCi/kg	7.4E-06	4.9E-06	9.3E-07	7.2E-07	6.2E-06	1.8E-06
Thorium 230 precision (±)	µCi/kg	4.2E-06		5.7E-07		1.9E-06	
Thorium MDC	µCi/kg	4.9E-06		7.2E-07		1.8E-06	
METALS							
Uranium	mg/kg	0.043 D	0.0015	0.0023	0.00040	0.20	0.02
Uranium Activity	µCi/kg	2.9E-05 D	9.9E-07	1.6E-06	2.7E-07	1.3E-04	1.0E-05

Location ID:		Marsland East					
Date Collected:		6/26/2013		7/19/2013		9/13/2013	
	UNITS	RESULTS	RL	RESULTS	RL	RESULTS	RL
RADIONUCLIDES							
Lead 210	µCi/kg	2.5E-05	2.6E-06	2.7E-05	2.4E-06	7.5E-05	2.5E-06
Lead 210 precision (±)	µCi/kg	2.3E-06		2.2E-06		3.0E-06	
Lead 210 MDC	µCi/kg	2.6E-06		2.4E-06		2.5E-06	
Polonium 210	µCi/kg	2.7E-06	1.3E-06	3.4E-06	1.3E-06	1.4E-05	2.1E-06
Polonium 210 precision (±)	µCi/kg	1.4E-06		1.7E-06		1.6E-06	
Polonium MDC	µCi/kg	1.3E-06		1.3E-06		2.9E-06	
Radium 226	µCi/kg	1.8E-06	4.7E-07	<2.4E-08	2.4E-08	2.6E-06	1.8E-07
Radium 226 precision (±)	µCi/kg	3.8E-07		1.2E-08		2.9E-07	
Radium MDC	µCi/kg	4.7E-07		2.4E-08		1.8E-07	
Thorium 230	µCi/kg	1.6E-06	1.5E-06	2.3E-06	1.5E-06	3.1E-06	1.1E-06
Thorium 230 precision (±)	µCi/kg	1.1E-06		1.2E-06		1.2E-06	
Thorium MDC	µCi/kg	1.5E-06		1.5E-06		1.1E-06	
METALS							
Uranium	mg/kg	0.0010 D	0.00072	0.0021	0.00030	0.16	0.02
Uranium Activity	µCi/kg	6.8E-07 D	4.9E-07	1.4E-06	2.0E-07	1.1E-04	1.0E-05

µCi/kg - microcuries per kilogram
mg/g - milligrams per gram
RL - Analyte Reporting Limit
D - RL increased due to sample matrix
LLD - Lower Limit of Detection
MDC - Minimum Detectable Concentration

Table 2.9-21. Marsland Expansion Area Wet-weight Vegetable Concentrations from Dry-weight Soil Concentrations

Parameter	Parameter Description	Plant Type	Radionuclide	Value	Concentration Factor[4] (C_{svhj})	Average Vegetable Concentration - Seven Gardens[5]
ML_v	Mass Loading factor	Root Vegetables Leafy Vegetables Fruits	Not Radionuclide Specific	0.1[1]		
B_{jv}	Concentration Factor for Root Uptake	Root Vegetables	Natural Uranium	0.014[2]	22.8	13.35
			Thorium-230	0.00012[2]	20.24	6.01
			Radium-226	0.0032[2]	20.64	13.85
			Lead-210	0.0032[2]	20.64	26.24
			Polonium-210	0.009[2]	21.8	Not detected
		Leafy Vegetables	Natural Uranium	0.017[2]	29.5	17.13
			Thorium-230	0.0025[2]	25.63	7.69
			Radium-226	0.075[2]	43.75	22.06
			Lead-210	0.0058[2]	26.54	38.74
			Polonium-210	0.0025[2]	25.63	Not detected
		Fruits	Natural Uranium	0.004[2]	18.72	11.87
			Thorium-230	0.000085[2]	18.02	5.4
			Radium-226	0.0061[2]	19.1	12.82
			Lead-210	0.009[2]	19.62	24.95
			Polonium-210	0.0004[2]	18.07	Not detected
W_v	Dry weight to Wet Weight Conversion Factor	Root Vegetables	Not Radionuclide Specific	0.2[3]		
		Leafy Vegetables		0.25[3]		
		Fruits		0.18[3]		

[1] pCi/kg dry-weight plant per pCi/g dry-weight soil
[2] pCi/kg dry-weight plant per pCi/g dry-weight soil
[3] Dry weight to wet-weight conversion factor, unitless
[4] pCi/kg wet-weight plant per pCi/g dry-weight soil
[5] pCi/kg wet-weight plant
ML_v = plant soil mass-loading factor for re-suspension of soil to plant v (pCi/kg dry-weight plant per pCi/g dry-weight soil)
Bj_v = concentration factor for uptake of radionuclide j from the soil in plant v (pCi/kg dry-weight plant per pCi/g dry-weight soil)
W_v = dry to wet-weight conversion factor (unitless)

Table 2.9-22. Marsland Expansion Area Radionuclide Analyses for Livestock Sample

Radionuclide, Total	Units	Reporting Limit (RL)	Beef Sample No. 1	Beef Sample No. 2	Beef Samples No. 3	Average Value[a]
Lead 210	µCi/kg	1.0E-6	8.8E-6	5.0E-6	6.1E-6	6.6E-6
Lead 210 Precision (±)	µCi/kg		4.0E-6	2.5E-6	6.2E-6	
Polonium 210	µCi/kg	1.0E-6	<1.0E-6	<1.0E-6	<1.0E-6	NA
Polonium 210 Precision (±)	µCi/kg		NA	NA	NA	
Radium 226	µCi/kg	5.0E-8	1.2E-6	2.0E-7	<5.0E-8	4.8E-7
Radium 226 Precision (±)	µCi/kg		4.0E-7	2.0E-7	NA	
Thorium 230	µCi/kg	2.0E-7	<2.0E-7	<2.0E-7	1.0E-6	4.0E-7
Thorium 230 Precision (±)	µCi/kg		NA	NA	6.0E-7	
Thorium 229 Tracer (30-120)	Percent		95.6	102	107	
Uranium	µCi/kg	2.0E-7	9.0E-7	2.0E-7	<2.0E-7	4.0E-7

NA - Not Applicable
[a] Values less than detection limits reduced by one-half in order to provide a conservative estimate.

Table 2.9-23 Total Radionuclides and Metals in Tissue of Northern Pike Collected from Inlet of Box Butte Reservoir

	May 25, 2014		September 26, 2014		
Radionuclide - Total	**Result [a]**	**Units**	**Result [a]**	**Units**	**RL**
Lead 210	2.8E-05	µCi/kg	<1.0E-06	µCi/kg	1.0E-06
Lead 210 Precision (+)	1.5E-05	µCi/kg	2.9E-06	µCi/kg	--
Lead 210 MDC	1.0E-06	µCi/kg	1.0E-06	µCi/kg	--
Polonium 210	8.1E-06	µCi/kg	<1.0E-06	µCi/kg	1.0E-06
Polonium 210 Precision (+)	7.0E-06	µCi/kg	8.0E-07	µCi/kg	--
Polonium 210 MDC	1.0E-06	µCi/kg	1.0E-06	µCi/kg	--
Radium 226	4.1E-06	µCi/kg	8.0E-07	µCi/kg	5.0E-08
Radium 226 Precision (+)	2.2E-06	µCi/kg	3.0E-07	µCi/kg	--
Radium 226 MDC	5.0E-08	µCi/kg	5.0E-08	µCi/kg	--
Thorium 230	8.0E-07	µCi/kg	4.0E-07	µCi/kg	2.0E-07
Thorium 230 Precision (+)	1.6E-06	µCi/kg	3.0E-07	µCi/kg	--
Thorium 230 MDC	2.0E-07	µCi/kg	2.0E-07	µCi/kg	--
Metals - Total					--
Uranium, Total	.0031	mg/kg	.0023	mg/kg	0.0003
Uranium Activity	2.1E-6	µCi/kg	1.5E-06	µCi/kg	2.0E-07

[a] Results reported on a wet weight basis (as received) for composite of two or more samples (digestion, radiochemistry).
µCi/kg = microcuries per kilogram.
RL = Analyte reporting limit.
MDC = Minimum detectable concentration.
mg/kg – milligram per kilogram

Table 2.9-24. Soils Analysis Results Crow Butte Project and Section 19

Sample Site	Soils Map Unit	Sample Date	Arsenic (μg/g)	Selenium (μg/g)
2	Sarben	7/24/82	0.59	<0.01
5	Keith	7/23/82	1.10	0.04
6	Keith	7/23/82	1.00	0.03
10	Rosebud	7/23/82	1.00	0.03
11	Rosebud	7/24/82	0.80	0.03
13	Jayem	7/23/82	0.80	0.03
15	Duroc	7/24/82	0.70	0.06
19	Sarben	7/24/82	0.88	0.03
22	Vetal	7/24/82	0.88	<0.01
24	Busher	7/24/82	1.00	0.03
24	Sandy Alluvial	7/24/82	0.64	0.04
26	Busher	7/24/82	0.99	0.01
27	Vetal	7/24/82	0.72	0.05
28	Jayem	7/24/82	0.94	0.03
49	Sarben	7/23/82	3.30	0.04

Notes: See Section 2.6 of this LRA for further information on soils map unit.

Table 2.9-25. Soils Analysis Results Crow Butte Project Restricted Area

Sample Site	Sample Date	Vanadium (μg/g)
51	12/15/82	22
52	12/15/82	28
53	12/15/82	22
54	12/15/82	27
55	12/15/82	27
56	12/15/82	29
59	12/15/82	26

Table 2.9.26. Marsland Expansion Area Summary of Soil Sampling

Soil Sampling Type	# of Sample Locations	# of Samples Collected[1]	Sample Depth[2]	Analysis Tested			
				Ra-226	Nat-U	Th-230	Pb-210
Surface Radial Grid	41	41	0-5 cm	41	17	4	4
Subsurface Radial Grid	5	15	0-1 m	15	3	3	3
Air Particulate Monitoring	5	15	0-5 cm	15	15	15	15
	5	5	0-15 cm	5	5	5	5
	5	5	15-30 cm	5	5	5	5

[1] This includes primary samples only, it does not include field QC samples
[2] The radial grid subsurface samples were collected to a depth of 1-m subsamples

Table 2.9-27. Marsland Expansion Area Summary Statistics of Surface Radial Grid Soil Sampling (0-5 cm bgs)

Analyte	Total # of Sample Analyzed	# of Non-Detects[1]	Average (pCi/g)[2]	Minimum (pCi/g)	Maximum (pCi/g)	Standard Deviation (pCi/g)	Median (pCi/g)
Ra-226	41	2	0.7	0.2	1.2	0.3	0.6
Pb-210	4	0	1.4	1.1	2.0	0.4	1.3
Th-230	4	0	0.4	0.3	0.6	0.1	0.4
U-nat	17[3]	0	0.5	0.4	1.6	0.1	0.6

[1] All non-detects were set to the value of the reporting limit prior to performing statistical analysis
[2] pCi/g = picocuries per gram
[3] 13 surface radial grid samples were used in the background analysis

Table 2.9-28. Marsland Expansion Area Summary Statistics of Subsurface Radial Grid Soil Sampling

Analyte	Total # of Sample Analyzed	# of Non-Detects[1]	Average (pCi/g)[2]	Minimum (pCi/g)	Maximum (pCi/g)	Standard Deviation (pCi/g)	Median (pCi/g)
0-33 cm Sample Statistics							
Ra-226	5	0	0.7	0.3	1.3	0.4	0.6
Pb-210	1	0	1.5	1.5	1.5	-	-
Th-230	1	0	0.5	0.5	0.5	-	-
U-nat	1	0	0.5	0.5	0.5	-	-
33-66cm Sample Statistics							
Ra-226	5	0	0.8	0.5	1.2	0.3	0.8
Pb-210	1	1	1.0	1.0	1.0	-	-
Th-230	1	0	0.8	0.8	0.8	-	-
U-nat	1	0	0.5	0.5	0.5	-	-
66-100 cm Sample Statistics							
Ra-226	5	1	0.6	0.2	0.8	0.3	0.7
Pb-210	1	0	1.4	1.4	1.4	-	-
Th-230	1	0	0.5	0.5	0.5	-	-
U-nat	1	0	0.5	0.5	0.5	-	-
All Subsurface Sample Statistics							
Ra-226	15	1	0.7	0.2	1.3	0.3	0.7
Pb-210	3	1	1.3	1.0	1.5	0.3	1.4
Th-230	3	0	0.6	0.5	0.8	0.2	0.5
U-nat	3	0	0.5	0.5	0.5	0.0	0.5

[1] All non-detects were set to the value of the reporting limit prior to performing statistical analysis
[2] pCi/g = picocuries per gram

Table 2.9-29 Marsland Expansion Area Laboratory Results for Air Particulate Monitoring Station Soil Samples

Air Monitoring Station ID	Sampling Depth (bgs)	Ra-226 Reported Value (pCi/g)	Ra-226 Precision +/- (pCi/g)	Pb-210 Reported Value (pCi/g)	Pb-210 Precision +/- (pCi/g)	Th-230 Reported Value (pCi/g)	Th-230 Precision +/- (pCi/g)	Un-Nat Reported Value (pCi/g)
MAR1	0-5 cm	1.8	1.0	3.9	0.5	0.2	0.1	0.4
	0-5 cm	0.4	0.5	3.1	0.4	0.4	0.2	0.4
	0-5 cm	0.3	0.4	2.4	0.4	0.2	0.1	0.4
	0-15 cm	0.2	0.5	3.4	0.6	0.3	0.2	0.5
	15-30 cm	0.7	0.5	6.3	0.5	0.5	0.2	0.5
MAR2	0-5 cm	1.1	0.4	2.2	0.5	0.4	0.1	0.4
	0-5 cm	1.1	0.5	1.8	0.3	0.5	0.1	0.5
	0-5 cm	0.9	0.4	1.3	0.3	0.4	0.1	0.5
	0-15 cm	1.0	0.4	2.1	0.6	0.3	0.1	0.5
	15-30 cm	1.5	0.4	<0.2	-	0.4	0.1	0.5
MAR3	0-5 cm	0.3	0.3	2.2	0.4	0.3	0.1	0.3
	0-5 cm	0.3	0.3	1.5	0.5	<0.2	-	<0.2
	0-5 cm	0.5	0.3	1.8	0.3	<0.2	-	0.3
	0-15 cm	0.4	0.4	2.5	0.4	<0.2	-	0.3
	15-30 cm	0.5	0.3	1.7	0.3	0.3	0.1	0.4
MAR4	0-5 cm	0.9	0.3	1.5	0.3	0.3	0.2	0.4
	0-5 cm	0.8	0.4	1.8	0.3	0.4	0.1	0.6
	0-5 cm	0.9	0.3	1.8	0.3	0.4	0.1	0.4
	0-15 cm	1.0	0.4	1.7	0.3	0.4	0.1	0.4
	15-30 cm	0.7	0.3	1.8	0.3	0.5	0.2	0.6
MAR5	0-5 cm	0.2	0.3	1.5	0.5	0.2	0.1	0.4
	0-5 cm	0.4	0.2	<0.2	-	0.3	0.1	0.3
	0-5 cm	0.4	0.2	<0.2	-	<0.2	-	0.3
	0-15 cm	0.6	0.3	1.3	0.5	0.2	0.1	0.4
	15-30 cm	0.5	0.3	<0.2	-	<0.2	-	0.3

Table 2.9-30. Radionuclide and Metal Analyses for Niobrara River Sample Locations N-1 and N-2 Sediment Samples

Radionuclide	Units	10/25/2013 (Fall Collection Date)		5/02/2014 (Spring Collection Date)	
		Result	Reporting Limit (RL)	Result	Reporting Limit (RL)
N - 1					
RADIONUCLIDES - TOTAL					
Lead-210	µCi/g - dry	1E-6	7E-7[a]	1.3E-6	2E-7
Lead 210 precision (+)	µCi/g - dry	4E-7		2E-7	
Radium 226	µCi/g - dry	6E-7	2E-7	7E-7	2E-7
Radium 226 precision (+)	µCi/g - dry	3E-7		3E-7	
Thorium 230	µCi/g - dry	3E-7	2E-7	2E-7	2E-7
Thorium 230 precision (+)	µCi/g - dry	1E-7		1E-7	
Thorium 229 Tracer (30-120)	%	51.2		107	
METALS - TOTAL					
Uranium Activity	µCi/g - dry	3E-7	2E-7	6E-7	2E-7
N - 2					
RADIONUCLIDES - TOTAL					
Lead-210	µCi/g - dry	3E-7	2E-7	5E-7	2E-7
Lead 210 precision (+)	µCi/g - dry	1E-7		1E-7	
Radium 226	µCi/g - dry	4E-7	2E-7	5E-7	2E-7
Radium 226 precision (+)	µCi/g - dry	3E-7		2E-7	
Thorium 230	µCi/g - dry	<2E-7	2E-7	<2E-7	2E-7
Thorium 230 precision (+)	µCi/g - dry	NA		NA	
Thorium 229 Tracer (30-120)	%	70.7		93.0	
METALS - TOTAL					
Uranium Activity	µCi/g - dry	2E-7	2E-7	3E-7	2E-7

RL - Analyte reporting limit
MDC – Minimum detectable concentration
mg/kg-dry – milligram/kilogram-dry weight
pCi/g-dry – picocuries per gram -dry weight
[a] The RL used by the laboratory exceeded the NRC RG 4.1 LLD of 2E-7, but the actual sample results exceeded the RL reported by the laboratory; therefore, the reported results are valid.

Table 2.9-31. Radionuclide and Metal Analyses for Marsland Ephemeral Drainage (MED)

Radionuclide	Units	Result	Reporting Limit (RL)		Result	Reporting Limit (RL)
		10/25/2013 (Fall Collection Date)			5/02/2014 (Spring Collection Date)	
MED - 1						
Lead-210	µCi/g-dry	2.1E-6	1E-6 [a]		3E-7	2E-7
Lead 210 precision (+)	µCi/g-dry	4E-7			1E-7	
Radium 226	µCi/g-dry	3E-7	2E-7		3E-7	2E-7
Radium 226 precision (+)	µCi/g-dry	3E-7			2E-7	
Thorium 230	µCi/g-dry	2E-7	2E-7		<2E-7	2E-7
Thorium 230 precision (+)	µCi/g-dry	1E-7			NA	
Thorium 229 Tracer (30-120)	%	92.8			95.2	
METALS						
Uranium Activity	µCi/g-dry	4E-7	2E-7		3E-7	2E-7
MED - 2						
Lead-210	µCi/g-dry	6E-7	2E-7		1.3E-6	2E-7
Lead 210 precision (+)	µCi/g-dry	2E-7			2E-7	
Radium 226	µCi/g-dry	4E-7	2E-7		5E-7	2E-7
Radium 226 precision (+)	µCi/g-dry	3E-7			4E-7	
Thorium 230	µCi/g-dry	<2E-7	2E-7		4E-7	2E-7
Thorium 230 precision (+)	µCi/g-dry	NA			1E-7	
Thorium 229 Tracer (30-120)	%	96.6			98.9	
METALS						
Uranium Activity	µCi/g-dry	2E-7	2E-7		6E-7	2E-7
MED - 3						
Lead-210	µCi/g-dry	4E-7	2E-7		1.4E-6	2E-7
Lead 210 precision (+)	µCi/g-dry	2E-7			2E-7	
Radium 226	µCi/g-dry	2E-7	2E-7		8E-7	2E-7
Radium 226 precision (+)	µCi/g-dry	3E-7			3E-7	
Thorium 230	µCi/g-dry	<2E-7	2E-7		3E-7	2E-7
Thorium 230 precision (+)	µCi/g-dry	NA			1E-7	
Thorium 229 Tracer (30-120)	%	95.6			94.1	
METALS						
Uranium Activity	µCi/g-dry	2E-7	2E-7		5E-7	2E-7

Table 2.9-31. Radionuclide and Metal Analyses for Marsland Ephemeral Drainage (MED) (Cont.)

Radionuclide	Units	Result	Reporting Limit (RL)		Result	Reporting Limit (RL)
		10/25/2013 (Fall Collection Date)			**5/02/2014 (Spring Collection Date)**	
MED - 4						
Lead-210	µCi/g-dry	1.7E-6	1E-6 [a]		2.1E-6	2E-7
Lead 210 precision (+)	µCi/g-dry	4E-7			3E-7	
Radium 226	µCi/g-dry	7E-7	2E-7		8E-7	2E-7
Radium 226 precision (+)	µCi/g-dry	4E-7			4E-7	
Thorium 230	µCi/g-dry	5E-7	2E-7		5E-7	2E-7
Thorium 230 precision (+)	µCi/g-dry	1E-7			1E-7	
Thorium 229 Tracer (30-120)	%	87.2			90.3	
METALS						
Uranium Activity	µCi/g-dry	5E-7	2E-7		5E-7	2E-7
MED - 5						
Lead-210	µCi/g-dry	1.2E-6	1E-6 [a]		2E-6	2E-7
Lead 210 precision (+)	µCi/g-dry	3E-7			2E-7	
Radium 226	µCi/g-dry	6E-7	2E-7		1.2E-6	2E-7
Radium 226 precision (+)	µCi/g-dry	4E-7			5E-7	
Thorium 230	µCi/g-dry	<2E-7	2E-7		5E-7	2E-7
Thorium 230 precision (+)	µCi/g-dry	NA			2E-7	
Thorium 229 Tracer (30-120)	%	54			85.4	
METALS						
Uranium Activity	µCi/g-dry	4E-7	2E-7		6E-7	2E-7
MED - 6						
Lead-210	µCi/g-dry	9E-7	7E-7 [a]		1E-6	2E-7
Lead 210 precision (+)	µCi/g-dry	4E-7			2E-7	
Radium 226	µCi/g-dry	7E-7	2E-7		7E-7	2E-7
Radium 226 precision (+)	µCi/g-dry	3E-7			3E-7	
Thorium 230	µCi/g-dry	4E-7	2E-7		2E-7	2E-7
Thorium 230 precision (+)	µCi/g-dry	1E-7			1E-7	
Thorium 229 Tracer (30-120)	%	93.5	93.5		88.3	
METALS						
Uranium Activity	µCi/g-dry	4E-7	2E-7		4E-7	2E-7

Table 2.9-31. Radionuclide and Metal Analyses for Marsland Ephemeral Drainage (MED) (Cont.)

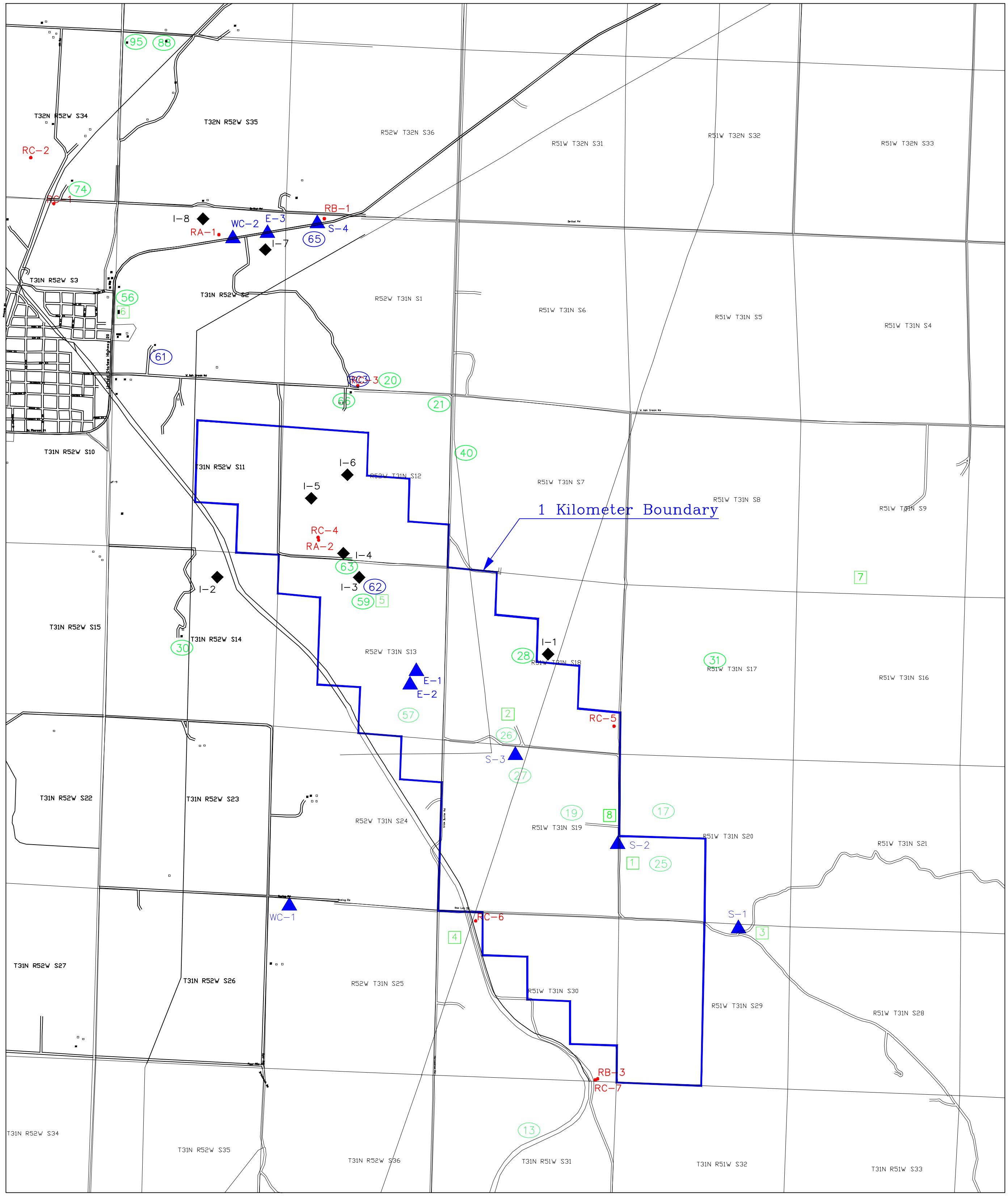
Radionuclide	Units	Result	Reporting Limit (RL)		Result	Reporting Limit (RL)
		10/17/2014 (Fall Collection Date)			**4/30/2015 (Spring Collection Date)**	
MED-7 [b]						
Lead-210	µCi/g-dry	7E-7	2E-7		1.8E-6	2E-7
Lead 210 precision (+)	µCi/g-dry	1E-7			5E-7	
Radium 226	µCi/g-dry	6E-7	2E-7		1E-6	2E-7
Radium 226 precision (+)	µCi/g-dry	1E-7			3E-7	
Thorium 230	µCi/g-dry	1.5E-6	2E-7		4E-7	2E-7
Thorium 230 precision (+)	µCi/g-dry	1.7E-6			2E-7	
Thorium 229 Tracer (30-120)	%	80.5			38.4	
METALS						
Uranium Activity	µCi/g-dry	7.2E-6	2E-7		5.4E-6	2E-7

Table 2.9-32. Marsland Expansion Area Gamma Exposure Results (2011 – 2012)

Location	Exposure of Dosimeter (mrems ambient dose equivalent)		Net Cumulative Totals			Number of Dosimeters Reported
	Gross	Net	Calendar Quarter	Year to Date	Permanent	
	Q4 - 2011					
Transient Control	13.9	-1.0	--	--	--	--
Deploy Control	15.0	0.0	--	--	--	--
MA-1	21.7	6.7	6.7	6.7	6.7	1
MA-2	21.6	6.7	6.7	6.7	6.7	1
MA-3	21.4	6.5	6.5	6.5	6.5	1
MA-4	19.9	5.0	5.0	5.0	5.0	1
MA-5	20.9	5.9	5.9	5.9	5.9	1
	Q1 - 2012					
Transient Control	25.7	-0.6	--	--	--	--
Deploy Control	26.3	0.0	--	--	--	--
MA-1	32.8	6.5	6.5	6.5	13.2	2
MA-2	33.8	7.5	7.5	7.5	14.2	2
MA-3	31.4	5.1	5.1	5.1	11.6	2
MA-4	40.8	14.5	14.5	14.5	19.5	2
MA-5	32.5	6.2	6.2	6.2	12.1	2
	Q2 - 2012					
Transient Control			--	--	--	--
Deploy Control	30.4	0.0	--	--	--	--
MA-1	40.0	9.6	9.6	16.1	22.8	1
MA-2	Badge lost at the monitor site			7.5	14.2	1
MA-3	34.9	4.6	4.6	9.7	16.2	1
MA-4	40.9	10.5	10.5	25.0	30.0	1
MA-5	38.1	7.7	7.7	13.9	19.8	1
	Q3 - 2012					
Transient Control			--	--	--	--
Deploy Control	28.8	0.0	--	--	--	--
MA-1	38.6	9.9	9.9	26.0	32.7	1
MA-2	39.2	10.4	10.4	17.9	24.6	1
MA-3	37.5	8.7	8.7	18.3	24.8	1
MA-4	39.2	10.4	10.4	35.5	40.5	1
MA-5	33.3	4.5	4.5	18.4	24.3	1
	Q4 - 2012					
Transient Control			--	--	--	--
Deploy Control	27.3	0.0	--	--	--	--
MA-1	39.2	11.9	11.9	37.9	44.6	1
MA-2	36.8	9.5	9.5	27.4	34.1	1
MA-3	34.5	7.2	7.2	25.6	32.1	1
MA-4	37.3	10.0	10.0	45.5	50.5	1
MA-5	34.0	6.8	6.8	25.2	31.1	1

mrem – millirems
MA-1 air sampling locations
Minimum Detectable Dose = 0.1 mrems ambient dose equivalent

Figure 2.9-1



CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

Preoperational Nonradiological Sampling Points

Prepared By : RG

Drawn By: WB

Date: 07/2024

- 8 — Air Monitoring Station, Radon, Vegetation Soil, Direct Radiation
- 129 — Water Supply Wells - Brule Formation
- I-2 — Impoundment Water Sample Location
- E-2 — English Creek Water Sample Location
- S-2 — Squaw Creek Water Sample Location
- RC-5 — Regional Baseline Water Wells

CROW BUTTE RESOURCES

0 500 1000 2000 meters

0 1000 3000 5000 feet

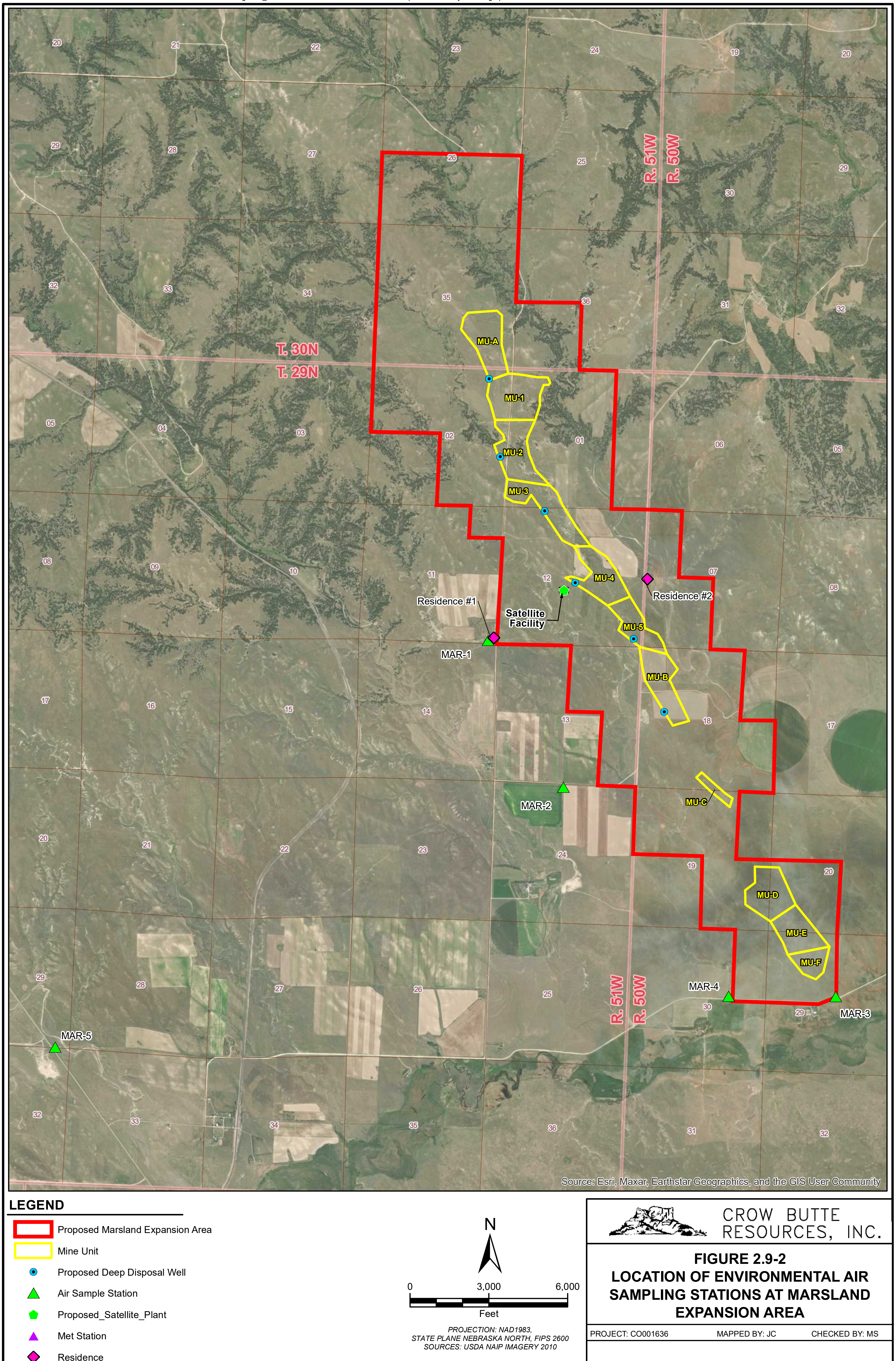
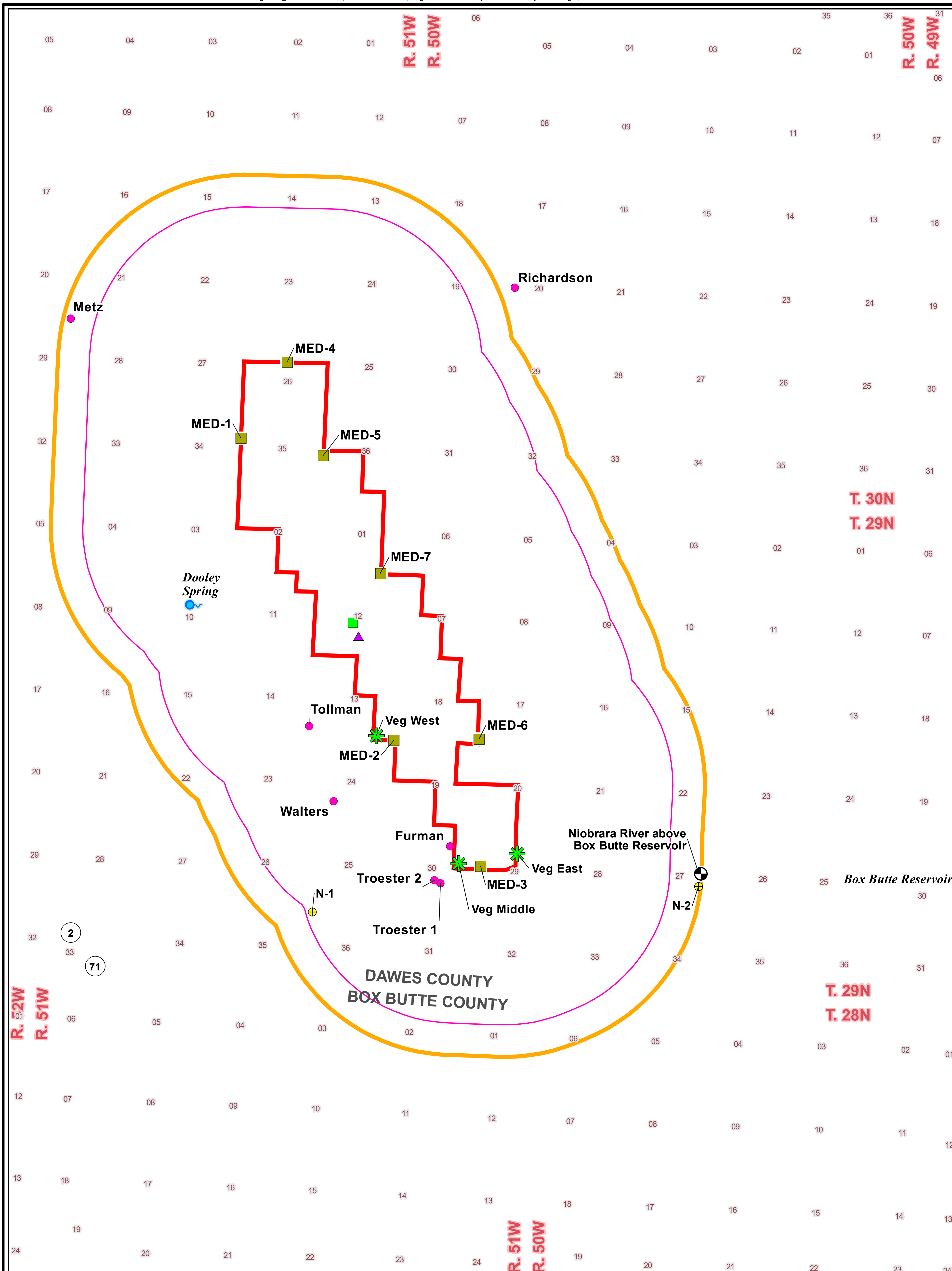


FIGURE 2.9-2
LOCATION OF ENVIRONMENTAL AIR SAMPLING STATIONS AT MARSLAND EXPANSION AREA

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: MS

Path: K:\Sheridan\Cameco Resources\2023078 Crow Butte LRA\06GIS\Figure 2_9-3 Marsland Expansion Area Sampling Locations.mxd | Last Saved By: rventling | Last Saved On: 9/17/2024



LEGEND

- Proposed Marsland Expansion Area
- 2.25-Mile Area of Review (AOR)
- 3-Kilometers AOR for Gardens
- Livestock Sampling Location
- Garden Soil Sampling Location
- Vegetation Sampling Location
- Proposed Marsland Satellite Facility Site
- CBR Surface Water/ Sediment Sampling Location
- Marsland Ephemeral Drainage (MED) Sediment and Surface Runoff Sampling Point
- USGS/NDNR 06454500 and NDEQ SNI4NIOBR402 Gaging Station
- Natural Spring
- Reservoir/Lake/Pond
- Perennial River
- Ephemeral Drainage
- Railroad
- StateHighway

N

0 0.5 1

Miles

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

Note: Fish sampling for radiological analysis occurs in headwaters of Box Butte Reservoir.

FIGURE 2.9-3
SURFACE WATER/SEDIMENT, VEGETATION, GARDEN AND LIVESTOCK SAMPLING LOCATIONS

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: JEC

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3.0 DESCRIPTION OF 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 ion exchange, and then from the ion exchange resin by elution. The leach solution can then be reused for mining purposes. The elution liquid containing the uranium (the "pregnant" eluant) is then processed by precipitation, dewatering, and drying to produce a transportable form of uranium.

In accordance, with SUA-1534 LC 10.2.3 the maximum flow rate of the CPF is 9,000 gpm, excluding restoration flow. Total annual yellowcake production is limited to 2 million pounds. The CPF uses a number of unit operations to recover uranium from the recovered leach solutions. These unit operations consist of:

- Ion exchange
- Uranium elution
- Uranium precipitation
- Uranium dewatering
- Uranium drying and packaging

At the Crow Butte Project, MU1 has been restored and MU2 through MU6 are in stability monitoring, MU7 and MU8 are undergoing groundwater restoration, and MU9 though MU11 are in standby.

Facility information described in Chapter 3 of the MEA TR has been incorporated into this Combined ER/TR. The MEA will consist of a satellite ion exchange plant, mine units, and ISR support facilities. The satellite facility will be located within Section 12, T29N, R51W. In accordance, with SUA-1534 LC 10.3.3 the maximum flow rate of the satellite plant is 5,400 gpm, excluding restoration flow. Waste management facilities at the MEA will include one deep disposal well. CBR will transport loaded resin from the satellite plant to the CPF for elution, precipitation, drying and packaging. Regenerated resin will be transported back to the satellite facility for reuse in the IX circuit.

3.1 ISR PROCESS AND EQUIPMENT

3.1.1 Ore Body

In the Crow Butte Project license area, uranium is recovered by ISR from the basal sandstone of the Chadron Formation at a depth that varies from 400 to 900 feet bgs. The overall width of the mineralized area varies from 1,000 to 5,000 feet. The orebody 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.

In the MEA license area, uranium will also be recovered via ISR from the basal sandstone of the Chadron Formation. The depth to the ore body within the basal sandstone of the Chadron

Formation in the MEA ranges from approximately 850 to 1,200 feet bgs. The width of the ore body varies from approximately 1,000 to 4,000 feet. The ore grade as U_3O_8 ranges from 0.11 to 0.33 percent U_3O_8 with an average ore grade of 0.22 percent U_3O_8.

Typical stratigraphic intervals to be mined by the ISR method are shown in the geologic cross-sections contained in Section 2.6 of this LRA. For ISR wellfields, the production zone is the geological sandstone unit where the leaching solutions are injected and recovered.

3.1.2 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.

3.1.2.1 Well Materials of Construction

The well casing material used by CBR is polyvinyl chloride (PVC), which is 5-inch Standard Dimension Ratio-17 (SDR-17) or equivalent. However, should a larger pump size be required, 6-inch SDR-17 or greater casing may be used. The PVC casing joints normally have a length of approximately 20 feet each, 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.

CertainTeed Certa-Lok well casing or like material will be used for well construction at MEA. Based on manufacturer's information, there is no one recommended maximum depth for a particular size and class of PVC well casing. As explained by the manufacturer, proper design criteria allow a wide range of applications for a particular size and class of PVC casing. For example, it is possible to use thinner-walled casing at significant depths as long as design criteria address hydraulic collapsing pressures and heat. Conversely, thicker-walled casing may fail at shallow depths if collapsing pressures and heat are not designed for accordingly. To ensure that hydraulic collapse pressures are not exceeded during well construction, wells will be constructed using pressure grouting and weighted displacement fluid.

Pressure grouting through the inside of the casing essentially eliminates hydraulic collapsing pressures by retaining pressure on the cement and displacement fluid with a closed well head valve. Weighted displacement fluid consisting of water, bentonite-based drilling mud, and/or a weighting agent (such as barite) may also be used to displace cement. Weighted displacement fluid helps maintain the hydraulic collapse pressure in case of a leaky well head and reduces the pumping pressures required to push the annular column of cement to the surface. The net external hydraulic collapsing pressure at the bottom of the casing will be calculated to ensure the weight of the displacement fluid provides sufficient offsetting internal pressure.

It is important to note that, once the cement has begun to cure and reaches a semi-rigid state, the collapse pressure forces are eliminated. The cured cement provides lateral support and holds the casing firmly in place. It seals the borehole against water infiltration from the surface and undesirable aquifers. Note also that all wells are required to successfully pass a Mechanical Integrity Test (MIT) prior to being placed into service.

CBR has widely used both PVC and stainless steel (SS) well screens in the injection, production, and monitoring wells at the Crow Butte Project since 1991. Both screen types have demonstrated good reliability with minimal maintenance required when operating within anticipated chemical and pressure environments required for mining.

Stainless steel well screens used by CBR are made out of type 304 and type 316L SS. PVC screens are constructed from white PVC Type 1, Grade 1 material as described in ASTM F480 and ASTM D1784, Class 12454B. Both stainless steel and PVC screens provide excellent resistance to corrosion and corrosion-stress cracking and pitting.

The PVC well casing used at the Crow Butte Project also shows excellent corrosion resistance and durability, meeting the ASTM F480 specifications for plastic pipe. Since 1991, more than 5,000 wells have been placed into production at the Crow Butte Project. Down-hole video surveys do show some calcite and sodium bicarbonate scale buildup on the casing walls. Wells identified with this type of fouling are rehabilitated using a drill rig to jet and flush the scale, generally restoring the well back to original flow rates. Post-rehabilitation down-hole video surveys have shown that the jet-and-flush process removes most foreign material, alleviating fouling and plugging. After removal, no evidence remains to indicate that corrosion or destructive forces have degraded the casing.

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 based on site conditions and purpose of the borehole. For example, PVC well screens are currently used in both shallow monitor wells and commercial production monitor wells. PVC screens are used for these types of wells primarily because these types of monitor wells 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, flow rate using PVC screens is less of a concern for these monitoring wells, as the amount of flow is limited by the formation, not the screen. 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 the Crow Butte Project. In most cases, a slot size of 0.020 inch is sufficient to prevent sand from entering the screens. All Class III wells will be screened and naturally developed. The SS well screen consists of longitudinal ribs of SS with a 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 the Crow Butte Project.

3.1.2.2 Well Construction Methods

Pilot holes for monitor, production, and injection wells are 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 is 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 NDEE under Class III UIC permits.

Method 1: Shown in Figure 3.1-1, involves the setting of an integral casing/screen string. The method consists of drilling a hole, 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 blinding 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 cured sufficiently, the residual cement and plug are drilled out, and the well is developed by airlifting or pumping. 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. Allowing for time for 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 2: Shown in Figure 3.1-2, uses a screen telescoped down inside the cemented casing. As in the first method, 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 packer and/or shale traps is then telescoped through the casing and set in the desired interval. The packer and/or shale traps serve to 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 3: Shown in Figure 3.1-3 and similar to Methods 1 and 2. This method involves setting an integral casing/screen string. The method consists of drilling a hole; 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 cured sufficiently, 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.

Current CBR Class III permits allow a 100-foot maximum spacing for casing centralizers. Historically, CBR has placed centralizers every 60 feet except when a centralizer is scheduled to fall within the potential zone to be screened. In those instances, that centralizer is moved upward on the casing string and out of the screened zone so that it does not interfere with the under-reaming and screening process. Centralizers placed at this spacing still ensure that there is sufficient annular space for the correct placement of the sealing grout and is supported by a successful MIT rate of 98 percent at the Crow Butte Project.

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 geologic staff. The location and amount of drill screen to be set in a well are 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 that is 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 geologic 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 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 is 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 maintained at the 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.

3.1.2.3 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.

3.1.2.4 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.

CBR currently owns one operational logging unit that was built by Century Geophysical Corporation in Tulsa, Oklahoma. The unit is capable of logging drill holes to a depth of approximately 2,000 feet. Additional logging units are available from Cameco operations in Wyoming.

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), SP, 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. 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.

3.1.2.5 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 and borehole walls along the screened interval. The primary goal for well development is to allow formation water to enter the well screen.

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 is continued until clear, sediment-free formation water is produced.

When the water begins to become clear, the development will be temporarily stopped and/or the flow rate will be varied. Sampling and examination for turbidity will be continued. 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. Monitoring for pH and conductivity is performed 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 contained and properly disposed of in either the Crow Butte Project or the MEA wastewater system. Section 3.1.8 of this LRA discusses process wastewaters generated by the wellfield and satellite facility in further detail. Section 4.2 of this LRA discusses handling and disposal of well drilling fluids and well development water.

3.1.2.6 Well Mechanical Integrity Testing

In accordance with SUA-1534 LC 10.1.4, all wells (i.e., injection, production, and monitor) are field tested using pressure-packer tests to demonstrate the mechanical integrity of the well casing. Every well undergoes MIT after well construction is completed before it can be placed into service; after any work-over with a drill rig or servicing with equipment or procedures that could damage the well casing; at least once every 5 years (plus or minus 20 percent) it is in use; 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 NDEE and is currently contained in the SHEQMS Volume III, *Operating Manual*. The following MIT procedure is used:

- The test consists of placement of one or 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 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 time period, the well has failed MIT. When possible, a well that fails MIT 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 Chapter 6.0.

CBR submits all MIT records to the NDEE for review after the initial construction of a mine unit or wellfield. Test results are also maintained on site for regulatory review.

3.1.3 ISR Chemistry

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)$\rightarrow$$UO_3$ (at solid surface) + H_2O

UO_2 (solid)+ $\frac{1}{2}O_2$ (in solution)$\rightarrow$$UO_3$ (at solid surface)

Dissolution: $UO_3 + 2HCO_3^{-1} \leftrightarrow UO_2(CO_3)_2^{-2} + H_2O$

$UO_3 + CO_3^{-2} + 2HCO_3^{-1} \leftrightarrow UO_2(CO_3)_3^{-4} + H_2O$

The principal uranyl carbonate complex 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.

The typical lixiviant concentration and composition is shown in Table 3.1-1.

3.1.4 Wellfield Design and Operation

3.1.4.1 Crow Butte Project

The mine units at the Crow Butte Project are depicted in Figure 3.1-4. The mine schedule is shown in Figure 1.7-1. Table 1.7-1 shows the history of mining operations to date.

Each mine unit contains a number of wellfield houses where injection and recovery solutions from the process building are distributed to the individual wells. Table 3.1-2 shows the current number of wellfield houses by Mine Unit. The injection and production manifold piping from the existing process facility to these wellfield houses is PVC, high-density polyethylene with butt welded joints or equivalent. In the wellfield house, injection pressure is monitored on the injection trunk lines. Oxygen is added to the injection stream in the wellfield house, and all injection lines off of the injection manifold are equipped with totalizing flowmeters that are monitored in the Control Room. Production solutions returning from the wells to the production manifold are also monitored with a totalizing flowmeter. All pipelines are leak tested and buried prior to production operations.

The wellfield injection/production pattern currently employed is based on a hexagonal seven spot pattern, which is 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 in a normal pattern are typically between 65 feet and 150 feet apart. A typical wellfield layout is shown in Figure 3.1-5. 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 perimeter monitor well ring, prior to stability monitoring, more water is produced than injected to create an overall hydraulic cone of depression in the production/restoration 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” and is required per SUA-1534 LC 10.1.6. The minimum over production or bleed rates are a nominal 0.5 percent of the total wellfield production rate and the maximum bleed rate typically approaches 1.5 percent. Bleed is adjusted as necessary to ensure that the perimeter ore zone monitor wells are influenced by the cone of depression until the initiation of stability monitoring.

Injection of solutions for mining will be at a maximum rate of 9,000 gpm with a 0.5 to 1.0 percent production bleed stream. Production solutions returning from the wells to the production manifold are monitored with a totalizing flowmeter. All pipelines and trunklines are leak tested and buried prior to production operations.

Monitoring of production (extraction) and injection rates and volumes enable an accurate assessment of water balance for the wellfields. Maintenance of the bleed causes an inflow of groundwater into the production area and prevents loss of leach solution.

Depth to groundwater measurements were collected in 147 monitor ring wells and an additional 55 idle injection wells completed in the Basal Chadron aquifer on December 6, 2024. The purpose of the water level data collection was to confirm mining solutions in the Basal Chadron aquifer are adequately contained within operating ISR wellfields by demonstrating the inward flow of groundwater from the monitor ring toward the operating wellfields (e.g. inward hydraulic gradient between the monitor ring and wellfield).

The contour map provided in Figure 3.1-6 illustrates the computed groundwater elevation in the Basal Chadron aquifer and the resulting inward flow of groundwater toward operating wellfields (e.g. inward hydraulic gradient). The observed inward hydraulic gradient confirms the containment of mining solutions within operating wellfield pattern areas, and without evidence of any potential excursion. It should be noted that the depth to groundwater cannot be measured in operating production wells at the Crow Butte Project given existing well construction and infrastructure. As a result, the maximum drawdown or minimum groundwater elevation within operating wellfields cannot be measured directly. Therefore, the groundwater elevation map provided in Figure 3.1-6 underestimates the magnitude of the inward hydraulic gradient and groundwater flow toward operating ISR wellfields (e.g. inward groundwater flow and hydraulic gradient is larger than illustrated in Figure 3.1-6).

Injection pressures are monitored in the wellhouse at the manifold with an audible and visible alarm monitored 24 hours per day, seven 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 the wellhouse manifold.

3.1.4.2 Marsland Expansion Area

The MEA mine schedule and MU map are shown on Figure 1.7-2 and Figure 3.1-7, respectively. The map and mine timeline are based on current knowledge of the area and may be refined as the MEA is further developed. The MEA will be subdivided into an appropriate number of mine units. Each mine unit will contain a number of 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 an equivalent. In the wellhouse, injection pressure will be monitored on the injection trunk lines. 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 mine units will be designed in a manner consistent with the existing CBR mine units.

The wellfield injection/production pattern will employ the hexagonal seven-spot pattern used at the Crow Butte Project. All wells will be completed so they can be used as either injection or recovery wells similar to the Crow Butte Project. Monitor wells will be placed in the basal sandstone of the Chadron Formation and in the overlying Brule Formation and Arikaree Group aquifers.

Injection of solutions for mining will be at a maximum rate of 5,400 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.

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 is limited to less than 0.63 psi per foot of well depth. Injection pressures also will be limited to the pressure at which the well was integrity tested.

Monitoring of production (extraction) and injection rates and volumes enable an accurate assessment of water balance for the wellfields. Maintenance of the bleed causes an inflow of groundwater into the production area and prevents 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, seven 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 the wellhouse manifold.

3.1.5 Water Balance

3.1.5.1 Crow Butte Project

A water balance for the CBR Facility is shown on Figure 3.1-8. The liquid waste generated at the CPF is primarily the production bleed which, at a maximum scenario, is estimated at 1.0 percent of the production flow. At 9,000 gpm, the volume of liquid waste is approximately 47,304,000 gallons per year. CBR adequately handles the liquid waste through the combination of deep disposal well injection and evaporation ponds.

3.1.5.2 Marsland Expansion Area

A water balance for the proposed satellite facility is presented in Figure 3.1-9. The primary liquid waste generated at the satellite facility will be the production bleed which, at a maximum scenario, is estimated at 1.2 percent of the production flow. At 5,400 gpm production rate the maximum volume of liquid waste would be approximately 65 gpm. At 1,550 gpm restoration rate, the maximum volume of liquid waste would be approximately 241 gpm. CBR proposes to handle the liquid waste using DDW injection.

3.1.6 Monitor Well Layout and Design

Monitor wells are placed in the Chadron Formation and in the first significant water-bearing Brule sand above the Chadron Formation. All monitor wells are completed by one of the three methods discussed above and developed prior to leach solution injection. In accordance with SUA-1534 LC 10.1.3 production zone monitor wells drilled after April 1999 may be spaced no greater than 300 feet from a wellfield unit and no greater than 400 feet between the wells.

The groundwater monitoring program is designed to establish baseline water quality prior to mining at each mine site; 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 includes sampling of monitoring wells and private wells within and surrounding the License Area to establish pre-mining baseline water quality. Water quality sampling is continued throughout the operational phase of mining for detection of excursions. Water quality sampling is also conducted 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 is 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.

Water level measurements are routinely performed 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 are adjusted to correct this situation. Increases in water levels in the overlying aquifer may be an indication of fluid migration from the production zone. Adjustments to well flow rates or complete shutdown of individual wells may be required to correct this situation. Increases in water levels in the overlying aquifer may also be an indication of casing failure in a production, injection or monitor well. Isolation and shut down of individual wells can be used to determine the well causing the water level increases.

To ensure the solutions are contained within the designated area of the aquifer being mined, the production zone and overlying aquifer monitor wells will continue to be sampled once every two weeks as discussed in Section 5.7.8 of this LRA.

Pumping tests at the MEA will be performed for each MU not covered by the regional pump test to demonstrate hydraulic containment above the production zone, demonstrate communication between the production zone mining and exterior monitor wells, and to further evaluate the hydrologic properties of the basal sandstone of the Chadron Formation.

Prior to the startup of a MEA MU the following wellfield package will be submitted to the NRC for review:

1. hydrologic test data;
2. completion reports on the monitoring wells;
3. water quality data used to determine excursion control parameters, and;
4. baseline preoperational groundwater quality including; well density, sampling frequency, and determination of groundwater restoration goals.

3.1.7 Flood Protection

3.1.7.1 Crow Butte Project

The potential for flooding or erosion that could impact the CPF and surface impoundments have been assessed based on data from the Federal Emergency Management Agency (FEMA 2007). All surface facilities within the Crow Butte Project License Area occur outside of the 100-year flood plain of the White River and are not likely to be within a "flood-prone" area.

CBR installs protective berms and dams around surface water features such as Squaw Creek and English Creek where their courses pass through an active wellfield. The purpose of the protective berms and dams is to minimize the potential for a spill of mining, process, or restoration solutions from entering the local creeks and impoundments. These berms and dams are constructed of native soil and are subject to erosion and damage from natural and manmade factors. All berms are inspected by CBR semi-annually.

CBR has installed a system of dams in areas where overland runoff passes through the wellfields and reaches surface water features. These dams are constructed of the native soil in the area. The purpose of the dams is to retain any collected runoff from wellfields to allow controlled discharges. All dams are inspected on a regular basis for structural integrity and the presence of water. In addition to scheduled inspections, dams are inspected at any time that it is suspected they may have sustained damage. Potential reasons for special inspections include notification by field personnel of observed damage, torrential rains or flooding in the area, or construction activities in the immediate area.

3.1.7.2 Marsland Expansion Area

The potential for flooding or erosion that could impact the MEA processing facilities and mine units has been assessed through two separate studies and detailed analysis was provided in the Technical Report for the Marsland Expansion Area. 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.

CBR will use the results of the two hydrologic and erosion studies to support current and future planning and additional project design and layout. Once more detailed engineering commences, the results of the 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 MU (locations of buildings, wells, and piping), DDWs, or the satellite facility building and associated structures.

3.1.8 Process Wastes

Several sources of liquid and solid wastes are generated during operation. A summary of major process waste streams is provided below for each site. These sources, and associated methods of handling, are discussed in detail in Chapter 4.

3.1.8.1 Crow Butte Project

3.1.8.1.1 Air Emissions

Airborne emissions from yellowcake drying are maintained at a minimum by a vacuum drying system. It is only radon gas that is mobilized during process operations and vented to the atmosphere.

3.1.8.1.2 Liquid Wastes

The operation of the CPF results in two primary sources of liquid waste, a production bleed and an eluant bleed. The production bleed stream is continuously withdrawn from the recovered lixiviant stream at a rate between 0.5 to 1.5 percent of the total volume of recovered lixiviant. The production bleed stream is taken following the recovery of the uranium by ion exchange and has the same chemical characteristics as the lixiviant. The eluant bleed stream is currently produced at a rate of approximately 5 to 10 gpm. The eluant bleed waste stream is managed by reuse in the plant or disposal in existing ponds and/or by deep well injection. The production bleed waste stream is managed by a combination of evaporation pond and deep disposal well injection.

3.1.8.1.3 Solid Waste

Solid waste generated at the Crow Butte Project consists primarily of spent resin, resin fines, empty reagent containers, miscellaneous pipe and fittings, and domestic trash. The solid waste is segregated based on whether it is clean or has the potential for contamination with 11e.(2) byproduct materials.

Byproduct material generated at the Crow Butte Project consists of wastes such as filters, personal protective equipment (PPE), spent resin, piping, etc. All byproduct material is disposed of at a licensed facility approved for disposal of 11e.(2) byproduct material. All other non-byproduct solid waste is disposed of in an approved landfill. There is no on-site disposal of these materials.

Septic system solid waste is generated in a septic system. Solids generated during periodic cleanouts of the septic tank are disposed of by companies or individuals licensed by the State of Nebraska.

3.1.8.1.4 Hazardous Waste

To date, CBR has only generated universal hazardous waste such as waste oil and batteries. Waste oil is disposed of by a licensed waste oil recycler. The Crow Butte Project is currently classified as a Conditionally Exempt Small Quantity Generator (CESQG).

3.1.8.2 Marsland Expansion Area

3.1.8.2.1 Liquid Waste

All well development water will be captured and disposed in the DDW. Alternatively, these fluids may be transported to the CPF evaporation ponds. The operation of the satellite facility will result in a production bleed stream that is continuously withdrawn from the recovered lixiviant stream at an expected rate of 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 using a DDW, which will be constructed and operational at the satellite facility prior to commencement of production.

3.1.8.2.2 Solid Waste

Solid waste generated at the MEA will consist primarily of 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 11e.(2) byproduct materials.

Byproduct material generated at the MEA will consist of wastes such as filters, personal protective equipment (PPE), spent resin, piping, etc. All byproduct material will be disposed of at a licensed facility approved for disposal of 11e.(2) byproduct material. All other non-byproduct solid waste will be disposed of in an approved landfill. There is no on-site disposal of these materials.

Septic system solid waste will be generated in a septic system. Solids generated during periodic cleanouts of the septic tank will be disposed of by companies or individuals licensed by the State of Nebraska.

3.1.8.2.3 Hazardous Waste

Similar to the Crow Butte Project, the MEA will be classified as CESQG and limited to 220 pounds (100 kilograms) of hazardous waste per month.

3.2 CPF, SATELLITE PLANT, PROCESSING, AND CHEMICAL STORAGE FACILITIES

3.2.1 Process Description

Solutions resulting from the leaching of uranium underground is recovered through the production wells and piped to the processing plant for extraction. The uranium recovery process utilizes the following steps:

1. Loading of uranium complexes onto an ion exchange resin;
2. Reconstitution of the leach solution by addition of carbonate and an oxidizer;
3. Elution of uranium complexes from the resin; and
4. Drying and packaging of the uranium.

The Crow Butte Project process flow sheet for the above steps is shown in Figure 3.2-1. At the MEA, the first two steps will be performed at the satellite facility. Steps 3 and 4 will be performed at the CPF.

3.2.1.1 Uranium Extraction

Recovery of uranium takes place in the ion exchange columns. The uranium bearing leach solution enters the column and as it passes through, the uranium complexes in solution are loaded onto the IX resin in the column. This loading process is represented by the following chemical reaction:

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

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

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

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.

3.2.1.2 Elution

Once the majority of the ion exchange sites on the resin in an IX column are filled with uranium, the column is taken off stream. At the MEA satellite plant the loaded resin will be transferred to a tanker truck for transport to the CPF for elution and final processing.

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

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

During the elution process, the pregnant eluant is transferred to the precipitation tank and intermediate eluant is stored in a tank for use during the next elution cycle.

After the uranium has been stripped from the resin, the resin is rinsed with a solution containing sodium bicarbonate. The rinse may also be performed with raw water or with water from another source. This rinse removes the high chloride eluant 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. After the MEA resin has been stripped of the uranium by elution, it will be returned to the satellite facility for reuse in the IX circuit.

3.2.1.3 Precipitation

When a sufficient volume of pregnant eluant 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:

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

Sodium hydroxide (NaOH) is added to raise the pH to a level conducive for precipitating pure crystals. Hydrogen peroxide is then added to the solution to precipitate the uranium according to the following reaction:

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

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 dryer for drying before shipping or is sent to storage for shipment as slurry to a licensed recovery or converting facility.

3.2.2 Crow Butte Project

3.2.2.1 CPF Equipment

A general arrangement for the CPF is presented in Figure 3.2-2. The recovery plant equipment can be placed in one of the following unit operations:

- Ion Exchange
- Filtration
- Lixiviant injection
- Elution/precipitation
- Dewatering/drying

The ion exchange system consists of eight up-flow and six down-flow ion exchange columns. The uranium loading process is continuous, but the elution process is operated on a batch process. The loaded up-flow columns are eluted in place; the down-flow loaded resin is either moved across a screen deck for washing before being eluted or is transferred directly in a separate elution column.

The up-flow injection filtration system consists of backwashable filters, with an option of installing polishing filters downstream. The down-flow system utilizes screens to prevent resin loss, and the resin itself acts as an injection filter, with an option of installing polishing filters downstream.

The up flow lixiviant injection system consists of the injection surge tanks and the injection pumps. The tanks are fabricated out of FRP, and the injection pumps are centrifugal. The down-flow injection system depends on the down-hole submersible pumps to push through the sealed down-flow system and reinject the lixiviant. There is an option for in-line centrifugal booster pumps as needed to maintain pressures.

The elution/precipitation circuit consists of the barren eluant tanks and the acidizer/precipitator tanks. The barren eluant tanks and the precipitation tanks are constructed of FRP. The eluant is pumped from the barren eluant tanks to the ion exchange column that is in the elution mode. After the resin is eluted, the pregnant eluant is transferred to the acidizer/precipitator where the uranium is precipitated.

Process tanks are vented for radon, O_2 and CO_2 removal. Building ventilation in the process equipment area is accomplished by the use of an exhaust system. This exhaust system draws fresh air in from ventilators and helps sweep radon, which can accumulate near the floor of the building, out to the atmosphere.

3.2.2.2 Chemical Storage Facilities

Chemical storage facilities at the Crow Butte Project include both hazardous and non-hazardous material storage areas. Bulk hazardous materials, which have the potential to impact radiological safety, are stored outside and segregated from areas where licensed materials are stored. Other non-hazardous bulk process chemicals (e.g., sodium carbonate) that do not have the potential to impact radiological safety are stored in a designated area.

3.2.2.2.1 Process Related Chemicals

Process-related chemicals stored in bulk are shown on Figure 3.2-2 and include carbon dioxide, hydrogen peroxide, oxygen, sodium hydroxide, hydrochloric acid, sodium carbonate, sodium bicarbonate, sodium chloride and sodium sulfide. Operating procedures, safety precautions and hazards associated with the handling and use of process-related chemicals are discussed in CBR's SHEQMS Volume V Industrial Safety Manual. CBR maintains current safety data sheets (SDSs) for each of the process-related chemicals onsite, and these sheets are available upon request.

- **Carbon Dioxide -** Carbon dioxide (CO_2) is added to the lixiviant and serves as a pH buffer to keep oxidized uranium carbonate in solution.

  Carbon dioxide is a suffocating agent and may cause nausea, respiratory problems and asphyxia in a confined area. It is a slightly toxic, nonflammable, colorless and odorless gas, with a slightly pungent taste. It is soluble in water, ethanol and acetone. It is an acidic oxide and reacts with water to form carbonic acid, and it reacts with alkalis to produce carbonates and bicarbonates.

- **Hydrogen Peroxide** – Hydrogen peroxide (H_2O_2) 50% aqueous solution is added to the lixiviant and serves as an oxidant used during the precipitation phase of uranium and can be used in place of oxygen.

  Hydrogen peroxide is a clear, colorless liquid that is soluble in water. It is a strong oxidizer capable of oxidizing uranium mineralization and killing some forms of well fouling bacteria. It can be corrosive to eyes, nose, throat and lungs, may cause skin irritation, and may cause irreversible tissue damage to the eyes including blindness. Hydrogen peroxide is not a stable compound; and as it decomposes, it generates oxygen and water, which cause an increase in the volume of product present. The storage container is vented to allow gaseous oxygen to escape as the hydrogen peroxide breaks down. The chemical is not allowed to become trapped in a closed vessel, valve or pipe, and this is accomplished through venting.

- **Oxygen** – Oxygen (O_2) is also typically stored at the CPF, or within wellfield areas, where it is centrally located for addition to the injection stream in each wellhouse. Since oxygen readily supports combustion, fire and explosion are the principal hazards that must be controlled. The oxygen storage facility is located a safe distance from the CPF and other chemical storage areas for isolation. The storage facility has been designed to meet industry standards in NFPA-50 (NFPA 1996). Oxygen is added to the lixiviant used for extraction of uranium forming UO_3.

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

- **Sodium Hydroxide** – Sodium hydroxide (NaOH) is used for pH adjustment during the uranium precipitation phase. The sodium hydroxide raises the pH to a level conducive for precipitating pure crystals.

  Sodium hydroxide is in the form of a fine granular, nonflammable, solid or a whitish liquid. It is stable under ordinary conditions of use and storage. It is very hygroscopic and can slowly pick up moisture from the air and react with carbon dioxide from air to form sodium carbonate. Sodium hydroxide is a strong irritant, with effects from inhalation of dust or mist varying from mild irritation to serious damage of the upper respiratory tract, depending on the severity of exposure. Symptoms may include sneezing, sore throat or runny nose. Severe pneumonitis may also occur.

- **Hydrochloric Acid** – Hydrochloric acid (HCl) is used for pH adjustment during the uranium precipitation phase. The HCl acidifies the pregnant eluant in order to destroy the uranyl carbonate complexion.

  HCl is highly corrosive, and the inhalation of vapors can cause coughing, choking, inflammation of the nose, throat, and can cause pulmonary edema, circulatory failure and death. It is very hazardous with regard to skin contact (corrosive, irritant and permeator), eye contact (irritant, corrosive) and ingestion. It is a colorless liquid with a pungent odor and is infinitely soluble.

  As part of the 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 HCl as the most hazardous chemical with the greatest potential for impacts to chemical and radiological safety. The HCl storage and distribution system at the CPF (Figure 3.2-2) has a maximum capacity of approximately 6,000 gallons. Strict unloading procedures are utilized to ensure that safety controls are in place during the transfer of HCl. Process safety controls are also in place at the CPF where HCl is added to the precipitation circuit.

- **Sodium Carbonate** – Sodium carbonate (Na_2CO_3) is combined with CO_2 to form sodium bicarbonate to keep oxidized uranium in solution. Sodium carbonate is used with carbon dioxide in oxidizing the uranium.

  Sodium carbonate is only slightly toxic but can be very irritating to the eyes and skin and poses an inhalation hazard when it is in its salt stage (dust inhalation) or from small leaks in the form of a spray. Symptoms from excessive inhalation of dust may include coughing and difficult breathing. Its appearance is a white powder or granules, and it is stable under ordinary conditions of use and storage. It is hygroscopic and readily absorbs moisture from the air. Solutions are strong bases.

- **Sodium Bicarbonate** – Sodium bicarbonate ($NaHCO_3$) is used to keep oxidized uranium in solution. Sodium bicarbonate is also used in the resin regeneration process. Sodium bicarbonate can be used without carbon dioxide in oxidizing the uranium. CBR maintains the option of using sodium carbonate/carbon dioxide or sodium bicarbonate in the oxidization of uranium.

  Inhalation of dust may cause irritation to the respiratory tract, and excessive contact is known to cause damage to the nasal septum. Symptoms from excessive inhalation of dust may include coughing and difficulty in breathing. Its appearance is in the form of a white powder or granules, and it is stable under ordinary conditions of use and storage. It is hygroscopic and readily absorbs moisture from the air. Solutions are strong bases.

- **Sodium Chloride** – Sodium chloride (NaCl) is used to regenerate/recycle the resin for further use in uranium extraction.

  Sodium chloride can be very irritating to the eyes and the skin and may cause mild irritation to the respiratory tract. However, it is not believed to present a significant hazard to health. Its appearance is in the form of crystals or white powder, odorless, and it is stable under ordinary conditions of storage and use. It is hygroscopic.

- **Sodium Sulfide** – Sodium sulfide (Na_2S) is used during groundwater restoration activities as a chemical reductant. The use of sodium sulfide in groundwater restoration decreases the solubility of various heavy metals.

  The sodium sulfide consists of a dry, flaked product and is typically purchased on pallets of 55-pound bags or super sacks of 1,000 pounds. The bulk inventory is stored outside of process areas in a cool, dry, clean environment to prevent contact with any acid, oxidizer, or other material that may react with the product.

  Both solid and liquid sodium sulfide can be hazardous and toxic. The chemical, which becomes alkaline when moist, is corrosive. Protective clothing and PPE should be worn to prevent any eye or skin contact, inhalation or ingestion. Contact lenses must not be worn when handling this material. Any contact with water, acids, oxidizers or heat can produce hydrogen sulfide gas, which is both flammable and toxic. Exposure to this gas, which, in low concentrations smells of rotten eggs, can result in loss of the sense of smell when present in concentrations greater than 100 ppm. At higher concentrations, hydrogen sulfide can cause paralysis and death. Fine sodium sulfide dust/air mixtures can also be explosive in confined spaces.

  If the correct operating procedures are followed, the risk of generating hydrogen sulfide gas while mixing this reagent is extremely low. The saturation tank at CBR is vented outside the building as a precaution. As an additional precaution, the building is equipped with a hydrogen sulfide (H_2S) monitor that presents an audible alarm to the CPF. During normal operating activities, Safety, Health, Environment and Quality (SHEQ) personnel may monitor chemical makeup activities with a portable H_2S monitor, if required. Whenever possible, the chemical is mixed during the day shift, Monday through Friday.

None of the hazardous chemicals used at the Crow Butte Project are covered under the USEPA's 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.

3.2.2.2.2 Non-Process Related Chemicals

Non-process related chemicals that are stored at the Crow Butte Project include petroleum (gasoline, diesel) and propane. Due to the flammable and/or combustible properties of these materials, all bulk quantities are stored outside of process areas at the satellite plant. All gasoline and diesel storage tanks are located above ground and within secondary containment structures to meet EPA requirements.

3.2.3 Marsland Expansion Area

3.2.3.1 Satellite Facility Equipment

A general arrangement of equipment for the satellite facility is shown on Figure 5.7-1. The satellite facility equipment will be housed in a building and will include the following systems:

- Ion exchange
- Filtration
- Resin transfer
- Chemical addition.

The satellite facility will house the IX columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, wastewater tanks, and an employee lunchroom/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 wellfield. Gaseous O_2 is added to the injection line for each injection well at the wellhouses.

The IX system will consist 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 maximum rate of 5,400 gpm. Once a set of columns is loaded with uranium, the resin is transferred to a truck for transport 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 occur only when the individual columns are disconnected from the circuit and opened to remove the resin for elution. Exposure pathways associated with downflow columns to be used at MEA are discussed in Section 7.3.1 of this LRA.

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.

The areas in the satellite facility where fumes or gases could be generated are discussed in Sections 7.3 and 7.4 of this LRA. 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.

3.2.3.2 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.

3.2.3.2.1 Process Related Chemicals

Process-related chemicals stored in bulk at the satellite facility will include carbon dioxide (CO_2), oxygen (O_2), and hydrogen peroxide (H_2O_2). Sodium sulfide (Na_2S) may also be stored for use as a reductant during groundwater restoration.

- **Carbon Dioxide** – Carbon dioxide will be stored adjacent to the satellite facility, where it will be added to the lixiviant prior to leaving the satellite facility.
- **Hydrogen Peroxide** – Hydrogen peroxide (50% aqueous solution) is added to the lixiviant and serves as an oxidant used during the precipitation phase of uranium and can be used in place of oxygen.
- **Oxygen -** Oxygen 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. Since oxygen readily supports combustion, fire and explosion are the principal hazards that must be controlled. The oxygen storage facility is located a safe distance from the satellite facility and other chemical storage areas for isolation. The storage facility has been designed to meet industry standards in NFPA-50 (NFPA 1996).

  Oxygen service pipelines and components must be clean of oil and grease since gaseous oxygen will cause these substances to burn with explosive violence if ignited. All components intended for use with the oxygen distribution system are properly cleaned using recommended methods in CGA G-4.1 (CGA 2000). The design and installation of oxygen distribution systems is based on CGA-4.4 (CGA 1993).
- **Sodium Sulfide -** Sodium sulfide is used during groundwater restoration activities as a chemical reductant. The use of sodium sulfide in groundwater restoration decreases the solubility of various heavy metals.

3.2.3.2.2 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 above ground and within secondary containment structures to meet regulatory requirements.

3.3 INSTRUMENTATION AND CONTROL

3.3.1 Crow Butte Project

The basic control system at the Crow Butte Project is built around a Sequential Control and Data Acquisition (SCADA) System. This system allows for extensive monitoring of all wellfield and recovery plant operations. The system is monitored twenty-four hours per day, seven days per week by operators. The operators rely on visual and audible alarms from a variety of systems to control mine operations. Examples include but are not limited to power failures, pressure exceedances, flow disruptions and the presence of liquids in the well houses.

The system consists of a series of menus which allows the plant operator to monitor and control a variety of systems and parameters. In addition, each wellfield house contains its own processor, which allows it to operate independent of the main computer. All critical equipment is equipped with uninterrupted power supply systems with a 30-minute supply in the event of a power failure.

Through this system, not only can the plant operators monitor and control every aspect of the operation on a real time basis, but management can review historical data to develop trend analysis for production operations. This not only ensures an efficient operation, but allows CBR personnel to anticipate problem areas, and to remain in compliance with appropriate regulatory requirements.

Wellfield instrumentation is provided to measure total production and injection flow. In addition, instrumentation is provided to indicate the pressure that is being applied to the injection wells. Wellfield houses are equipped with wet alarms to detect the presence of liquids in the wellfield house sumps. The deep injection well is also equipped with a variety of sensors to monitor its status.

Instrumentation is provided to monitor the total flow into the CPF, the total injection flow leaving the CPF, and the total waste flow leaving the plant. Instrumentation is provided on the CPF injection manifold to record an alarm in the event of any pressure loss that might indicate a leak or rupture in the injection system. The injection pumps are equipped with pressure reducing valves so that they are incapable of producing pressures high enough to exceed the design pressure of the injection lines or the maximum pressure to be applied to the injection wells. During power failures, over pressuring of wells is not possible as all pump systems are shut down.

In the process areas, tank levels are measured in chemical storage tanks as well as process tanks. A number of different monitors are in place for the dryer system, and drum logging is automated.

Handheld radiation detection instruments and portable samplers are used to monitor radiological conditions at the Crow Butte Project. Specifications for this equipment are included in CBR's SHEQMS Program Volume IV, Health Physics Manual, and are discussed in further detail in Chapter 5. The location of monitoring points, monitoring procedures, and monitoring frequencies for in-plant radiation safety is also discussed in Chapter 5 of this LRA.

3.3.2 Marsland Expansion Area

The instrumentation and controls at the MEA will be configured similar to those at the CPF. Other than newer equipment, the interaction among the operators, computers, instrumentation, alarm systems, and process equipment will not change. The configuration employed at the CPF has effectively minimized upsets and provides balanced operation.

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. A wellhouse will be equipped with wet alarms to monitor the presence of liquids in the wellhouse sumps. The system will be monitored 24 hours per day, 7 days per week by control room operators. The operators will 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, and piezoelectric and vortex flow meters.

The injection pumps will be equipped with pressure reducing valves so that they are incapable of producing pressures high enough to exceed design pressure of the injection lines, the 125 psi integrity test, the maximum pressure demonstrated in each injection well, or the 100 psi maximum injection pressure measured at the wellhouse manifold. Pressure gauges, pressure shutdown switches, and pressure transducers will be used to monitor and control the trunkline pressures. During power failures, over-pressuring of wells will not be possible, as all pump systems will be shut down.

The basic control system at the satellite facility and associated wellfield will be built around a SCADA 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 SCADA 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. The injection manifold in each wellhouse will be alarmed at 90 to 95 psi, to ensure that the pressure remains below the 100 psi maximum injection pressure measured at the wellhouse manifold.

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 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 will be 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. The final design, including installation and use of devices to monitor injection pressure, flow rate, and volume, must be submitted for approved by the NDEE and written verification by the NRC.

3.4 REFERENCES

Compressed Gas Association (CGA), 1993, CGA G-4.4, Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems.

Compressed Gas Association (CGA), 2000, CGA G-4.1, Cleaning Equipment for Oxygen Service.

Federal Emergency Management Agency (FEMA), 2007, Map Service Center.

Lewis, B., 2024, Updated groundwater flow model for the CBR facility.

National Fire Protection Association (NFPA), 1996, NFPA-50, Standard for Bulk Oxygen Systems at Consumer Sites.

Table 3.1-1: Typical Lixiviant Concentration and Composition

Species	Range	
	Low	High
Na	≤ 400	6000
Ca	≤ 20	500
Mg	≤ 3	100
K	≤ 15	300
CO_3	≤ 0.5	2500
HCO_3	≤ 400	5000
Cl	≤ 200	5000
SO_4	≤ 400	5000
U_3O_8	≤ 0.01	500
V_2O_5	≤ 0.01	100
TDS	≤ 1650	12000
pH	≤ 6.5	10.5

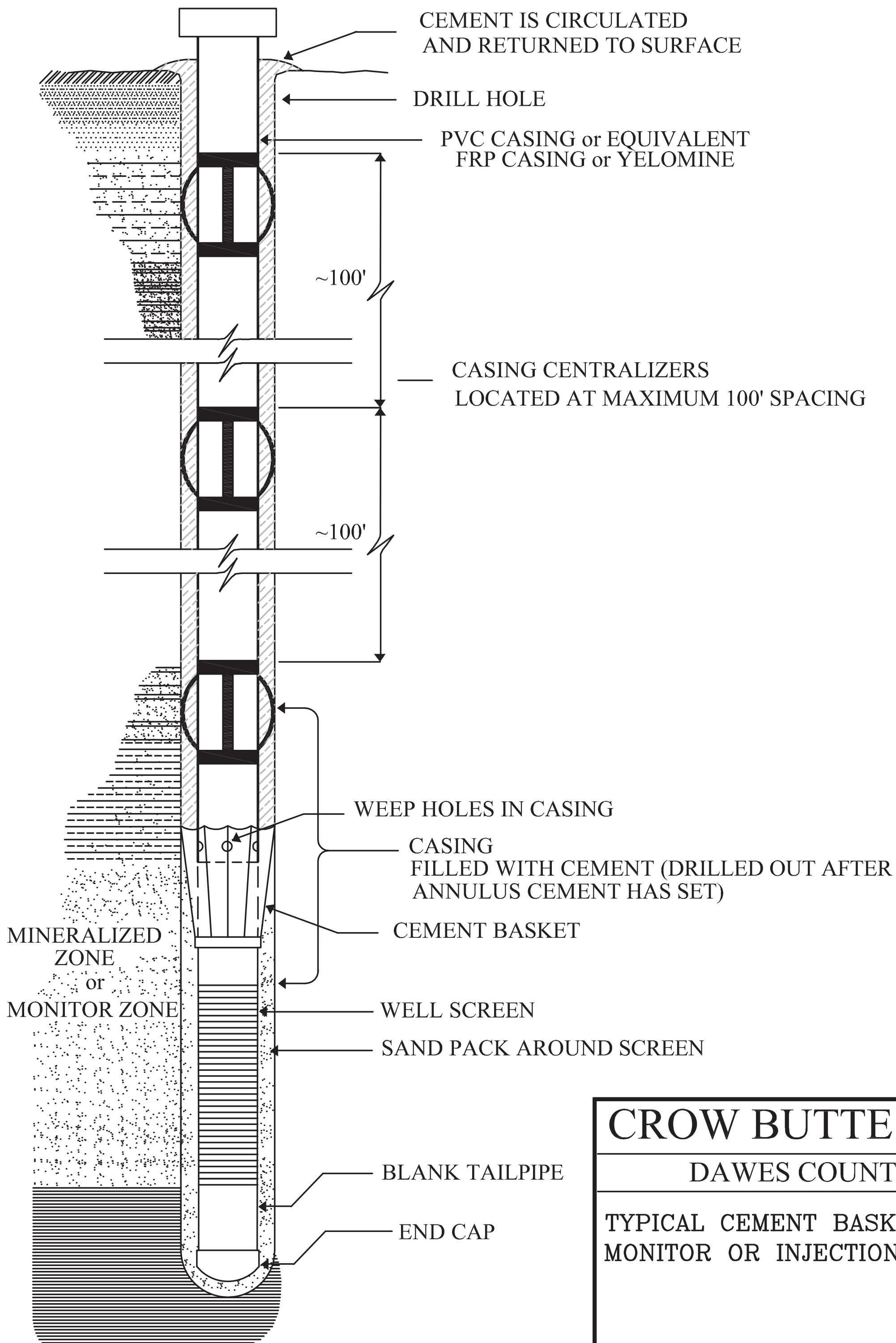
* All values in mg/L except pH (units).
Note: The above values represent the concentration ranges that could be found in barren lixiviant or pregnant lixiviant and would include the concentration normally found in “injection fluid”.

Table 3.1-2: Wellfield Houses by Mine Unit

Mine Unit	Wellfield Houses
Mine Unit 1	2
Mine Unit 2	3
Mine Unit 3	3
Mine Unit 4	5
Mine Unit 5	7
Mine Unit 6	7
Mine Unit 7	6
Mine Unit 8	8
Mine Unit 9	7
Mine Unit 10	9
Mine Unit 11	5

Figure 3.1-1

Well Completion Method No. 1



CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

TYPICAL CEMENT BASKET COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS

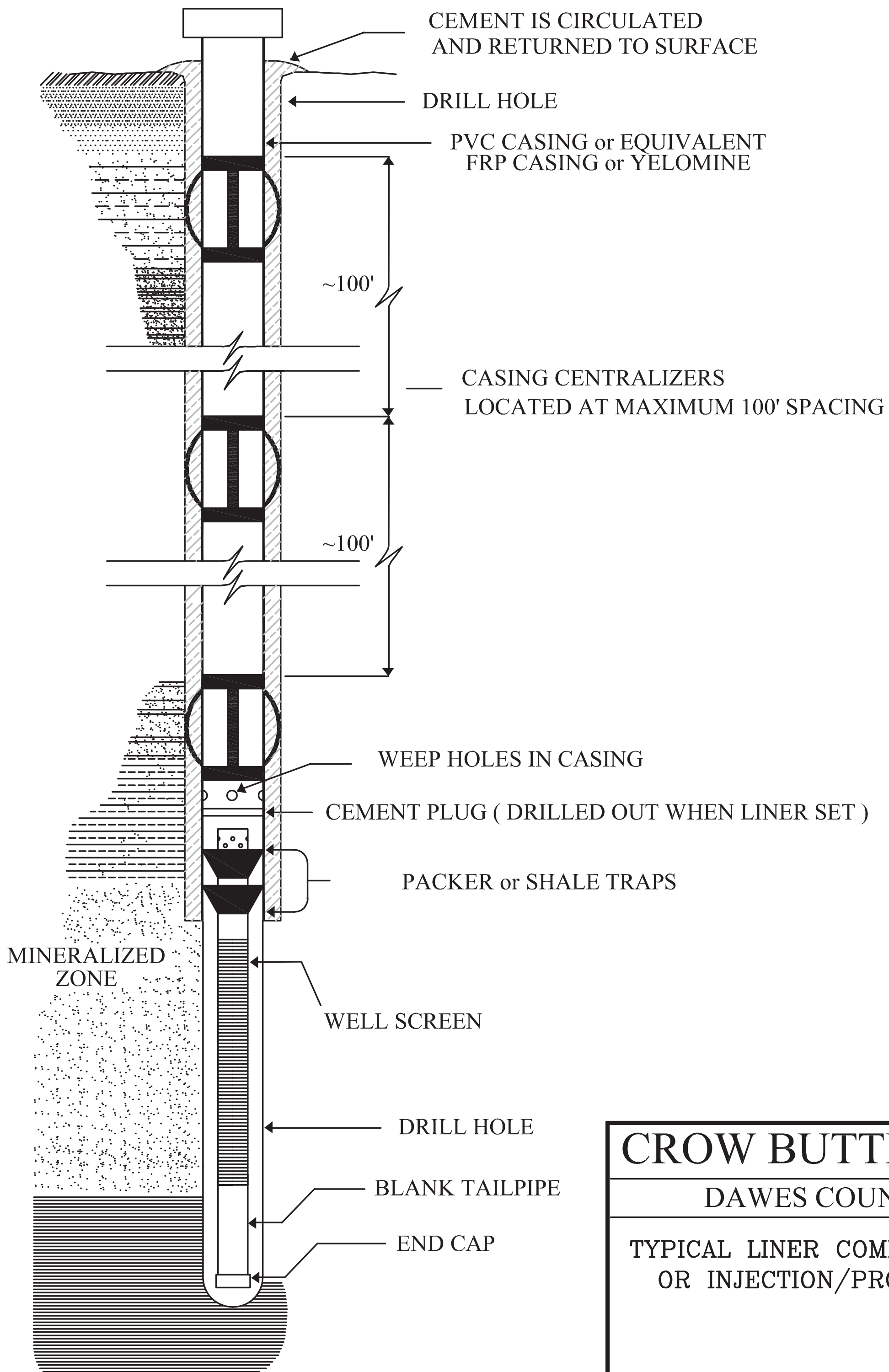
Prepared By : WB

Drawn By: WB

Date: 1/07

Figure 3.1-2

Well Completion Method No. 2



CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

TYPICAL LINER COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS

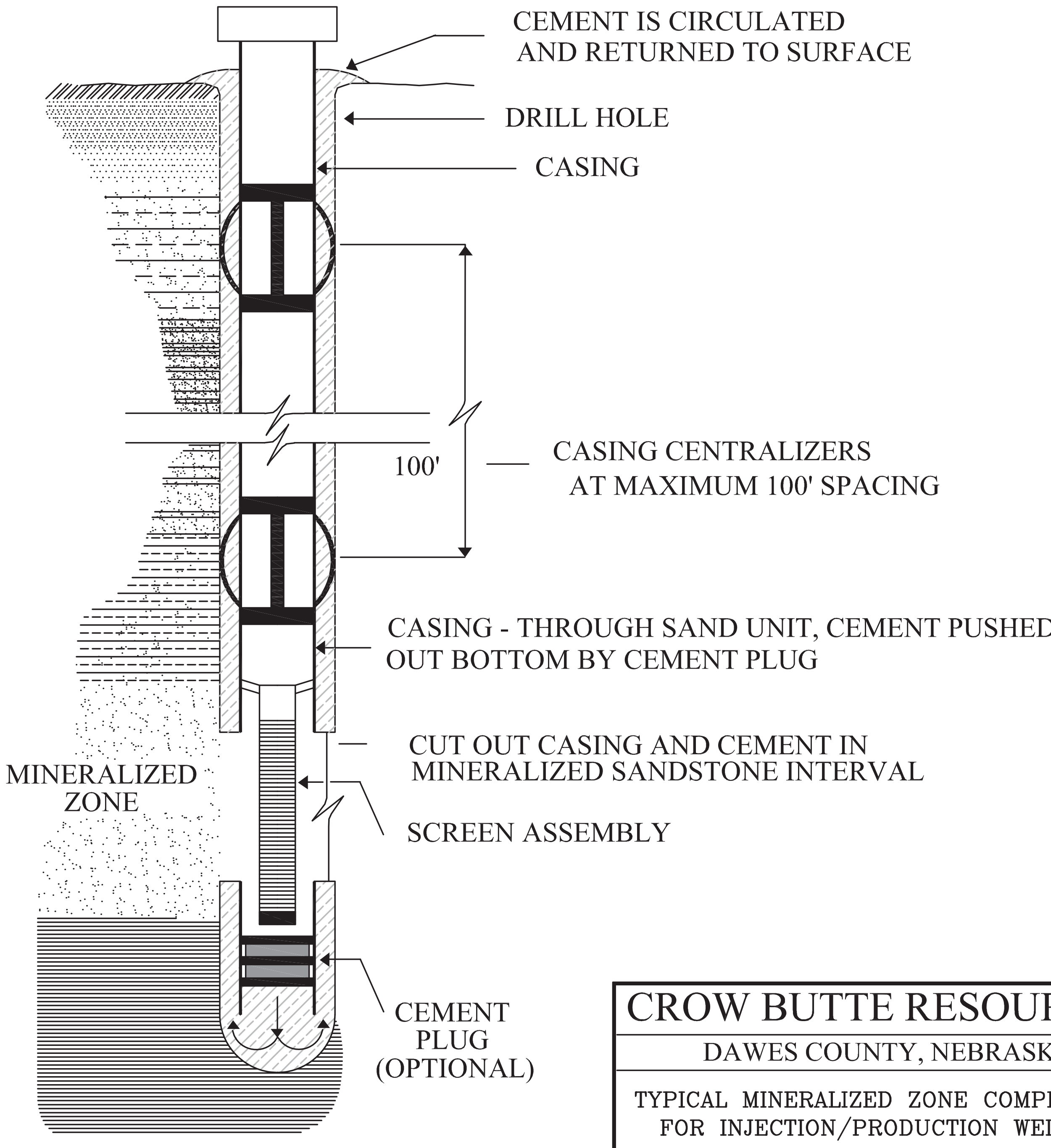
Prepared By : WB

Drawn By: WB

Date: 1/07

Figure 3.1-3

Well Completion Method No. 3



CROW BUTTE RESOURCES

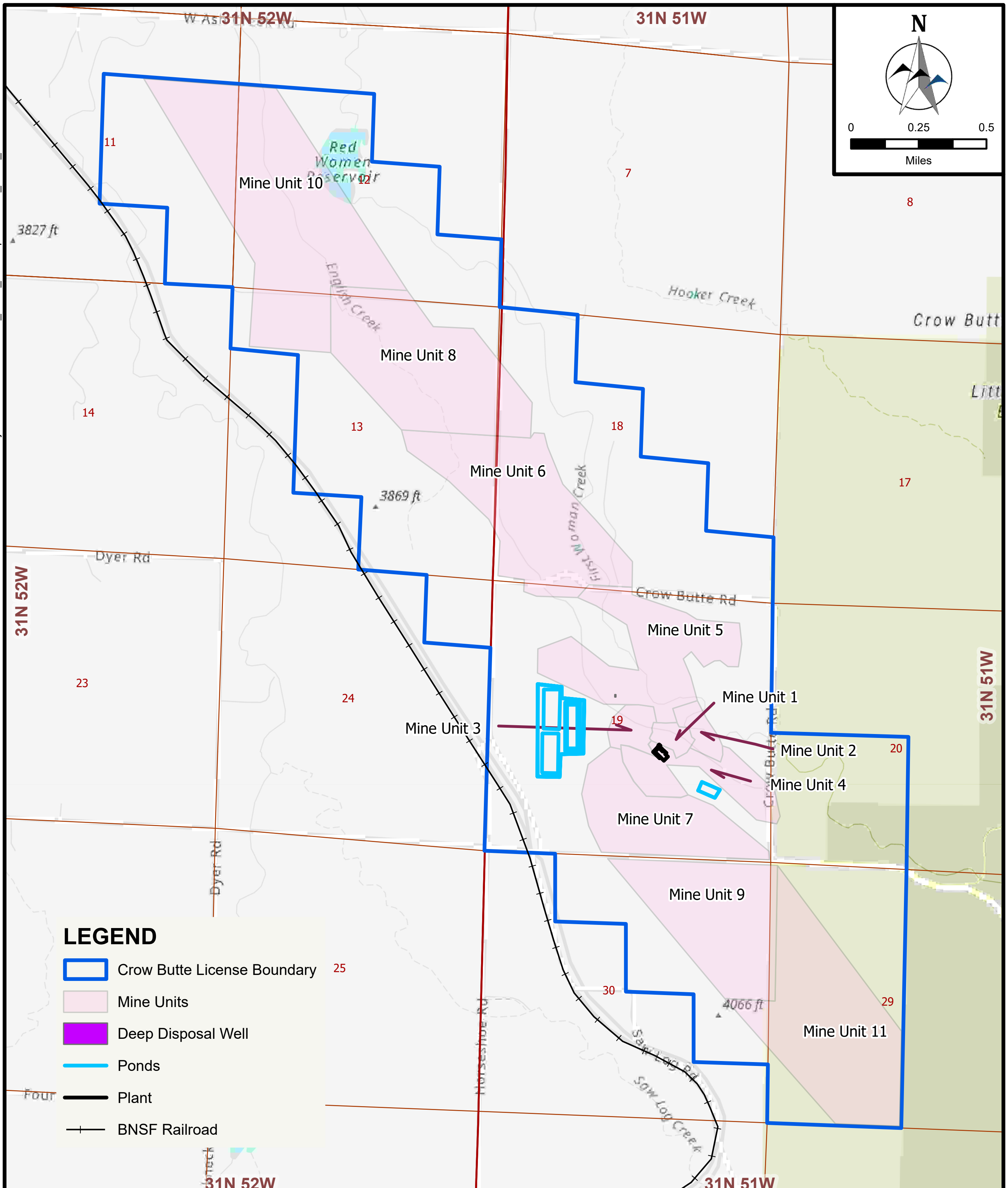
DAWES COUNTY, NEBRASKA

TYPICAL MINERALIZED ZONE COMPLETION FOR INJECTION/PRODUCTION WELLS

Prepared By : WB

Drawn By: WB

Date: 1/07



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PERMIT TO MINE NO.

NO.	REVISION	BY	DATE
4	---	---	---
3	---	---	---
2	---	---	---
1	---	---	---
0	---	---	---

CROW BUTTE RESOURCES, INC., 86 CROW BUTTE ROAD, CRAWFORD, NE 69339

CROW BUTTE RESOURCES, INC.

DAWES COUNTY, NEBRASKA

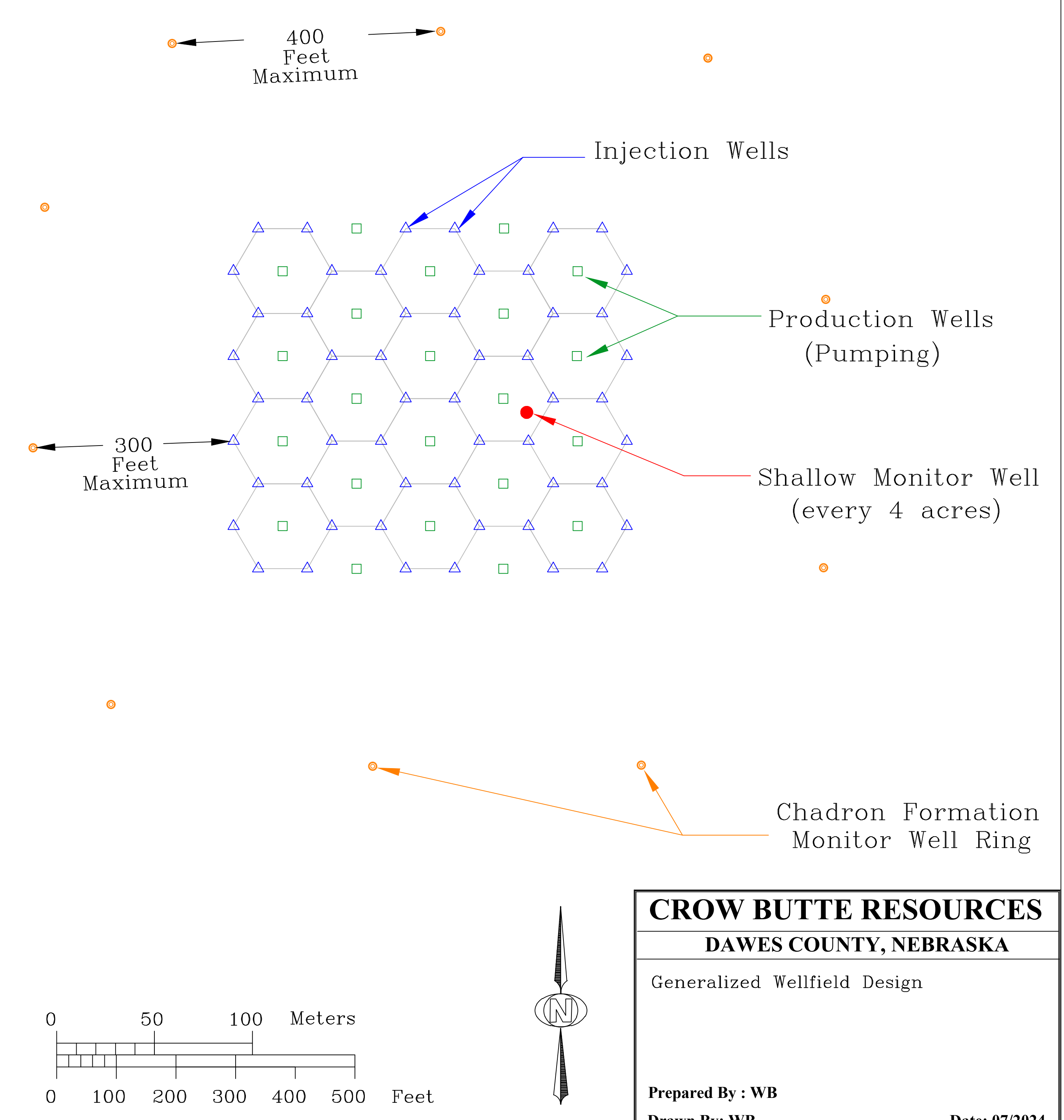
DRAWN BY: RAV
CHECKED BY: BAW
APPROVED BY: --
DATE: 09/2024

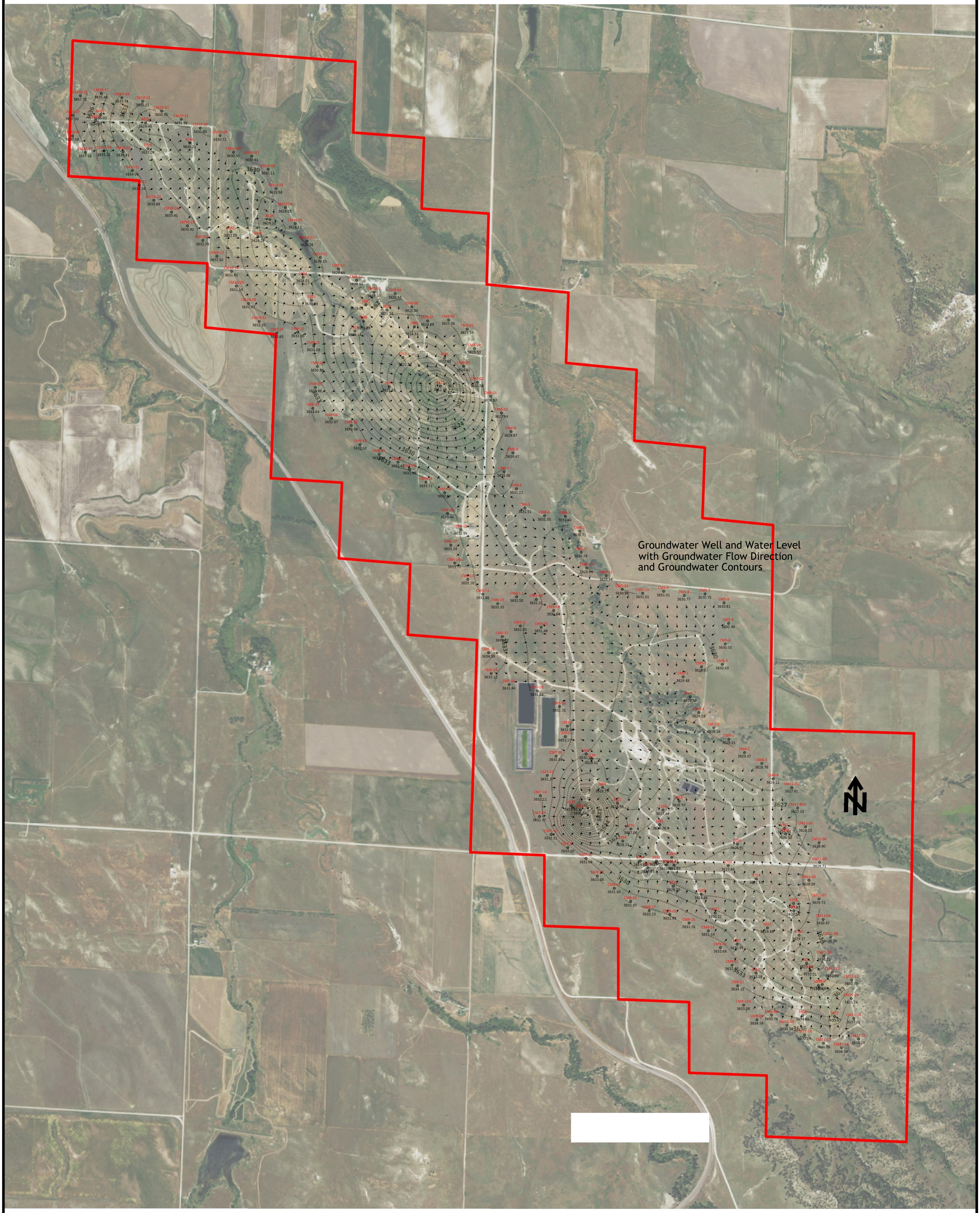
CROW BUTTE PROJECT
MINE UNIT LAYOUT

FIGURE **3.1-4**

FIGURE 3.1-5

Typical Wellfield Layout





LEGEND

- Crow Butte Permit Boundary
- 13683 Active Injection Well
- P2916 Active Production Well
- Water Level Monitoring Well (12/06/2024)
- Potentiometric Surface Contour
- Flow Direction

0 3,500 7,000 14,000

SCALE IN FEET 1" = 7,000 FEET

N W E

CROW BUTTE RESOURCES, INC.

FIGURE 3.1-6

CROW BUTTE PROJECT GROUNDWATER FLOW IN THE BASAL CHADRON AQUIFER (DECEMBER 2024)

PROJECT: 223-37	DATE: APRIL 2025
	BY: CHECKED:

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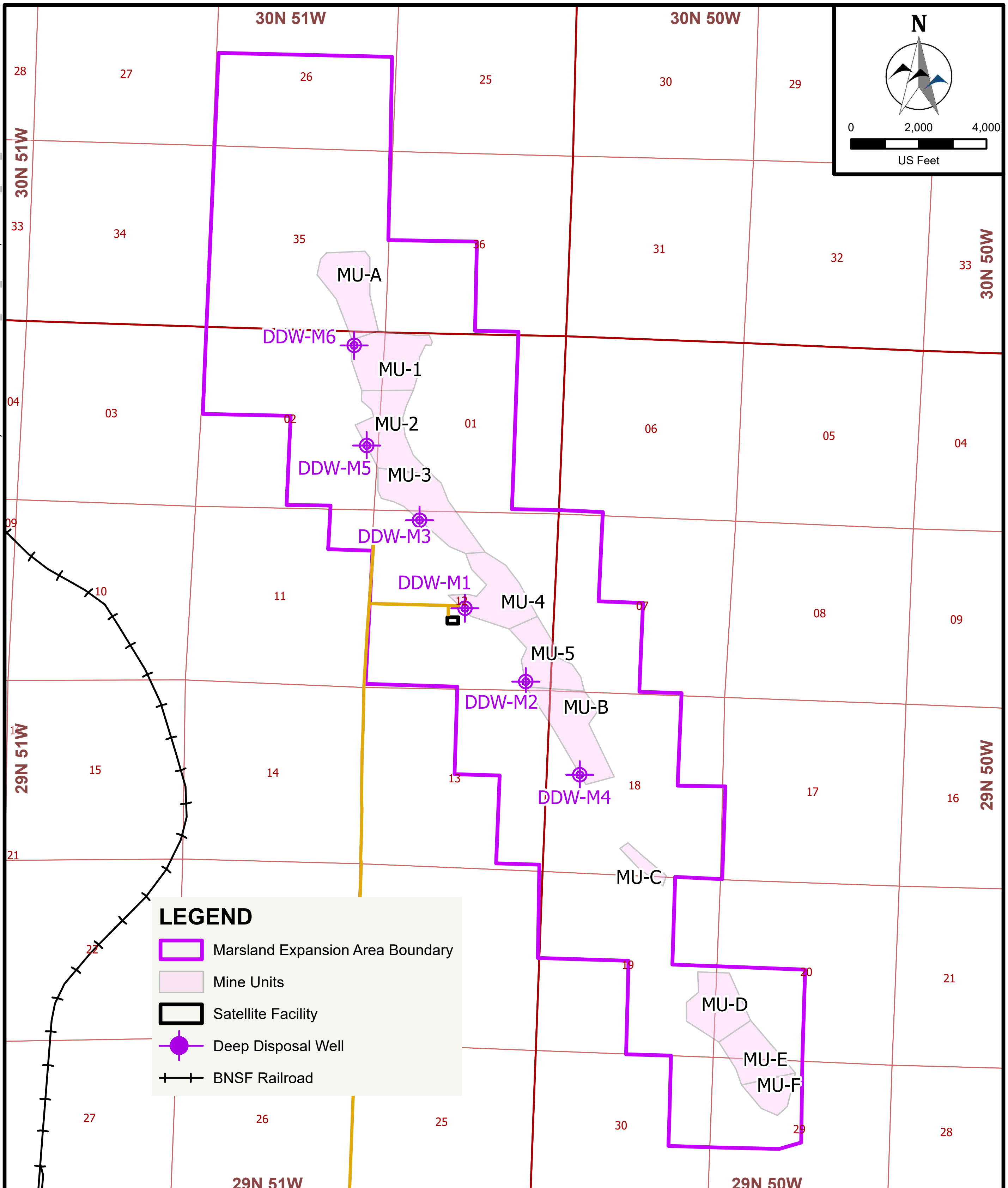


PERMIT TO MINE NO.			
NO.	REVISION	BY	DATE
4	---	---	---
3	---	---	---
2	---	---	---
1	---	---	---
0	---	---	---

CROW BUTTE RESOURCES, INC., 86 CROW BUTTE ROAD, CRAWFORD, NE 69339

CROW BUTTE RESOURCES, INC.

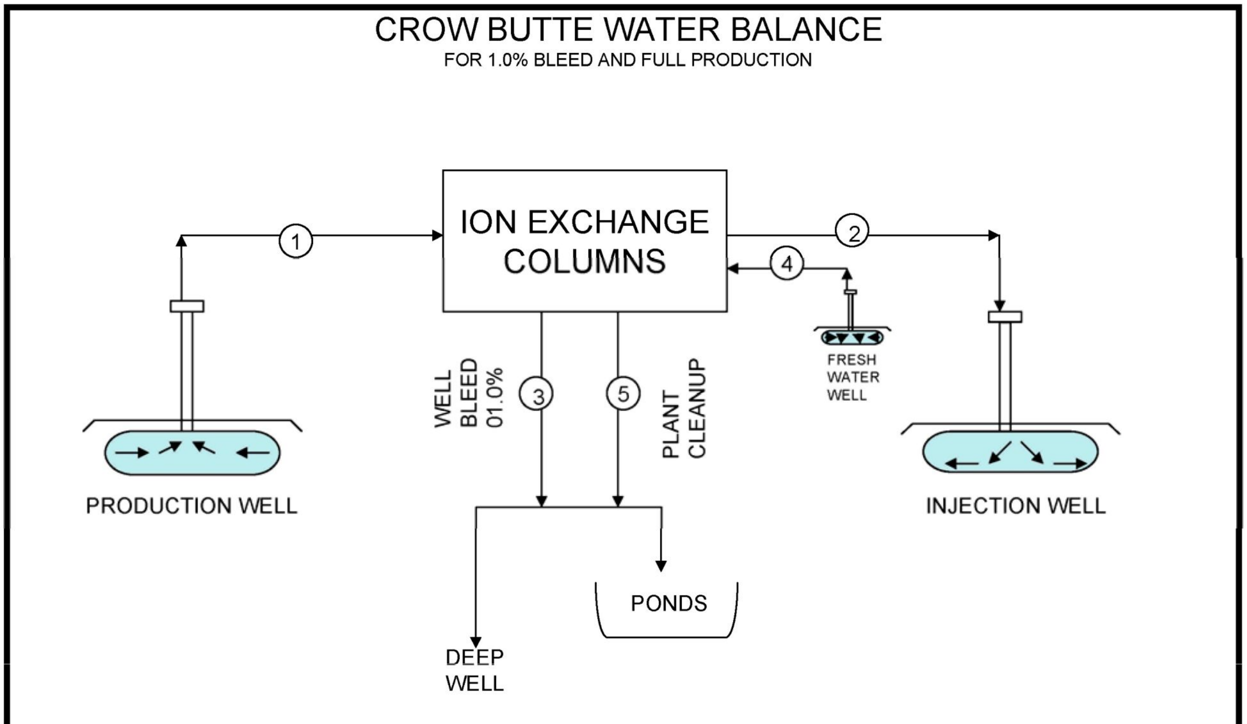
DAWES COUNTY, NEBRASKA

MARSLAND EXPANSION AREA
MINE UNIT LAYOUT

DRAWN BY: RAV
CHECKED BY: BAW
APPROVED BY: --
DATE: 09/2024

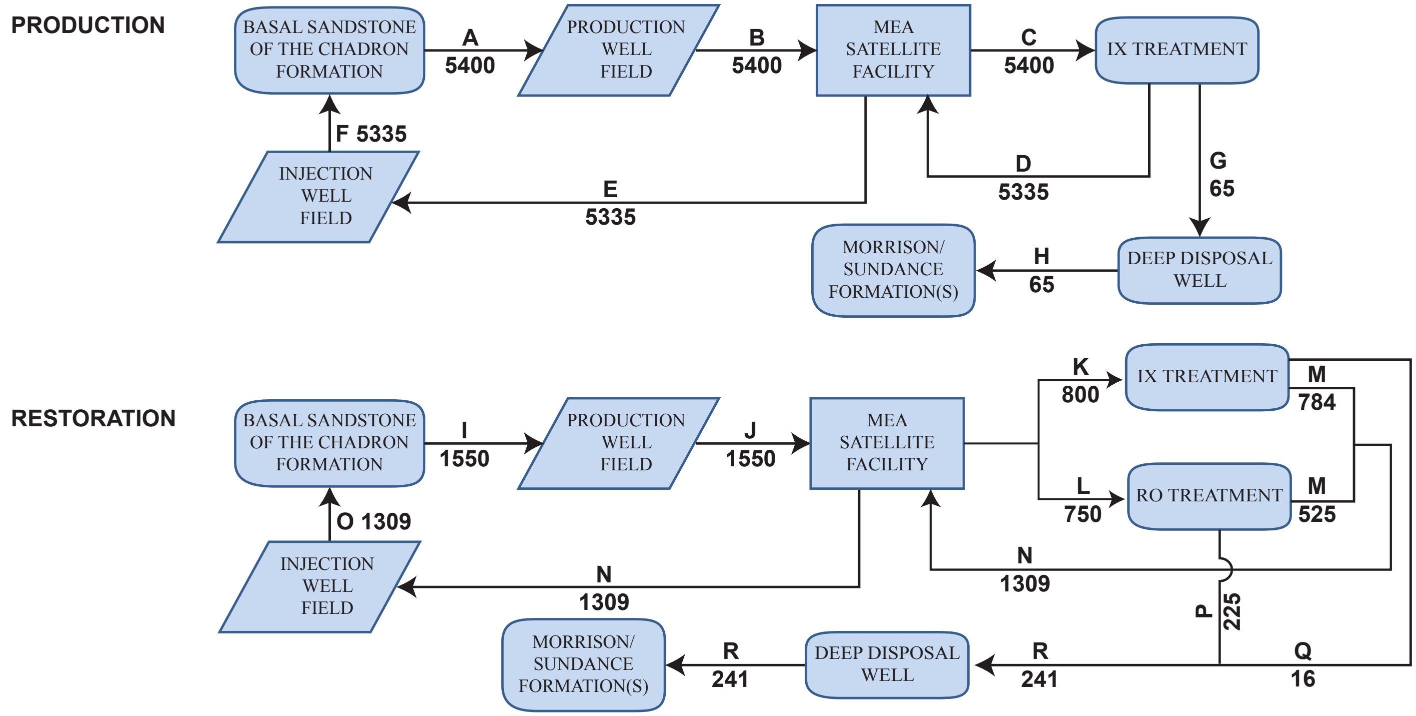
FIGURE **3.1-7**

Figure 3.1-8. Crow Butte Project Water Balance



STREAM #	1	2	3	4	5
SOLUTION GPM*	9000	8910	90	2	2

*BALANCE IS NOMINAL FOR A 1.0% BLEED. ACTUAL BALANCE MAY VARY ACCORDINGLY.



Stream ID	Description
A	Extraction from Basal Sandstone of the Chadron Formation 850-1,200 ft bgs
B	Extraction solution piped from production well field to satellite facility
C	Sent for IX Treatment
D	Recovered solution
E	Recovered solution piped from satellite facility to injection well field
F	Injection into Basal Sandstone of the Chadron Formation
G	Production bleed (1.2%) sent to deep disposal well
H	Injection into Morrison/Sundance Formations 3,400-3,700 ft bgs
I	Extraction from Basal Sandstone of the Chadron Formation
J	Extraction solution piped from production well field to satellite facility
K	Sent for IX Treatment
L	Sent for RO Treatment
M	Recovered solution
N	Recovered solution piped from satellite facility to injection well field
O	Injection into Basal Sandstone of the Chadron Formation
P	RO Bleed sent to deep disposal well
Q	IX Bleed sent to deep disposal well
R	Injection into Morrison/Sundance Formations

NOTES:
1. Balanced for maximum flow rates projected to occur during 3Q 2024.
2. All flow rates are in gallons per minute.

ABBREVIATIONS:

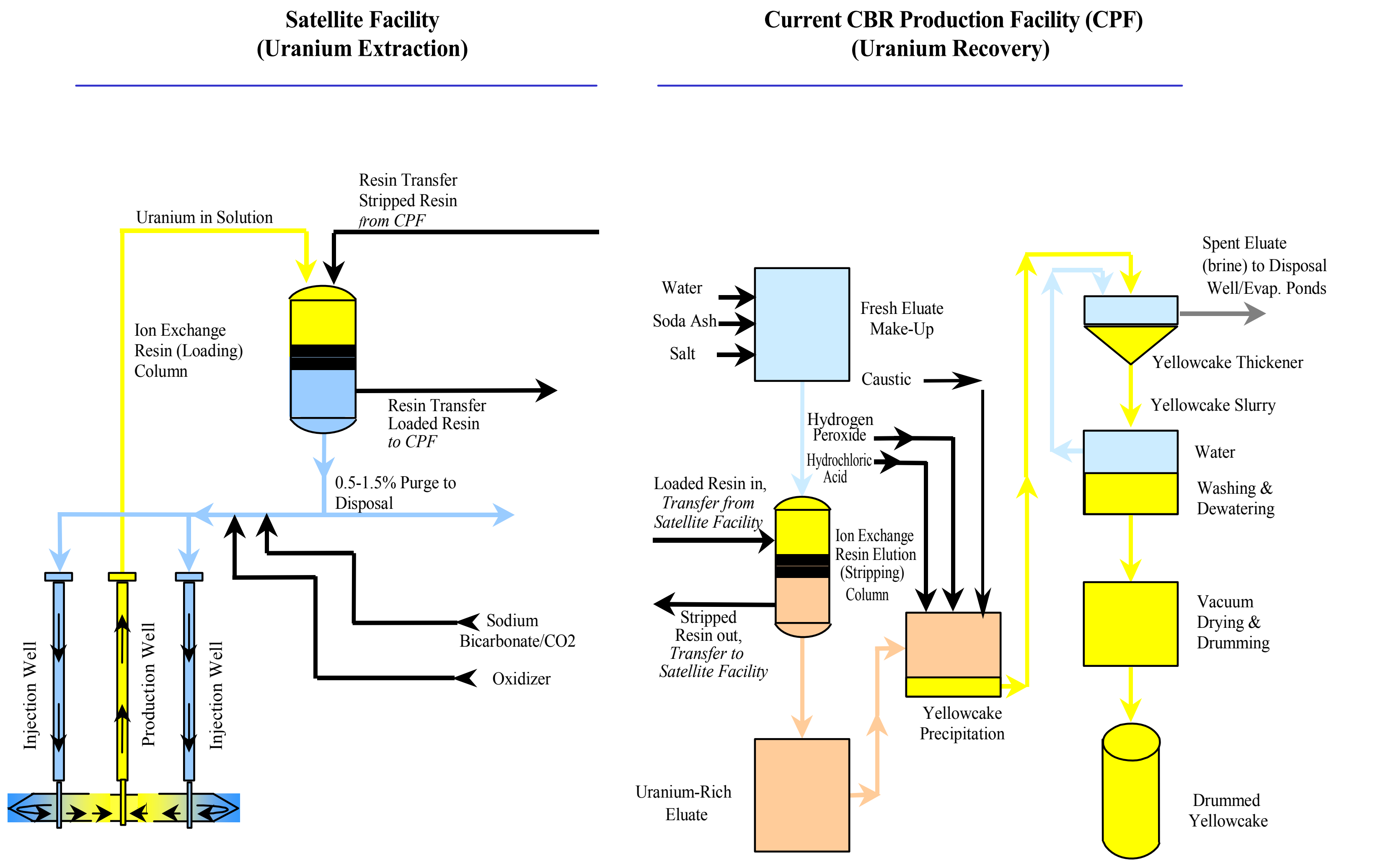
IX Ion Exchange
RO Reverse Osmosis
MEA Marsland Expansion Area

September 2015

CROW BUTTE RESOURCES, INC.

FIGURE 3.1-9
MARSLAND EXPANSION AREA WATER BALANCE AND PROCESS FLOW DIAGRAM

K:\CBR_Projects\CO001636_Marsland\3_IMAGES\Illustrator\MEA_WaterBalance_v3.ai @ 01/16/2015



CROW BUTTE RESOURCES, INC.

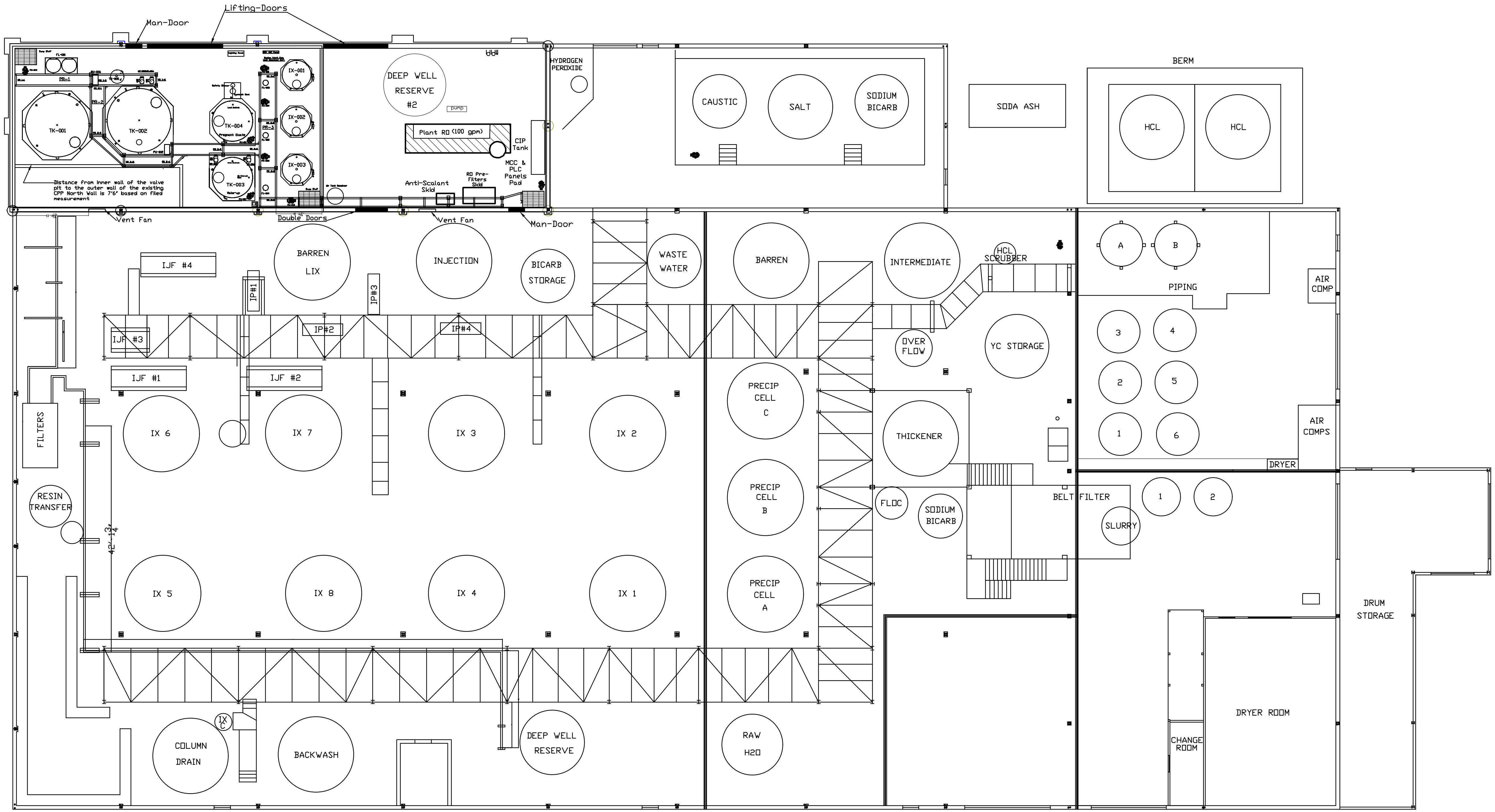
FIGURE 3.2-1
MARSLAND EXPANSION AREA
SATELLITE FACILITY AND
CURRENT CBR PRODUCTION FACILITY
PROCESS FLOW DIAGRAM

PROJECT: CO001636.00001 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

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

CENTRAL PROCESSING PLANT
FIGURE 3.2-2



CAMECO RESOURCES

CROW BUTTE PROJECT

CPP GENERAL ARRANGEMENT

SIZE	DATE: 12/21/09	DWG NO. CB-GA-103	REV C
SCALE		SHEET	

TABLE OF CONTENTS

4.0 EFFLUENT CONTROL SYSTEMS

This section describes the effluent control systems currently used at the Crow Butte Project and incorporates the effluent control systems that will be used at the MEA as described in Chapter 4 of the MEA TR. The effluents of concern at ISR operations include the release or potential release of radon gas (radon-222), radionuclides in liquid process streams, and dried yellowcake. Yellowcake processing and drying operations are conducted at the CPF. Loaded IX resin from the satellite facility will be transported to the CPF for elution, precipitation, drying, and packaging. As such, emissions from these sources will not occur at the MEA.

The yellowcake drying facilities at the CPF are comprised of one vacuum dryer. The current license allows for the addition of a second dryer. Yellowcake processing and drying is carried out using a vacuum dryer with a wet condenser system, thus there are no airborne effluents from this system. By design, vacuum dryers do not discharge any uranium when operating. Effluent controls for yellowcake drying at the CPF have been reviewed by NRC and approved in the current license.

4.1 GASEOUS EMISSIONS AND AIRBORNE PARTICULATES

4.1.1 Non-radioactive Airborne Emissions

The operation of internal combustion engines is the primary source of non-radioactive gaseous airborne emissions. The majority of the combustion emissions are diesel emissions, which are limited. Other minor releases include: drilling rigs and support equipment (e.g., pipe trucks, water trucks, cement units, haul trucks, and pipe and other well completion equipment); maintenance vehicles; wellfield utility vehicles (e.g., work-over units, mechanical integrity testing units, and swabbing units); and light vehicles used during operations, construction, and travel to and from the site. Non-radioactive emissions that can be expected from such activities include CO_2, carbon monoxide, nitrogen dioxide, sulfur dioxide, PM_{10}, and total hydrocarbon (THC).

One of the primary non-radioactive emissions is fugitive dust generated during all project phases (construction, operation, and decommissioning). Minor non-radioactive airborne effluents may include: dust from small releases of particulates during delivery and unloading of dry bicarbonate powder to storage silos; CO_2, O_2, and water vapor vented from process operations; and dust generated during cementing operations, building construction activities (e.g., welding fumes and grinding), and various maintenance activities.

There are no significant combustion-related emissions from the CPF or satellite facility, as commercial electrical power is available at the sites.

4.1.2 Radioactive Airborne Emissions

The principal radioactive airborne gaseous radiological effluent is radon-222 gas. Since the CPF uses a vacuum dryer, the airborne uranium concentrations are expected to be at or near background levels.

4.1.2.1 *Airborne Uranium Emissions*

Small quantities of airborne uranium particulates have the potential for occurring within the CPF and at the resin transfer station within the satellite facility. Spills can occur during resin transfer, and this is where exposure to uranium particulates is possible. All spills are 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. All non-routine operations or maintenance activities where the potential exists for significant exposure to radioactive materials, and for which there is no SOP, require a Radiation Work Permit (RWP). The RWP ensures that the applicable radiological safety measures are used by the workers and identifies the type of personnel monitoring that would be required for determining radiation exposure (i.e., internal and external radiation).

4.1.2.2 *Wellfield Radon Emissions*

Injection wells are generally closed and pressurized, but are periodically vented, releasing radon to the atmosphere. Production wells are continually vented to the surface, but water levels are typically low and radon venting is minimal. All of the well releases outside of buildings are directly vented to the atmosphere.

Wellhouses are vented, with exhaust fans located in the wall directly opposite the entryway. This allows personnel to immediately verify that the vent is operational. In addition, all wellhouse vents are inspected daily. Direct release to the atmosphere from the wellhouses results in rapid dispersion of the radon emissions. For the majority of the year (except during extreme cold weather), the doors remain opened when the buildings are accessed, allowing for additional ventilation of the building during entry by personnel.

4.1.2.3 *CPF Radon Emissions*

Radon-222 is contained in the pregnant lixiviant that comes from the wellfield into the CPF. The majority of the radon-222 is released in the injection surge tanks and in the ion exchange columns. These vessels are covered and vented to the atmosphere. The vents from the individual vessels go into a manifold that is exhausted to atmosphere outside the CPF via an induced draft fan. Venting the radon-222 gas to atmosphere outside the plant minimizes employee exposure. Redundant exhaust fans direct collected gases to discharge piping that exhaust fumes to the outside atmosphere. The design of the fans is such that the system is capable of limiting employee exposures with the failure of a single fan. Discharge stacks are located away from building ventilation intakes to prevent introducing exhausted radon into the facility as recommended in RG 8.31. Airflow through any openings in the vessels is from the process area into the vessel and into the ventilation system, controlling any releases that may occur inside the vessel.

At the CPF, a combination of passive and active ventilation systems keeps radon and radon progeny levels ALARA. An evaluation of these systems was provided as Appendix C in the 2007 LRA and Appendix Y in the MEA Technical Report. The evaluation found that operational radiological in-plant monitoring for radon concentrations, and recent upgrades demonstrate that the CPF ventilation is effective for minimizing employee exposure. The evaluation noted that the large overhead doors may be open or closed at any time during the course of a day and that even when all the overhead doors are closed, there is sufficient air intake capacity to maintain the desired negative pressure.

Small amounts of radon-222 may be released via solution spills, filter changes, RO operation, and maintenance activities, but these are minimal releases on an infrequent basis. The exhaust system in the CPF further reduces employee exposure. The air in the CPF is sampled for radon daughters (Section 5.7 of this LRA) to assure that concentration levels of radon and radon daughters is maintained as low as reasonably achievable (ALARA).

The type of dryer used in the CPF is a vacuum dryer. With this dryer, the yellowcake is dried in a heating chamber that is maintained at negative pressure. Airflow in a vacuum dryer is minimal and is from the outside of the drying chamber into the chamber. Any particulate that may be released go to a bag filter, with the moisture-laden air going to a closed loop condenser where the water condenses and entrains any remaining particulate, with the vacuum source being a liquid ring vacuum pump acting as a final filter against any particulate escape. The water is periodically transferred to the yellowcake thickener. With a vacuum dryer, there is no release of particulate by way of a stack since there is no positive airflow. During packaging, the drum is sealed via a gasket to the dryer discharge. As the dryer is operating under vacuum, any leaks around this gasket result in air being drawn into the drum during the packaging of yellowcake, thus no contaminants are released. The air that may enter the discharge to the drum is also routed to the condenser system described above.

If the yellowcake emission control equipment fails to operate within specifications established in standard operating procedures (SOPs), the drying and packaging room is immediately closed and declared an airborne radioactivity area. Heating operations are switched to cool down, or packaging operations are temporarily suspended.

4.1.2.4 Satellite Plant Radon Emissions

At the satellite plant exhaust fans will be installed in the walls and hard-piped ventilation systems will be installed for all indoor non-sealed process tanks and vessels where radon-222 or process fumes would be expected. The system consisting of air ducts or piping system connected to the top of each of the process tanks that could produce radon will include:

- IX tanks
- resin transfer tanks
- bicarbonate mix tanks (when process solution is used for mixing)

Separate hard-piped ventilation systems will be installed for areas known to emanate especially large amounts radon, to ensure that exposures are maintained ALARA.

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 RG 8.31. Airflow through any openings in the vessels will be from the process area into the vessel and into the ventilation system, controlling any releases that occur inside the vessel. These exhaust fans would be located at different levels to ensure sufficient ventilation of areas where radon could accumulate. The exhaust fans will create negative pressure, ensuring that air will not enter the process areas from vessels and systems within the satellite building. Separate ventilation systems may be used as needed for the functional areas within the satellite facility.

The ventilation system at the satellite plant will be similar to that used at the CPF. Separate and independent local ventilation systems may be used temporarily as needed for non-routine activities such as maintenance. Similar to the CPF, the satellite plant will be designed to achieve 4 to 5 air exchanges per hour. A preoperational test will be conducted to verify the air exchange rate.

4.2 LIQUID WASTE

4.2.1 Sources of Liquid Waste

As a result of ISR mining process, there are several sources of liquid waste that are collected at each site.

4.2.1.1 <u>Water and Drill Cuttings Generated during Well Drilling and Development</u>

Well drilling and development will generate the following wastewaters:

- "well drilling fluids" (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)

<u>Well Drilling Fluid</u>

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 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 NDEE Title 135, Chapter 5, paragraph 002.02E (NDEE 2020).

Well Development Water

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.

At the Crow Butte Project, the water is discharged directly to one of the solar evaporation ponds and silt, fines and other natural suspended matter collected during well development is settled out in the pond. Well development water may be treated with filtration and/or reverse osmosis and used as plant make-up water or disposed of in a DDW.

At the MEA, the water will be captured and 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 used if there were equipment issues with the separation system.

4.2.1.2 Liquid Process Waste

The operation of the process plant results in two primary sources of liquid waste, an eluant bleed and a production bleed. At the Crow Butte Project, these bleeds are routed to either the DDWs or an evaporation pond. At the MEA, the bleeds will be routed to wastewater tanks housed in the satellite building and then pumped from the tanks to the DDWs.

4.2.1.3 Aquifer Restoration

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. Based on historical restoration activities at the Crow Butte Project, it is unlikely that groundwater transfer and/or groundwater sweep will be used.

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 is used as makeup water or sent to the wastewater disposal system, such as deep well disposal and/or onsite evaporation ponds. Historically CBR has not used groundwater sweep, but this option could be used in the future if warranted by site conditions. As has been the case with past operations at the Crow Butte Project, it is anticipated that during restoration, groundwater will be treated using IX and RO. Using this method, there will be no water consumption activities and only the bleed would need to be addressed for disposal; the remainder of the treated water would be 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.

4.2.1.4 Stormwater Runoff

Stormwater management is controlled under permits issued by the NDEE. CBR is subject to stormwater NPDES permitting requirements for industrial facilities and construction activities. The NDEE NPDES regulatory program contained in Nebraska Title 119 (NDEE 2023) requires that procedural and engineering controls be implemented so that runoff will not pose a potential source of pollution.

The design of the Crow Butte facilities and existing engineering controls is such that runoff is not considered to be a potential source of pollution. Therefore, this water is not specifically collected and routed to a pond for disposal.

The design and engineering controls for the 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 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.

4.2.1.5 Domestic Liquid Waste

Domestic liquid wastes from the restrooms and lunchrooms are disposed of in an approved septic system that meets the requirements of the State of Nebraska. CBR currently maintains a Class V UIC Permit issued by the NDEE for operation of the septic system at the Crow Butte Project. A similar permit will be required for the MEA satellite facility. The septic system will be designed, constructed, operated, and permitted as per applicable NDEE Title 124 regulations.

4.2.1.6 Laboratory Waste

Approximately 3,000 gallons per month of nonhazardous liquid waste from the laboratory, comprised of sample discards, lab solutions, dish washing wastewater, and lab cleanup wastewater is disposed of in either the evaporation pond or the DDWs.

4.2.2 Deep Disposal Well Injection

4.2.2.1 Crow Butte Project

CBR currently operates two non-hazardous Class I injection wells in the current license area for disposal of wastewater under Permits #NE0206369 and #NE0210825 (Well No. 1 and Well No. 2, respectively). The wells are permitted under NDEE regulations in Title 122 (NDEE 2002) and operated under a Class I UIC Permit. The permits for both wells allow unlimited flow and a maximum operating pressure of 650 psi. To preserve optimum performance, Well No. 1 has typically been operated at up to 40 psi with a 200 gpm flow and Well No. 2 has typically been operated at up to 320 psi with a 25 gpm flow.

CBR has operated Well No. 1 at the current license area for over 25 years with excellent results and no serious compliance issues. Maintenance has been performed on Well No. 1 and NDEE issued a major modification in 2015 to raise the packer depth. Well No. 2 was incorporated into the license by action of the SERP on November 18, 2011 and has not experienced any issues. CBR has found that permanent deep disposal is preferable to evaporation in evaporation ponds.

4.2.2.2 Marsland Expansion Area

Like the CPF, CBR will initially use two DDWs as the primary liquid waste disposal system at the MEA site. The basic components of the system include:

- Alarmed and ventilated equalization/storage tanks in the satellite plant
- Underground piping to the deep disposal well
- A deep disposal wellhouse containing a set of filters, flowmeters, check valve, and annulus fluid tank

The DDWs will be operated without the need for surge tanks or surge/evaporation ponds.

CBR has submitted an application to the NDEE for an Area Permit to install and operate Class I Nonhazardous Waste Injection Wells on private lands within the MEA license boundary. CBR has since requested NDEE suspend review of all permit applications, including the Class I application. The formation receiving the injected waste fluids (Injection Zone) are 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 concentrations of their total dissolved solids.

4.2.3 Evaporation Pond

Evaporation pond design, installation and operation criteria are those found in RG 3.11. CBR maintains three commercial and two R&D evaporation ponds at the Crow Butte Project. Each commercial pond is nominally 900 feet by 300 feet by 17 feet in depth. The ponds are constructed with a primary and secondary liner system. An underdrain system consisting of perforated piping between the primary and secondary liners is installed to monitor for leaks. The underdrain slopes gradually to the ends of the ponds where they are connected to a surface monitor pipe. Checking for an increase in measurable moisture inside the leak detection system and/or analyzing the water in the pipe can discover a leak in the pond liner.

Each of the ponds has the capability of being pumped to a water treatment plant prior to discharge under the NPDES permit. A variety of treatment options exist depending upon the specific chemical contaminants identified in the wastewater. In general, a combination of chemical precipitation and reverse osmosis is adequate to restore the water to a quality that falls well within the NPDES criteria.

The current pond inspection program is based on NRC recommendations in RG 3.11 and LC 11.2.1 of SUA-1534. Routine inspections are required as follows:

Daily Inspections

Daily inspections consist of checking the pond depth and visually inspecting the pond embankments for slumping, movement, or seepage. The pond depth measurements are checked against the freeboard requirements.

Weekly Inspections

Weekly inspections consist of checking the perimeter game-proof fence and restricted area signs, checking the pond inlet piping, making underdrain measurements, checking the pond enhanced evaporation system (if installed), visually inspecting the liner, and measuring the vertical depth of fluid in the pond underdrain standpipes. During periods of seismic activity, flooding, severe rainfall, or other event that could cause the pond to leak, underdrain measurements are taken daily and recorded.

Monthly Inspections

During monthly inspections, the waste piping from the plant building to the ponds is visually inspected for signs of seepage indicating a possible pipeline break. Diversion channels surrounding the ponds are examined for channel bank erosion, obstruction to flow, undesirable vegetation, or any other unusual conditions.

Quarterly Inspections

Quarterly inspections check for embankment settlement and for irregularities in alignment and variances from originally constructed slopes (i.e., sloughing, toe movement, surface cracking or erosion). Embankments are inspected for any evidence of seepage, erosion, and any changes to the upstream watershed areas that could affect runoff to the ponds. Emergency lines are inspected to ensure that the rope has not deteriorated and the ropes reach to the pond water level.

Annual Inspection

A technical evaluation of the pond system is done annually, which addresses the hydraulic and hydrologic capacities of the ponds and ditches and the structural stability of the embankments. A survey of the pond embankments is done on an annual basis and the survey results documented and incorporated into the annual inspection report. The survey is reviewed for evidence of embankment settlement, irregularities in embankment alignment, and any changes in the originally constructed slopes. The technical evaluation is the result of an annual inspection and a review of the weekly, monthly, and quarterly inspection reports by a professional engineer registered in the State of Nebraska. Examination of the pond monitor well sampling data is also reviewed for signs of seepage in the embankments. The inspection report presents the results of the technical evaluation and the inspection data collected since the last report. The report is kept on file at the site for review by regulatory agencies. A copy is also submitted to the NRC.

Pond Leak Corrective Actions

If six inches or more of fluid is present in the standpipes, the contents will be analyzed for specific conductance. If the water quality in the standpipe is degraded beyond the action level, the water will be further sampled for chloride, alkalinity, sodium, and sulfate. The action level is defined as a specific conductivity of the fluid of the standpipe that is 50% of the specific conductivity of the pond contents.

If there is an abrupt increase in both the vertical fluid depth of a standpipe and the specific conductance of the fluid of the standpipe, the liner will be immediately inspected for liner damage. Abnormal increases of these two indicators confirm a potential liner leak and agency reporting (i.e., NRC and NDEE) will be required.

Upon verification of a liner leak, the fluid level will be lowered by transferring the cell's contents to the other cell. Water quality in the affected standpipes will be analyzed for the five parameters listed above once every 7 days during the leak period, and once every 7 days for at least 14 days following repairs.

4.2.4 Land Application

In addition to the use of DDWs as a disposal method, the NDEE 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 an approved commercial disposal facility for disposal.

4.3 SOLID WASTE

Any facility or process with the potential to generate industrial wastewater 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 that are 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 sites consists of spent resin, resin fines, empty reagent containers, miscellaneous pipe and fittings, and domestic trash. The solid waste is segregated based on whether it is clean or has the potential for contamination with 11e.(2) byproduct materials. Solid wastes are classified as contaminated or non-contaminated waste according to survey results. The solid waste is segregated based on whether it is clean or has the potential for contamination with 11e.(2) byproduct materials. Non-hazardous wastes are stored in appropriate containers prior to disposal by a contracted waste disposal operator, at an approved off-site waste disposal facility.

4.3.1 Non-contaminated Solid Waste

Non-contaminated solid waste is waste which is not contaminated with 11e.(2) byproduct material or which can be decontaminated and re-classified as non-contaminated waste. This type of waste may include piping, valves, instrumentation, equipment and any other item which is not contaminated, or which may be successfully decontaminated. Release of contaminated equipment and materials is discussed in further detail in Chapter 5.

CBR has estimated that the Crow Butte Project produces approximately 500 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. Non-contaminated solid waste is collected on the site in designated areas and disposed of in the nearest permitted sanitary landfill.

4.3.2 11e.(2) Byproduct Material

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

11e.(2) byproduct material generated at ISR facilities consists of filters, personal protective equipment (PPE), spent resin, piping, and other materials. CBR estimated that over the last 10 years the CPF produced approximately 75 yd^3 of 11e.(2) byproduct material waste per year. This estimate is based on the historical number of shipments to licensed disposal facilities. These materials are stored on site until such time that a full shipment can be sent to a site that is authorized by NRC or an NRC agreement state to receive byproduct material. CBR currently maintains an agreement for waste disposal at a properly licensed facility as required by LC 9.9 of SUA-1534. If the agreement expires or is terminated CBR is required to notify NRC within 7 working days after the date of expiration or termination and submit a new agreement to NRC within 90 days after expiration or termination.

If decontamination is possible, records of the surveys for residual surface contamination are made prior to releasing the material. Decontaminated materials have activity levels lower than those specified in NRC guidance. CBR will maintain an area at both sites within the restricted area boundary for temporary storage of contaminated materials prior to their disposal.

4.3.3 Septic System Solid Waste

Domestic liquid wastes from the toilets, lavatories and a sink in the lunchroom/break areas are disposed of in an approved septic system that meets the requirements of the State of Nebraska. The satellite facility 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. NDEE regulations for control of these systems are contained in Title 124 (NDEE 2022).

4.3.4 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 (NDEE 2016). Based on waste determinations conducted by CBR as required in Title 128, CBR is a Conditionally Exempt Small Quantity Generator. To date, CBR only generates universal hazardous wastes such as fluorescent light tubes, used waste oil, and batteries. CBR estimated that the current operation generates approximately 230 liters of waste oil per year. CBR estimates that the satellite facility will 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.

4.4 REFERENCES

Nebraska Department of Environment and Energy (NDEE), 2002, Title 122, Rules and Regulations for Underground Injection and Mineral Production Wells. Effective Date: April 2, 2002. Available on the internet as of July 2024 at: http://dee.ne.gov/RuleAndR.nsf/Title_122.xsp

Nebraska Department of Environment and Energy (NDEE), 2016, Title 128, Nebraska Hazardous Waste Regulations. Effective Date: July 6, 2016. Available on the internet as of July 2024 at: http://dee.ne.gov/RuleAndR.nsf/Title_128.xsp

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5.0 OPERATIONS

This chapter updates the corporate organization and provides operational data for the Crow Butte Project. In addition, this chapter incorporates information on operations from Chapter 5 of the MEA TR.

CBR operates a commercial-scale in-situ leach uranium mine (the Crow Butte Project) and the fully licensed unconstructed MEA. All CBR operations, including the Crow Butte Project operations, are conducted in conformance with applicable laws, regulations, and requirements of the various regulatory agencies. The responsibilities described below have been designed to both ensure compliance and further implement CBR's policy for providing a safe working environment with cost-effective incorporation of the philosophy of maintaining radiation exposures as low as is reasonably achievable (ALARA).

5.1 CORPORATE ORGANIZATION AND ADMINISTRATIVE PROCEDURES

CBR maintains a performance-based approach to the management of the environment and employee health and safety including radiation safety. The Safety, Health, Environment, and Quality Management System (SHEQMS) encompasses licensing, compliance, environmental monitoring, industrial hygiene, and health physics programs under one umbrella, and it includes involvement for all employees from the individual worker to senior management. This SHEQMS allows CBR to operate efficiently and maintain an effective environment, health, and safety program.

Figure 5.1-1 is a partial organization chart for CBR with respect to the operation of the Crow Butte Project and the MEA and represents the management levels that play a key part in the SHEQMS Program. The personnel identified are responsible for the development, review, approval, implementation, and adherence to operating procedures, radiation safety programs, environmental and groundwater monitoring programs, as well as routine and non-routine maintenance activities. These individuals may also serve a functional part of the SERP described under Section 5.2.3.

Specific responsibilities of the organization are provided below.

5.1.1 Board of Directors

The CBR Board of Directors has the ultimate responsibility and authority for radiation safety and environmental compliance for CBR. The Board of Directors sets corporate policy and provides procedural guidance in these areas. The Board of Directors provides operational direction to the President of CBR.

5.1.2 President

The President is responsible for interpreting and acting upon the Board of Directors' policy and procedural decisions. The President directly supervises the General Manager of U.S. Operations. The President is empowered by the Board of Directors to have the responsibility and authority for the radiation safety and environmental compliance programs. The President is responsible for ensuring that the operations staff is complying with all applicable regulations and permit/license conditions through direct supervision of the Senior Vice President and Chief Operating Officer.

5.1.3 Senior Vice President and Chief Operating Officer

The Senior Vice President and Chief Operating Officer is responsible for managing all U.S. operations. The Senior Vice President and Chief Operating Officer is responsible for ensuring that personnel comply with Industrial Safety, Radiation Safety, Environmental Protection Programs, and all relevant state and federal regulations. The Senior Vice President and Chief Operating Officer has the responsibility and the authority to suspend, postpone or modify, immediately if necessary, any activity that is determined to be a threat to employees, public health, the environment, or potentially a violation of state or federal regulations. The Senior Vice President and Chief Operating Officer reports directly to the President.

5.1.4 Mine Manager

The Mine Manager is responsible for all uranium production and restoration activities at the project. The Mine Manager is also responsible for implementing any industrial and radiation safety and environmental protection programs associated with operations and restoration. The Mine Manager is authorized to immediately implement any action to correct or prevent hazards. The Mine Manager has the responsibility and the authority to suspend, postpone, or modify, immediately if necessary, any activity that is determined to be a threat to employees, public health, the environment, or potentially a violation of state or federal regulations. The Mine Manager cannot unilaterally override a decision for suspension, postponement, or modification if that decision is made by the Manager of Safety, Health, Environment and Quality, or the RSO. The Mine Manager reports directly to the Senior Vice President and Chief Operating Officer.

5.1.5 Manager of Safety, Health, Environment and Quality

The Manager of Safety, Health, Environment and Quality (SHEQ) is responsible for all health and safety, and environmental programs as stated in the SHEQMS Program and for ensuring that CBR complies with all applicable regulatory requirements. The Manager of SHEQ reports directly to the Mine Manager. This position assists in the development and review of radiological and environmental sampling and analysis procedures and is responsible for routine auditing of the programs. The Manager of SHEQ has no production-related responsibilities. The Manager of SHEQ assists in the development and submittal of regulatory permits and license applications. Provides analysis and guidance in the areas of Safety, Health, Environment and Quality and is responsible for assisting site management with coordination of the corrective and preventative action process. The Manager of SHEQ maintains and updates documents associated with the activities relating to the SHEQ system. The Manager of SHEQ also has the responsibility and authority to suspend, postpone, or modify any activity that is determined to be a threat to employees, public health, the environment or potentially a violation of state or federal regulations.

5.1.6 Plant Supervisor

The Plant Supervisor supervises plant operations, including the safe and efficient recovery and processing of uranium oxide while staying within regulatory and technical constraints. The Plant

Supervisor is responsible for carrying out any procedures or actions implemented by the Mine Manager, Manager of SHEQ, or the RSO to correct or prevent radiation safety hazards in the plant. The RSO and the Plant Supervisor or the RSO and Mine Manager are responsible for conducting weekly inspections of all facility areas to observe general radiation control practices and review required changes in procedures and equipment. The Plant Supervisor reports directly to the Mine Manager.

5.1.7 Radiation Safety Officer

The RSO is responsible for the development, administration, and enforcement of all radiation safety programs. The RSO is authorized to conduct inspections and to immediately order any change necessary to preclude or eliminate radiation safety hazards and/or maintain regulatory compliance. The RSO is responsible for the implementation of all on-site environmental programs including emergency procedures. The RSO inspects facilities to verify compliance with all applicable requirements in the areas of radiological health and safety. The RSO works closely with all supervisory personnel to ensure that established programs are maintained. The RSO is also responsible for the collection and interpretation of employee exposure-related monitoring including data from radiological safety. The RSO makes recommendations to improve radiological safety-related controls. The RSO has no production-related responsibilities. The RSO reports directly to the Mine Manager and has a secondary reporting requirement to the Senior Vice President and Chief Operating Officer.

5.1.8 Health Physics Technician

The HPT assists the RSO with the implementation of the radiological and industrial safety programs. The HPT is responsible for the orderly collection and interpretation of all monitoring data, to include data from radiological safety and environmental programs. The HPT reports directly to the RSO.

5.1.9 Lab Foreman

The Lab Foreman has direct oversight of the on-site analytical laboratory including implementing laboratory quality assurance procedures. The Lab Foreman is responsible for carrying out any procedures or actions implemented by the Mine Manager, Manager of SHEQ, or the RSO to correct or prevent radiation safety hazards in the laboratory. The Lab Foreman reports directly to the Mine Manager.

5.1.10 Safety Supervisor/Technician

The Safety Supervisor/Technician is responsible for the non-radiation-related health and safety programs. The Safety Supervisor/Technician is authorized to conduct inspections and to immediately order any change necessary to preclude or eliminate safety hazards and/or maintain regulatory compliance. Responsibilities include the development and implementation of health and safety programs in compliance with Occupational Safety and Health Administration (OSHA) regulations. Responsibilities of the Safety Supervisor/Technician include development of industrial safety and health programs and procedures, coordination with the RSO where industrial and radiological safety concerns are interrelated, safety and health training of new and existing employees, and the maintenance of appropriate records to document compliance with regulations. The Safety Supervisor/Technician may be a qualified HPT and may function in that capacity when needed. The Safety Supervisor/Technician reports directly to the Mine Manager.

5.1.11 Qualified Designated Operator

The qualified Designated Operator is responsible for performing daily inspection in the occasional absence of the RSO and the HPT. The qualified Designated Operator must meet the minimum qualifications and perform only those duties as outlined in Section 5.5.4.1.

5.1.12 ALARA Program Responsibilities

The purpose of the ALARA Policy is to keep exposures to all radioactive materials and other hazardous material as low as reasonably possible and to as few personnel as possible. The policy considers the state of technology and the economics of improvements related to benefits to the public health and safety, other societal and socioeconomic considerations, and the utilization of atomic energy in the public interest.

In order for an ALARA Policy to correctly function, all individuals, including management, supervisors, health physics staff, and workers, must take part in and share responsibility for keeping all exposures as low as reasonably achievable. This policy addresses this need and describes the responsibilities of each level in the organization.

5.1.12.1 Management Responsibilities

Consistent with RG 8.31, the licensee management is responsible for the development, implementation, and enforcement of applicable rules, policies, and procedures as directed by regulatory agencies and company policies. These shall include the following:

- The development of a strong commitment to and continuing support of the implementation and operations of the ALARA program;
- An Annual Audit Program which reviews radiation monitoring results, procedural, and operational methods;
- A continuing evaluation of the Health Physics Program including adequate staffing and support; and
- Proper training and discussions that address the ALARA program and its function to all facility employees and, when appropriate, to contractors and visitors.

5.1.12.2 Radiation Safety Officer Responsibilities

The RSO shall be charged with ensuring the technical adequacy of the radiation protection program, implementation of proper radiation protection measures, and the overall surveillance and maintenance of the ALARA program. The RSO shall be assigned the following:

- The responsibility for the development and administration of the ALARA program;
- Sufficient authority to enforce regulations and administrative policies that affect any radiological aspect of the SHEQMS Program;

- Assist with the review and approval of new equipment, process changes or operating procedures to ensure that the plans do not adversely affect the radiological aspects of the SHEQMS Program;
- Maintain equipment and surveillance programs to assure continued implementation of the ALARA program;
- Assist with conducting an Annual ALARA Audit as discussed in Section 5.3.3 to determine the effectiveness of the program and make any appropriate recommendations or changes as may be dictated by the ALARA philosophy;
- Review annually all existing operating procedures involving or potentially involving any handling, processing, or storing of radioactive materials to ensure the procedures are ALARA and do not violate any newly established or instituted radiation protection practices; and
- Conduct or designate daily inspections of pertinent facility areas to observe that general radiation control practices, hygiene, and housekeeping practices are in line with the ALARA principle.

5.1.12.3 Supervisor Responsibilities

Supervisors shall be the front line for implementing the ALARA program. Each supervisor shall be trained and instructed in the general radiation safety practices and procedures. The supervisor's responsibilities include:

- Receiving and providing adequate training to implement the general philosophy behind the ALARA program;
- Providing direction and guidance to subordinates in ways to adhere to the ALARA program;
- Enforcement of rules and policies as directed by the SHEQMS Program, which implement the requirements of regulatory agencies and company management; and
- Seeking additional help from management and the RSO should radiological problems be deemed by the supervisor to be outside their sphere of training.

5.1.12.4 Worker Responsibilities

Because success of both the radiation protection and ALARA programs are contingent upon the cooperation and adherence to those policies by the workers themselves, the facility employees must be responsible for certain aspects of the program in order for the program to accomplish its goal of keeping exposures ALARA. Worker responsibilities include:

- Making valid suggestions which might improve the radiation protection and ALARA programs;
- Reporting promptly, to immediate supervisor, any malfunction of equipment or violation of procedures which could result in an increased radiological hazard;
- Proper use of protective equipment; and

- Proper performance of required contamination surveys.

5.1.13 Contractor Management

CBR may employ contractors to accomplish a variety of tasks at the Crow Butte Project and the MEA. CBR contractor interactions are governed by the Cameco Resources SHEQ Management System, Contractor Management Program, Document Number CR-CMP. The CMP describes the requirement for managing both long term and short term contractors, including subcontractors at all CBR work sites. The purpose of the contractor management program is to ensure a consistent approach to managing contractor activities. The major elements of the program include:

Development of a Scope of Work that identifies and addresses Safety, Radiation, Environmental, and Quality objectives:

- Cameco review of required subcontractor submissions
- Establishment and control of site access
- Training
- Job Hazard Analyses where appropriate
- Communication with the subcontractor
- Documentation
- Change Control
- Emergency preparedness and response
- Roles and responsibilities
- Supervision and Oversight of Contractor Performance
    - Graded approach
    - Inspections and audits
    - Tracking
    - Non-conformances and corrective actions
- Management reviews

The overall objectives of this program are to insure that:

- People and the environment are protected;
- SHEQ risks associated with contractor activities are managed in a risk-informed manner;
- Contractor's work in accordance with Cameco's SHEQ Policy, CBR's integrated SHEQ management system and applicable regulatory requirements; and
- CBR is duly diligent with respect to contractor management.

5.2 MANAGEMENT CONTROL PROGRAM

5.2.1 Safety Health Environment and Quality Management System

CBR's SHEQMS Program formalizes CBR's approach to environmental, health, and safety management to ensure consistency across its operations. The SHEQMS Program is a key element in ensuring that all employees demonstrate "due diligence" in addressing environmental, health, and safety issues and describes how the operations of the facility will comply with the requirements of the CBR SHEQ Policy and regulatory requirements. The Manager of SHEQ, with assistance from the RSO and Plant Supervisor, is responsible for drafting, approving, and updating (as needed) the SHEQMS site-specific procedures annually. More frequent updates may be made if site activities and/or conditions warrant such actions.

The CBR SHEQMS Program:

- Ensures that sound management practices and processes are in place to ensure that strong environmental, health, and safety performance is sustainable;
- Clearly sets out and formalizes the expectations of management;
- Provides a systematic approach to the identification of issues and ensures that a system of risk identification and management is in place;
- Provides a framework for personal, site, and corporate responsibility and leadership;
- Provides a systematic approach for the attainment of CBR's objectives; and
- Ensures continued improvement of programs and performance.

The SHEQMS Program has the following characteristics:

- The system is compatible with the ISO 14001 Environment Management System.
- The system is straightforward in design, is intended as an effective management tool for all types of activities and operations and is capable of implementation at all levels of the organization.
- The system is supported by standards that clearly spell out CBR's expectations while leaving the means by which these are attained as a responsibility of line management.
- The system is readily auditable.
- The system is designed to provide a practical tool to assist the operations in identifying and achieving their objectives while satisfying CBR's governance requirements.

The SHEQMS Program uses a series of standards that align with specific management processes and sets out the minimum expectations for performance. The standards consist of management processes that include assessment, planning, implementation (training, corrective actions, safe work programs, and emergency response), checking (auditing, incident investigation, compliance management, and reporting), and management review. These standards meet the recommendations contained in RG 8.2.

5.2.1.1 Operating Procedures

CBR has developed procedures consistent with the corporate policies and standards and local, state and federal regulatory requirements to implement these management controls. The SHEQMS Program consists of the following standards and operating procedures contained in eight volumes:

Volume 1 – *Standards*

Volume 2 – *Management Procedures*

Volume 3 – *Operations Manual (SOPs)*

Volume 4 – *Health Physics Manual*

Volume 5 – *Industrial Safety Manual*

Volume 6 – *Environmental Manual*

Volume 7 – *Training Manual*

Volume 8 – *Emergency Manual*

Written operating procedures have been developed for all process activities including those involving radioactive materials for the Crow Butte Project. Similar procedures will be developed for all process activities at the MEA. Where radioactive material handling is involved, pertinent radiation safety practices are incorporated into the operating procedure. Additionally, written operating procedures have been developed for non-process activities including environmental monitoring, health physics procedures, emergency procedures, and general safety.

The procedures enumerate pertinent radiation safety procedures to be followed. The procedures can be accessed electronically on all CBR computers. Written copies are also maintained and available in the office area. All procedures involving radiation safety will be reviewed and approved in writing by the RSO or another individual with similar qualifications prior to being implemented. The RSO will also perform a documented annual review of the operating procedures.

5.2.1.2 Radiation Work Permits

In the case that employees are required to conduct activities of a non-routine nature where there is the potential for significant exposure to radioactive materials and for which there is no operating procedure, a Radiation Work Permit (RWP) will be required. The RWP will describe the scope of the work, precautions necessary to maintain radiation exposures to ALARA, and any supplemental radiological monitoring and sampling to be conducted during the work. The RWP shall be reviewed and approved in writing by the RSO (or qualified designee in the absence of the RSO) prior to initiation of the work.

The RSO may also issue Standing Radiation Work Permits (SRWPs) for periodic tasks that require similar radiological protection measures (e.g., maintenance work on a specified plant system). The SRWP will describe the scope of the work, precautions necessary to maintain radiation exposures to ALARA, and any supplemental radiological monitoring and sampling to be conducted during the work. The SRWP shall be reviewed and approved in writing by the RSO (or qualified designee in the absence of the RSO) prior to initiation of the work.

5.2.1.3 Record Keeping and Retention

The SHEQMS Volume II, *Management Procedures*, provides specific instructions for the proper maintenance, control, and retention of records associated with implementation of the program. The program is consistent with the requirements of 10 CFR 20 Subpart L and 10 CFR §40.61 (d) and (e). Records of surveys, calibrations, personnel monitoring, bioassays, transfers or disposal of source or byproduct material, and transportation accidents will be maintained on site until license termination. Records containing information pertinent to decommissioning and reclamation, such as descriptions of spills, excursions, contamination events, as well as information related to site and aquifer characterization and background radiation levels, will be maintained on site until license termination. Duplicates of all significant records will be maintained in the corporate office or other offsite locations.

5.2.2 Performance Based License Conditions

This license application is the basis of the Performance-Based License (PBL) originally issued in 1998. Under that license, CBR may, without prior NRC approval or the need to obtain a License Amendment:

- Make changes to the facility or process, as presented in the license application (as updated),
- Make changes in the procedures presented in the license application (as updated), and
- Conduct tests or experiments not presented in the license application (as updated).

A License Amendment and/or NRC approval is necessary prior to implementing a proposed change, test, or experiment if the change, test, or experiment would:

- Result in any appreciable increase in the frequency of occurrence of an accident previously evaluated in the license application (as updated);
- Result in any appreciable increase in the likelihood of occurrence of a malfunction of a structure, system, or component (SSC) important to safety previously evaluated in the license application (as updated);
- Result in any appreciable increase in the consequences of an accident previously evaluated in the license application (as updated);
- Result in any appreciable increase in the consequences of a malfunction of an SSC previously evaluated in the license application (as updated);
- Create a possibility for an accident of a different type than any previously evaluated in the license application (as updated);
- Create a possibility for a malfunction of an SSC with a different result than previously evaluated in the license application (as updated);
- Result in a departure from the method of evaluation described in the license application (as updated) used in establishing the final safety evaluation report, the EA, technical evaluation reports (TERs), or other analysis and evaluations for license amendments;

- For purposes of this paragraph as applied to this license, SSC means any SSC that has been referenced in a staff SER, TER, EA, or environmental impact statement (EIS) and supplements and amendments thereof.

Additionally, CBR must obtain a license amendment unless the change, test, or experiment is consistent with the NRC conclusions, or the basis of, or analysis leading to, the conclusions of actions, designs, or design configurations analyzed and selected in the site or facility SER, TERs, EIS, or EA. This would include all supplements, amendments, TERs, EAs, and EISs issued with amendments to this license.

5.2.3 Safety and Environmental Review Panel

A SERP determines compliance concerning the conditions discussed in Section 5.2.2. The SERP consists of a minimum of three individuals. One member of the SERP has expertise in management and is responsible for managerial and financial approval for changes; one member has expertise in operations and/or construction and has expertise in implementation of any changes; and one member is the RSO or equivalent. Other members of the SERP may be utilized as appropriate to address technical aspects of the change, experiment, or test in several areas such as health physics, groundwater hydrology, surface water hydrology, specific earth sciences, and others. Temporary members, or permanent members other than the three identified above, may be consultants.

The SERP is responsible for monitoring any proposed change in the facility or process, making changes in procedures, and conducting tests or experiments not contained in the current NRC license. As such, they are responsible for ensuring that any such change results in no degradation in the essential safety or environmental commitments of CBR.

5.2.3.1 Safety and Environmental Review Panel Review Procedures

The CBR SERP implements the following review procedures for the evaluation of all appropriate changes to the facility operations. The SERP may delegate any portion of these responsibilities to a committee of two or more members of the SERP. Any committees so constituted will report their findings to the full SERP for a determination of compliance with Section 5.2.2. In their documented review of whether a potential change, test, or experiment (hereinafter called "the change") is allowed under the PBL (or Performance-Based License Condition [PBLC]) without a license amendment, the SERP shall consider the following.

Current NRC License Requirements

The SERP reviews the most current NRC license conditions to assess which, if any, conditions will have an impact on or be impacted by the potential SERP action. If the SERP action will conflict with a specific license requirement, then a license amendment is necessary before initiating the change. This review includes information contained in the approved license application.

Ability to Meet USNRC Regulations

The SERP determines if the change, test, or experiment conflicts with applicable NRC regulations (example: 10 CFR Parts 20 and 40 requirements). If the SERP action conflicts with NRC regulations, a license amendment is necessary.

Licensing Basis

The SERP reviews whether the change, test, or experiment is consistent with NRC's conclusions regarding actions analyzed and selected in the licensing basis. Documents that the SERP must review in conducting this evaluation include the SER and EA prepared in support of LRAs and any SERs, TERs, EAs, or EISs prepared to support amendments to the license. The RSO maintains a current copy of all pertinent documents for review by the SERP during these evaluations.

Financial Surety

The SERP reviews the proposed action to determine if any adjustment to financial surety arrangement or approved amount is required. If the proposed action will require an increase to the existing surety amount, the financial surety instrument must be increased accordingly before the change can be approved. The surety estimate must be updated either through a license amendment or through the course of the annual surety update to the NRC. The NRC incorporates the annual surety update by license amendment.

Essential Safety and Environmental Commitments

The SERP assures that there is no degradation in the essential safety or environmental commitment in the license application, or as provided by the approved reclamation plan.

5.2.3.2 *Documentation of SERP Review Process*

After the SERP conducts the review process for a proposed action, the proceedings, findings, recommendations and conclusions are provided in a written report format. All members of the SERP sign concurrence on the final report. If the report concludes that the action meets the appropriate PBL or PBLC requirements and does not require a license amendment, the proposed action may then be implemented. If the report concludes that a license amendment is necessary before implementing the action, the report will document the reasons why and what course CBR plans to pursue. The SERP report shall include the following:

- A description of the proposed change, test, or experiment (proposed action);
- A listing of all SERP members conducting the review and their qualifications (if a consultant or other member was not previously qualified);
- The evaluation of the proposed action including all aspects of the SERP review procedures listed above;
- Conclusions and recommendations;
- Signatory approvals of the SERP members; and
- Any attachments such as all applicable technical, environmental, or safety evaluations, reports, or other relevant information including consultant reports.

All SERP reports and associated records of any changes made pursuant to the PBL or PBLC shall be maintained through termination of the NRC license.

CBR submits an annual report to the NRC that describes all changes, tests, or experiments made pursuant to the PBL or PBLC. The report includes a summary of the SERP evaluation of each change. In addition, CBR annually submits any pages of the license renewal application to reflect changes or supplementary information. Each replacement page includes both a change indicator for the area of change, (e.g., bold marking vertically in the margin adjacent to the portion actually changed) and a page change identification (date of change, change number, or both).

5.3 MANAGEMENT AUDIT AND INSPECTION REPORT

The following internal inspections, audits, and reports are performed for the Crow Butte Project operations and will be performed for the MEA.

5.3.1 Radiation Safety Inspections

5.3.1.1 Daily Inspections

The RSO, HPT or a qualified designated operator conducts a daily facility inspection. The purpose of the walk-through inspection is to ensure proper implementation of radiation safety requirements and standard operating procedures (SOPs).

The RSO will determine the specific areas at the facility that will be included in the daily inspection based on the potential for radiological hazards and specific license requirements. The inspection is primarily a visual inspection to ensure that process designs and procedural methods for maintaining exposures ALARA are being implemented and used correctly. During the walk-through inspection, the RSO, HPT, or trained designated operator will document on a standard inspection form or in a logbook the results of the inspection. The documentation contains the radiological/safety hazards examined, which are reviewed with the Mine Manager.

In all areas where corrective actions are needed the appropriate employee or supervisor will be notified. A RWP will be issued if the RSO or designee determines a significant radiological hazard or potential hazard exists and for which there is no SOP.

5.3.1.2 Weekly RSO Inspections

The RSO and Mine Manager (or designees in their absence) will conduct a weekly inspection of all facility areas to observe general radiation control practices and review required changes in procedures and equipment.

5.3.1.3 Monthly RSO Reports

The RSO will provide a written summary of the month's radiological activities at the facilities. The report includes a review of all monitoring and exposure data for the month, a summary of worker protection activities, a summary of all pertinent radiation survey records, a discussion of any trends in the ALARA program, and a review of adequacy of the implementation of the

NRC license conditions. Recommendations are made for any corrective actions or improvements in the process or safety programs.

At least monthly, the RSO reviews the results of daily and weekly inspections, including a review of all monitoring and exposure data for the month. The RSO provides the resident manager and all department heads for their review a written summary of the month's significant worker protection activities that contains (1) a summary of the most recent personnel exposure data, including bioassays and time-weighted calculations, and (2) a summary of all pertinent radiation survey records.

In addition, the monthly summary report specifically addresses any trends or deviations from the radiation protection and ALARA program, including an evaluation of the adequacy of license conditions regarding radiation protection and ALARA. The summary describes unresolved problems and the proposed corrective measures. Monthly summary reports are maintained on file and readily accessible for at least 5 years.

5.3.2 Evaporation Pond Inspections

The inspection program developed by CBR for use on the ponds at the Crow Butte Project is contained in SHEQMS Program Volume VI, *Environmental Manual* and is based on the guidance in NRC RG 3.11. The inspection program is summarized below.

5.3.2.1 Daily Inspections

- Pond Depth – The depth of water in each pond is measured and recorded.
- Pond Embankments – The pond embankments are visually inspected for signs of cracking, slumping, movement, or seepage.

5.3.2.2 Weekly Inspections

- Perimeter Fence - The game-proof perimeter fence is inspected for holes that would allow animals to enter the pond area.
- Inlet Pipes - The pond inlet piping is inspected to verify that it is not clogged with ice, dirt, etc.
- Underdrain Measurements - The underdrains are measured, and the vertical depth of fluid in the standpipe is recorded.
- Pond Sprays - When in use, the enhanced evaporation systems should be checked at regular intervals.
- Pond Liner - The liner is visually inspected weekly for holes or other signs of distress.
- Leak Detection System - The leak detection pipes for all ponds are measured for fluid in the standpipes, and the vertical depth of the fluid shall be recorded on the Pond Inspection Forms.

5.3.2.3 Quarterly Inspections

- Embankment Settlement - The tops of the embankments and downstream toe area are examined for settlement or depressions.
- Embankment Slopes - Embankment slopes are examined for irregularities in alignment and variances from originally constructed slopes (sloughing, toe movement, surface cracking, or erosion).
- Seepage - Evidence of seepage in any areas surrounding the ponds (especially the downstream toes) is investigated and documented.
- Slope Protection - Vegetation on the outslopes of the pond is examined. Any evidence of rills or gullies forming is noted.
- Post-Construction Changes - Any changes to the upstream watershed areas that could affect runoff to the ponds is noted.
- Emergency lines are inspected to ensure that the rope has not deteriorated and the ropes reach to the pond water level.

5.3.2.4 Annual Inspection

A technical evaluation of the pond system which addresses the hydraulic and hydrologic capacities of the ponds and ditches and the structural stability of the embankments is conducted annually. A survey of the pond embankments is conducted annually, and the survey results documented and incorporated into the annual inspection report. The survey is reviewed for evidence of embankment settlement, irregularities in embankment alignment, and any changes in the originally constructed slopes.

The technical evaluation is the result of an annual inspection and a review of the weekly, monthly, and quarterly inspection reports by a professional engineer registered in the State of Nebraska. The pond monitor well sampling data is also reviewed for signs of seepage in the embankments.

The inspection report presents the results of the technical evaluation and the analysis of inspection data collected since the last report. The report is kept on file at the site for review by regulatory agencies. A copy is also submitted to the NRC within one month of the annual inspection.

5.3.3 Annual ALARA Audit

CBR conducts annual audits of the radiation safety and ALARA programs. The Manager of SHEQ may conduct these audits. Alternatively, CBR may employ qualified personnel from other uranium recovery facilities or an outside radiation protection auditing service to conduct these audits. The purpose of the audits is to confirm that all radiation health protection procedures and license condition requirements are being conducted properly at the Crow Butte Project and the MEA facilities. Any outside personnel employed for this purpose will be qualified in radiation safety procedures as well as environmental aspects of solution mining operations. Whether conducted internally or through the use of an audit service, the auditor will meet the same minimum qualifications for education and experience as for the RSO as described in Section 5.5.

The audit of the radiation protection and ALARA program is conducted in accordance with the recommendations contained in NRC RG 8.31. A written report of the results is submitted to corporate management. The RSO may accompany the auditor but may not participate in the documentation of conclusions.

The annual ALARA audit report summarizes the following data:

- Employee exposure records (external and time-weighted calculations)
- Bioassay results
- Inspection log entries and summary reports of daily, weekly, and monthly inspections
- Documented training program activities
- Radiation safety meeting reports
- Radiological survey and sampling data
- Reports on overexposure of workers submitted to the NRC
- Operating procedures that were reviewed during this time period

The ALARA audit report specifically discusses the following:

- Trends in personal exposures for identifiable categories of workers and types of operational activities
- Whether equipment for exposure control is being properly used, maintained, and inspected
- Recommendations on ways to further reduce personnel exposures from uranium and its daughters

The ALARA Audit includes an audit of the QA/QC program. The RSO is primarily responsible for reviewing the results of the Audit and the radiological QA/QC program at the Crow Butte Project and MEA facilities. The ALARA audit report is submitted to the NRC annually.

5.4 QUALIFICATIONS FOR PERSONNEL CONDUCTING THE RADIATION SAFETY PROGRAM

CBR staff is highly experienced in the management of uranium development, mining and operations. The following minimum personnel specifications and qualifications are strictly adhered to.

5.4.1 Radiation Safety Officer Qualifications

The minimum qualifications for the RSO are as follows:

- Education: A Bachelor’s degree in the physical sciences, industrial hygiene, or engineering from an accredited college or university or an equivalent combination of training and relevant experience in uranium recovery facility radiation protection. Two years of relevant experience are generally considered equivalent to one year of academic study.

- Health Physics Experience: At least 1 year of work experience relevant to uranium recovery operations in applied health physics, radiation protection, industrial hygiene, or similar work. This experience should involve actual work with radiation detection and measurement equipment, not strictly administrative or “desk” work.
- Specialized Training: At least 4 weeks of specialized classroom training in health physics specifically applicable to uranium recovery. In addition, the RSO should attend refresher training on uranium recovery facility health physics every 2 years.
- Specialized Knowledge: A thorough knowledge of the proper application and use of all health physics equipment used in the uranium recovery facility, the chemical and analytical procedures used for radiological sampling and monitoring, methodologies used to calculate personnel exposure to uranium and its daughters, and a thorough understanding of the uranium recovery process and equipment used in the facility and how hazards are generated and controlled during the uranium recovery process.

5.4.2 Health Physics Technician Qualifications

The HPT should have one of the following combinations of education, training, and experience:

- Education: An Associate’s degree or 2 or more years of study in the physical sciences, engineering, or a health-related field
- Training: A total of at least 4 weeks of generalized training (up to 2 weeks may be on-the-job training) in radiation health protection applicable to uranium recovery facilities
- Experience: One year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety measures to be applied in a uranium recovery facility

OR

- Education: A high school diploma;
- Training: A total of at least 3 months of specialized training (up to 1 month may be on-the-job training) in radiation health protection relevant to uranium recovery facilities; and
- Experience: Two years of relevant work experience in applied radiation protection.

The HPT should demonstrate a working knowledge of the proper operation of health physics instruments used in the uranium recovery facility, surveying and sampling techniques, and personnel dosimetry requirements. The HPT’s qualifications are reviewed and documented by a Safety and Environmental Review Panel in accordance with Section 5.2.3

5.5 RADIATION SAFETY TRAINING

All site employees and contractor personnel are administered a training program based upon the SHEQMS covering radiation safety, radioactive material handling, and radiological emergency procedures. The CBR Training Program in the SHEQMS Volume VII, *Training Manual*, provides requirements for radiation safety training. The training program is administered in keeping with standard radiological protection guidelines and the guidance provided in RG 8.29, RG 8.31, and RG 8.13. The technical content of the training program is under the direction of the RSO. The RSO or an HPT conducts all radiation safety training. CBR will implement this training program for activities at the MEA.

5.5.1 Training Program Content

5.5.1.1 Visitors

Visitors to the Crow Butte Project who have not received training are escorted by on-site personnel who are properly trained and familiar with the hazards of the facility. At a minimum, visitors are instructed specifically on what they should do to avoid possible hazards in the area of the facility that they are visiting.

5.5.1.2 Contractors

Any contractors having work assignments at the facility are given appropriate radiological safety training. Contract workers who will be performing work on heavily contaminated equipment receive the same training normally required of Crow Butte workers as discussed in Section 5.5.3.

5.5.1.3 Crow Butte Resources Employees

All CBR employees (and some contractors as noted in Section 5.5.1.2) receive training as radiation workers. The program incorporates the following topics recommended in RG 8.31:

1. Fundamentals of Health Protection
   - The radiologic and toxic hazards of exposure to uranium and its daughters,
   - How uranium and its daughters enter the body (inhalation, ingestion, and skin penetration)
   - Why exposures to uranium and its daughters should be kept ALARA.
2. Personal Hygiene at Uranium Recovery Facilities
   - Wearing protective clothing,
   - Using respiratory protective equipment correctly,
   - Eating, drinking, and smoking only in designated area,
   - Using proper methods for decontamination (i.e., showers).
3. Facility-Provided Protection
   - Ventilation systems and effluent controls,

- Cleanliness of the work place,
- Features designed for radiation safety for process equipment,
- Standard operating procedures,
- Security and access control to designated areas,
- Electronic data gathering and storage,
- Automated processes.

4. Health Protection Measurements
   - Measurement of airborne radioactive materials,
   - Bioassays to detect uranium (urinalysis and in vivo counting),
   - Surveys to detect contamination of personnel and equipment,
   - Personnel dosimetry.
5. Radiation Protection Regulations
   - Regulatory authority of NRC, the Occupational Safety and Health Administration (OSHA), and the state,
   - Employee rights in 10 CFR Part 19
   - Radiation protection requirements in 10 CFR Part 20.
6. Emergency Procedures

All new workers, including supervisors, are given specialized instruction on the health and safety aspects of the specific jobs they will perform. Instruction is provided in the form of individualized on-the-job training. Retraining is performed annually and documented. All workers attend periodic general safety meetings.

Consistent with RG 8.13, Appendix A, it is CBR policy to accommodate pregnant workers when possible. To that end, CBR uses the following approach to address potential and actual prenatal exposure risks:

- Instructions
  - Give to all female new hires
  - Give to supervisors in charge of female workers
  - Provide prenatal instruction
  - Provide RG 8.13 and its appendix, review with worker
  - Provide opportunity to ask questions
  - Discuss possible effect on job status, which may involve adjustment of work duties as necessary
- Written declaration

- View prenatal instructions again and review RG 8.13
- Review worker-specific exposure monitoring (e.g., dosimetry, bioassay where appropriate) following declaration
- Adjust work duties as necessary

5.5.2 Testing Requirements

A written test with questions directly relevant to the principals of radiation safety and health protection in the facility covered in the training course is given to each worker. The instructor reviews the test results with each worker and discusses incorrect answers to the questions with the worker until the worker understands the correct answer. Workers who fail the exam are retested, and test results remain on file.

5.5.3 On-the-Job Training

5.5.3.1 Health Physics Technician

On-the-job training is provided to HPTs in radiation exposure monitoring and exposure determination programs, instrument calibration, facility inspections, posting requirements, respirator programs and health physics procedures contained in the SHEQMS Volume IV, *Health Physics Manual*.

5.5.3.2 Refresher Training

Following initial radiation safety training, all permanent employees and long-term contractors receive ongoing radiation safety training as part of the annual refresher training and, if determined necessary by the RSO, during monthly safety meetings. This ongoing training is used to discuss problems and questions that have arisen, any relevant information or regulations that have changed, exposure trends, and other pertinent topics.

5.5.3.3 Training Records

Records of training are kept until license termination for all employees trained as radiation workers (i.e., occupationally exposed employees).

5.5.4 Qualifications and Requirements for Daily Inspections

CBR conducts daily walk-through inspections of all work and storage areas of the facility to ensure proper implementation of good radiation safety procedures, including good housekeeping and cleanup practices that minimize unnecessary contamination. Normally, these inspections are conducted by the RSO or an HPT. However, on certain occasions, such as weekends or holidays, a qualified operator may be designated to conduct the daily inspection.

CBR will use an alternative approach to qualify designated operators to conduct daily walkthrough inspections of all work and storage areas at the Crow Butte Plant and satellite facilities. Qualified designated operators will be identified to perform daily inspections in the occasional absence of the RSO and HPT.

As described in Section 1.1.1, CBR is requesting a revision to LC 9.7 of SUA-1534. The license condition currently states that:

> *"A qualified designee may perform daily inspections on weekends, holidays, and times when both the RSO and HPTs must both be absent (e.g., illness or offsite training). With the exceptions of those instances when a Federal holiday falls on a Friday or Monday, the Thanksgiving holiday, or a site closure due to weather or other safety or security related event, qualified designees will not conduct the daily inspections for more than a total of two days per week. When a Federal holiday falls on a Friday or Monday, qualified designees may perform the daily inspections for a total of three consecutive days. For the Thanksgiving holiday only, qualified designees may perform the daily inspections for a total of four consecutive days. When weather or other safety or security related event causes a site closure, a qualified designee, if available, will continue performing the daily inspections until the RSO or HPT can access the site after such an event. The licensee will also have the RSO or HPT available by telephone while a qualified designee is performing the daily inspections."*

CBR proposes to revise LC 9.7 of SUA-1534 to the following:

> *A qualified designated operator may only perform the daily inspections on weekends, holidays, and times when no adequately qualified health physics staff (RSO, HPT) are available to perform the inspection (e.g. illness, offsite training, periods of leave). With the exceptions of those instances when observed holidays, in conjunction with health physics staff's scheduled time off (e.g. weekends or other leave), or a site closure due to weather or other safety or security related event, qualified designated operators will not conduct the inspection for more than two days per week. When an observed holiday falls on a Friday or Monday, qualified designated operators may perform the daily inspections for a total of three consecutive days. For those instances where the observed holiday in conjunction with health physics staff's scheduled time off results in the absence of health physics staff for greater than three consecutive days (Thanksgiving, Christmas, etc.), a qualified designated operator may perform the daily inspections for a total of four consecutive days. When a weather or other safety or security related event causes a site closure or inability to safely access the site, a qualified designated operator, if available, will continue performing the daily inspections until an RSO or HPT can access the site after such an event. The licensee will also have the RSO or HPT available by telephone while a qualified designated operator is performing the daily inspections.*

Reports generated by a qualified designated operator will be reviewed by the RSO or an HPT as soon as practicable, but not later than the close of business the next work day following an absence (including site closure due to weather or other safety or security related event), weekend or holiday. The RSO or HPT review shall be annotated with date and time on the report or other document that can be inspected upon request.

Any problems noted by the designated operator during the daily inspection will be recorded on an inspection form, signed and dated, and retained on file. The RSO will review the inspection forms and take appropriate action to correct any noted problems.

A qualified designated operator has no authority for the development and administration of the radiation protection program, other than conducting daily inspections. They may not approve plans for new equipment, process changes, or changes in operating procedures that may affect the radiation protection program. They will not conduct radiation safety audits or make determinations about personnel dosimetry. A qualified designated operator may not authorize non-routine maintenance jobs involving potential for personnel radiation exposure or radioactive contamination for which there are no standard operating procedures nor an existing radiation work permit. The designated operator will not have the authority to release materials for unrestricted use. In the event of an emergency, the on-call RSO or HPT will be responsible for radiation protection decisions.

At the Crow Butte Plant and satellite facilities, the only activity required to be performed by an RSO or HPT on a daily basis is the daily inspection. Instrument efficiency calculations and performance checks are conducted during the regular workweek by the RSO or HPT. For that reason, it is not necessary for the designated operator to perform any other HPT function on weekends or holidays.

The designated operator will observe, through visual inspection, radiation safety practices, housekeeping and implementation of the radiation safety program throughout the plant/satellite. Such duties include, but may not be limited to, inspecting for compliance with radiation safety postings, contamination control, proper control point ingress and egress, control of airborne radioactivity, worker protection practices in the yellowcake drying and packaging area, and proper storage of byproduct material.

5.5.4.1 Minimum Qualifications for Designated Operators

Before a designated operator may conduct such inspections, they must be qualified by reason of training and experience to observe proper implementation of good radiation safety practices. In addition to the annual radiation worker training required by RG 8.31, Section 2.5, the operator seeking designation must not only complete one-time training specific to daily inspections, but also demonstrate proficiency. The additional training will emphasize how the inspections affect employee safety.

At a minimum, the operator seeking designation must have the following combination of education, training and experience:

- Education: a high school diploma or equivalent
- Training: New employee radiation safety training, including guidance pertinent to prenatal radiation exposure (RG 8.13) and instruction concerning risks from occupational radiation exposure (RG 8.29) and additional training specific to conducting daily inspections at the Crow Butte Plant and satellite facilities. In addition, the designated operator will be required to demonstrate proficiency during daily inspections to the RSO.
- Experience: A minimum of three months' work experience in operations or maintenance at a uranium recovery facility, including procedures that involve health physics, industrial safety or industrial hygiene at a uranium recovery facility to demonstrate qualification is required.

5.5.4.2 *Additional Training for Designated Operators*

The additional radiation safety training afforded to operators seeking designation involves four hours training and a test covering the topics discussed below with an 80 percent passing grade, but does not include the more advanced topics required for the facility RSO or HPT.

The additional training for Designated Operator includes the following topics:

1. Employee PPE usage
2. Personal contamination control (ingress and egress)
3. Radiation area boundaries
4. Signage
5. Labeling
6. Leaks
7. Yellowcake spillage
8. Ventilation
9. General housekeeping
10. Reporting procedures specific to type of finding (e.g., how and when to contact the on-call RSO or HPT)
11. Completion and control of the daily inspection form

5.5.4.3 *Demonstration and Proficiency*

Upon completion of training and prior to designation, an operator will be required to demonstrate to the RSO an understanding of and proficiency in conducting the daily inspections. Prior to performing inspections, the operator seeking designation will perform a minimum of four (4) daily inspections under the supervision of the RSO or HPT. The supervised inspections will cover the training topics listed above and will be documented with signatures of the RSO or HPT and the operator seeking designation on the daily inspection form. An operator who fails to qualify will be re-evaluated after performing additional supervised inspections until proficiency is demonstrated to the satisfaction of the RSO.

5.5.4.4 *Documentation*

The designation process will be documented in a file which includes education, training results with a passing test score, and signed supervised daily inspection forms. The designation itself will be co-signed by the Designated Operator and the RSO when the RSO is satisfied that the training and supervised inspections demonstrate proficiency.

5.5.4.5 Maintaining Designated Operator Status

To remain qualified, the Designated Operators must complete annual refresher training which addresses the same topics covered in the additional training described above. In addition, the Designated Operator must complete at least a supervised inspection performed annually under the direct supervision of the RSO or HPT.

5.6 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, healthy, and secure working environment;
- Maintaining control and security of NRC licensed material;
- Ensuring the safe and secure handling and transportation of hazardous materials; and
- 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 facility, 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.

5.6.1 License Area and Facility Security

5.6.1.1 Crow Butte Project

5.6.1.1.1 Central Processing Facility Area

All CPF areas where source or byproduct material is handled are fenced. The main access road is equipped with a locking gate. Strategically placed surveillance cameras monitor the access road and areas around the CPF. A 24-hour-per-day, 7-day-per-week staff is on duty in the CPF.

CPF operators perform inspections to ensure the proper storage and security of licensed material at the beginning of each shift. The inspection determines whether all licensed material is properly stored in a restricted area or, if in controlled or unrestricted areas, is properly secured. In particular, operators ensure that loaded ion exchange resin, slurry, drummed yellowcake, and byproduct material are properly secured. If licensed material is found outside a restricted area, the operator will ensure that it is secured, locked, moved to a restricted area, or kept under constant surveillance by direct observation by site personnel or surveillance cameras. The results of this inspection will be properly documented.

5.6.1.1.2 Office Building

There is a reception area located at the main entrance into the office building. All other entrances are locked during off-shift hours. There are a limited number of traceable keys to the office, and they are given out to select employees. The main door and the door to the CPF entrance are also equipped with an access keypad.

Visitors entering the office are greeted and announced to the receiving person. All visitors are required to sign the access log and indicate the purpose of their visit and the employee to be visited. The person being visited is responsible to supervise the visitors at all times when they are on site. Visitors are only allowed at the facility during regular working hours unless prior approval is obtained from the Mine Manager or the Manager of SHEQ.

5.6.1.2 MEA

Security at the MEA site will be consistent with policies and procedures used at the Crow Butte Project. The security systems used at the current site and 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.

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.

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).

Other than access through the main gate, there are two means by which members of the public could gain access to the site. First, for those members of the general public traveling public roads adjacent to the license area, access is controlled by perimeter fences on one or both sides of the roads. These fences are posted with signs. For the abutting ranchers who have leased property to Cameco (lessors), a second approach is used to control access. Prior to putting an MU into production, the area is closed to grazing or haying until the MU has been decommissioned and reclaimed. To accomplish this, Cameco uses a combination of existing and/or new perimeter fencing specific to each MU. Any new perimeter fencing will include appropriate signage advising of access restrictions prior to production.

Proposed restricted areas for the satellite facility are shown on Figure 5.7-2. 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 situations and unique situations that can reasonably be expected to occur will be considered.

All visitors, contractors, or inspectors entering the MEA 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 RSO or designee.

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 building 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 or 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.

5.6.1.3 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 who 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 take measures to provide personnel security by screening job applicants, preventing unauthorized access to the hazardous materials or vehicles being prepared for shipment, and providing for enroute 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 the MEA to the CPF and 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 by 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’s 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 procedures will be utilized:

- 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 unit is to be kept visible by an employee at all times when left unattended 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.

5.7 RADIATION SAFETY CONTROLS AND MONITORING

CBR has a strong corporate commitment to and support for the implementation of the radiological control program at the Crow Butte Project and the MEA facilities. This corporate commitment to maintaining personnel exposures ALARA has been incorporated into the radiation safety controls and monitoring programs described in the following sections.

Radiological surveys and sampling have been conducted at the Crow Butte Project since 1994 in accordance with the requirements of license SUA-1534. This license renewal application contains the results of the radiological control program through 2023. Figure 5.7-1 presents the radiological control sampling locations within the CPF. Where the monitoring results indicate that the program should be modified, proposed changes in the program are also discussed. As previously indicated, no construction or operation has occurred at MEA to date. The proposed radiological control program will be the same as that conducted at the Crow Butte Project. The proposed radiological control sampling locations for the satellite facility are shown on Figure 5.7-2.

The CBR radiological monitoring program is based principally on the recommendations contained in RG 8.30 and includes operational monitoring for airborne uranium, radon daughters, external radiation, and surface contamination. Environmental monitoring performed by CBR is based principally on the recommendations contained in RG 4.14 and includes monitoring environmental media surrounding the Crow Butte Project such as air, water, soil, and sediment.

5.7.1 Effluent Control Techniques

5.7.1.1 Crow Butte Project Gaseous and Airborne Particulate Effluents

Under routine operations, the only radioactive effluent at the Crow Butte Project is the release of radon-222 gas from the production solutions. A vacuum dryer is used for drying the yellowcake product. There is no airborne effluent from the vacuum dryer system.

The radon-222 is found in the pregnant lixiviant that comes from the wellfield into the CPF. The production flow is directed to the process building for separation of the uranium. The uranium is separated by passing the recovery solution through fluidized bed upflow ion exchange units or pressurized downflow ion exchange units. Radon gas is released from the solution in the ion exchange columns and in the injection surge tanks. The vents from the individual vessels are connected to a manifold that is exhausted outside the plant building through the CPF stacks.

Venting to the atmosphere outside of the CPF building minimizes personnel exposure. Small amounts of radon-222 may be released in the plant building during solution spills, filter changes, and maintenance activities. The CPF building is equipped with exhaust fans to remove any radon that may be released in the CPF building. No significant personnel exposure to radon gas has been noted during operation of the Crow Butte Project. Results of radon daughter monitoring in the process areas are discussed in Section 5.7.3.

5.7.1.2 MEA Gaseous and Airborne Particulate Effluents

Under routine operations, the only radioactive effluent at the satellite facility will be the release of radon-222 gas from the production solutions. Uranium product will be eluted and processed at the CPF, where a vacuum dryer is used for drying the yellowcake product. Therefore, there will be no airborne particulate effluent from the satellite facility.

The radon-222 is found in the pregnant lixiviant that comes from the wellfield into the satellite facility. The production flow will be directed to the satellite facility process building for separation of the uranium. The uranium will be separated by passing the recovery solution through pressurized downflow IX units. The vents from the individual vessels will be connected to a manifold that will be exhausted outside the satellite facility building through the facility stack.

Venting to the atmosphere outside of the satellite facility building minimizes personnel exposure. Small amounts of radon-222 may be released in the satellite facility building during solution spills, filter changes, IX resin transfer operations, and maintenance activities. The satellite facility building will be equipped with exhaust fans to remove any radon that may be released in the building. No significant personnel exposure to radon gas is expected based on operating experience from similar facilities. Ventilation and effluent control equipment will be inspected for proper operation as recommended in RG 3.56. Ventilation and effluent control equipment will be inspected during radiation safety inspections as discussed in Section 5.3.1.

One process area at the MEA where small quantities of airborne uranium particulates has the potential for occurring is the resin transfer station, where minor spills may occur. The loaded IX resin will be 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.

5.7.1.3 *Crow Butte Project Liquid Effluents*

The liquid effluents from the Crow Butte Project can be classified as follows:

- **Water generated during well development -** This water is recovered groundwater and has not been exposed to any mining process or chemicals. The water is discharged directly to one of the solar evaporation ponds and silt, fines, and other natural suspended matter collected during well development is settled out.
- **Liquid process waste -** The operation of the CPF results in two primary sources of liquid waste, an eluant bleed and a production bleed.
- **Aquifer restoration -** Following mining operations, 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, and 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 (i.e., deep well disposal injection). Historically CBR has not used groundwater sweep, but this option could be used in the future if warranted.

  Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected mining area. A RO unit may be used to reduce the total dissolved solids of 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. The permeate may be further treated if necessary to meet the quality requirements of the NPDES permit for land application disposal.

The existing NRC License allows CBR to dispose of wastewater by three methods:

- Evaporation from the evaporation ponds;
- Deep well injection; and
- Land application.

The design, installation, inspection and operation criteria for the solar evaporation ponds are those found to be applicable in RG 3.11. Each commercial pond is nominally 900 feet by 300 feet by 17 feet in depth. The ponds are membrane lined with a leak detection system under the membrane and are designed to allow the contents of any given pond to be transferred into another pond in the event of a pond problem.

Each of the ponds has the capability of being pumped for water treatment prior to discharge under the NPDES permit. A variety of treatment options exist depending upon the specific chemical contaminants identified in the wastewater. In general, a combination of chemical precipitation and reverse osmosis is adequate to restore the water to a quality that falls within the NPDES parameters.

5.7.1.4 MEA Liquid Effluents

The liquid effluents from the satellite facility can be classified as follows:

- **Water generated during well development** - This water is recovered groundwater and has not been exposed to any mining process or chemicals. The water will be discharged directly to the well work-over fluid tank and silt, fines, and other natural suspended matter collected during well development will settle out.
- **Liquid process waste** - The operation of the satellite facility results in one primary source of liquid waste: a production bleed stream. The production bleed will be disposed of in the DDW permitted under the NDEE Class I UIC Program.
- **Aquifer restoration** - Restoration of the affected aquifer following mining operations results in the production of wastewater. The current groundwater restoration plan consists of four activities: 1) Groundwater transfer; 2) Groundwater sweep; 3) Groundwater treatment; and, 4) Wellfield recirculation. Only the groundwater sweep and groundwater treatment activities will generate wastewater.

As has been the case with past operations at the Crow Butte Project, it is anticipated that during restoration groundwater at the MEA will be treated using IX and RO. Only the wellfield bleed and brine from the RO requires disposal, the remaining treated water will be injected.

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 is typically used to reduce the TDS of the groundwater. The RO unit produces clean water (permeate) and brine. Permeate is normally injected into the formation but, under certain circumstances, may be disposed of in the wastewater disposal system. The brine is sent to the wastewater disposal system. There are no plans for land application as an alternate groundwater disposal option.

At the MEA, CBR proposes to handle liquid effluents from the satellite facility using only deep well injection.

5.7.1.5 Spill Contingency Plans

The RSO is charged with the responsibility to develop and implement appropriate procedures to handle potential spills of radioactive materials. Personnel representing the engineering and operations functions of the Crow Butte Project and MEA will assist the RSO in this effort. Basic responsibilities include:

- Assignment of resources and manpower
- Responsibility for materials inventory
- Responsibility for identifying potential spill sources
- Establishment of spill reporting procedures and visual inspection programs
- Review of past incidents of spills
- Coordination of all departments in carrying out goals of containing potential spills
- Establishment of employee emergency response training programs

- Responsibility for program implementation and subsequent review and updating
- Review of new construction and process changes relative to spill prevention and control.

Spills can take two forms within an in-situ uranium mining facility: 1) surface spills such as tank failures, piping ruptures, transportation accidents, and other incidents; and 2) subsurface releases such as a well excursion, in which process chemicals migrate beyond the wellfield, or a pond liner leak that results in a subsurface release of waste solutions.

Engineering and administrative controls are in place to prevent both surface and subsurface releases to the environment and to mitigate the effects should a release occur. Where appropriate, similar controls will be instituted for the satellite facility.

Supervisory personnel, satellite facility operators, and wellfield operators receive spill response training for release of radiological and non-radiological materials. In the event of a spill, a designated supervisor (dependent upon location of spill) takes the lead, providing guidance and direction to the facility operators responding to the spill. Supervisory personnel take guidance and direction from the RSO, Safety Supervisor, and Manager of SHEQ, as applicable.

5.7.1.5.1 Surface Releases

The most common form of surface releases from ISR mining operations occurs from breaks, leaks, or separations within the piping system that transfers mining fluids between the CPF and the wellfield. These are generally small, short-duration releases because engineering controls detect pressure changes in the piping systems and alert the facility operators through system alarms.

In general, piping from the CPF and satellite facility to and within the wellfield will be constructed of PVC or HDPE pipe with butt-welded joints or an equivalent. All pipelines are pressure-tested at operating pressures prior to operation. It is unlikely that a break would occur in a buried section of line because no additional stress is placed on the pipes. In addition, underground pipelines are protected from vehicles driving over the lines, which could cause breaks. The only exposed pipes will be at the CPF, the satellite facility, the wellheads, and in the wellhouses. Trunkline flows and wellhead pressures are monitored for process control. Spill response is specifically addressed in the Radiological Emergencies and Emergency Reporting chapters of SHEQMS Volume VIII, *Emergency Manual*.

Any failures of process tanks will be contained within the CPF or satellite building. The entire building will drain to a sump that will allow transfer of the spilled solutions to appropriate tankage or DDW.

CBR spill control programs have been very effective at limiting surface releases from mining operations. CBR has only had one spill that was reportable under 10 CFR 20 requirements, which is described in Section 1.2.2.4. All spills are analyzed for root causes and contributing factors. Periodically, the CBR SERP meets to analyze recent spill events and to determine whether engineering or administrative improvements are indicated to reduce the frequency and magnitude of spills.

5.7.1.5.2 Releases Associated with Transportation

The Transportation Emergencies chapter of the SHEQMS Volume VIII, *Emergency Manual*, provides the CBR emergency action plan for responding to a transportation accident involving a radioactive materials shipment. The chapter provides instructions for proper packaging, documentation, driver emergency and accident response procedures, and cleanup and recovery actions. This chapter includes instructions that specifically address the CBR emergency action plan for responding to a transportation accident involving a shipment of eluent or IX resin enroute to or from the CPF. Tanker trailers used for transportation of IX resin between the satellite facility and the CPF will meet or exceed DOT and NRC requirements. Section 7.5.5 describes five potential transportation accident scenarios.

5.7.1.5.3 Sub-Surface Releases

Well Excursions - Mining fluids are normally maintained in the production aquifer within the immediate vicinity of the wellfield. The function of the encircling monitor well ring is to detect any mining solutions that may migrate away from the production area due to fluid pressure imbalance. This system has been proven to function satisfactorily over many years of operating experience with ISR mining.

At the Crow Butte Project and the MEA, an undetected excursion is highly unlikely. A ring of perimeter monitor wells located no further than 300 feet from the wellfield and screened in the ore-bearing Chadron Aquifer surround all wellfields. Additionally, shallow monitor wells are placed in the first overlying aquifer above each wellfield segment. These wells are sampled biweekly. Past experience at the Crow Butte Project and other ISR mining facilities has shown that this monitoring system effectively detects lixiviant migration. The total effect of the close proximity of the monitor wells, the low flow rate from the well patterns, and over-production of leach fluids (production bleed) makes the likelihood of an undetected excursion extremely remote.

Migration of fluids to overlying aquifers has also been considered. Several controls are in place to prevent this. First, CBR plugs all exploration holes to prevent commingling of the Brule and Chadron Aquifers and to isolate the mineralized zone. In addition, MIT is conducted prior to placing a well into service. This requirement of the NDEE UIC Program ensures that all wells are constructed properly and are capable of maintaining pressure without leakage. Finally, monitor wells completed in the overlying aquifer are sampled regularly for the presence of leach solution.

Pond Leak – Seepage of solutions from the evaporation ponds into the subsurface is also a potential pollution source. However, no subsurface releases of wastewater from the ponds have occurred at the Crow Butte Project since engineering controls and safeguards were integrated into the pond designs. These include synthetic liners and leak detection systems that provide a dual barrier between the pond wastewater and the subsurface, as well as the capability to detect and sample for leaks. In addition, the pond soil foundation has low ambient moisture due to its elevation, soil type, and preparation. In the unlikely event of pond fluids seeping into the compacted subgrade, the liquid would be quickly absorbed and would not migrate. Pond monitor wells are also located downstream of the evaporation ponds to detect leaks into the uppermost aquifer.

5.7.2 External Radiation Exposure Monitoring Program

5.7.2.1 Gamma Survey

5.7.2.1.1 Program Description

External gamma radiation surveys are performed routinely at the Crow Butte Project. The required frequency is quarterly in designated Radiation Areas and semiannually in all other areas of the plant. Surveys are performed at specified locations in worker occupied stations and areas of potential gamma sources such as tanks and filters. CBR establishes a Radiation Area if the gamma survey exceeds the action level of 5.0 mRem in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates. An investigation is performed to determine the probable source and survey frequency for areas exceeding 5.0 mR/hr are increased to quarterly. Records are maintained of each investigation and the corrective action taken. If the results of a gamma survey identifies areas where gamma radiation is in excess of levels that delineate a "radiation area", access to the area is restricted and the area is posted as required in 10 CFR §20.1902(a). Designated Radiation Areas are defined in 10 CFR §20.1003: Radiation area is an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

External exposure at the Crow Butte Project is monitored using Optically-Stimulated Luminescent (OSL) dosimeters provided by Landauer Corp. Landauer is a NVLAP-certified vendor for the use of this technology for monitoring external exposures. Dosimeters are exchanged on a quarterly basis.

5.7.2.1.2 Historical Program Results

Routine gamma surveys have been performed as required at the Crow Butte Project. A Radiation Area is established around the injection filter system due to gamma levels above 5.0 mR/hr. Radiation Areas have also been established around several other areas within the CPF. These areas include the other process filter systems, around selected portions of the ion exchange piping, the waste demister box, and the reverse osmosis system. In addition, several of the wellhouses have been designated as Radiation Areas due to scale buildup in the injection manifold piping. Engineering controls such as lead sheeting and water block walls have been employed to maintain personnel exposures ALARA. Results of the gamma survey program are maintained at the Crow Butte Project site.

5.7.2.1.3 Gamma and Beta Survey Program

CBR proposes to continue with the same gamma exposure-monitoring program of worker occupied stations and areas likely to have significant gamma exposure rates at the Crow Butte Project that has been performed to date.

Gamma exposure rate surveys continue to be performed in accordance with the instructions currently contained in SHEQMS Program Volume IV, *Health Physics Manual*. Gamma survey instruments are operationally checked each day of use in accordance with the manufacturer's instructions.

Beta surveys of specific operations that involve direct handling of large quantities of aged yellowcake will continue to be performed as discussed in RG 8.30, Section 1.4. Beta evaluations may be substituted for surveys using radiation survey instruments. Surveys or evaluations are performed whenever a change in equipment or procedures has occurred that may significantly affect worker exposures.

5.7.2.2 *Personnel Dosimetry*

5.7.2.2.1 *Program Description*

All employees working in the CPF or wellfield operations who have the potential to receive ten percent of the annual allowable dose limits are issued dosimeters for determination of external gamma exposure. Dosimeters are provided by a vendor that is accredited by NVLAP of the National Institute of Standards and Technology as required in 10 CFR §20.1501. The dosimeters have a range of 1 mR to 1000 R. Dosimeters are exchanged and read on a quarterly basis.

5.7.2.2.2 *Historical Program Results*

Figure 5.7.3 depicts the average and maximum external exposure levels for all employees at the Crow Butte Project from 1994 through 2023. The average annual exposures to gamma radiation have been well below the annual regulatory limit of 5 Rem and the CBR administrative limit of 1.25 Rem for this time period. The average external exposure for this 30-year period is 65 mRem, ranging from 7 to 165 mRem. The maximum external exposure for this time period ranged from 30 to 495 mRem.

As shown on Figure 5.7-3, there was a noticeable elevation in the maximum exposure levels for the years 2001, 2002, 2005, and 2012. As explained in the 2007 LRA, the most likely cause of the elevated maximum exposures in 2001 and 2002 was the requirement by CBR to store yellowcake during periods when the yellowcake dryer was unable to maintain production (CBR 2001, CBR 2002). The maximum exposure in 2005 (425 mRem) was received by a maintenance worker that was involved in several significant projects in areas with elevated gamma levels, including rebuilding one set of injection filters and installation of a new deep disposal well filtering system (CBR 2005). The maximum exposure in 2012 (316 mRem) was received by a maintenance worker that was again involved in several significant projects in areas with elevated gamma levels, including work in the downflow column area.

Since the 2007 LRA, a downward trend in average exposure levels is apparent, indicating that radiation protection procedures are being refined as operational experience is gained, and that these procedures are effective at maintaining worker doses ALARA. Overall, average and maximum exposure rates dropped significantly when production ceased in 2018.

Figure 5.7-4 depicts the total Person-Rem due to external exposure for each year from 1994 through 2023. The results of the trend analysis indicate a significant decrease in the combined external exposure to gamma radiation from 2001/2002 Crow Butte Project. In 2003, the yellowcake dryer was able to maintain production and the combined external exposure decreased. In 2012, uranium production dropped off as did the combined external exposure. The external exposure has been below 1 Person-Rem since 2018.

More detailed information as to the external exposure measurements are described in CBR's Semi-Annual Radiological Effluent and Environmental Monitoring Report and annual ALARA Review reports (1997 – 2023).

5.7.2.2.3 Personnel Dosimetry Program

10 CFR §20.1502(a)(1) requires exposure monitoring for "Adults likely to receive, in 1 year from sources external to the body, a dose in excess of ten percent of the limits in §20.1201 (a)". Ten percent of the dose limit would correspond to a Deep Dose Equivalent (DDE) of 0.500 Rem. Maximum individual annual exposures at the Crow Butte Project since 1987 have been well below ten percent of the limit. CBR believes that it is unlikely that any employee will exceed ten percent of the regulatory limit. Although monitoring of external exposure may not be required in accordance with §20.1201(a), CBR will continue to issue dosimeters to all process and wellfield employees with the potential to receive ten percent of the annual allowable dose limits and exchange them on a quarterly basis. Results from dosimeter monitoring will be used to determine individual DDE for use in determining Total Effective Dose Equivalent (TEDE) in accordance with the instructions currently contained in SHEQMS Program Volume IV, *Health Physics Manual*.

5.7.3 In-Plant Airborne Radiation Monitoring Program

5.7.3.1 <u>Airborne Uranium Particulate Monitoring</u>

5.7.3.1.1 Program Description

Yellowcake drying operations began at the CPF in 1993. Monitoring for airborne uranium has been performed routinely at Crow Butte Project through the use of area sampling and breathing zone sampling. The monitoring programs are described below.

5.7.3.1.2 Area Sampling

There are five required airborne uranium survey locations in the CPF plus the dryer room. The monitoring frequency for all locations is monthly with additional sampling in the dryer room when the dryer is in operation. If a location meets the criteria for an Airborne Radioactivity Area as defined in 10 CFR §20.1003, the monitoring frequency increases to weekly. The only location at the Crow Butte Project that has met this criterion has been the dryer room during operation of the dryer.

During operation of the dryer, the dryer room is isolated and posted as an Airborne Radioactivity Area. CBR limits access to personnel wearing the proper respiratory protective equipment. A breathing zone sample for the dryer operator is collected during packaging operations. An area air sample is also collected outside of the dryer room. When packaging is completed, the room is washed down and the dryer is reloaded. To open the room, an area air sample is collected inside the dryer room to verify that the airborne concentrations are low enough to remove the Airborne Radioactivity Area designation and allow access without respiratory protection. The breathing zone sample obtained during dryer operation is used to determine internal exposure for the dryer operator. The results of the area samples are used, along with monitoring results for the other four monitoring locations, to determine monthly plant average airborne uranium concentrations for routine exposure calculations. Airborne uranium samples are analyzed for gross alpha at the CPF. The conservative assumption is made that all alpha activity on the samples is due to airborne uranium.

Area samples are taken in accordance with the instructions currently contained in SHEQMS Program Volume IV, *Health Physics Manual*. Samples are taken with a glass fiber filter and a regulated air sampler such as an F&J DF-75-BL-AC or equivalent. Sample volume is adequate to achieve the lower limit of detection (LLD) for uranium in air. The LLD value for uranium in air used for the Crow Butte Project is 5 E-11 µCi/ml, which is 10% of the current Derived Air Concentration (DAC) of 5 E-10 µCi/ml. Samplers are calibrated at the manufacturer's suggested interval or semiannually with a primary air flow calibrator. Sampler calibration is performed in accordance with the instructions currently in SHEQMS Program Volume IV, *Health Physics Manual*.

Measurement of airborne uranium is performed by gross alpha counting of the air filters using an alpha scaler such as a Ludlum Model 2000 or equivalent. Prior to 1994, the Maximum Permissible Concentration (MPC) value for natural uranium of 1 E-10 µCi/ml from Appendix B to 10 CFR §§20.1 - 20.601 was applied to the gross alpha counting results. After implementation of the new 10 CFR 20 on January 1, 1994, the DAC for soluble (D classification) natural uranium of 5 E-10 µCi/ml from Appendix B to 10 CFR §§20.1001 - 20.2401 replaced the use of MPC. The expected mix of long-lived radionuclides is predominantly natural uranium with a lesser amount of radium-226. The DAC for radium-226 is 3 E-10 µCi/ml. The DAC for the mixture is between the natural uranium DAC and the radium-226 DAC. CBR believes the use of natural uranium DAC for comparison to administrative action levels is appropriate since most of the expected mixture of airborne radionuclides is natural uranium and the DAC for natural uranium and radium-226 are similar. An action level of 25% of the DAC for soluble natural uranium has been established at the Crow Butte Project. If an airborne uranium sample exceeds the action level of 25% of the DAC during routine monthly surveys, an investigation of the cause is performed. If a monthly airborne uranium sample exceeds 25% of the action level, the sampling frequency is increased from monthly to weekly until the airborne uranium levels do not exceed the action level for four consecutive weeks. As deemed necessary, the RSO may initiate corrective actions that may reduce future exposures.

No dose is calculated when comparing the measured airborne uranium concentrations to the natural uranium DAC. The purpose for this comparison is to determine whether the airborne uranium concentration is greater than the administrative action level of 25% DAC, which triggers an investigation. If internal doses are required to be estimated pursuant to 10 CFR §20.1202, methods described in Section 5.7.4 are used.

As per 10 CFR §20.1201(e), in addition to the annual dose limits, the intake of soluble uranium by an individual is limited to 10 mg in a week, with consideration of chemical toxicity. If exposure to soluble uranium exceeds 25% of the weekly allowable intake of 10 mg, which would be 2.5 mg/week, then the RSO initiates an investigation into the cause of the occurrence and initiates corrective actions that may reduce future exposures. As with any hazardous material handled on the site, the ALARA program is applied to such potential chemical exposures as described in Section 2.5 of CBR's SHEQMS Program Volume IV, *Health Physics Manual*.

Any worker likely to receive, in 1 year, an occupational dose in excess of 10% of the limits in 10 CFR §20 1201(a) is monitored. The RSO uses historical and current monitoring and survey data to ensure worker external radiation exposures. The external and internal dose that an individual is allowed to receive in the current year is reduced by the amount of occupational dose received or amount of intake while employed by any other person. The record of prior occupational dose that the individual received while performing work involving radiation exposure is obtained, as per 10 CFR §20.2104. All new employees are asked to provide their past radiological exposure history and asked to sign an Exposure Release Form so that previous radiological exposure history may be obtained. If a complete record of the individual's current and previously accumulated occupational dose is not available, it is assumed that in establishing administrative controls under 10 CFR §1201(f) for the current year, that the allowable dose limit for the individual be reduced by 1.25 rems (12.5 mSv) for each quarter for which records are unavailable and the individual worker engaged in activities that could have resulted in occupational radiation exposure. It would also be assumed that the individual would not be available for planned special exposures. As per 10 CFR §20.2104, CBR is not required to partition historical data between external dose equivalent(s) and internal committed dose equivalent(s).

5.7.3.1.3 Historical Program Results

- Airborne Uranium Monitoring – CPF

Airborne uranium monitoring has been performed at the CPF at the locations shown in Figure 5.7-1 since 1994. Table 5.7-1 provides the results of gross alpha monitoring for airborne uranium from the period of 1994 through 2023. The annual average and maximum monthly average airborne gross alpha activity for this period are reported. All activity levels were well below 25 percent of the DAC.

The results of the airborne uranium monitoring program are fairly consistent since operation of the dryer began in 1993. The annual average for the years 1994 through 2023 was 2.61E-12 µCi/ml (0.5 percent of DAC), with a range of 1.78E-13 to 4.02E-12 µCi/ml. The maximum average airborne activity values ranged from 4.76E-13 to 2.56E-11 µCi/ml (0.1 percent and 5.1 percent of the DAC, respectively). In 2022 and 2023, the average airborne activity was 1.80 E-13 µCi/ml (0.04 percent DAC) and 1.79E-13 µCi/ml (0.04 percent DAC), respectively, with a maximum value of 4.76E-13 µCi/ml (0.10 percent DAC) and 7.01E-12 µCi/ml (0.1 percent DAC), respectively. The decrease is expected commensurate with the declining U_3O_8 facility throughput.

- Airborne Uranium Exposures

Exposure to airborne uranium is based upon the results obtained from air sampling discussed in Section 5.7.3.1.2 above. Routine exposure is based upon the monthly average plant airborne uranium concentrations. A conservative occupancy time of 100 percent is used to determine exposure. CBR may, for those personnel not assigned full-time to the CPF, utilize actual time in the CPF for exposure calculations. Exposures assigned during work performed under a RWP or during routine dryer operations are based upon the results of specific monitoring and actual exposure times.

Uranium intakes for the time period 1994 through 2023 have been well below the annual regulatory limit of 1 µCi and the CBR administrative action level of 0.25 µCi. The average and maximum values over this period of time have been relatively consistent, with a general downtrend in intake rates after 2010.

The maximum individual uranium intake for 2022 and 2023 was 5.92E-4 µCi and 6.60E-4 µCi, respectively, corresponding to a dose of 13 mrem (0.06-0.07 percent of the regulatory limit) for both years. The average for all monitored employees in 2022 and 2023 was 3.27E-4 µCi and 3.64E-4 µCi, respectively, corresponding to a dose of 8 mrem (0.03-0.04 percent of the regulatory limit) for both years. The combined uranium intake at the Crow Butte Project for 2022 was 5.57E-3 µCi for the 17 employees that were monitored. This corresponds to a combined dose due to uranium intake of 0.028 Person-Rem. Uranium intake for 2023 was 6.14E-3 µCi for 17 monitored employees, which corresponds to a combined dose due to uranium intake of 0.031 Person-Rem.

Figure 5.7-5 depicts the average and maximum exposure in Rem for each year from 1994 through 2023. The results of the exposure analysis indicate a noticeable increase in both the average and maximum exposure to airborne uranium at the Crow Butte Project in 2005 and 2006, and an increase in the maximum exposure again in 2009 and 2010. The maximum exposure increased by 65 mrem from 2007 (53 mrem) to 2009 (118 mrem), followed by an additional elevated value of 117 mrem in 2010.

The maximum airborne uranium exposure in 2006 was to the dryer operator and the result of increased yellowcake handling during the year. In the last half of the year CBR began receiving yellowcake slurry from the Smith Ranch Project for drying. The yellowcake shipments were unloaded from slurry trailers and the yellowcake was dried and packaged. Fifteen shipments containing approximately 30,000 pounds of yellowcake slurry per shipment were received between September 15 and December 29, 2006. Packaging of the additional yellowcake increased the dose of the dryer operator.

Figure 5.7-6 plots the combined exposure due to airborne uranium exposure for each year from 1994 through 2023. After reaching a high in 2006 of 1.041 Person-Rem, the combined exposure decreased to 0.83 Person-Rem in 2007 followed by increases in 2008 and 2009 (0.958 and 1.328 Person-Rem, respectively). The exposure remained elevated in the period between 2009 and 2017 with all exposure values above 1 Person-Rem, with the exception of 2013. Exposure values steadily decreased from 2017 to 2021.

Airborne uranium exposures have historically been low with the average airborne uranium exposures for facility staff remaining relatively stable. The observed trends in the maximum airborne uranium exposures correlate reasonably well with historic facility production. The exposures are continually monitored in efforts to keep doses ALARA through the assessment of additional controls. In 2011, a second dryer room operator was utilized to that end in an effort to reduce the maximum exposure.

- Proposed In-Plant Airborne Uranium Monitoring Program

CBR proposes to continue with the same airborne uranium-monitoring program (Figure 5.7-1) at the Crow Butte Project that has been performed to date.

5.7.3.2 In-Plant Radon Daughter Surveys

Program Description

There are 16 monitoring locations for radon daughter concentrations in the CPF, the RO Building, and the office areas. The required radon daughter monitoring frequency is monthly unless results are greater than 0.08 Working Levels (WL) (25 percent of the DAC). If this action level is exceeded, the monitoring frequency is increased to weekly until the levels are below the action level for 4 consecutive weeks.

Exposure calculations for radon daughters are based on the results of radon daughter sampling discussed below. Routine exposure is based on the monthly average of the plant radon daughter sampling. A conservative occupancy time of 100 percent is used to determine exposure. CBR may, for those personnel not assigned full-time to the CPF, utilize actual time in the CPF for exposure calculations. Exposure received from work performed under a RWP is based on the results of monitoring performed during the work and the actual exposure times.

Samples are collected with a low-volume air pump and then analyzed with an alpha scaler using the Modified Kusnetz method described in ANSI-N13.8-1973. Air samplers are calibrated before each day's use.

Results of radon daughter sampling are expressed in WL where one WL is defined as any combination of short-lived radon-222 daughters in 1 liter of air without regard to equilibrium that emit 1.3 x 105 mega-electronvolt (MeV) of alpha energy. The DAC limit from Appendix B to 10 CFR §§20.1 - 20.601, as well as the current DAC limit from Appendix B to 10 CFR §§20.1001 - 20.2402, for radon-222 with daughters present is 0.33 WL. CBR has established an action level of 25 percent of the DAC or 0.08 WL. The LLD for radon measures is 0.033 WL, which is 10% of the DAC limit. Radon daughter results in excess of the action level trigger an investigation of the cause and an increase in the sampling frequency to weekly until the radon daughter levels do not exceed the action level for 4 consecutive weeks.

Historical Program Results

- Radon Daughter Monitoring – CPF

Table 5.7-2 provides the results of monitoring for radon daughters from the period of 1995 through 2023. The annual average and maximum values are presented. The data show that the average radon daughter activity concentration at the Crow Butte Project was consistently less than 25 percent of the regulatory limit.

The monthly CPF average radon daughter concentrations from 1994 through 2023 averaged 0.021 WL (6.2 percent of DAC of 0.33 WL) with a range of 0.004 to 0.048 WL. The average for the same period of the maximum monthly average radon concentrations was 0.040 WL (12.1 percent of DAC) with a range of 0.007 to 0.151 WL (2.1 percent and 45.8 percent of DAC, respectively). Since 2012, the annual average radon daughter concentration has been less than

5 percent of the DAC and the maximum monthly average radon concentrations have been less than 10 percent of the DAC.

- Radon Daughter Exposures

Individual exposures to radon daughters at the Crow Butte Project between 1994 and 2023 were well below the annual regulatory limit of 4 Working Level Months (WLM) and below the CBR administrative action level of 1 WLM. The maximum individual radon daughter exposures for 2022 and 2023 were 0.081 WLM and 0.071 WLM, respectively, corresponding to a dose of 102 mrem (2 percent of the regulatory limit) and 88 mrem (1.8 percent of regulatory limit), respectively. The average exposure for all monitored employees was 0.051 WLM in 2022 and 2023, corresponding to a dose of 63 mrem (1.3 percent of the regulatory limit) for both years. The combined radon daughter exposure at the Crow Butte Project for 2022 was 0.869 Person-WLM for the 17 monitored employees, corresponding to a dose of 1.09 Person-Rem. For 2023, the combined radon daughter exposure was 0.859 Person-WLM for the monitored employees, corresponding to a dose of 1.07 Person-Rem.

The results of the exposure analysis indicate an increase in the individual average and maximum exposures to radon daughters at the Crow Butte Project between 2005 and 2011. After 2011, individual average and maximum exposures significantly declined and have remained consistently low since 2018 (less than 2 Person-Rem).

Figure 5.7-7 depicts the average and maximum radon exposures due to radon daughters for each year from 1994 through 2023. A comparison of these exposures indicates that individual average and maximum exposures have steadily decreased since the high in 1997 (average 583 mRem, maximum 804 mRem) with the exception of an increasing trend beginning in 2008 and ending with a localized high (average 298 mRem, Maximum 563 mRem) in 2011. The increasing trend from 2008 to 2011 was likely due to the use of process water for bicarbonate makeup solution in conjunction with a faulty demister identified. Once found, the faulty demister was remedied resulting in the subsequent decreasing trend. Since the localized high in 2011, the average radon exposure has decreased almost 80 percent from 298 mRem in 2011 to 63 mRem in 2023. The maximum individual exposure showed a similar decrease of over 80 percent from 563 mRem in 2011 to 88 mRem in 2023. The 2023 exposure levels for radon daughters are the third lowest recorded during the 30-year period.

Figure 5.7-8 plots the combined exposure for all monitored employees for each year from 1994 through 2023. The combined exposure due to radon daughters peaked in 2011 at 16.39 Person-Rem and has been in a downward trend to present, resulting in the lowest combined exposure in the 30-year period in 2023 (1.07 Person-Rem).

- In-Plant Radon Daughter Monitoring Program

CBR proposes to continue with the same radon daughter monitoring program at the Crow Butte Project that has been performed to date. Routine radon daughter monitoring will continue to be performed monthly in accordance with the instructions currently contained in SHEQMS Program Volume IV, *Health Physics Manual*. Air samplers will continue to be calibrated in accordance with the instructions contained in SHEQMS Program Volume IV, *Health Physics Manual*.

5.7.3.3 Total Effective Dose Equivalent

The TEDE for each monitored employee at the Crow Butte Project from 1994 through 2023 was well below the annual regulatory limit of 5 Rem. Figure 5.7-9 depicts the combined and average TEDE for the project in Person-Rem and mrem, respectively, for each year from 1994 through 2023. The combined dose from 1994 through 2023 averaged 9.5 Person-Rem, with a range of 1.2 Person-Rem in 2022 to 21.0 Person-Rem

Since the last renewal, the average TEDE values have shown a gradual downward trend since the peak in 2011. The highest average TEDE value was 374 mRem in 2011. Recent average TEDE values in 2021 (96 mRem), 2022 (72 mRem), and 2023 (77 mRem) represent some of the lowest values measured for the Crow Butte Project, although the historic low occurred in 2018 (67 mRem) following cessation of mining operations.

Figure 5.7-10 shows the total dose contributions of external exposure, radon daughter exposure, and airborne uranium exposure to the total effective dose from 1994 through 2023. The primary contributors to the total dose over the 30-year period were radon daughter exposures and external radiation exposures. External exposures have remained relatively constant during the period of 2003 to 2017 and were reduced significantly in the time period from 2018 to 2023. Similarly, airborne uranium exposures have stayed relatively consistent through the entire time period up to 2018 when exposures were again reduced significantly. As previously discussed, the increasing trend from 2008 to 2011 was likely due to the use of process water for bicarbonate makeup solution in conjunction with a faulty demister identified. Once found, the faulty demister was remedied resulting in the subsequent decreasing trend.

5.7.3.4 Respiratory Protection Program

Respiratory protective equipment is supplied by CBR for activities where engineering controls may not be adequate to maintain acceptable levels of airborne radioactive materials or toxic materials. Use of respiratory equipment at the Crow Butte Project is in accordance with the procedures currently set forth in the SHEQMS Program Volume IV, *Health Physics Manual*.

The respirator program is designed to implement the guidance contained in RG 8.15. The respirator program is administered by the RSO as the Respiratory Protection Program Administrator (RPPA).

5.7.4 Exposure Calculations

Employee internal exposure to airborne radioactive materials has been determined at the Crow Butte Project since commercial operations began in 1991. Since January 1, 1994, CBR has determined internal exposures based on the requirements of 10 CFR §20.1204. Prior to January 1, 1994, internal exposure was calculated using the MPC-Hour method based on 10 CFR §20.103. The following subsections present a discussion of the exposure calculation methods and results.

5.7.4.1 Natural Uranium Exposure

Exposure calculations for airborne natural uranium are carried out using the intake method from RG 8.30. The intake is calculated using the following equation:

$$I_u = b \sum_{i=1}^{n} \frac{X_i \times t_i}{PF}$$

where:

I_u	=	uranium intake, µg or µCi
t_i	=	time the worker is exposed to concentrations Xi (hr) [per sampling event]
X_i	=	average concentration of uranium in breathing zone, µg/m^3, µCi/m^3, with "i" representing the number of sampling events for uranium (X).
b	=	breathing rate, 1.2 m^3/hr
PF	=	respirator protection factor, if applicable
n	=	number of exposure periods during the week or quarter

The intake for uranium is calculated on Time Weighted Exposure (TWE) forms. The intakes are totaled and entered onto each employee's Occupational Exposure Record.

The data required to calculate internal exposure to airborne natural uranium are determined as follows.

Time of Exposure Determination

When calculating radiological exposures for the Crow Butte Project, the occupancy time for "routine" operations is an exposure period based on actual hours worked (12-hour shift period for plant personnel). This is considered to be a 100% occupancy time, which is used to determine routine worker exposures. For such routine exposures (i.e., 12-hour shift period), it is assumed that the worker was exposed to the measured "work area" average concentration of uranium for the entire work period (exposure 100% of the time). During part of that exposure period, the worker would be expected to spend some time in non-work areas such as the lunchroom, office, restroom, hallways, etc. The 100% occupancy time approach generally results in a conservative (i.e., higher than actual) estimate of internal exposure to airborne natural uranium because it does not account for time the employee may have spent outside the work area, such as described above.

The measured average airborne uranium concentration is multiplied by the time of worker exposure (12 hours) to obtain the estimated average worker exposure for that time period. Routine operations refer to the facilities operating in a normal fashion with no upsets, maintenance activities, or other activities that may result in non-routine and elevated exposures. If a worker works more than the normal 12-hour shifts, the measured average airborne uranium concentration and the total hours actually worked are used to establish exposure levels.

For exposures during non-routine work tasks (e.g., maintenance or cleanup), measured exposures are based on actual time. The results of breathing zone samples collected during maintenance activities or RWPs are taken over a specific time period and are added to the calculations of routine employee exposures for a given work period. For example, a worker working under a RWP for 2 hours would have exposures based on measurements taken for that time period (actual time), with the exposures for the remaining 10 hours of routine work based on the measured average concentration of airborne uranium.

Airborne Uranium Activity Determination

Airborne uranium activity is determined from surveys performed as described in Section 5.7.3.1.

Historical Program Results

Table 5.7-3 summarizes internal exposure results at Crow Butte Project from airborne uranium. The data show that internal exposure at Crow Butte Project has been maintained ALARA. The maximum individual internal exposure to airborne uranium during the period between 1994 and 2023 was significantly lower than the allowable regulatory limit of 1 µCi. For example, the maximum exposure level occurred in 2015 at 2.35 E-02 µCi, which was 2.4 percent of the 1 µCi allowable level.

Proposed Airborne Uranium Exposure Monitoring Program

CBR proposes to institute the same internal airborne uranium exposure calculation methods at Crow Butte Project that have been used to date and which are currently contained in SHEQMS Program Volume IV, *Health Physics Manual*. Exposures to airborne uranium will be compared to the site-specific Crow Butte Operations DAC developed in response to NRC comments. The information was provided pursuant to a request for confidentiality by email dated March 14, 2011, with further clarifications submitted by email on April 5, 2011 (ADAMS Accession No. ML11102020132). The results show that the average ALI for the Crow Butte Project yellowcake is 0.98 µCi and the average DAC is 4.8 E-10 µCi/ml. For consistency with the convention used to round values in the regulation, an ALI and DAC of 1 µ/Ci and 5 µCI/ml will be used. Footnote 3 in Table 1 of Appendix B to 10 CFR 20 states "the specific activity for natural uranium is 6.77 E-7 curies per gram U." This is equivalent to 6.77 E-7 µCi per microgram of natural uranium. This is the specific activity CBR uses to calculate the mass of uranium from an activity measurement and vice versa.

When required by 10 CFR §20.1202, CBR uses methods in RG 8.30 to estimate internal doses. As an example, the Committed Effective Dose Equivalent (CEDE) can be calculated using Equation 2 in RG 8.30 where:

H_{iE} = CEDE from radionuclide (rem)

I_i = Intake in µCi of Class D natural uranium as determined by the equation in Section 5.3.4.1 of the application

ALI_{iE} = Value of the stochastic inhalation ALI for natural uranium from Column 2 of Table 1 in Appendix B to 10 CFR Part 20 (2 µCi). ALI is the Annual Limit on Intake, which refers to the annual intake of a given radionuclide, e.g., natural uranium.

5 = CEDE from intake of 1 ALI (rem)

If an intake (I_i) of 0.5 µCi was determined using the stated equation, the estimate CEDE from this intake would be:

H_{iE} = 5x0.5/2 = 1.25 rem

If an intake (I_i) of 0.5 µg of natural uranium was determined using the stated equation, the estimated CEDE from this intake would be:

H_{iE} = 5x0.5x6.77 E-7/2 = 8.5 E-7 rem

It should be noted that the weekly limit for soluble uranium in 10 CFR §20.1202(e) due to chemical toxicity is 10 milligram (10,000 µg), which would be equivalent to a CEDE of 17 mrem per week or 844 mrem per year. The occupational weekly toxicity limit for Class D natural uranium is more restrictive than the radiological limit.

5.7.4.2 *Radon Daughter Exposure*

Exposure calculations for airborne radon daughters are carried out using the intake method from RG 8.30. The radon daughter intake is calculated using the following equation:

$$I_r = \frac{1}{170}\sum_{i=1}^{n}\frac{W_i \times t_i}{PF}$$

where:

I_r = radon daughter intake, WLM

t_i = time the worker is exposed to concentrations Wi (hr) [per sampling event]

W_i = average number of working levels in the air near the workers breathing zone during the time (t_i), where "i" represents the number of sampling events for working levels (W)

170 = number of hours in working month

PF = respirator protection factor, if applicable

n = number of exposure periods during the year

The data required to calculate exposure to radon daughters are determined as follows.

Time of Exposure Determination

When calculating radon daughter's exposures for the CBR facility, the occupancy time for "routine" operations is an exposure period based on actual hours worked (12-hour shift period for plant personnel). This is considered to be a 100% occupancy time, which is used to determine routine worker exposures. For such routine exposures (i.e., 12-hour shift period), it is assumed that the worker was exposed to the measured "work area" average concentration of radon daughters for the entire work period (exposure 100% of the time). During part of that exposure period, the worker would be expected to spend some time in non-work areas such as the lunchroom, office, restroom, hallways, etc. The 100% occupancy time approach generally results in a conservative (i.e., higher than actual) estimate of internal exposure to radon daughters because it does not account for time the employee may have spent outside the work area, such as described above.

The measured average radon daughter's concentration is multiplied by the time of worker exposure (12 hours) to obtain the estimated average worker exposure for that time period. Routine operations refer to the facilities operating in a normal fashion with no upsets, maintenance activities, or other activities that may result in non-routine and elevated exposures. If a worker works more than the normal 12-hour shifts, the measured average radon daughter's concentration and the total hours actually worked are used to calculate exposure levels.

For exposures during non-routine work tasks (e.g., maintenance or cleanup), measured exposures are based on actual time. The results of breathing zone samples collected during maintenance activities or RWPs are taken over a specific time period and are added to the calculations of routine employee exposures for a given work period. For example, a worker working under a RWP for 2 hours would have exposures based on measurements taken for that time period (actual time), with the exposures for the remaining 10 hours of routine work based on the measured average concentration of radon daughters.

Radon Daughter Concentration Determination

Radon-222 daughter concentrations are determined from surveys performed as described in Section 5.7.3.2.

The WLMs for radon daughter exposure are calculated on the appropriate forms. The WLMs are totaled and entered into each employee's Occupational Exposure Record.

Historical Program Results

Table 5.7-4 summarizes the results of radon daughter exposure calculations at the Crow Butte Project between 1994 and 2023. The data show that internal exposure due to radon daughters at Crow Butte Project has been maintained ALARA, being significantly lower than the allowable level of 4.0 WLM. Since 1994, the average individual internal exposure to radon daughters was at its lowest in 2018 at 0.029 WLM. This level is less than 1 percent of the allowable regulatory limit of 4 WLM. The maximum internal exposure to radon daughters was also at its lowest over the 30-year period at 0.059 WLM in 2018, approximately 1.5 percent of the regulatory limit.

Proposed Radon Daughter Exposure Monitoring Program

CBR proposes to institute the same internal radon daughter exposure calculation methods at Crow Butte Project that have been used to date and which are currently contained in SHEQMS Program Volume IV, *Health Physics Manual*. Exposures to radon daughters will be compared to the DAC for radon daughters from Appendix B of 10 CFR §§20.1001 - 20.2401 (0.33 WL).

The equation above calculates WLM. If required by 10 CFR §20.1202, CBR can calculate a CEDE from the WLM estimate using Equation 2 in RG 8.30 where:

H_{iE} = CEDE from radionuclide (rem)

I_i = is the intake in WLM of radon-222 and its associated progeny as determined by the equation in Section 5.7.4.2 of the application

ALI_{iE} = Value of the stochastic inhalation ALI for radon-222 with progeny present from Column 2 of Table 1 in Appendix B to Part 20 (4 WLM)

5 = CEDE from intake of 1 ALI (rem)

If an intake (I_i) of 1 WLM was determined using the stated equation, the estimate CEDE from this intake would be:

H_{iE} = 5x1/4 = 1.25 rem

5.7.4.3 *Prenatal and Fetal Exposure*

- Dose Equivalent to an Embryo/Fetus

10 CFR §20.1208 requires that licensees ensure that the dose equivalent to an embryo/fetus during the entire pregnancy, due to the occupational exposure of a declared pregnant woman does not exceed 0.5 rem (5 mSv). Licensees are also required to make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman that would satisfy the 0.5 Rem limit. The dose equivalent to the embryo/fetus is calculated as the sum of (1) the DDE to the declared pregnant woman; and, (2) the dose equivalent to the embryo/fetus resulting from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman. If the dose equivalent to the embryo is determined to have exceeded 0.5 rem (5 mSv), or is within 0.05 rem (0.5 mSv) of this dose, by the time the woman declares the pregnancy to the licensee, the licenses shall be deemed to be in compliance with 10 CFR §20.1208 if the additional dose equivalent to the embryo/fetus does not exceed 0.05 rem (0.5 mSv) during the remainder of the pregnancy.

- Individual Monitoring of External and Internal Occupational Exposure

The dose equivalent to the embryo/fetus is determined by the monitoring of the declared pregnant woman. 10 CFR §20.1502(a)(3) requires monitoring the exposure of a declared pregnant woman when the external dose to the embryo/fetus is likely to receive during the entire pregnancy, from radiation sources external to the body, a deep dose equivalent in excess of 0.1 rem (1 mSv). All of the occupational doses in 10 CFR §20.1201 continue to be applicable to the declared pregnant worker as long as the embryo/fetus dose limit is not exceeded. 10 CFR §20.1502(b)(3) requires the monitoring of the occupational intake of radioactive material by, and assess the committed effective dose equivalent to, a declared pregnant woman likely to receive, during the entire pregnancy, a committed effective dose equivalent in excess of 0.1 rem (1 mSv). Based on this 0.1 rem threshold, the dose to the embryo/fetus must be determined if the intake is likely to exceed 1% of ALI during the entire period of gestation.

Prior to declaration of pregnancy, the woman may not have been subject to monitoring based on the conditions specified in 10 CFR §20.1502. In this case, CBR will estimate the exposure during the period monitoring was not provided, using any combination of surveys or other available data (for example, air monitoring, area monitoring and bioassay). Exposure calculations will be performed, as recommended in RG 8.36.

- External Dose to the Embryo/Fetus

The DDE to the declared pregnant woman during the gestation period will be taken as the external dose for the embryo/fetus. The determination of external dose will consider all occupational exposures of the declared pregnant woman since the estimated date of conception and will be based on the methods discussed in Section 5.7.2. External dose to the declared pregnant woman after declaration for the duration of the pregnancy shall be accomplished by personnel dosimetry with exchanges on a monthly basis.

- Internal Dose to the Embryo/Fetus

The internal dose to the embryo/fetus will consider the exposure to the embryo/fetus from radionuclides in the declared pregnant woman and in the embryo/fetus. The dose to the embryo/fetus will include the contribution from any radionuclides in the declared pregnant woman (body burden) from occupational intakes occurring prior to conception.

The intake for the declared pregnant woman will be determined as discussed in Sections 5.7.3.1 and 5.7.3.2.

5.7.5 Bioassay Program

5.7.5.1 Program Description

CBR has implemented a urinalysis bioassay program at the Crow Butte Project that meets the guidelines contained in RG 8.22. The primary purpose of the program is to detect uranium intake in employees who are regularly exposed to uranium. The bioassay program consists of the following elements:

1. Prior to assignment to the facility, all new employees are required to submit a baseline urinalysis sample. Upon termination, an exit bioassay is requested. Additionally, bioassay samples are obtained annually from all employees.
2. During operations, urine samples are collected from workers whose routine work assignment requires them to enter areas where the potential for inhalation of yellowcake exists. Samples from these workers are collected quarterly. Workers who have the potential for exposure to dried yellowcake are sampled monthly when performing those duties. Samples are analyzed by an outside analytical lab for uranium content. Blank and spiked samples are also submitted to the lab with employee samples as part of the Quality Assurance program. The measurement sensitivity for the analytical lab is 5 µg/L.
3. Action levels for urinalysis are established based on Table 1 in RG 8.22
4. *In vivo* measurements are performed in accordance with the recommendations contained in RG 8.22. Because CBR does not produce insoluble, high-fired yellowcake (defined as yellowcake dried at more than 400°C), no *in vivo* measurements have been required.

5.7.5.2 Historical Program Results

The following subsections summarize the results of the bioassay program since 1990, as reported in the ALARA audits.

1990 – Bioassay Results

All bioassay samples were reported at lower than the 5 µg/L detection limit.

1991 – Bioassay Results

All bioassay samples were reported at lower than the 5 µg/L detection limit.

1992 – Bioassay Results

All bioassay samples were reported at lower than the 5 µg/L detection limit.

1993 – Bioassay Results

All bioassay samples were reported at lower than the 5 µg/L detection limit.

1994 – Bioassay Results

All bioassay samples were reported at or lower than the 5 µg/L detection limit with the exception of one sample, which was 13.9 µg/L. Resamples of the individual that submitted this sample were lower than 5 µg/L.

1995 – Bioassay Results

All bioassay samples were reported at lower than the 5 µg/L detection limit.

1996 – Bioassay Results

All bioassay samples were reported at lower than the 5 µg/L detection limit.

1997 – Bioassay Results

All bioassay samples had results that were lower than the detection limit of 5 µg/L.

1998 – Bioassay Results

All bioassay samples taken during 1998 yielded results that were lower than the detection limit of 5 µg/L, with the exception of three quarterly samples. The three samples that were higher than the detection limit were 5.0 µg/L, 9.0 µg/L, and 10.7 µg/L, which are below the 15 µg/L criterion for increased surveillance from RG 8.22. Subsequent samples obtained from these individuals immediately after receipt of the results were lower than the detection limit.

1999 – Bioassay Results

All bioassay samples taken during 1999 yielded results that were lower than the detection limit of 5 µg/L, with the exception of one sample. The one sample that was higher than the detection limit was 81 µg/L, which is well above the 15 µg/L criterion for increased surveillance from RG 8.22. An operator submitted this sample after noticing a loose drum ring when moving yellowcake drums in the Dryer Room. This event occurred during a weekend shift. The operator obtained a bioassay sample approximately 1 hour after the incident. The RSO was not notified of the incident until the following Monday. Additional samples were obtained following a 48-hour and 72-hour elapsed time after the incident. All three samples were submitted for analysis. The 48- and 72-hour samples were lower than the detection limit. CBR believes that the 1-hour sample was probably contaminated during collection. If the initial sample result of

81 µg/L had been correct, natural uranium above the detection limit would have also been detected in the 48- and 72-hour samples due to retention time in the body. Subsequent samples from the operator were also below the detection level.

Diagnostic samples were also necessary when a plant operator performed maintenance work on the yellowcake belt filter during a weekend shift. The work was performed without an RWP, and the RSO was not notified until the following Monday. The bioassay samples obtained from the operator were lower than the detection limit. In response to this incident, the RSO met with all operators to emphasize that work on yellowcake-related equipment must be cleared with the RSO. The RWP SOP was also revised to specifically state what activities require the issuance of an RWP.

2000 – Bioassay Results

In addition to routine bioassays, diagnostic samples were necessary on several instances during 2000:

- A diagnostic bioassay was obtained when a wellfield operator was sprayed in the face with injection water.
- Diagnostic bioassays were obtained when problems with yellowcake drum lid integrity resulted in a visible release of material.
- Diagnostic bioassays were obtained when a plant engineer and maintenance worker tore down the deep well feed pump for repairs without an RWP.
- Diagnostic bioassays were obtained when plant operators moved a drum of yellowcake with a hole in the lid without an RWP or respiratory protection.
- Diagnostic bioassays were obtained from personnel who were in the plant during the yellowcake dryer oil leak.

In most cases, diagnostic bioassays were necessary due to unforeseen situations where representative air sample results were not available. The diagnostic bioassay samples were all lower than the detection limit of 5 µg/L.

2001 – Bioassay Results

All routine bioassay samples taken during 2001 yielded results that were lower than the detection limit of 5 µg/L.

In addition to routine bioassays, diagnostic samples were necessary on several instances during 2001:

- Bioassays were obtained from five welding contractor employees after completion of repairs on the yellowcake dryer in conjunction with RWP 01-04.
- Diagnostic bioassays were obtained from a drum handler and a Health Physics technician after yellowcake leaked around the drum ring on a dry product drum that was being loaded for shipment.
- A diagnostic bioassay was obtained from a plant operator after performing work on the yellowcake belt filter without obtaining an RWP.

- Diagnostic bioassays were obtained from three individuals after the yellowcake dryer was overfilled, spilling product on the dryer room floor.
- Bioassays were obtained in conjunction with RWP 01-32 for changing filters in the yellowcake dryer baghouse.

In most cases, diagnostic bioassays were necessary due to unforeseen situations where representative air sample results were not available. The diagnostic bioassay samples were all lower than the detection limit of 5 µg/L.

2002 – Bioassay Results

With two exceptions, all routine bioassay samples taken during 2002 had results that were lower than the detection limit of 5 µg/L. In April, samples taken from a Plant Operator yielded a bioassay result of 6.2 µg/L. In June, samples taken from a Wellfield Operator yielded a bioassay result of 7.1 µg/L. Investigations conducted by the RSO did not identify any potential cause for the positive bioassay results for these two individuals. Subsequent bioassay samples were below the 5 µg/L detection level.

In addition to routine bioassays, diagnostic samples were necessary on several instances during 2002:

- Bioassays were obtained from Plant Operators after a yellowcake feed hose was disconnected, causing yellowcake to leak onto Precipitation Cell A.
- Diagnostic bioassays were obtained from two engineering personnel after working on the yellowcake packaging scale in the Dryer Room without an RWP.
- A bioassay was obtained from the welder working on replacing the belt filter room floor.
- Bioassays were collected from Plant Operators after the dryer heat was left on following a loss of vacuum and subsequent dryer emissions into the dryer room.
- A bioassay was collected from a Plant Operator after completion of support at Power Resources, Inc. for toll drying CBR product.
- Bioassays were collected on four occasions from personnel working under RWPs in conjunction with work on the Yellowcake Dryer.

In most cases, diagnostic bioassays were necessary due to unforeseen situations where representative air sample results were not available. The diagnostic bioassay samples were all lower than the detection limit of 5 µg/L.

2003 – Bioassay Results

With six exceptions, all routine bioassay samples taken during 2003 yielded results that were lower than the detection limit of 5 µg/L.

- In March, samples taken from a Plant Lead Operator yielded a bioassay result of 5.4 µg/L, which is slightly above the detection limit.
- In December, samples taken from two Plant Operators yielded bioassay results of 8.0 and 14.0 µg/L.

- In December, samples taken from three contractors working on installation of the new yellowcake dryer yielded bioassay results of 6.0, 6.0, and 10.0 µg/L.

Investigations conducted by the RSO did not identify any potential cause for the positive bioassay results for these individuals. No work was performed on heavily contaminated equipment, and all air sampling results were normal. It is possible that the empty bioassay bottles became cross-contaminated in the CBR lab. The bottles were replaced and moved to a different storage location in early 2004.

In addition to routine bioassays, diagnostic samples were necessary on several instances during 2003:

- Bioassays were obtained from three Plant Operators cleaning yellowcake out of the old dryer under RWP 03-2.
- Bioassays were obtained on two occasions from two Plant Operators replacing bag filters in the yellowcake dryer baghouse under RWPs 03-4 and 03-14.
- A bioassay was obtained from one Plant Operator replacing the yellowcake dryer plug valve handle under RWP 03-6.
- A diagnostic bioassay was obtained from a Plant Operator after elevated air sample results were noted during a yellowcake transfer from a Precipitation Cell.
- A diagnostic bioassay was obtained from a Plant Operator who was sprayed with yellowcake during a slurry transfer after a feed line broke.

The diagnostic bioassay samples were all lower than the detection limit of 5 µg/L.

2004 – Bioassay Results

With two exceptions, all routine bioassay samples taken during 2004 yielded results that were less than the detection limit of 5 µg/L.

- In February, samples taken from a Plant Lead Operator yielded a bioassay result of 96 µg/L. Rechecks of this sample yielded 101 µg/L and 103 µg/L. The investigation by the RSO concluded that the most likely cause of this uranium level was contamination of the sample at CBR or at the analytical lab. Follow-up samples yielded concentrations that were below the detection limit. Using the guidance contained in RG 8.9, subsequent samples should have shown measurable levels of uranium if the original concentration was accurate.
- In November, samples taken from the Dryer Operator yielded a bioassay result of 17 µg/L. The investigation conducted by the RSO concluded that improper use of PPE and inadequate engineering design for transferring yellowcake to the dryer were the most likely causes of the elevated sample.

In addition to routine bioassays, diagnostic samples were necessary on several instances during 2004:

- Bioassays were obtained from three workers in February 2004 who were in the same area at the time the Pant Operator had the elevated bioassay noted above.

- Bioassays were obtained on two occasions in April from a maintenance worker involved in dryer maintenance.
- Bioassays were obtained on two occasions in November when breathing zone samples taken during dryer loading activities approached the DAC for soluble uranium.

The diagnostic bioassay samples were all lower than the detection limit of 5 µg/L.

2005 – Bioassay Results

With one exception, all routine bioassay samples taken during 2005 yielded results that were lower than the detection limit of 5 µg/L.

- In August, samples taken from the Dryer Operator yielded a bioassay result of 10 µg/L on a sample taken 5.5 hours after he relieved pressure from a drum of yellowcake. A follow-up 24-hour composite begun immediately after the 5.5-hour grab sample yielded 7.0 µg/L. A second 24-hour composite taken immediately after collection of the first yielded less than 5.0 µg/L.

In addition to routine bioassays, diagnostic samples were necessary on several instances during 2005:

- In April, samples were collected from employees involved in cleaning up yellowcake after the lower discharge valve was broken off of the yellowcake overflow tank.
- In July, samples were collected from employees working under RWP 05-12 to change the bags in the dryer baghouse.

The diagnostic bioassay samples were all lower than the detection limit of 5 µg/L.

2006 – Bioassay Results

All routine bioassay samples taken during 2006 yielded results that were lower than the detection limit of 5 µg/L. In addition to routine bioassays, the following bioassay samples were conducted:

- Diagnostic Bioassay. Employees who changed the bags in the baghouse of the yellowcake dryer were monitored for a 2-day period. All bioassay samples yielded concentrations that were lower than the detection limit of 5 µg/L.
- Bioassay Spike Agreement. A termination bioassay was conducted, resulting in a 10 to 20 µg/L spike that exceeded the Bioassay Spike Agreement range by 33%. All samples were rerun, and after the second run, the agreement range was 24%. The cause of the exceedance was an ELI analytical error made by the contract lab.

2007 – Bioassay Results

All routine bioassay samples taken during 2007 yielded results that were lower than the detection limit of 5 µg/L. In addition to routine bioassays, baseline, termination, and diagnostic bioassays were conducted. All bioassay samples yielded concentrations that were lower than the detection limit of 5 µg/L. All bioassay spiked samples were within the acceptable agreement range.

- Diagnostic Bioassay. The yellowcake feed line to the dryer broke while loading yellowcake into the dryer. Yellowcake was sprayed around the plant as well as drenching the operator loading the dryer. The yellowcake was cleaned up and diagnostic bioassays were collected from the employee to verify that no yellowcake was ingested. Results of the bioassays were negative indicating that the employee did not receive an internal exposure.

2008 – Bioassay Results

All routine bioassay samples taken during 2008 yielded results that were lower than the detection limit of 5 µg/L. In addition to routine bioassays, baseline, termination, and diagnostic bioassays were conducted. All bioassay samples yielded concentrations that were lower than the detection limit of 5 µg/L. With the exception of one sample, all bioassay spiked samples were within the acceptable agreement range. Additional details on the bioassay spike exceedance are discussed below.

- Diagnostic Bioassay. Diagnostic bioassays were collected in May after an employee was sprayed with loaded resin beads. When the employee was sprayed, he got a relatively large amount of resin in his mouth. Although he did not believe that he swallowed any beads, bioassays were performed to verify that he did not receive an intake of uranium. The results of the bioassays were negative.
- Bioassay Spike Agreement. During May, the results of one set of spiked bioassay samples exceeded the allowable agreement range of 30%. The spiked samples had been submitted for analysis with a set of baseline bioassays collected on May 5-6. The results of the 10-20 µg/l spiked sample exceeded the CBR calculated spiking value by 139%. As required by RG 8.22, the lab was instructed to rerun the entire batch of samples to verify the results. When the samples were analyzed the second time, the results were similar to the first. A set of split samples, which the CBR lab retains from each set of spiked bioassay samples, was sent for analyses to determine if the error in the agreement range was due to sample preparation or sample analyses. The results of the split samples closely agreed with the initial set of samples, indicating that an error has been made in the CBR lab while preparing the spiked samples.
- In October, CBR also collected a bioassay sample that was analyzed for radium-226. The sample results were less than the detection limit of 0.1 µg/L. A wellfield operations employee was sprayed with injection water containing black scale while attempting to pull the stinger pipe from an injection well. There was some pressure at the wellhead when the connection was broken, and water and scale sprayed the operator in the face. Bioassay samples were collected from the individual to analyze for both uranium and radium-226 ingestion. The results of the bioassays were negative.

2009 – Bioassay Results

All routine bioassay samples taken during 2009 yielded results that were lower than the detection limit of 5 µg/L, or lower than the action limit of 15 µg/L as recommended in RG 8.22. In addition to routine bioassays, baseline, termination, and diagnostic bioassays were conducted. All bioassay samples yielded concentrations that were lower than the detection limit of 5 µg/L, or lower than the action limit of 15 µg/L as recommended in RG 8.22. With the exception of one sample, all bioassay spiked samples were within the acceptable agreement range. Additional details on the bioassay spike exceedance are discussed below.

- Diagnostic Bioassay. Diagnostic bioassays were collected from a plant operator after he disposed of a barrel of contaminated sediment without collecting a breathing zone air sample while doing the work. The sediment looked like it had originated in the precipitation/yellowcake circuit and had the potential to expose him to airborne uranium. The bioassays were collected to determine if an intake had occurred.
- Diagnostic Bioassay. A wellfield operations employee was drenched with injection water when a wellhouse transition piece came loose. The operator was sprayed in the face and swallowed some of the water. Bioassay samples were collected from the individual to determine if he received an internal dose of uranium. The results of the bioassays for the uranium analysis were negative.
- Bioassay Spike Agreement. During May, the results of one set of spiked bioassay samples exceeded the allowable agreement range of 30%. The spiked samples had been submitted for analysis with monthly bioassays collected on May 11. The results of the 10-20 µg/l spiked sample exceeded the CBR calculated spiking value by 76%. As required by Regulatory Guide 8.22 Bioassay at Uranium Mills, the lab was instructed to rerun the entire batch of samples to verify the results. When the samples were analyzed the second time, the results were similar to the first. A set of split samples, which the CBR lab retains from each set of spiked bioassay samples, was sent for analyses to determine if the error in the agreement range was due to sample preparation or sample analyses. The results of the split samples were received on June 4. The results of the split samples closely agreed with the initial set of samples, indicating that an error had been made in the CBR lab while preparing the spiked the samples.

<u>2010 – Bioassay Results</u>

All routine bioassay samples taken during 2010 yielded results that were lower than the action limit of 15 µg/L as recommended in RG 8.22. In addition to routine bioassays, baseline, termination, and diagnostic bioassays were conducted. All bioassay samples yielded concentrations that were lower than the action limit of 15 µg/L as recommended in RG 8.22. All bioassay spiked samples were within the acceptable agreement range.

- Diagnostic Bioassay. A plant operator performed maintenance and clean out of the washing machine that was used to wash used yellowcake overflow filters when the machine stopped working. There were used filters in the machine which was full of water when the machine quit working. The operator removed the filters, pumped out the machine, and then proceeded to clean out the yellowcake buildup in the machine, the pump, and the lines. He did not use a breathing zone air pump to monitor for potential yellowcake intake nor did he obtain a Radiation Work Permit to perform the work. Diagnostic bioassays were collected from him to determine if he received an internal intake of yellowcake. The results of the bioassays were negative.

2011 – Bioassay Results

All routine bioassay samples taken during 2011 yielded results that were lower than the action limit of 15 µg/L as recommended in RG 8.22. In addition to routine bioassays, baseline, termination, and diagnostic bioassays were conducted. All bioassay samples yielded concentrations that were lower than the action limit of 15 µg/L as recommended in RG 8.22. With the exception of the samples collected in January, all bioassay spiked samples were within the acceptable agreement range. Additional details on the bioassay spike exceedance are discussed below.

- Diagnostic bioassays were collected from an employee that was sprayed in the face with deep well feed water while changing the deep well filters. As he was trying to remove the cover from the filter canisters the lid cracked and blew off. The employee was sprayed with water from the canister and was unsure if he had gotten any in his mouth. Bioassay samples were collected 48 hours and 72 hours after he was sprayed. The results of the bioassays were negative and verified that he had not ingested any of the liquid.
- Diagnostic bioassays were collected from the employees that performed the work under RWP #11-11 to change the bags in the baghouse of the yellowcake dryer. All bioassay sample results were negative and verified that the respiratory protection worn prevented inhalation and ingestion of yellowcake during the bag change operation.
- Diagnostic bioassays were collected from two wellfield operators after BZ air samples collected while the individuals were chipping contaminated pipe indicated elevated concentrations. The individuals were working under an RWP at the time that the elevated concentrations were encountered, and chipping pipe was halted until the RWP could be revised to require the use of respiratory protection. The results of the bioassays were negative confirming that no intake of airborne uranium occurred as a result of the activity.
- Diagnostic bioassays were collected from an employee after the cover from the dryer load out chute fell off while he was standing in the area without respiratory protection. Results of the bioassays were negative, verifying that no uranium intake occurred.
- Bioassay Spike Agreement. All of the monthly spike samples collected in January exceeded the 30% agreement range recommended by RG 8.22. When CBR received the results, the lab was instructed to rerun all samples. In addition, sample splits that are retained onsite by CBR each time a set of spiked samples is prepared were also sent to the lab for analysis. The results of the rerun and split samples were all within the acceptable agreement range, indicating that there was a problem with the initial analysis. The lab did not have an explanation for the discrepancy.

2012 – Bioassay Results

All routine bioassay samples taken during 2012 yielded results that were lower than the action limit of 15 µg/L as recommended in RG 8.22. In addition to routine bioassays, baseline, termination, and diagnostic bioassays were conducted. All bioassay samples yielded concentrations that were lower than the action limit of 15 µg/L as recommended in RG 8.22. All bioassay spiked samples were within the acceptable agreement range.

- Diagnostic bioassays were collected after dried yellowcake was identified leaking from a used drum lid. The drum was being returned to the Blind River Refinery along with 72 other drums. When the drum was set down on the concrete floor a small, but noticeable, amount of yellowcake powder was jarred loose from drum lid. The yellowcake was in the form of a coarse powder. Bioassays were collected from the individuals involved. The results of the bioassays were negative verifying that no yellowcake intake occurred from the event.

2013 – Bioassay Results

All routine bioassay samples taken during 2013 yielded results that were lower than the action limit of 15 µg/L as recommended in RG 8.22. In addition to routine bioassays, baseline, termination, and diagnostic bioassays were conducted. All bioassay samples yielded concentrations that were lower than the action limit of 15 µg/L as recommended in RG 8.22. All bioassay spiked samples were within the acceptable agreement range.

- Diagnostic Bioassay. While loading a shipment of yellowcake drums the skid steer operator accidentally punctured one of the drums with the drum handler. A very small amount of yellowcake powder filtered to the floor of the trailer. Diagnostic bioassays were collected from the operator to verify that no yellowcake intake had occurred as a result of the spill. The results of the bioassays were negative.

2014 – Bioassay Results

All routine bioassay samples taken during 2014 yielded results that were lower than the action limit of 15 µg/L as recommended in RG 8.22. One bioassay sample collected in September yielded a result of 6.15 µg/L. Since bioassay sample results are normally below the detection limit of 5 µg/L, CBR instructed the lab to rerun the samples. The results of the rerun sample were still elevated with a high of 6.67 µg/L. After receiving the sample retest results, the employee submitted another bioassay sample and the results were less than 5 µg/L. The employee was interviewed to determine the possible cause of the elevated sample and was unable to identify any specific circumstances or issues that contributed to the elevated sample. In addition, the employee did not recall any instances of contamination on their hands or clothing when surveying prior to leaving the Restricted Area. No corrective actions were identified by CBR in response to the elevated sample results.

In addition to routine bioassays, baseline, termination, and diagnostic bioassays were conducted. All bioassay samples yielded concentrations that were lower than the action limit of 15 µg/L as recommended in RG 8.22. All bioassay spiked samples were within the acceptable agreement range.

- Diagnostic Bioassays were collected from a plant operator that was hit in the head by a ball valve end when a PVC line broke as the operator was attempting to move a water hose. The water line serviced the raw water system, and the operator sustained a 2.5 cm long laceration on his head. The raw water tank has in the past had times when yellowcake has been identified in the tank. Since the water line was live at the time of the incident, the bioassays were collected to verify that operator did not receive an internal yellowcake dose from the raw water that sprayed the operator when the cut occurred. The results of the bioassays were negative.

- Diagnostic bioassays were collected from the employees working under RWP #14-14. Results of the bioassays were negative verifying that there was no intake of yellowcake while working under the RWP.

2015 – Bioassay Results

All routine bioassay samples taken during 2015 yielded results that were lower than the action limit of 15 µg/L as recommended in RG 8.22. In addition to routine bioassays, termination bioassays were conducted. All termination bioassay samples yielded concentrations that were lower than the action limit of 15 µg/L as recommended in RG 8.22. All bioassay spiked samples were within the acceptable agreement range.

2016 – Bioassay Results

All routine bioassay samples taken during 2016 yielded results that were lower than the action limit of 15 µg/L as recommended in RG 8.22. In addition to routine bioassays, termination and diagnostic bioassays were conducted. All bioassay samples yielded concentrations that were lower than the action limit of 15 µg/L as recommended in RG 8.22. All bioassay spiked samples were within the acceptable agreement range.

2017 – Bioassay Results

All routine bioassay samples taken during 2017 yielded results that were lower than the action limit of 15 µg/L as recommended in RG 8.22. In addition to routine bioassays, diagnostic bioassays were conducted. All diagnostic bioassay samples yielded concentrations that were lower than the action limit of 15 µg/L as recommended in RG 8.22. All bioassay spiked samples were within the acceptable agreement range.

One investigative bioassay sample was conducted during 2017.

- In December an investigative bioassay was collected due to a lost BZ air sample filter. The sample results came back at 17.1 µg/L. Since the action limit of 15 µg/L as recommended in RG 8.22 was exceeded, CBR initiated a 24-hour period of bioassay sampling. All sample results were lower than the action limit of 15 µg/L. No dose was assessed as a result of the investigative bioassay sample results.

2018 – Bioassay Results

All routine bioassay samples taken during 2018 yielded results that were lower than the action limit of 15 µg/L as recommended in RG 8.22. All bioassay spiked samples were within the acceptable agreement range.

2019 – Bioassay Results

All routine bioassay samples taken during 2019 yielded results that were lower than the action limit of 15 µg/L as recommended in RG 8.22. All bioassay spiked samples were within the acceptable agreement range.

2020 – Bioassay Results

All routine bioassay samples taken during 2020 yielded results that were lower than the action limit of 15 µg/L as recommended in RG 8.22. All bioassay spiked samples were within the acceptable agreement range.

2021 – Bioassay Results

All routine bioassay samples taken during 2021 yielded results that were lower than the action limit of 15 µg/L as recommended in RG 8.22. All bioassay spiked samples were within the acceptable agreement range.

2022 – Bioassay Results

All routine bioassay samples taken during 2022 yielded results that were lower than the action limit of 15 µg/L as recommended in RG 8.22. All bioassay spiked samples were within the acceptable agreement range.

2023 – Bioassay Results

All routine bioassay samples taken during 2023 yielded results that were lower than the action limit of 15 µg/L as recommended in RG 8.22. Two bioassay samples collected in May and June yielded results of 6.1 µg/L and 9.3 µg/L respectively. Since bioassay sample results are normally below the detection limit of 5 µg/L, samples were retaken and sent to the lab. The results of both samples were lower than the detection limit of 5 µg/L. The employees were interviewed to determine the possible cause of the elevated samples and no circumstances or issues that contributed to the elevated samples were identified. In addition, the employees did not recall any instances of contamination on their hands or clothing when surveying prior to leaving the Restricted Area. No corrective actions were identified by CBR in response to the elevated sample results.

In addition to routine bioassays, termination bioassays were conducted. All termination bioassay samples yielded concentrations that were lower than the action limit of 15 µg/L as recommended in RG 8.22. All bioassay spiked samples were within the acceptable agreement range.

Bioassay Quality Assurance Program Description and Historical Results

Elements of the Quality Assurance requirements for the Bioassay Program are based on the guidelines contained in RG 8.22. These elements included the following:

- Each batch of samples submitted to the analytical laboratory is accompanied by two blind control samples. In mid-2005, the CBR facility began using control samples prepared from synthetic urine, rather than using urine from persons that were not occupationally exposed. The synthetic blind control samples are spiked to a uranium concentration of 10 mg/L to 20 mg/L and 40 mg/L to 60 mg/L. The results of analysis for these samples are required to be within ±30% of the spiked value. CBR has tracked the results of the blind spike analysis since 1990. Historically, the majority of the samples have been within the ±30% of the spiked value, with exceedances being rare. Since the last license renewal in 2007, there were only three exceedances in 2008, 2009, and 2011. The exceedance in 2011 was determined to be lab error. Past exceedances have been due to either occasional lab error or incorrect facility spike results. When these infrequent errors were observed, the most recent batch of affected samples were rerun and steps taken to review, and as necessary correct the procedures for spiking or the procedures for lab analysis. Actions taken and investigations pertaining to spiked sample value exceedances are recorded and maintained on file at the facility.

- The analytical laboratory spikes 10% to 30% of all samples received with known concentrations of uranium and the recovery fraction determined. Results are reported to CBR. All results have been within ±30%.

Proposed Bioassay Program

CBR proposes to continue the Bioassay Program including urinalysis and *in vivo* measurements as described in this section in accordance with the guidance contained in RG 8.22 and with the instructions currently contained in SHEQMS Program Volume IV, *Health Physics Manual*.

5.7.6 Contamination Control Program

CBR utilizes the method described in (Strata Energy Inc. 2015) for calculating radionuclide-weighted alpha and beta counting efficiencies for the major radionuclide mixtures, namely aged yellowcake and pregnant lixiviant.

First, in regard to aged yellowcake alpha emissions, CBR uses a certified NIST traceable natural uranium source for determining alpha efficiencies of the handheld contamination monitoring equipment. The records are available on site for inspection. Because the source is identical in energy emissions to the alpha emitters from aged yellowcake (i.e. U_{238}, U_{235} and U_{234} in natural abundance), the alpha instrument efficiencies calculated with this source are radionuclide-weighted efficiencies for aged yellowcake alpha emissions. No additional calculations are required for this radiation type and product. These sources have a 150 cm^2 surface area and the ratio between source and probe surface areas are included in the equipment efficiency calculation. A source efficiency of 0.25, as recommended by ISO 7503-1, is used in combination with the instrument efficiency to calculate total efficiency.

In regard to beta emissions from aged yellowcake, Sr/Y-90 and C14 sources, which are NIST traceable with records available on site for inspection, are used to determine instrument efficiency for beta emissions and the methodology from (Strata Energy Inc. 2015) used to determine a total radionuclide weighted efficiency.

Tables 5.7-5 and 5.7-6 show an example of the calculation of the instrument efficiency for the Ludlum Model 43-93. The instrument efficiency, ε_i, was calculated according to the method outlined in ISO 7503-1 (ISO 1988), namely that ε_i = (measured counts (cpm) – background counts (cpm)) / source surface emission rate (dpm). Note if the source area is greater than the probe area, source emissions (dpm) must be modified by ratio of (probe area/source area) to ensure the correct emissions are used. The instrument efficiency for the Model 43-93 is 35.9% for alpha (as per discussion above) and 52.2% for beta. It is important to note for clarity that the term 'source efficiency' as used by ISO 7503-1 refers to an actual alpha or beta contamination source (i.e. the object being measured for release), not to a reference source.

The radionuclide mixture weighted counting efficiency for beta for aged yellowcake was calculated using the methodology outlined in the draft (Strata Energy Inc. 2015) and is shown in Table 5.7-7. The efficiency for the lower energy emissions will be determined using a C14 source, however, in this example the instrument efficiency has been assumed to be zero for these energies. The source for the uranium and activity fraction are for NRC correspondence (NRC 2015). The source for the energy and branching ratio is from Table 2-2 of DOE Technical Standard DOE-STD-1136-2009 (DOE 2009) (low yield radiations are not included). The total weighted beta efficiency for the Model 43-93 for aged yellowcake is 12.5%. As stated earlier the total weighted alpha instrument efficiency for aged yellowcake is 9.0%.

The pregnant lixiviant contains higher concentrations of radionuclides than the “barren lixiviant”, or the process fluids which return to the wellfield after passing over the resin beds. In considering the mixtures, CBR has not taken into account radon gas (Rn-222) nor the short-lived decay products of radon (radon daughters). Although the radon daughters are alpha and beta emitters, they were excluded from the calculations as the calculations are considering surface contamination levels, not airborne contamination levels.

Strata (Strata Energy Inc. 2015) provided a very detailed explanation as to the assumptions used to determine the radionuclide composition for pregnant lixiviant. Currently, no assays of the Crow Butte lixiviant are available, therefore the same assumptions as those in the approved Strata application are used. CBR uses an alkaline based mining method similar to Stata and the referenced data sources. As such, the same assumptions will be adopted for CBR. Specifically, Strata identified (DOE 2009) as the source for aged yellowcake composition and two sources of data were identified regarding the radionuclide composition in lixiviant (Brown 1982 and LCI 2015). The LCI 2015 document contained a radionuclide composition analysis on pregnant lixiviant from a uranium recovery facility in Wyoming, using alkaline based mining techniques similar to that proposed by CBR. The LCI 2015 document showed that the concentrations of the long-lived decay products of natural uranium in the pregnant lixiviant are negligible. Two radionuclides had elevated concentrations, namely Ra-226 and Th-234, with concentrations of 2,700 and 2,290 pCi/L respectively. Converting to Bq/L yields Ra-226 and Th-234 concentrations of 99.9 and 84.7 Bq/L respectively. The paper (Brown 1982) lists concentrations for Th-230 and Ra-226. The concentration ranges for Th-230 are 56 - 93 Bq/L, and for Ra-226 are 10 - 150 Bq/L. To be conservative, the upper end of the higher concentrations, specifically 150 Bq/L for Ra-226 and 93 Bq/L for Th-230, are used for this analysis.

As there was no data regarding the concentrations of Th-231 and Pa-234m for the pregnant lixiviant, in alignment with the Strata application, CBR made the following estimations: for Th-231 and Pa-234m, it is assumed that Th-231 was in secular equilibrium with U-235 and Pa-234m was in secular equilibrium with Th-234. This estimation is valid as the half-lives of the parent radionuclides are much longer than the half-lives of the daughter radionuclides.

The activity fractions for pregnant lixiviant were calculated using the data and estimations listed above. The specific activity of 6.77E-7 Ci/g for natural uranium was found in footnote (3) to Appendix B of 10 CFR 20. An average concentration of uranium in pregnant lixiviant is 25-30 ppm, and a conservative estimate of the concentration of uranium in the pregnant lixiviant used 40 ppm. Converting to Bq/L yields:

Concentration of U in pregnant lixiviant = 40 ppm = 40 mg/L = 0.04 g/L = 1E3 Bq/L

Therefore, the primary radionuclides of concern for contamination from pregnant lixiviant in regard to alpha and beta radiation are shown in Tables 5.7-8 and 5.7-9. Natural uranium, in Table 5.7-8, has been broken down by radionuclide according to natural abundance ratios.

Again, following the process described in NRC (2015) the radionuclide mixture weighted counting efficiency was determined for lixiviant for both alpha and beta, shown in Table 5.7-10. The instrument efficiencies were again taken from Table 5.7-6 and the default source efficiencies, as recommended by ISO 7503-1 were used. The source for the activity fractions is Strata Energy Inc. 2015, LCI 2015, and Brown 1982. The sources for the energy and branching ratio are from Table 2-2 of DOE 2009 and the Health Physics and Radiological Health Handbook (Shleien 1992) (low yield radiations are not included).

The Y90 emission at 2.245 MeV is comparable to the 2.29 MeV emission of Pa-234m. To better account for the low energy emissions, a C-14 source is used for the lower energy beta emitters (i.e. Th-230 and Th-234).

In regard to the alpha efficiency for pregnant lixiviant, the same final efficiency can be achieved by simply multiplying the instrument efficiency (35.9%) by the source efficiency (25%). Therefore, for alpha efficiency determination, the simpler methodology of multiplying the instrument and source efficiency will be used for both yellowcake and lixiviant total efficiency calculations.

In summary, the two mixture weighted efficiencies for alpha and beta are shown in Table 5.7-11, note this is based on the instrument efficiency calculation shown in Table 5.7-6.

While in some cases it may be possible to establish the actual nature of the contaminant on a surface, e.g. yellowcake drums; this would be the exception. In most cases, it will not be possible to conclusively say that a surface had the potential to be contaminated exclusively by only one form of material or another. In addition, trying to manage material specific efficiencies increases error potential due to the increased complexity of the process. Therefore, practically, the only reasonable option is to use the more restrictive efficiency unless it is possible to conclusively say what the contaminant is. CBR will calculate the efficiency for both mixtures for its equipment, however, if the contaminant is unclear, it will be the more restrictive efficiency that is used for the calculations.

The minimum detectable concentration (MDC) for scalar alpha and beta/gamma measurements using handheld probes is determined based on the method in NUREG-1507, shown in the following equation:

$$MDC\ \left(\frac{DPM}{100cm^2}\right) = \frac{3 + 3.29\sqrt{R_b\ t_g(1+\frac{t_g}{t_b})}}{(counting\ efficiency)t_g(\frac{SA}{100cm^2})}$$

where:

R_b = the background count rate
t_g = the sample count time
t_b = the background count time

counting efficiency = $\Sigma F_{activity} F_{branching} \varepsilon_i \varepsilon_s$ (as per Issue 2)
SA = probe surface area (cm^2)
$F_{activity}$ = fraction of isotopes activity to total activity of source
$F_{branching}$ = frequency of emission for specific beta energy
ε_i = instrument efficiency
ε_s = surface efficiency for emission

The maximum allowable MDC for alpha static and scanning measurements is 500 dpm/100 cm^2, as per RG 8.30. For beta measurements, static and scanning, the maximum allowable MDC is 1000 dpm/100 cm^2, which is the stated applicable removable surface contamination limit from Table 5.7-5 of Policy and Guidance Directive FC 83-23 (NRC 1983) and aligns with previously approved allowable MDC values (NRC 2016).

CBR's contamination control program at Crow Butte Project consists of the following elements.

5.7.6.1 Surveys for Contamination of Skin and Personal Clothing

Personnel entering an unrestricted area are required to perform alpha and beta/gamma surveys as well as record the results and sign the survey logs. At a minimum the hands and soles of the boots/shoes are surveyed. The requirements to be free of visible uranium prior to leaving the restricted area reduces the potential for the spread of contamination outside of the restricted area. The monitoring consists of an examination to detect any visible yellowcake. All contamination on skin and clothing is considered removable, therefore the limit of 1,000 dpm/100cm^2 is applied to personnel monitoring. If this limit is exceeded, personnel must decontaminate their skin and/or clothing and repeat the survey along with RSO notification. As stated in RG 8.30, if the action level is exceeded, the RSO will perform an investigation of the cause of the contamination and take corrective action if appropriate. The limits are established based on routine background measurements taken at the survey stations. Surveys of personnel are generally performed using scalar, or integrated, counting instead of scanning.

5.7.6.2 Surveys for Surface Contamination and Equipment Prior to Release to an Unrestricted Area

For materials and equipment being released for unrestricted use, RG 8.30 indicates the removable release limit is 1000 dpm/100 cm^2, the average total activity limit is 5000 dpm/100 cm^2 and the total maximum activity limit is 15,000 dpm/100 cm^2. Using the previously mentioned assumptions, if the background levels for beta/gamma reach 3450 counts in 5 minutes or 500 counts in 1 minute, this will result in MDCs of 745 dpm/100 cm^2 and 741 dpm/100 cm^2, respectively. If this background count rate is exceeded then removable contamination surveys will be required in order to release the equipment, as per existing site procedure, or the equipment will need to be moved to a lower background area within the controlled area for surveying. Prior to leaving the restricted zone, the equipment must meet the alpha release limits outlined in RG 8.30.

Surveys of materials and equipment will be performed by the RSO or a qualified HPT. Equipment must meet the limits for alpha contamination before entering a controlled area (controlled area is described in more detail below).

Though scanning is not the preferred method, it is a potential survey option. For instruments used in ratemeter mode, the beta/gamma MDC will be based on NUREG-1507. The beta/gamma scan MDC is calculated as follows:

$$Scan\ MDC\ \left(\frac{DPM}{100cm^2}\right) = \frac{d'\left(\frac{60}{t_s}\right)\sqrt{b_i\ \left(\frac{t_s}{60}\right)}}{\sqrt{p}\epsilon_i\epsilon_s\frac{Probe\ Area}{100\ cm^2}}$$

where:

t_s = Scan time (sec)
d' = level of performance (Table 6-1 from NUREG-1507)
(false positive portion =0.6, true positive = 0.95)
b_i = average number of bkg counts in interval (cpm)
p = surveyor efficiency; assumed 0.5
ϵ_i = instrument efficiency (18%)
ϵ_s = surface efficiency (0.5) from section 5 of NUREG-1507

As described above, the beta/gamma efficiency of 18% will be used in the nominal MDC calculations. The surface efficiency is 0.50, based on the beta emission energy of 2.195 MeV from Pa234m, the primary beta emitter of uranium 238. The planned scan rate is 1 cm/sec. With a 15 cm probe length, this scan rate equates to a scan time of 15 seconds. Using this method, a background count rate of 575 cpm will result in an MDC of 750 dpm/100 cm^2. If the background count rate is exceeded, either smears will be required in order to release the equipment, or the equipment will need to be moved to a low background area within the controlled area and resurveyed. If a different scanning rate is used, the MDC will be recalculated based on actual values.

The MDC of 500 dpm/100 cm^2, as referenced in RG 8.30, will be used for the alpha MDC value. The alpha static MDC will be calculated using the following formula:

$$MDC\ \left(\frac{DPM}{100cm^2}\right) = \frac{3 + 3.29\sqrt{R_b\ t_g(1 + \frac{t_g}{t_b})}}{(counting\ efficiency)t_g(\frac{SA}{100cm^2})}$$

where:

R_b = the background count rate
t_g = the sample count time
t_b = the background count time
counting efficiency = $\Sigma F_{activity}\ F_{branching}\ \varepsilon_i\varepsilon_s$ (as per Issue 2)
SA = probe surface area (cm^2)
$F_{activity}$ = fraction of isotopes activity to total activity of source
$F_{branching}$ = frequency of emission for specific beta energy
ε_i = instrument efficiency
ε_s = surface efficiency for emission

Assuming a background count rate of 15 counts in 1 minutes, a 100 cm^2 probe area and a 30 second sample count time, the MDC for a mixture efficiency of 9.0% would be 312 dpm/100 cm^2. These values are conservative, because alpha background rates are typically less than 15 cpm, meaning actual MDC's will typically be less than this value.

In rooms where work with uranium is not performed, a lower level of surface contamination is likely to be present such as eating rooms, change rooms, control rooms, and offices. Therefore, weekly spot checks will be performed for removable surface contamination using smear tests. All eating rooms, change rooms, control rooms, and offices will be spot checked monthly. If surface contamination levels exceed the values shown in RG 8.30, Table 2, the RSO will be notified, and the contaminated area will be promptly cleaned and resurveyed.

The instrument used to quantify removable beta/gamma contamination is the Ludlum model 3030 counter or an equivalent. The typical efficiency for this instrument is 25%. A background count will be taken daily prior to use and samples will be counted for 1 minute. Using the equation (3), to achieve an MDC of 250 dpm/100 cm^2, the background count must be below 15,000 counts in 50 minutes. Actual MDC values will be calculated based on measured instrument efficiencies.

$$MDC = \frac{3 + 3.29\sqrt{R_b\ t_g(1 + \frac{t_g}{t_b})}}{\varepsilon_i t_g}$$

Where:

R_b = the background count rate
t_g = the sample count time
t_b = the background count time
ε_i = the instrument efficiency

Radiation staff performing a scan will stop and perform a scalar measurement if the scan result exceeds 1000 dpm/100 cm^2 beta or the applicable number of counts in the scanning interval as described for alpha scanning.

5.7.6.3 Controlled Area

CBR has the right and ability to carry out mining operations within the license boundaries as described in SUA-1534 and the right to control access to areas within the license boundary. Controlling access is done for both a safety and operational standpoint to protect CBR employees and members of the public. CBR has the right to remove any person who has not been through CBR's required training or does not have permission from CBR to be in the controlled area. CBR has defined the controlled areas as all areas within the license boundary.

In circumstances where the MDC is exceeded within the restricted area, the materials and equipment will be transported to a low background area within the controlled area and surveyed for unrestricted use. The surveys for unrestricted use will be conducted in areas immediately adjacent to the CPF, RO Building and Maintenance Building. No materials or equipment that have not been surveyed for unrestricted use will be allowed to be stored in the controlled area. If equipment is moving from one restricted area to another through the controlled area, it must meet the alpha limits outlined in RG 8.30 prior to leaving the first restricted area.

Personnel are required to perform alpha and beta/gamma surveys as well as record and sign the logs prior to entering an unrestricted area. If personnel are required to move through the controlled area to perform the required survey after exiting the restricted area, they may not enter the office area, lunchroom or their personal vehicles prior to performing the alpha and beta/gamma surveys.

5.7.6.4 Historical Program Results

The weekly contamination survey results indicate that the contamination control program at the Crow Butte Project is effective. The quarterly spot checks performed throughout the period show that the personnel contamination program is effective. Results of the contamination surveys, spot checks, and equipment release surveys are maintained at the Crow Butte Project site.

Results of the surveys for contamination of skin and personal clothing show that alpha surveys are effective. Beta/gamma survey results are typically below the MDC. In those instances where the beta/gamma survey results meet the MDC, meaning a definitive conclusion can be made regarding the presence of contamination, the alpha survey results adequately demonstrate the presence of contamination. Table 5.7-12 includes data from the site personnel spot checks performed using the current approved survey program. Only those results that met the threshold of MDC for either alpha and or beta/gamma were included in the data set for analysis. Since inception of the current survey program, the MDC threshold has been met 287 times during the personnel spot checks. Of those 287, alpha surveys positively identified contamination 100 percent of the time while beta/gamma surveys identified contamination 4 percent of the time. In no instance did the beta/gamma survey identify contamination where the alpha survey did not. Beta surveys failed to identify the presence of contamination on skin and clothing in 96% percent of cases. Alpha surveys for personnel and clothing are extremely reliable for identifying contamination of skin and clothing in contrast to the beta/gamma surveys.

5.7.6.5 Proposed Contamination Control Program

LC 11.1.9 of SUA-1534 currently states the following:

> *The licensee shall develop a survey program for beta/gamma contamination for personnel exiting from restricted areas, and beta/gamma contamination in unrestricted and restricted areas that will meet the requirements of 10 CFR Part 20, Subpart F and submit the program to NRC for review and written verification.*
>
> *The licensee shall provide for NRC review and written verification the surface contamination detection capability (minimum detection concentration (MDC)) for radiation survey instruments, including scan MDC for portable instruments, used for contamination surveys to release equipment and materials for unrestricted use and for personnel contamination surveys. The detection capability in the scanning mode for the alpha and beta radiation expected shall be provided in terms of dpm per 100 cm^2.*

CBR proposes to remove the beta/gamma requirements from the surveys for contamination of skin and personal clothing. As described in Section 5.7.6.4, surveys for the presence of alpha contamination adequately demonstrate the presence of contamination on skin and personal clothing. Based on this and in alignment with RG 8.30, Section 2.6, CBR proposes to continue alpha surveys for contamination of skin and personal clothing, as previously described in Section 5.7.6.1, while eliminating the beta/gamma survey from the contamination surveys of skin and clothing. Based on this CBR proposes to revise LC 11.1.9 of SUA-1534 as follows:

> *The licensee shall develop a survey program for ~~beta/gamma contamination for personnel exiting from restricted areas, and~~ beta/gamma contamination in unrestricted and restricted areas that will meet the requirements of 10 CFR Part 20, Subpart F and submit the program to NRC for review and written verification.*
>
> *The licensee shall provide for NRC review and written verification the surface contamination detection capability (minimum detection concentration (MDC)) for radiation survey instruments, including scan MDC for portable instruments, used for contamination surveys to release equipment and materials for unrestricted use ~~and for personnel contamination surveys~~. The detection capability in the scanning mode for the alpha and beta radiation expected shall be provided in terms of dpm per 100 cm^2.*

No changes are proposed to the surface contamination or the equipment release. These programs have proven to be effective at controlling surface contamination and the release of equipment. The program is carried out in accordance with the instructions currently contained in SHEQMS Program Volume IV, *Health Physics Manual*.

5.7.7 Airborne Effluent and Environmental Monitoring Program

5.7.7.1 Operational Environmental Monitoring Program

This section presents the methods that are used for the Crow Butte Project airborne effluent and environmental monitoring program during operations. The airborne effluent and environmental monitoring programs are designed to monitor the release of airborne radioactive effluents from the Crow Butte Project facilities. To evaluate the effectiveness of the effluent control systems, the results of the monitoring program are compared with the background levels and with regulatory limits. Table 5.7-13 provides the sampling locations, types, frequency, methods, and parameters for the Crow Butte Project facilities. Groundwater and surface water radiological sampling is discussed in Section 5.7.8.

5.7.7.1.1 Radon

The radon gas effluent released to the environment is currently monitored at eight locations (AM-1 through AM-6 and AM-8 and AM-9). Location AM-6 is considered the background location. The monitoring program included seven locations (AM-1 through AM-6 and AM-8) up to 2015, when a new residence was constructed near the CBR Project. Location AM-9 was added at that time and this location represents the highest exposed member of the public. Monitoring is performed using Track-Etch radon cups provided by Landauer Corporation. The cups are exchanged on a semi-annual basis in order to achieve the required LLD. The SHEQMS Program Volume VI, *Environmental Manual*, currently provides the instructions for radon gas monitoring.

In addition to the manufacturer's Quality Assurance program, CBR has conducted a duplicate monitoring program at the Crow Butte Project where CBR exposes duplicate radon Track Etch cups for each monitoring period. Between 1991 and 2004, duplicate radon cups were taken at sites AM-3 and AM-6. The duplicate cups are identified as AB locations using the same number as the existing monitoring location (for example AB-3 is the duplicate cup at monitoring location AM-3). Starting in 2004, CBR began taking duplicate samples at all locations with the exception of AM-4, and between 2006 and 2013, CBR took duplicate samples at only AM1, AM-2, and AM-6. The duplicate monitoring program between 2014 and the first half of 2016 consisted of 2 duplicate samples at each of the monitoring locations. Currently, duplicate samples are collected from the background location (AM-6) and the location of the highest exposed member of the public (AM-9). Table 5.7-14 contains the results of radon monitoring for the Crow Butte Project facility between 1991 and 2023. Figure 5.7-11 through Figure 5.7-17 depict the trends for radon monitoring between 1991 and 2023 for locations AM-1 through AM-6 and AM-8, and Figure 5.7-18 depicts the trends for radon monitoring between 2015 and 2023 for location AM-9.

As recommended in RG 8.37, a trend analysis of the radon monitoring results since commercial operations began in 1991 was performed. In 2008, all seven monitoring stations had ambient radon concentrations higher than the previous reporting period. The laboratory indicated that the track etch cups may have received some exposure during shipping or storage.

Overall, the radon monitoring results trend with the background site, although there are few instances of higher reported radon concentrations at individual sites. Overall, there are no discernable trends.

The total radon release trend between 1991 and 2023 is shown in Figure 5.7-19. In 2016, CBR was required to begin taking measurements of radon emissions in accordance with LC 11.2.3 of SUA-1534. Therefore, Figure 5.7-18 reflects calculated radon estimates from 1991 to 2015, and actual radon emission measurements beginning in the year 2016. For the actual radon emissions, CBR uses the maximum radon concentration for the individual tanks. This provides a conservate estimate of the actual radon emissions.

5.7.7.1.2 Air Particulate

Composite airborne particulate samples for natural uranium, radium 226, thorium-230, and lead 210 are obtained quarterly from seven air monitoring locations. As recommended in RG 8.37, the results of airborne uranium monitoring performed since 1991 when commercial operations began were reviewed. Figures 5.7-20 through 5.7-27 contain trend analysis graphs for airborne uranium at each air monitoring location. There were no meaningful trends noted at any of the air monitoring locations. Although there appears to be a few anomalously high uranium concentrations, these isolated occurrences did not correlate directly to site activities. The results noted at these sampling stations indicate no significant impact on the environment or the public.

The 1997 LRA stated that the environmental airborne particulate monitoring will be performed for 2 weeks of each month when the yellowcake dryer is in operation. CBR determined in early 2001 that increasing the sample frequency to continuously during dryer operation would provide monitoring data that would be more complete. Environmental air sampling has been performed continuously since 2001.

5.7.7.1.3 Surface Soil

In the 2014 SER for the LRA, the NRC determined that without reviewing annual soil samples taken throughout the operating phase of the applicant's facility, staff does not have the ability to confirm the applicant's ability to comprehensively evaluate environmental impacts or detect potential long-term effects of its operations as required by 10 CFR Part 40, Appendix A, Criterion 7. Based on this, in 2015 CBR resumed annual soil sampling at the air monitoring locations at the request of NRC. Annual results for surface soil are included in Table 5.7-15. Results indicate that uranium, radium-226, and lead-210 concentrations are generally low. The highest uranium concentration (1.3 pCi/g) was measured at site AM-5 in 2016. All other samples were below (1 pCi/g). The highest radium-226 concentration (1.5 pCi/g) was measured three times, while the highest lead-210 concentration (6.1 pCi/g) was measured at site AM-2 in 2022. All other lead-210 concentrations at site AM-2 were below 2.5 pCi/g.

5.7.7.1.4 Subsurface Soil

Subsurface soil has been sampled at the plant as described in Table 5.7-13.

5.7.7.1.5 Vegetation

Vegetation samples from the Crow Butte Project were collected annually beginning in 1992 in animal grazing areas in the direction of the prevailing wind. Sampling was normally performed during the summer months. Vegetation sampling was discontinued with the license renewal in 1998. The samples were collected using the following procedures:

A minimum of 1 pound of vegetation was composited on three occasions during the grazing season. The materials collected were primarily the seed/flower head and leafy portions of grasses and forbes along with young shoots of shrubs. Vegetation was analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. The results of annual vegetation sampling from 1992 through 1997 at the Crow Butte Project are presented in Table 5.7-16.

5.7.7.1.6 Direct Radiation

Environmental gamma radiation levels are monitored continuously at the eight air quality monitoring stations. Gamma radiation is monitored using dosimeters obtained from a qualified vendor. Environmental dosimeters are exchanged quarterly. Results of the quarterly gamma radiation monitoring are shown in Table 5.7-17. The trend data for environmental gamma monitoring are depicted in Figures 5.7-28 through 5.7-35. There were elevated gamma radiation levels from 2001 through 2002 at the designated monitoring sites. However, since 2003, there were no meaningful trends noted at any of the air monitoring locations. The results noted at these sampling stations indicate no significant impact on the environment or the public.

5.7.7.1.7 Sediment

Sediment in Squaw and English Creeks and impoundments were sampled at upstream and downstream locations semiannually for 1 year prior to any construction in the area. Following construction, samples have been taken annually. Samples are taken upstream and downstream of the Crow Butte Project site and analyzed for natural uranium, radium-226, thorium-230, and lead-210. Samples are generally taken in October or November. The results of sediment sampling are shown in Table 5.7-18. Figures 5.7-36 through 5.7-38 contain graphs of the results of the annual sediment analysis program between 1991 and 2023 for Squaw Creek and Figures 5.7-39 through 5.7-41 contain graphs of the results of the annual sediment analysis program between 1998 and 2023 for English Creek. These graphs plot the upstream and downstream locations for each creek and the inlet to the impoundments for each radioisotope.

There were no apparent trends for any sample location for any analyte. The concentrations of natural uranium in several English Creek samples were well above regional background levels. However, these elevated concentrations were noted in the English Creek drainage during preoperational monitoring, which would indicate that these levels are anomalous natural background concentrations. Composite samples obtained from E-1 and E-2 as part of the preoperational sampling program between 1982 and 1986 had average results with elevated natural uranium (3.4 pCi/g) and lead-210 (1.4 pCi/g) when compared with the other surface water sample locations. Samples obtained in 1998 before mining operations began in this area showed similar elevated uranium concentrations.

The sample locations are in a wetland and are in the upper course of English Creek and downstream impoundments. The area has a large amount of organic matter and low water flows compared with the other surface water sampling locations for the project. CBR believes that the upper courses of English Creek are an area with reducing conditions that favor deposition of radionuclides. Figure 5.7-39 is a trend graph for English Creek sediment sample points since 1998 that shows the elevated uranium concentrations noted in past sediment samples.

5.7.7.2 <u>Estimation of Radionuclide Effluents and Reporting</u>

10 CFR §40.65 requires licensees to report quantities of radionuclides in liquid and gaseous effluent releases to the environment. As part of the effluent monitoring program CBR estimates the total radon and air particulate emissions from the Crow Butte Project. The following summarizes the program and historical results.

5.7.7.2.1 Radon Gas and Radon Progeny

Total radon emissions from the Crow Butte Project are estimated for the following sources: plant floor vents, plant tanks/vents, wellhouses, and spills. The following describes how the radon from each of these sources is measured and how the effluent emissions are calculated.

The amount of radon that is vented through the building exhaust fans is determined using Track Etch cups with semi-annual exposures. There are seven sample locations throughout the facility (floor exhaust vents). Each semi-annual sample result from the seven locations is averaged to determine the ambient radon concentration in the facilities air. The rate of radon released from the process facility is based on the manufactures flowrate for each of the exhaust fans. It is assumed that the fans are operational 100% of the time which represents the worst-case scenario.

Releases of radon from vented tanks is calculated by measuring the concentration of radon being emitted from the tank vents. Lucas cells are used to sample the air in the vent and quantify the concentration of radon at each vent. The use of scintillation cells for the measurement radon is an approved method, as outlined in Method 115 from 40 CFR Part 61,

Appendix B. While the method describes the use of scintillation cells for underground mining and tailing piles, it can be applied to this application. Measurements of the radon from tank vents is performed at a minimum of once per quarter.

Once the concentration of radon in the tank vent is determined, the quantity of radon emitted from the vent can be calculated assuming the manufacturer's flowrate (cfm) for the ventilation fan associated with the tank vent. Fans are assumed to be running continuously.

Radon daughter measurements are performed concurrently with the radon gas measurements from the tank vents and converted to an equivalent radon gas concentration using the conversion 0.33 WL is equivalent to 3E-8 µCi/ml. As with the results of the Lucas cell measurements, the emissions from the vent can be calculated assuming the manufacturer's flowrate (cfm) for the ventilation fan associated with the tank vent. The radon progeny releases from tanks are added to the total radon emission from the CPF.

Radon daughter concentrations are taken at routine sampling locations throughout the main plant in accordance with RG 8.30. On a semi-annual basis these samples are averaged and converted to an equivalent radon gas concentration as described above. The rate of radon released from the CPF is based on the manufactures flowrate for each of the exhaust fans. It is assumed that the fans are operational 100% of the time which is conservative. These emissions are added to the total CPF emissions.

The concentration of radon in air released from the wellhouses is based on radon measurements taken within the wellhouse utilizing Track Etch cups with a six month exposure time. Eight wellhouses are monitored and the average radon emission per wellhouse is attributed to the remaining operational wellhouses in each group. The wellhouses are rotated annually so that each wellhouse is sampled over time. If an individual wellhouse yields results determined to be an outlier, then the results from that wellhouse are not included in the average. The average semi-annual radon concentrations are used along with the manufacture's rating on the wellhouse exhaust fan to determine the total radon released from the wellhouse. This assumes that all radon in the wellhouse is released into the environment at a rate of the exhaust fan and that the wellhouse exhaust fans are operational 100% of the time. Radon daughters measurements are collected semi-annually within the wellhouses in which radon gas samples are collected and converted to an equivalent radon gas concentration using the conversion factor 0.33 WL equals 3E-8 µCi/ml. These average semi-annual radon concentrations are used along with the manufacture's rating on the wellhouse exhaust fan to determine the total activity released from the wellhouses.

Potential emission of radon in the wellfield is limited to the production wells. Injection wells have sealed well heads and the potential for radon release is negligible. The potential source of radon emitted from the production wells occurs when the wellheads are opened to the atmosphere to depressurize a wellhead that has become pressurized. Because this situation is transient and very short lived, in addition to being highly localized, emissions from this situation are measured through the use of grab samples collected with scintillation cells. Currently, no wells are depressurized at the Crow Butte Project so no grab samples are collected.

The other potential source of radon release from the wellfields is the unplanned releases of process fluid resulting from spills in the wellfield. The amount of radon released as a result of a spill is estimated based on the volume of fluid released and an estimate of the radon concentration in that fluid as well as an assumption of 100% of the radon in the spilled fluid being released. The concentration of radon in the fluid is based on the calculations used to determine the radon concentration in production fluid by the program MILDOS. While the quantity of radon released as a result of spills in the wellfields is minor this procedure represents a conservative estimate of the radon released.

5.7.7.2.2 Air Particulate

Total air particulate emissions from the Crow Butte Project are estimated for the following sources: plant floor vents, wellhouses, and deep disposal well buildings. The following describes how the air particulate emissions from each of these sources is calculated.

Annual air particulate sampling occurs at seven locations throughout the CPF for isotopic analysis, five from the routine sampling locations and two from additional locations within the CPF. The samples are analyzed for U-nat, Th-230, Ra-226 and Pb-210. Samples for Po-210 and Th-230 are not collected as there is no chemical or physical mechanism to separate or generate them. Instead, they are calculated based on the reasonable assumption of equilibrium. The sampling results are used in conjunction with the flowrate of exhaust fans to calculate emission. It is assumed that the fans are operational 100% of the time.

Air particulate emissions from the wellhouses are estimated based upon semi-annual isotopic analysis of filters used for semi-annual air particulate in air samples in each of the wellhouses that are monitored for radon as well as the deep disposal well buildings. The wellhouse exhaust rate is based on the manufactures rating on the fans in the wellhouses.

5.7.7.2.3 Reporting

Release of effluent radon and air particulates from process operations are reported in the semi-annual reports required by 10 CFR §40.65 and LC 11.1.1 of SUA-1534.

Table 5.7-19 contains annual calculated radon releases from the Crow Butte Project from 1995 through 2015. Table 5.7-20 shows annual measured radon releases from the Crow Butte Project from 2016 through 2023. Tables 5.7-19 and 5.7-20 show that 99% percent of the radon released from the Crow Butte Project is from the CPF tanks and vents. Based on this, CBR plans to cease radon sampling in the wellhouses. CBR will continue to collect radon gas samples from the CPF and calculate radon emissions associated with spill.

Table 5.7-20 provides the annual calculated air particulate releases from the Crow Butte Project. The results show that the contribution from air particulate effluent to the total effluent release is negligible. Based on this, CBR proposes to cease air particulate sampling in the wellhouses and the deep disposal well buildings. CBR will continue to collect air particulate samples from the CPF.

5.7.7.3 Proposed Airborne Effluent and Environmental Monitoring Program

CBR proposes to continue the Airborne Effluent and Environmental Monitoring Program described in this section with the exceptions discussed below.

As described in Section 5.7.7.2, CBR proposes to discontinue radon effluent sampling in the wellhouses. Table 5.7-21 contains a summary of emissions by source as provided in the Semiannual Effluent and Environmental Monitoring Reports for the years 2016 through 2024. The maximum contribution of radon gas from the wellhouses to overall facility emissions was 9.25 Ci in 2017 representing 0.102% of the total emissions that year. The average contribution of wellhouse radon gas from 2016 to 2024 was 4.14 Ci or 0.336% of total emissions.

In addition, CBR proposes to discontinue air particulate effluent sampling in the wellhouses and deep disposal well buildings. Table 5.7-21 illustrates that contributions from particulates from wellhouse and the deep disposal well buildings to be negligible. From 2016 through 2024 the maximum contribution from the wellhouse particulates was 3.81e-05 Ci, representing 0.000% of total emissions in 2018. The average contribution from wellhouse particulates was 2.34e-05 Ci during the reporting period. The deep disposal wells particulate contributions are similar in significance, with a maximum value of 2.21e-06 Ci representing 0.000% of total emissions from 2016 to 2024.

CBR also proposes the elimination of specific stack monitoring locations given the status of operation. Table 5.7-22 identifies systems which are no longer utilized, or which contribute very little to the overall emissions and should be considered for removal from the program.

The Pond Water Treatment fan services a series of tanks within the CPP that are no longer in use. On average, from 2016 to 2024, the fan has contributed 0.57% of total radon gas emissions and 0.06% of radon progeny emissions. The maximum contribution to emissions from the Pond Water Treatment fan occurred in 2017 prior to the cessation of operation of the system which it serviced. It contributed 4.13% of radon gas emissions and 0.32% of radon daughter emissions in 2017. From 2018 through 2024, the Pond Water Treatment Blower has contributed very little to overall site emissions. If CBR resumes operation of the Pond Water Treatment System, monitoring of the Pond Water Treatment Blower will resume.

The Chem Mix Demister Fan services the bicarb makeup system at the CPP. Previously, the system utilized process water to make up a bicarbonate solution. Currently the system uses raw water from the Brule aquifer for makeup thereby eliminating the source of radon daughters as well as radon gas. If the practice of using process water for bicarb makeup is resumed CBR will resume monitoring of the Che Mix Demister Fan.

In 2018 CBR ceased production orientated operations. Since that time emissions have steadily declined. The Precip Demister Fan, Eluent Tank Blower and Precip A Blowers contribute very little to current emissions with each averaging less than 1% of total emissions. CBR proposes removal of these sources from monitoring. If active production resumes at site, CBR commits to reevaluating each fan or blower removed by this action and resuming monitoring and reporting for a period of two years. At that time the data will be evaluated. Any source contributing greater than 1% will remain in the monitoring program.

5.7.8 Groundwater/Surface Water Monitoring Program

5.7.8.1 Program Description

During operations at the Crow Butte Project facilities, a detailed water sampling program is conducted to identify any potential impacts to water resources of the area. CBR's operational water monitoring program includes the evaluation of groundwater on a regional basis and groundwater within the permit or licensed area and surface water on a regional and site-specific basis. An overview of the groundwater and surface water monitoring programs at the Crow Butte Project can be found in Table 5.7-13.

5.7.8.2 Groundwater Monitoring

The groundwater excursion monitoring program is designed to detect excursions of lixiviant into the ore zone aquifer outside of the wellfield being leached and into the overlying water bearing strata. Excursion monitoring is performed throughout operations, restoration and stabilization, until stabilization is approved by the NRC. The Pierre Shale below the ore zone is more than 1,200 feet thick and contains no water-bearing strata. Therefore, it is not necessary to monitor any water-bearing strata below the ore zone.

Table 5.7-23 provides a summary of excursions reported for the Crow Butte Project. To date, there have been several confirmed horizontal excursions in the Chadron sandstone at the Crow Butte Project. These excursions were quickly detected and recovered through overproduction in the immediate vicinity of the excursion. In all cases of reported vertical excursions the excursion was a result of 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 since the monitor wells are located well within the aquifer exemption area approved by the EPA and the NDEE. All exursions at the Crow Butte Project have been recovered in a timely manner. In accordance with LC 11.1.5 of SUA-1534, all confirmed excursions are reported to NRC and NDEE within 24 hours and a letter is submitted to NRC within 7 days. A written report describing the excursion event, corrective actions taken, and the corrective action results is submitted to the NRC within 60 days of the excursion confirmation.

Time-series plots showing the average concentration of excursion indicator parameters (chloride, alkalinity and conductivity) from monitor ring wells in MU-8, 9,10 and 11 are provided in Figures 5.7-42 through 5.7-44. The time-series plots show stable concentrations of uranium and excursion indicator parameters without discernable or ongoing increasing trends over the trunkline sampling period, consistent with proper wellfield operation and hydraulic containment of mining solutions.

As evident with the CM11-11 excursion in 2018, CBR can detect and pull back mining zone fluid from the monitoring perimeter. Figures 5.7-45 through 5.7-47 depict the excursion indicator parameters for CM11-11. The figures also include the MCL and SCL for each parameter.

Some concern seems to be around “standby” mine units and whether an excursion would be detected at the monitor well ring. A 2010 response to the NDEQ was written by WorleyParsons. “An excursion generally occurs when the rate of injection exceeds the rate of groundwater extraction (“over-injection”) within a portion of an actively mined wellfield for a period of time. An excursion normally occurs locally over a small portion of the mine unit, usually on the scale of a few mine patterns or well house” (WorleyParsons 2010). Standby mine units receive no injection, which is the main cause of an excursion. Production wells are utilized in standby areas to remove a slight bleed and overcome the natural ground water movement. With no injection into these mine units and a large bleed being taken in mine units 7 and 8 for reverse osmosis treatment the management of ground water has become less complicated and excursions less frequent.

Tables 5.7-24 and 5.7-25 summarize the uranium and radium-226 sampling results for all private wells within 1 kilometer of the wellfield area boundary that are sampled quarterly, respectively. The private wells are depicted on Figure 5.7-48. Samples are analyzed for natural uranium and radium-226. The maximum contaminant level (MCL) for uranium and combined radium-226 and radium-228 concentration as specified by EPA are 0.030 mg/L and 5 pCi/L respectively. Generally, sampling results reported in Tables 5.7-21 and 5.7-22 have been below the EPA MCLs for uranium and radium. Since the last LRA in 2007, there have been eight exceedances of the EPA MCL for uranium with the maximum measured value of 0.135 mg/L in Well #8 (third quarter 2023). No trends of the exceedances were apparent, since no one well had uranium exceedances more than twice, and exceedances were not on consecutive quarters or even within the same year. During the same time period, radium-226 exceeded the combined radium-226 and radium-228 MCL four times. With the maximum occurring in the second quarter of 2019 at Well #12. Similarly, no trends in the radium-226 exceedances were apparent, although three of the exceedances occurred in the second quarter of 2019.

Monitor Well Baseline Water Quality

After delineation of the production unit boundaries, monitor wells are installed approximately 300 feet from the wellfield boundary. After completion, wells are washed out and developed (by air flushing or pumping) until water quality in terms of pH and specific conductivity appeared stable and consistent with the anticipated quality of the area. After development, wells are sampled to obtain baseline water quality. For baseline sampling, all wells are purged until field parameters are stable. All monitor wells including ore zone and overlying monitor wells are sampled three times at least 14 days apart. The first, second, and third samples are analyzed for the excursion indicator parameters (chloride, conductivity, and alkalinity). Results from the samples are averaged arithmetically to obtain a baseline value as well as an average value for determine upper control limits for excursion detection.

Upper Control Limits and Excursion Monitoring

After baseline water quality is established for the monitor wells for a particular production unit, UCLs are set for certain chemical constituents that would indicate a migration of lixiviant from the wellfield. The parameters and constituents chosen for indicators of lixiviant migration and for which UCLs are set are chloride, conductivity, and total alkalinity. Chloride was chosen due to its low natural levels in the native groundwater and because chloride is introduced into the lixiviant from the ion exchange process (uranium is exchanged for chloride on the ion exchange resin). Chloride is also a highly mobile constituent in the groundwater and will show up very quickly in the case of a lixiviant migration to a monitor well. Conductivity was chosen because it is an excellent general indicator of overall groundwater quality. Total alkalinity concentrations should be affected during an excursion, as bicarbonate is the major constituent added to the lixiviant during mining. Water levels are obtained and recorded prior to each well sampling. However, levels are not used as an excursion indicator. All wells are purged until field parameters are stable prior to collection of the sample. Upper control limits are set at 20 percent above the maximum baseline concentration for the excursion indicator. For excursion indicators with a baseline average below 50 mg/L, the UCL may be determined by adding 5 standard deviations or 15 mg/L to the baseline average for the indicator.

Operational monitoring consists of sampling the monitor wells no more than 14 days apart and analyzing the samples for the excursion indicators chloride, conductivity, and total alkalinity. In special circumstances, including inclement weather, mechanical failure, conditions which place an employee at risk while sampling, and conditions which could cause damage to the environment if sampling was performed, the sampling could be delayed by a period not to exceed 5 days. The circumstances requiring postponement of the sampling are documented.

Excursion Verification and Corrective Action

Excursion monitoring is required under LC 11.1.5 of SUA-1534. During routine sampling, if two of the three UCL values are exceeded in a monitor well, or if one UCL value is exceeded by 20%, the well is resampled within 48 hours and analyzed for the excursion indicators. If the second sample does not exceed the UCLs, a third sample is taken within 48 hours. If neither the second nor third sample results exceeded the UCLs, the first sample is considered in error.

If the second or third sample verifies an exceedance, the well in question is placed on excursion status. Upon verification of the excursion, the NRC Project Manager is notified by telephone within 48 hours and notified in writing within 30 days in accordance with LC 11.1.6 of SUA-1534.

If an excursion is verified, the following methods of corrective action are instituted (not necessarily in the order given, depending on the circumstances):

- A preliminary investigation is completed to determine the probable cause.
- Production and/or injection rates in the vicinity of the monitor well are adjusted as necessary to increase the net over recovery, thus forming a hydraulic gradient toward the production zone.
- Individual wells are pumped to enhance recovery of mining solutions.

Injection into the wellfield area adjacent to the monitor well may be suspended. Recovery operations continue, thus increasing the overall bleed rate and the recovery of wellfield solutions.

In addition to the above corrective actions, sampling frequency of the monitor well on excursion status is increased to once every seven days. An excursion is considered concluded when the concentrations of excursion indicators do not exceed the criteria defining an excursion for three consecutive weekly samples.

5.7.8.3 Surface Water Monitoring

Initial baseline water quality measurements were completed prior to construction and operations of the current CBR licensed facility. Preoperational baseline groundwater quality data [radiological and non-radiological] for the CBR site from 1982 to 1987 were initially reported in the 1987 Application and Supporting Environmental Report for NRC Commercial Source Material License submitted to the NRC by the previous owner and operator, Ferret of Nebraska, Inc. (FEN 1987). CBR continued with the surface water quality monitoring program for radiological and non-radiological parameters starting in 1987 and ending in the third quarter

1994. Following the third quarter of 1994, CBR was only required to monitor for two radiological parameters natural uranium and radium-226.

Development of a wellfield requires additional preoperational monitoring of surface water located within the affected mine unit(s). Therefore, the pre-operational water quality monitoring program assessed water quality and quantity for Squaw Creek due to mine development. CBR samples two surface water locations for Squaw Creek. The CBR SERP approved Mine Unit 6 on March 6, 1998. This expansion required that the downstream Squaw Creek monitoring location be relocated. The new sample point was designated as S-5. Sampling at the previous downstream location, S-3, was discontinued.

With the approval of Mine Unit 6, operational surface water sampling was initiated at the English Creek upstream and downstream locations. The upstream sample is a composite of the springs that are the sources of English Creek and were identified as E-1 and E-2 during the preoperational monitoring program. Preoperational monitoring location E-3 was not used for downstream monitoring because its location is well beyond the Mine Unit 6 wellfield. Instead, a new downstream location designated E-4 was chosen immediately outside the Mine Unit boundary and sampling was begun.

With the addition of Mine Unit 8, downstream sampling on English Creek was moved to location E-5. Additionally, the expansion to Mine Unit 8 required sampling of the impoundments identified as I-3 and I-4 in the preoperational monitoring program when they are located within the wellfield. Impoundment I-5 was added to the operational sampling program after Mine Unit 10 was approved. Samples from all locations are obtained quarterly. Surface monitoring results are submitted in the semi-annual activity and monitoring reports submitted to NRC.

Tables 5.7-23 and 5.7-24 summarize surface water sampling that occurs quarterly. Surface water samples are taken in accordance with the instructions contained in SHEQMS Program Volume VI, *Environmental Manual*. Samples are analyzed for natural uranium and radium-226. The most current results of this sampling for uranium are shown in Table 5.7-23. The results for radium are shown in Tables 5.7-24.

The results show that uranium concentrations in Squaw Creek and English Creek have generally been consistent since sampling commenced, with few elevated concentrations of uranium. Similarly, uranium concentrations at the upstream and downstream locations on Squaw Creek show no noticeable differences. On English Creek, the upstream site has continually measured higher concentrations of uranium compared to the downstream site. Uranium concentrations in the impoundments have been the lowest in impoundment I-5, while impoundments I-3 and I-4 have measured uranium concentrations less than 0.2 mg/L. Radium-226 in Squaw Creek was less than 1 pCi/L at all sites, with the exception of the second quarter 2019 in which elevated radium-226 was measured at all sites. Both sites on English Creek and the impoundments measured radium-226 concentrations well below 2 pCi/L.

5.7.8.4 Evaporation Pond Leak Detection Monitoring

The evaporation ponds are lined and equipped with a leak detection system. During operations, the leak detection standpipes are checked for evidence of leakage. Visual inspection of the pond embankments, fences, and liners and the measurement of pond freeboard are also performed during normal operations. A minimum freeboard of 5 feet is allowed for the commercial ponds during normal operations. Anytime 6 inches or more of fluid is detected in a leak detection system standpipe, it is analyzed for specific conductivity. Should the analyses indicate that the liner is leaking (by comparison to chemical analyses of pond water), the following actions are taken:

- The NRC Project Manager is notified by telephone within 48 hours of leak verification.
- Transferring its contents into an adjacent pond lowers the level of the leaking pond. While lowering the water level in the pond, the liner is inspected to determine the cause and location of the leakage. The area of investigation first centers on the pond area specific for the particular standpipe that contains fluid.
- Once the source of the leakage is found, the liner is repaired and water is reintroduced to the pond.
- A written report is submitted to the NRC within 30 days of leak verification. The report includes analytical data and describes the cause of the leakage, corrective actions taken, and the results of those actions.

Over the course of the current licensed operation, CBR has experienced several leaks associated with the primary pond liner on the commercial evaporation ponds. In addition, a leak occurred in the primary liner of the east cell of the R&D pond in March 2023. These small leaks are virtually unavoidable since the liners are exposed to the elements. In each case these leaks were quickly discovered during routine inspections, primarily due to a response in the underdrain system. Corrective actions included lowering the pond level and locating the leak to allow repairs. In none of these situations was the shallow groundwater affected since the outer pond liner functioned as designed and prevented release of the pond contents. All pond leaks, causes, and corrective actions are reported to the NRC and the NDEE.

5.7.9 Quality Assurance Program

A quality assurance program (QAP) is in place at Crow Butte Project for all relevant operational monitoring and analytical procedures. The QAP was approved by NRC in 2017 and the license condition was removed from SUA-1534 in Amendment 2. The objective of the program is to identify any deficiencies in the sampling techniques and measurement processes so that corrective action can be taken and to obtain a level of confidence in the results of the monitoring programs. The QAP provides assurance to both regulatory agencies and the public that the monitoring results are valid.

The QAP addresses the following:

- Formal delineation of organizational structure and management responsibilities. Responsibility for both review/approval of written procedures and monitoring data/reports is provided.
- Minimum qualifications and training programs for individuals performing radiological monitoring and those individuals associated with the QAP.

- Written procedures for QA activities. These procedures include activities involving sample analysis, calibration of instrumentation, calculation techniques, data evaluation, and data reporting.
- Quality control (QC) in the laboratory. Procedures cover statistical data evaluation, instrument calibration, and duplicate and spike sample programs. Outside laboratory QA/QC programs are included.
- Provisions for periodic management audits to verify that the QAP is effectively implemented, to verify compliance with applicable rules, regulations and license requirements, and to protect employees by maintaining effluent releases and exposures ALARA.

The SHEQMS Program developed by CBR is a critical step to ensuring that quality assurance objectives are met. Current procedures exist for a variety of areas, including but not limited to:

1. Environmental monitoring procedures,
2. Testing procedures,
3. Exposure procedures,
4. Equipment operation and maintenance procedures,
5. Employee health and safety procedures,
6. Incident response procedures, and
7. Laboratory procedures.

5.7.10 Monitoring Program Summary

Section 5.7 of this renewal application has reviewed the radiological monitoring data produced at Crow Butte Project for the years 1990 through 2023. Each section has discussed the historical results of the data with an emphasis on regulatory compliance and trend analysis to determine whether CBR's ALARA goals are being met. Where the data indicated that some adjustments in the monitoring program were indicated, CBR has noted those changes in the "Proposed Program" portion of each Section. In order to aid the reviewer in comparing the elements of the current monitoring program with those of the proposed program, Table 5.7-25 provides a tabular summary of both programs as well as the regulatory guidance provided in RG 8.30.

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Table 5.7-1. CPF Airborne Uranium Monitoring Results

Monitoring Period	Annual Average Airborne Activity		Maximum Monthly Average Airborne Activity	
	µCi/ml Gross α	% DAC[1]	µCi/ml Gross α	% DAC[1]
1994	3.22 E-12	0.6%	6.07 E-12	1.2%
1995	3.80 E-12	0.8%	9.36 E-12	1.9%
1996	1.28 E-12	0.3%	4.71 E-12	0.9%
1997	2.77 E-12	0.5%	5.43 E-12	1.1%
1998	3.06 E-12	0.6%	5.36 E-12	1.1%
1999	2.87 E-12	0.6%	4.44 E-12	0.9%
2000	2.63 E-12	0.5%	5.84 E-12	1.1%
2001	3.30 E-12	0.7%	7.05 E-12	1.4%
2002	2.25 E-12	0.5%	3.70 E-12	0.7%
2003	4.02 E-12	0.8%	2.33 E-11	4.7%
2004	1.65 E-12	0.3%	5.99 E-12	1.0%
2005	3.80 E-12	0.8%	5.03 E-12	1.0%
2006	3.86 E-12	0.8%	4.87 E-12	1.0%
2007	2.50 E-12	0.5%	4.53 E-12	0.9%
2008	2.48 E-12	0.5%	5.33 E-12	1.1%
2009	2.95 E-12	0.6%	6.76 E-12	1.4%
2010	2.90 E-12	0.6%	5.05 E-12	1.0%
2011	3.66 E-12	0.7%	6.78 E-12	1.4%
2012	2.80 E-12	0.6%	4.16 E-12	0.8%
2013	3.76 E-12	0.8%	2.56 E-11	5.1%
2014	2.93 E-12	0.6%	4.45 E-12	0.9%
2015	3.82 E-12	0.8%	7.32 E-12	1.5%
2016	3.37 E-12	0.7%	5.03 E-12	1.0%
2017	3.13 E-12	0.6%	4.86 E-12	1.0%
2018	2.32 E-12	0.5%	1.12 E-11	2.2%
2019	9.78 E-13	0.2%	4.46 E-12	0.9%
2020	1.41 E-12	0.3%	5.69 E-12	1.1%
2021	3.57 E-13	0.1%	1.57 E-12	0.3%
2022	1.80 E-13	0.0%	4.76 E-13	0.1%
2023	1.79 E-13	0.0%	7.01 E-13	0.1%

[1] Samples compared to the DAC, where DAC = 5 E^{-10} µCi/ml (Appendix B to 10 CFR §§ 20.1001 - 20.2401)

Table 5.7-2. CPF Radon Daughter Monitoring Results

Monitoring Period	Annual Average Radon Daughter Activity		Maximum Monthly Average Radon Daughter Activity	
	WL	% DAC[1]	WL	% DAC[1]
1994	0.032	9.7%	0.046	13.9%
1995	0.041	12.4%	0.070	21.2%
1996	0.038	11.5%	0.069	20.9%
1997	0.048	14.5%	0.068	20.6%
1998	0.027	8.2%	0.042	12.7%
1999	0.041	12.4%	0.049	14.8%
2000	0.023	7.0%	0.042	12.7%
2001	0.032	9.7%	0.049	14.8%
2002	0.027	8.2%	0.048	14.5%
2003	0.030	9.1%	0.045	13.6%
2004	0.024	7.3%	0.036	10.9%
2005	0.015	4.5%	0.026	7.9%
2006	0.020	6.1%	0.026	7.9%
2007	0.017	5.2%	0.028	8.5%
2008	0.017	5.2%	0.032	9.7%
2009	0.021	6.4%	0.068	20.6%
2010	0.031	9.4%	0.132	40.0%
2011	0.040	12.1%	0.151	45.8%
2012	0.016	4.8%	0.031	9.4%
2013	0.009	2.7%	0.013	3.9%
2014	0.010	3.0%	0.018	5.5%
2015	0.009	2.7%	0.014	4.2%
2016	0.007	2.1%	0.009	2.7%
2017	0.007	2.0%	0.011	3.3%
2018	0.004	1.3%	0.007	2.1%
2019	0.005	1.6%	0.013	3.9%
2020	0.008	2.6%	0.013	3.9%
2021	0.007	2.1%	0.010	3.0%
2022	0.005	1.6%	0.009	2.7%
2023	0.005	1.4%	0.008	2.4%

[1] Samples compared to the DAC, where DAC = 0.33 WL (Appendix B to 10 CFR §§ 20.1001 - 20.2401)

Table 5.7-3. Annual Airborne Uranium Exposure Results

Monitoring Period	Average Airborne Uranium Exposure (µCi)[1]	Maximum Airborne Uranium Exposure (µCi)[1]
1994	3.66 E-3	9.03 E-3
1995	4.04 E-3	1.07 E-2
1996	2.59 E-3	4.70 E-3
1997	5.49 E-3	8.37 E-3
1998	5.81 E-3	8.26 E-3
1999	5.14 E-3	7.89 E-3
2000	4.38 E-3	8.23 E-3
2001	4.55 E-3	1.06 E-2
2002	3.24 E-3	7.82 E-3
2003	5.24 E-3	1.28 E-2
2004	4.05 E-3	9.17 E-3
2005	5.87 E-3	1.94 E-2
2006	6.94 E-3	2.14 E-2
2007	3.86 E-3	1.05 E-2
2008	3.42 E-3	1.66 E-2
2009	4.58 E-3	2.35 E-2
2010	4.33 E-3	2.34 E-2
2011	4.17 E-3	1.58 E-2
2012	4.44 E-3	1.40 E-2
2013	3.35 E-3	1.66 E-2
2014	4.89 E-3	1.63 E-2
2015	7.34 E-3	1.58 E-2
2016	5.98 E-3	1.00 E-2
2017	5.63 E-3	8.12 E-3
2018	3.00 E-3	6.48 E-3
2019	1.81 E-3	2.79 E-3
2020	2.80 E-3	3.95 E-3
2021	6.96 E-4	1.05 E-3
2022	3.27 E-4	5.92 E-4
2023	3.61 E-4	6.60 E-4

[1] The annual uranium intake limit for calendar years 1990 through 1993 was 0.252 µCi based on 10 CFR §§ 20.103. In 1994, the annual limit on intake (ALI) was 1 µCi based upon "D" class natural uranium.

Table 5.7-4. Annual Radon Daughter Exposure Results

Monitoring Period	Average individual Exposure (Working-Level Months)[1]	Maximum Individual Exposure (Working-Level Months)[1]
1994	0.188	0.418
1995	0.212	0.570
1996	0.322	0.527
1997	0.467	0.643
1998	0.250	0.359
1999	0.356	0.539
2000	0.183	0.325
2001	0.199	0.416
2002	0.180	0.364
2003	0.208	0.402
2004	0.197	0.312
2005	0.101	0.213
2006	0.161	0.283
2007	0.105	0.224
2008	0.101	0.244
2009	0.151	0.297
2010	0.182	0.375
2011	0.238	0.450
2012	0.126	0.223
2013	0.066	0.116
2014	0.074	0.137
2015	0.076	0.133
2016	0.054	0.091
2017	0.060	0.082
2018	0.029	0.059
2019	0.045	0.068
2020	0.082	0.115
2021	0.064	0.089
2022	0.051	0.081
2023	0.051	0.071

[1] The annual limit is 4 working-level months.

Table 5.7-5. Calibration Source Data

Source Isotope	Source ID	Source Activity (dpm)	Source Surface Emission (dpm)
U_{nat}	K1-076	23000	11390
Sr/Y-90	M2-098	189800	113800

Table 5.7-6. Instrument Efficiency Calculation

Source #	**K1-076**	**M2-098**
Total Activity (dpm)	11,390	113,800
Alpha 5 min bkg	31	
Beta 5 min bkg		1,093
Source Size	150 cm^2	
Probe Size	100 cm^2	100 cm^2
	Alpha	Beta
Count 1	2,657	59,567
Count 2	2,799	59,632
Count 3	2,772	59,479
Count 4	2,791	59,319
Count 5	2,747	60,018
Count 6	2,638	59,449
Count 7	2,781	59,937
Count 8	2,720	59,637
Count 9	2,671	59,535
Count 10	2,764	59,924
Average cpm	2,734	59,650
Source Surface Emission (dpm)	11,390	113,800
Instrument Efficiency**	**35.9%**	**52.2%**
**(radionuclide weighted)		

Table 5.7-7. Mixture Weighted Beta Efficiency for Aged Yellowcake for Model 43-93

Isotope	Energy (keV)	Activity Fraction	Branching Ratio	Instrument Efficiency	Surface Efficiency	Weighted Efficiency
Th-234	103	0.489	0.21	0	0.25	0.0000
Th-234	193	0.489	0.79	0	0.25	0.0000
Pa-234m	2290	0.489	0.98	0.522	0.50	0.1251
Th-231	206	0.022	0.13	0	0.25	0.0000
Th-231	287	0.022	0.12	0	0.25	0.0000
Th-231	288	0.022	0.37	0	0.25	0.0000
Th-231	305	0.022	0.35	0	0.25	0.0000

Beta Counting Efficiency = 0.1251

Table 5.7-8. Primary Alpha Emitting Radionuclides in Lixiviant

	Bq/L	Fraction
U (total)	1,000	0.805
U-238	486	0.391
U-235	22	0.018
U-234	492	0.396
Th-230	93	0.075
Ra-226	150	0.121

Table 5.7-9. Primary Beta Emitting Radionuclides in Lixiviant

	Bq/L	Fraction
Th-234	84.7	0.443
Th-231	22	0.115
Pa-234m	84.7	0.443

Table 5.7-10. Mixture Weighted Efficiencies for Pregnant Lixiviant

Isotope	Energy (MeV)	Activity Fraction	Branching Ratio	Instrument Efficiency	Surface Efficiency	Weighted Efficiency
U-238	4.15	0.391	0.21	0.359	0.25	0.0074
U-238	4.20	0.391	0.79	0.359	0.25	0.0277
U-234	4.72	0.396	0.28	0.359	0.25	0.0100
U-234	4.77	0.396	0.72	0.359	0.25	0.0256
U-235	4.21	0.018	0.06	0.359	0.25	0.0001
U-235	4.37	0.018	0.17	0.359	0.25	0.0003
U-235	4.40	0.018	0.55	0.359	0.25	0.0009
U-235	4.60	0.018	0.05	0.359	0.25	0.0001
Th-230	4.62	0.075	0.24	0.359	0.25	0.0016
Th-230	4.68	0.075	0.76	0.359	0.25	0.0051
Ra-226	4.60	0.121	0.06	0.359	0.25	0.0007
Ra-226	4.78	0.121	0.95	0.359	0.25	0.0103

Alpha Counting Efficiency = 0.089

Isotope	Energy (keV)	Activity Fraction	Branching Ratio	Instrument Efficiency	Surface Efficiency	Weighted Efficiency
Th-234	103	0.443	0.21	0	0.25	0.0000
Th-234	193	0.443	0.79	0	0.25	0.0000
Pa-234m	2290	0.443	0.98	0.522	0.50	0.1133
Th-231	206	0.115	0.13	0	0.25	0.0000
Th-231	287	0.115	0.12	0	0.25	0.0000
Th-231	288	0.115	0.37	0	0.25	0.0000
Th-231	305	0.115	0.35	0	0.25	0.0000

Beta Counting Efficiency = 0.113

Table 5.7-11. Summary of Instrument Weighted Efficiencies

Mixture	Radiation Type	Total Efficiency (NRC 2015 method)
Aged Yellowcake	Alpha	9.0%
	Beta	12.5%
Pregnant Lixiviant	Alpha	9.0%
	Beta	11.3%

Table 5.7-12. Results of Surveys for Contamination of Skin and Personal Clothing

Date	Alpha Eff.	Beta Eff.	5 min Alpha BKG	5 min Beta BKG	Alpha MDC	Beta MDC	Alpha Counts/ 0.5 min	Beta Counts/ 0.5 min	Alpha DPM	Beta DPM
4/19/2018	0.099	0.081	33	955	187	907	18	92	297	-86
4/19/2018	0.099	0.081	33	955	187	907	19	126	317	753
5/30/2018	0.115	0.121	27	1390	151	722	26	167	405	463
5/30/2018	0.115	0.121	27	1390	151	722	15	156	214	281
5/30/2018	0.115	0.121	27	1390	151	722	12	125	162	-231
6/19/2018	0.103	0.093	27	1390	218	823	21	118	355	-452
6/19/2018	0.103	0.093	27	1390	218	823	25	120	433	-409
6/19/2018	0.103	0.093	27	1390	218	823	17	114	278	-538
7/11/2018	0.11	0.097	22	951	148	756	14	105	215	204
7/11/2018	0.11	0.097	22	951	148	756	21	113	342	369
7/11/2018	0.11	0.097	22	951	148	756	12	103	178	163
9/20/2018	0.121	0.114	10	1169	107	707	23	153	364	633
9/20/2018	0.121	0.114	10	1169	107	707	9	111	132	-104
9/20/2018	0.121	0.114	10	1169	107	707	9	100	132	-296
9/20/2018	0.121	0.114	10	1169	107	707	19	131	298	247
9/20/2018	0.121	0.114	10	1169	107	707	17	129	264	212
9/20/2018	0.121	0.114	10	1169	107	707	10	122	149	89
9/20/2018	0.121	0.114	10	1169	107	707	14	136	215	335
9/20/2018	0.121	0.114	10	1169	107	707	13	163	198	809
10/18/2018	0.098	0.105	14	891	145	678	15	84	278	-97
10/18/2018	0.098	0.105	14	891	145	678	16	116	298	512
10/18/2018	0.098	0.105	14	891	145	678	12	97	216	150
10/18/2018	0.098	0.105	14	891	145	678	15	95	278	112
10/18/2018	0.098	0.105	14	891	145	678	10	83	176	-116
10/18/2018	0.098	0.105	14	891	145	678	10	81	176	-154
10/18/2018	0.098	0.105	14	891	145	678	16	98	298	170
10/18/2018	0.098	0.105	14	891	145	678	16	102	298	246
10/18/2018	0.098	0.105	14	891	145	678	16	97	298	150
10/18/2018	0.098	0.105	14	891	145	678	12	95	216	112
10/18/2018	0.098	0.105	14	891	145	678	16	116	298	512
10/18/2018	0.098	0.105	14	891	145	678	27	115	522	493
10/18/2018	0.098	0.105	14	891	145	678	10	86	176	-59
10/18/2018	0.098	0.105	14	891	145	678	15	122	278	627
11/13/2018	0.101	0.103	31	973	180	719	16	116	255	363
11/13/2018	0.101	0.103	31	973	180	719	13	119	196	421
11/13/2018	0.101	0.103	31	973	180	719	20	113	335	305
11/13/2018	0.101	0.103	31	973	180	719	13	120	196	441
11/13/2018	0.101	0.103	31	973	180	719	20	120	335	441
12/18/2018	0.101	0.132	18	1344	151	652	18	168	321	509
12/18/2018	0.101	0.132	18	1344	151	652	14	122	242	-188
12/18/2018	0.101	0.132	18	1344	151	652	11	113	182	-324
12/18/2018	0.101	0.132	18	1344	151	652	15	150	261	236
12/18/2018	0.101	0.132	18	1344	151	652	15	184	261	752
12/18/2018	0.101	0.132	18	1344	151	652	15	169	261	524
12/18/2018	0.101	0.132	18	1344	151	652	21	146	380	176
12/18/2018	0.101	0.132	18	1344	151	652	14	143	242	130
12/18/2018	0.101	0.132	18	1344	151	652	13	130	222	-67
12/18/2018	0.101	0.132	18	1344	151	652	20	161	360	403
2/6/2019	0.09	0.089	4	940	115	819	11	92	236	-45
2/6/2019	0.09	0.089	4	940	115	819	7	124	147	674
2/6/2019	0.09	0.089	4	940	115	819	8	100	169	135
2/6/2019	0.09	0.089	4	940	115	819	7	102	147	180
2/6/2019	0.09	0.089	4	940	115	819	10	107	213	292

Table 5.7-12. Results of Surveys for Contamination of Skin and Personal Clothing (Cont.)

Date	Alpha Eff.	Beta Eff.	5 min Alpha BKG	5 min Beta BKG	Alpha MDC	Beta MDC	Alpha Counts/ 0.5 min	Beta Counts/ 0.5 min	Alpha DPM	Beta DPM
2/6/2019	0.09	0.089	4	940	115	819	15	118	324	539
2/6/2019	0.09	0.089	4	940	115	819	9	111	191	382
2/6/2019	0.09	0.089	4	940	115	819	8	100	169	135
2/6/2019	0.09	0.089	4	940	115	819	6	113	124	427
4/23/2019	0.096	0.091	10	899	134	785	10	98	188	178
6/18/2019	0.101	0.106	16	1104	146	741	9	109	147	-26
6/18/2019	0.101	0.106	16	1104	146	741	10	136	166	483
6/18/2019	0.101	0.106	16	1104	146	741	113	125	2206	275
7/9/2019	0.088	0.095	20	1166	179	848	18	141	364	514
7/9/2019	0.088	0.095	20	1166	179	848	16	115	318	-34
7/9/2019	0.088	0.095	20	1166	179	848	18	104	364	-265
7/9/2019	0.088	0.095	20	1166	179	848	11	125	205	177
7/9/2019	0.088	0.095	20	1166	179	848	12	79	227	-792
8/14/2019	0.093	0.088	12	1072	146	880	8	111	146	86
8/14/2019	0.093	0.088	12	1072	146	880	8	84	146	-527
8/14/2019	0.093	0.088	12	1072	146	880	9	104	168	-73
8/14/2019	0.093	0.088	12	1072	146	880	9	103	168	-95
8/14/2019	0.093	0.088	12	1072	146	880	10	86	189	-482
8/14/2019	0.093	0.088	12	1072	146	880	9	98	168	-209
9/17/2019	0.086	0.085	23	914	191	847	21	106	435	344
9/17/2019	0.086	0.085	23	914	191	847	11	71	202	-480
9/17/2019	0.086	0.085	23	914	191	847	13	106	249	344
9/17/2019	0.086	0.085	23	914	191	847	12	85	226	-151
10/22/2019	0.086	0.086	19	836	180	803	10	111	188	637
10/22/2019	0.086	0.086	19	836	180	803	30	118	653	800
10/22/2019	0.086	0.086	19	836	180	803	12	119	235	823
10/22/2019	0.086	0.086	19	836	180	803	19	111	398	637
10/22/2019	0.086	0.086	19	836	180	803	32	120	700	847
10/22/2019	0.086	0.086	19	836	180	803	24	103	514	451
10/22/2019	0.086	0.086	19	836	180	803	20	122	421	893
11/15/2019	0.094	0.094	42	1091	214	831	24	119	421	211
11/15/2019	0.094	0.094	42	1091	214	831	30	141	549	679
1/16/2020	0.102	0.122	21	1382	157	714	15	139	253	13
1/16/2020	0.102	0.122	21	1382	157	714	24	124	429	-233
1/16/2020	0.102	0.122	21	1382	157	714	18	183	312	734
1/16/2020	0.102	0.122	21	1382	157	714	12	134	194	-69
1/16/2020	0.102	0.122	21	1382	157	714	11	133	175	-85
1/16/2020	0.102	0.122	21	1382	157	714	18	154	312	259
1/16/2020	0.102	0.122	21	1382	157	714	18	129	312	-151
1/16/2020	0.102	0.122	21	1382	157	714	11	137	175	-20
1/16/2020	0.102	0.122	21	1382	157	714	11	109	175	-479
1/16/2020	0.102	0.122	21	1382	157	714	29	129	527	-151
1/16/2020	0.102	0.122	21	1382	157	714	18	117	312	-348
1/16/2020	0.102	0.122	21	1382	157	714	12	145	194	111
2/12/2020	0.094	0.099	19	1185	165	819	14	118	257	-10
2/12/2020	0.094	0.099	19	1185	165	819	11	126	194	152
2/12/2020	0.094	0.099	19	1185	165	819	15	117	279	-30
2/12/2020	0.094	0.099	19	1185	165	819	10	105	172	-273
4/28/2020	0.103	0.121	19	1231	151	682	15	163	254	660
5/27/2020	0.087	0.091	16	880	169	777	14	95	285	154
5/27/2020	0.087	0.091	16	880	169	777	13	106	262	396
6/17/2020	0.086	0.096	22	1209	189	853	13	119	251	-40
8/20/2020	0.08	0.086	24	1000	209	872	17	129	365	674

Table 5.7-12. Results of Surveys for Contamination of Skin and Personal Clothing (Cont.)

Date	Alpha Eff.	Beta Eff.	5 min Alpha BKG	5 min Beta BKG	Alpha MDC	Beta MDC	Alpha Counts/ 0.5 min	Beta Counts/ 0.5 min	Alpha DPM	Beta DPM
10/22/2020	0.087	0.096	29	1206	204	852	14	128	255	154
10/22/2020	0.087	0.096	29	1206	204	852	23	138	462	363
10/22/2020	0.087	0.096	29	1206	204	852	18	146	347	529
10/22/2020	0.087	0.096	29	1206	204	852	13	159	232	800
10/22/2020	0.087	0.096	29	1206	204	852	17	136	324	321
11/10/2020	0.093	0.084	8	892	131	847	9	92	176	67
11/10/2020	0.093	0.084	8	892	131	847	19	105	391	376
11/10/2020	0.093	0.084	8	892	131	847	12	99	241	233
11/10/2020	0.093	0.084	8	892	131	847	11	53	219	-862
11/10/2020	0.093	0.084	8	892	131	847	15	86	305	-76
11/10/2020	0.093	0.084	8	892	131	847	31	107	649	424
11/10/2020	0.093	0.084	8	892	131	847	23	107	477	424
11/10/2020	0.093	0.084	8	892	131	847	11	81	219	-195
11/10/2020	0.093	0.084	8	892	131	847	22	103	456	329
11/10/2020	0.093	0.084	8	892	131	847	18	82	370	-171
11/10/2020	0.093	0.084	8	892	131	847	13	72	262	-410
11/10/2020	0.093	0.084	8	892	131	847	13	100	262	257
11/10/2020	0.093	0.084	8	892	131	847	10	106	198	400
12/9/2020	0.104	0.086	13	873	133	820	19	106	340	435
12/9/2020	0.104	0.086	13	873	133	820	31	101	571	319
12/9/2020	0.104	0.086	13	873	133	820	18	105	321	412
12/9/2020	0.104	0.086	13	873	133	820	17	109	302	505
1/11/2021	0.084	0.09	21	1083	190	865	12	113	236	104
1/11/2021	0.084	0.09	21	1083	190	865	11	119	212	238
1/11/2021	0.084	0.09	21	1083	190	865	11	95	212	-296
1/11/2021	0.084	0.09	21	1083	190	865	23	109	498	16
1/11/2021	0.084	0.09	21	1083	190	865	13	114	260	127
1/11/2021	0.084	0.09	21	1083	190	865	13	95	260	-296
2/5/2021	0.099	0.11	30	1110	181	716	29	144	525	600
2/5/2021	0.099	0.11	30	1110	181	716	12	117	182	109
2/5/2021	0.099	0.11	30	1110	181	716	18	132	303	382
2/5/2021	0.099	0.11	30	1110	181	716	15	93	242	-327
2/5/2021	0.099	0.11	30	1110	181	716	12	162	182	927
3/16/2021	0.096	0.083	15	769	151	801	11	84	198	171
3/16/2021	0.096	0.083	15	769	151	801	10	95	177	436
3/16/2021	0.096	0.083	15	769	151	801	11	77	198	2
3/16/2021	0.096	0.083	15	769	151	801	15	93	281	388
3/16/2021	0.096	0.083	15	769	151	801	11	62	198	-359
3/16/2021	0.096	0.083	15	769	151	801	9	62	156	-359
4/30/2021	0.083	0.082	40	792	239	822	14	110	241	751
4/30/2021	0.083	0.082	40	792	239	822	17	79	313	-5
4/30/2021	0.083	0.082	40	792	239	822	16	90	289	263
4/30/2021	0.083	0.082	40	792	239	822	18	102	337	556
4/30/2021	0.083	0.082	40	792	239	822	19	97	361	434
6/22/2021	0.09	0.099	20	1138	175	804	13	109	244	-97
6/22/2021	0.09	0.099	20	1138	175	804	13	122	244	166
6/22/2021	0.09	0.099	20	1138	175	804	15	122	289	166
6/22/2021	0.09	0.099	20	1138	175	804	10	102	178	-238
7/20/2021	0.095	0.104	21	1006	168	723	11	113	187	238
8/26/2021	0.089	0.095	13	941	156	768	10	95	196	19
8/26/2021	0.089	0.095	13	941	156	768	11	98	218	82
8/26/2021	0.089	0.095	13	941	156	768	9	95	173	19
10/19/2021	0.097	0.105	28	1157	181	764	23	140	416	463

Table 5.7-12. Results of Surveys for Contamination of Skin and Personal Clothing (Cont.)

Date	Alpha Eff.	Beta Eff.	5 min Alpha BKG	5 min Beta BKG	Alpha MDC	Beta MDC	Alpha Counts/ 0.5 min	Beta Counts/ 0.5 min	Alpha DPM	Beta DPM
10/19/2021	0.097	0.105	28	1157	181	764	14	143	231	520
10/19/2021	0.097	0.105	28	1157	181	764	17	144	293	539
10/19/2021	0.097	0.105	28	1157	181	764	12	138	190	425
10/19/2021	0.097	0.105	28	1157	181	764	15	144	252	539
10/19/2021	0.097	0.105	28	1157	181	764	18	148	313	615
10/19/2021	0.097	0.105	28	1157	181	764	15	137	252	406
10/19/2021	0.097	0.105	28	1157	181	764	14	122	231	120
11/9/2021	0.084	0.094	21	1065	190	821	14	111	283	96
11/9/2021	0.084	0.094	21	1065	190	821	16	85	331	-457
11/9/2021	0.084	0.094	21	1065	190	821	13	105	260	-32
11/9/2021	0.084	0.094	21	1065	190	821	12	146	236	840
11/9/2021	0.084	0.094	21	1065	190	821	14	120	283	287
11/9/2021	0.084	0.094	21	1065	190	821	20	130	426	500
11/9/2021	0.084	0.094	21	1065	190	821	21	134	450	585
12/14/2021	0.087	0.091	28	1026	202	834	16	100	303	-57
12/14/2021	0.087	0.091	28	1026	202	834	16	122	303	426
12/14/2021	0.087	0.091	28	1026	202	834	18	111	349	185
12/14/2021	0.087	0.091	28	1026	202	834	19	97	372	-123
12/14/2021	0.087	0.091	28	1026	202	834	16	103	303	9
12/14/2021	0.087	0.091	28	1026	202	834	12	89	211	-299
1/12/2022	0.098	0.123	36	1389	195	710	19	137	314	-31
1/12/2022	0.098	0.123	36	1389	195	710	19	138	314	-15
1/12/2022	0.098	0.123	36	1389	195	710	16	144	253	83
1/12/2022	0.098	0.123	36	1389	195	710	14	130	212	-145
1/12/2022	0.098	0.123	36	1389	195	710	19	122	314	-275
1/12/2022	0.098	0.123	36	1389	195	710	18	142	294	50
1/12/2022	0.098	0.123	36	1389	195	710	15	144	233	83
2/10/2022	0.093	0.099	20	1015	169	763	15	124	280	455
3/10/2022	0.076	0.101	23	1261	217	827	13	152	282	513
3/10/2022	0.076	0.101	23	1261	217	827	19	121	439	-101
3/10/2022	0.076	0.101	23	1261	217	827	18	144	413	354
3/10/2022	0.076	0.101	23	1261	217	827	11	103	229	-457
4/27/2022	0.081	0.1	50	1315	265	851	24	133	469	30
4/27/2022	0.081	0.1	50	1315	265	851	23	113	444	-370
4/27/2022	0.081	0.1	50	1315	265	851	18	135	321	70
4/27/2022	0.081	0.1	50	1315	265	851	16	130	272	-30
5/25/2022	0.081	0.087	44	863	253	806	16	107	286	476
7/22/2022	0.101	0.123	64	1469	232	729	26	180	388	538
7/22/2022	0.101	0.123	64	1469	232	729	20	144	269	-47
7/22/2022	0.101	0.123	64	1469	232	729	20	140	269	-112
9/22/2022	0.078	0.087	26	850	220	800	19	121	421	828
9/22/2022	0.078	0.087	26	850	220	800	16	87	344	46
9/22/2022	0.078	0.087	26	850	220	800	14	79	292	-138
9/22/2022	0.078	0.087	26	850	220	800	24	92	549	161
9/22/2022	0.078	0.087	26	850	220	800	16	115	344	690
9/22/2022	0.078	0.087	26	850	220	800	12	70	241	-345
9/22/2022	0.078	0.087	26	850	220	800	16	86	344	23
9/22/2022	0.078	0.087	26	850	220	800	12	100	241	345
9/22/2022	0.078	0.087	26	850	220	800	12	85	241	0
9/22/2022	0.078	0.087	26	850	220	800	14	84	292	-23
12/21/2022	0.093	0.12	90	1489	287	752	26	177	366	468
12/21/2022	0.093	0.12	90	1489	287	752	24	154	323	85
1/31/2023	0.095	0.123	16	1255	155	677	15	118	282	-122

Table 5.7-12. Results of Surveys for Contamination of Skin and Personal Clothing (Cont.)

Date	Alpha Eff.	Beta Eff.	5 min Alpha BKG	5 min Beta BKG	Alpha MDC	Beta MDC	Alpha Counts/ 0.5 min	Beta Counts/ 0.5 min	Alpha DPM	Beta DPM
1/31/2023	0.095	0.123	16	1255	155	677	15	144	282	301
1/31/2023	0.095	0.123	16	1255	155	677	11	119	198	-106
1/31/2023	0.095	0.123	16	1255	155	677	16	162	303	593
1/31/2023	0.095	0.123	16	1255	155	677	15	126	282	8
1/31/2023	0.095	0.123	16	1255	155	677	10	114	177	-187
1/31/2023	0.095	0.123	16	1255	155	677	15	123	282	-41
2/21/2023	0.085	0.091	39	1059	231	846	17	116	308	222
2/21/2023	0.085	0.091	39	1059	231	846	18	138	332	705
3/1/2023	0.095	0.125	35	1569	199	740	16	167	263	162
3/1/2023	0.095	0.125	35	1569	199	740	15	157	242	2
4/24/2023	0.081	0.089	48	951	261	824	36	118	770	515
4/24/2023	0.081	0.089	48	951	261	824	17	109	301	312
4/24/2023	0.081	0.089	48	951	261	824	20	129	375	762
4/24/2023	0.081	0.089	48	951	261	824	17	99	301	88
5/9/2023	0.082	0.122	42	1672	246	781	17	161	312	-102
5/9/2023	0.082	0.122	42	1672	246	781	17	154	312	-216
5/9/2023	0.082	0.122	42	1672	246	781	16	195	288	456
7/10/2023	0.088	0.121	33	1559	211	762	15	157	266	18
8/16/2023	0.082	0.12	85	1682	319	796	25	189	402	347
8/16/2023	0.082	0.12	85	1682	319	796	38	205	720	613
8/16/2023	0.082	0.12	85	1682	319	796	35	196	646	463
8/16/2023	0.082	0.12	85	1682	319	796	25	155	402	-220
9/11/2023	0.078	0.119	78	1763	324	820	29	180	544	62
9/11/2023	0.078	0.119	78	1763	324	820	21	136	338	-677
11/28/2023	0.089	0.109	70	1330	273	785	24	165	382	587
12/14/2023	0.085	0.107	36	1401	225	819	15	147	268	129
12/14/2023	0.085	0.107	36	1401	225	819	20	163	386	428
1/4/2024	0.088	0.101	35	1069	215	766	19	120	352	259
1/4/2024	0.088	0.101	35	1069	215	766	14	148	239	814
2/20/2024	0.083	0.101	10	920	155	715	14	106	313	277
2/20/2024	0.083	0.101	10	920	155	715	12	100	265	158
2/20/2024	0.083	0.101	10	920	155	715	9	69	193	-455
2/20/2024	0.083	0.101	10	920	155	715	18	116	410	475
2/20/2024	0.083	0.101	10	920	155	715	8	94	169	40
2/20/2024	0.083	0.101	10	920	155	715	8	99	169	139
3/1/2024	0.097	0.126	7	1441	121	705	7	147	130	46
3/1/2024	0.097	0.126	7	1441	121	705	8	122	151	-351
3/1/2024	0.097	0.126	7	1441	121	705	7	116	130	-446
3/1/2024	0.097	0.126	7	1441	121	705	39	177	790	522
3/1/2024	0.097	0.126	7	1441	121	705	15	147	295	46
3/1/2024	0.097	0.126	7	1441	121	705	14	132	274	-192
3/1/2024	0.097	0.126	7	1441	121	705	9	106	171	-605
3/1/2024	0.097	0.126	7	1441	121	705	7	96	130	-763
3/1/2024	0.097	0.126	7	1441	121	705	10	134	192	-160
4/1/2024	0.084	0.121	68	1438	286	734	39	177	767	549
5/7/2024	0.085	0.105	31	1227	214	785	15	124	280	25
5/7/2024	0.085	0.105	31	1227	214	785	17	131	327	158
5/7/2024	0.085	0.105	31	1227	214	785	37	161	798	730
6/1/2024	0.093	0.127	19	1457	167	703	13	153	239	115
6/1/2024	0.093	0.127	19	1457	167	703	15	132	282	-216
6/1/2024	0.093	0.127	19	1457	167	703	19	192	368	729
6/1/2024	0.093	0.127	19	1457	167	703	14	132	260	-216
7/1/2024	0.094	0.117	33	1540	197	783	15	152	249	-34

Table 5.7-12. Results of Surveys for Contamination of Skin and Personal Clothing (Cont.)

Date	Alpha Eff.	Beta Eff.	5 min Alpha BKG	5 min Beta BKG	Alpha MDC	Beta MDC	Alpha Counts/ 0.5 min	Beta Counts/ 0.5 min	Alpha DPM	Beta DPM
7/1/2024	0.094	0.117	33	1540	197	783	14	137	228	-291
8/1/2024	0.095	0.116	15	1414	152	759	10	131	179	-179
8/1/2024	0.095	0.116	15	1414	152	759	10	114	179	-472
9/19/2024	0.082	0.108	28	1312	214	787	15	132	298	15
9/19/2024	0.082	0.108	28	1312	214	787	15	106	298	-467
10/16/2024	0.093	0.108	26	1397	184	811	20	148	374	154
10/16/2024	0.093	0.108	26	1397	184	811	12	142	202	43
10/16/2024	0.093	0.108	26	1397	184	811	13	144	224	80
10/16/2024	0.093	0.108	26	1397	184	811	17	129	310	-198
10/16/2024	0.093	0.108	26	1397	184	811	12	146	202	117
10/16/2024	0.093	0.108	26	1397	184	811	16	124	288	-291
10/16/2024	0.093	0.108	26	1397	184	811	18	189	331	913
10/16/2024	0.093	0.108	26	1397	184	811	12	150	202	191
11/25/2024	0.089	0.111	26	1340	192	774	28	164	571	541
11/25/2024	0.089	0.111	26	1340	192	774	21	126	413	-144
11/25/2024	0.089	0.111	26	1340	192	774	13	144	234	180
11/25/2024	0.089	0.111	26	1340	192	774	31	165	638	559
11/25/2024	0.089	0.111	26	1340	192	774	15	156	279	396
11/25/2024	0.089	0.111	26	1340	192	774	16	145	301	198
12/11/2024	0.088	0.099	14	1012	161	762	11	89	218	-246
12/11/2024	0.088	0.099	14	1012	161	762	37	138	809	743
12/11/2024	0.088	0.099	14	1012	161	762	16	112	332	218

Table 5.7-13. Operational Environmental and Effluent Monitoring Program

Sample Type	Location	Type	Number	Frequency	Analysis
Air (Radon)	Nearest residences and in the prevalent wind direction Environmental control station near Crawford, NE.	Continuous	7 1	Semiannual	Rn-222
Air (particulate)	Same locations as radon air monitoring	Continuous	8	A minimum of 2 weeks per month when dryer is in use	U-nat Ra-226 Pb-210 Th-230
Surface Soil (top 5 cm)	Plant site before topsoil removal	Grab	2	Once	U-nat Ra-226
	Plant site after topsoil removal	Grab	2	Once	U-nat Ra-226
	Evaporation ponds before excavation	Grab	2	Once	U-nat Ra-226
	Air sampling stations	Grab	7	Once	U-nat Ra-226
Subsurface Soil	Plant site	1/3-meter composites to 1 meter depth	1	Once	U-nat Ra-226
Groundwater	Water supply wells within 1 km of area wellfields	Grab	1	Quarterly	U-nat Ra-226
Surface Water	Each stream passing through wellfield area (one upstream and one downstream)	Grab	2	Quarterly	U-nat Ra-226
	Each water impoundment in wellfield area	Grab	1	Quarterly	U-nat Ra-226
Direct Radiation	Air sampling stations	Continuous	7	Quarterly exchange of dosimeters	External gamma
Sediment	Each body of water where surface water sampling is performed	Grab, upstream and downstream of wellfields	1 or 2	Annually	U-nat Ra-226 Pb-210 Th-230

Table 5.7-14. Ambient Radon Gas Monitoring Results

Monitoring Period		Monitoring Location									
		AM-1	AM-2	AM-3	AM-4	AM-5	AM-6	AM-8	AM-9	AB-3 (AM-3)	AB-6 (AM-6)
Year	Qtr	pCi/L (Accuracy pCi/L)									
1991	1	0.3	0.3	0.5	0.5	0.4	0.5	0.3		0.3	0.4
	2	0.3	0.3	0.3	0.5	0.3	0.3	0.3		0.3	0.3
	3	0.3	0.6	0.3	0.9	0.4	1.0	0.6		0.3	0.5
	4	0.3	0.5	0.6	0.9	0.7	0.3	0.4		0.4	0.6
1992	1	0.5	0.5	0.5	0.7	0.7	0.6	< 0.3		0.5	0.7
	2	0.7	0.4	0.3	0.7	0.4	0.6	0.7		0.6	< 0.3
	3	< 0.3	0.3	< 0.3	0.5	0.4	< 0.3	0.5		< 0.3	< 0.3
	4	0.4	0.4	0.5	0.7	0.9	0.7	0.7		0.6	0.3
1993	1	0.5	0.4	0.5	< 0.3	0.5	< 0.3	< 0.3		< 0.3	< 0.3
	2	0.4	0.6	< 0.3	0.4	0.5	0.4	0.6		< 0.3	< 0.3
	3	0.5	1.0	0.6	1.0	0.6	0.4	0.4		0.4	0.5
	4	0.7	0.9	0.6	0.6	1.1	0.7	0.8		0.6	0.7
1994	1	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3		< 0.3	< 0.3
	2	0.6	0.6	0.4	0.5	0.6	< 0.3	0.6		0.5	0.4
	3	0.9	0.7	0.9	0.7	0.8	0.8	0.8		0.5	0.7
	4	0.5	0.5	0.4	0.5	0.8	0.3	0.7		< 0.3	0.5
1995	1	<0.3	0.5	<0.3	<0.3	<0.3	<0.3	0.4		<0.3	<0.3
	2	<0.3	0.5	<0.3	0.5	<0.3	<0.3	<0.3		0.6	<0.3
	3	<0.3	0.7	<0.3	<0.3	0.8	0.4	0.5		<0.3	0.6
	4	1.2	0.6	0.9	1.7	0.7	0.3	1.3		0.8	<0.3
1996	1	<0.3	0.3	<0.3	0.4	<0.3	<0.3	<0.3		<0.3	<0.3
	2	0.5	<0.3	<0.3	0.5	<0.3	0.4	0.5		<0.3	<0.3
	3	0.7	0.7	0.5	0.6	1.1	0.8	0.9		0.5	1.0
	4	0.8	0.9	0.3	0.9	1.1	0.8	0.8		0.8	0.6
1997	1	0.6+0.11	0.5+0.10	<0.3	<0.3	<0.3	<0.3	0.7+0.12		<0.3	0.5+0.11
	2	0.8+0.13	1.3+0.17	0.6+0.12	0.8+0.13	0.9+0.14	0.7+0.13	0.9+0.14		0.50.11	0.8+0.13
	3	0.6+0.11	0.9+0.14	1.0+0.15	1.2+0.17	1.5+0.19	0.9+0.14	1.2+0.16		0.8+0.13	1.0+0.15
	4	1.2+0.16	1.2+0.16	0.6+0.11	1.3+0.16	1.5+0.18	1.3+0.17	1.4+0.18		1.1+0.15	0.9+0.13

Table 5.7-14. Ambient Radon Gas Monitoring Results (Cont.)

Monitoring Period		Monitoring Location									
		AM-1	AM-2	AM-3	AM-4	AM-5	AM-6	AM-8	AM-9	AB-3 (AM-3)	AB-6 (AM-6)
Year	Half	Average Radon Concentration - x 10^{-9} µCi/ml (Accuracy x 10^{-9} µCi/ml)									
1998	1	0.2+0.03	0.7+0.08	0.4+0.06	0.4+0.06	0.7+0.08	<0.02	0.5+0.07		0.2+0.03	0.2+0.03
	2	0.4+0.05	0.7+0.07	0.6+0.07	0.6+0.07	0.9+0.08	0.4+0.05	0.7+0.07		0.4+0.05	0.4+0.05
1999	1	0.2+0.03	0.5+0.07	0.2+0.04	0.3+0.05	0.4+0.06	0.2+0.04	0.4+0.06		0.3+0.05	0.4+0.06
	2	0.7+0.08	0.7+0.08	0.5+0.06	0.7+0.08	0.8+0.08	0.5+0.06	0.5+0.06		0.5+0.06	0.4+0.05
2000	1	0.5+0.07	1.0+0.11	0.6+0.08	0.8+0.09	0.9+0.10	0.8+0.12	0.9+0.12		0.7+0.08	0.5+0.07
	2	1.2+0.14	1.1+0.11	0.8+0.09	1.2+0.11	1.6+0.14	0.9+0.09	1.1+0.11		1.0+0.10	1.1+0.11
2001	1	0.4+0.06	0.9+0.10	0.3+0.05	0.5+0.08	0.4+0.05	0.4+0.05	0.6+0.08		0.5+0.08	0.5+0.06
	2	0.6+0.09	1.0+0.12	0.9+0.11	[a]	1.7+0.16	1.7+0.16	1.2+0.14		0.5+0.07	0.2+0.04
2002	1	0.5+0.07	0.8+0.11	0.2+0.05	0.3+0.06	0.6+0.09	0.3+0.06	1.7+0.14		0.4+0.07	0.5+0.08
	2	0.5+0.07	0.6+0.08	0.2+0.04	0.2+0.04	0.4+0.06	0.5+0.08	0.8+0.10		0.2+0.04	0.2+0.04
2003	1	0.4+0.07	0.9+0.12	0.4+0.07	0.7+0.10	0.9+0.12	0.9+0.12	1.0+0.12		0.7+0.10	0.5+0.08
	2	3.4+0.24	3.5+0.24	0.5+0.08	0.3+0.05	0.7+0.10	0.5+0.07	3.7+0.25		0.4+0.07	0.3+0.05
2004	1	0.3+0.04	0.4+0.05	0.3+0.04	0.4+0.05	0.7+0.06	0.4+0.05	1.0+0.08		0.2+0.04	0.3+0.04
	2	0.3+0.04	0.5+0.05	0.2+0.03	0.2+0.03	0.6+0.06	0.2+0.04	0.3+0.04		0.2+0.04	0.2+0.2
		0.3+0.04[b]	0.4+0.05[c]			0.6+0.06[d]		0.3+0.04[e]			
2005	1	0.4+0.05	0.6+0.06	0.3+0.04	0.4+0.04	0.7+0.06	0.3+0.04	0.6+0.06		0.2+0.04	0.2+0.03
		0.3+0.04[b]	0.6+0.06[c]			0.8+0.07[d]		0.5+0.05[e]			
	2	0.2+0.03	0.9+0.07	0.2+0.03	0.3+0.04	1.1+0.08	0.3+0.04	0.5+0.05		0.4+0.05	0.4+0.05
		0.4+0.05[b]	0.9+0.07[c]			0.8+0.07[d]		0.6+0.06[e]			
2006	1	0.5+0.05	0.6+0.06	0.3+0.04	0.5+0.05	0.8+0.07	0.5+0.05	0.7+0.06			0.3+0.04
		0.3+0.04[b]	0.8+0.07[c]								
	2	0.3+0.04	0.8+0.07	0.4+0.05	[a]	0.8+0.07	0.4+0.05	0.6+0.06			0.4+0.05
		0.3+0.04[b]	0.7+0.06[c]								
2007	1	0.3+0.04	0.3+0.04	0.3+0.04	0.3+0.04	0.7+0.06	0.4+0.05	0.6+0.06			0.4+0.05
		0.5+0.05[b]	0.7+0.06[c]								
	2	0.5+0.05	0.7+0.06	[a]	0.6+0.06	0.9+0.07	0.4+0.05	0.7+0.06			0.4+0.04
		0.5+0.05[b]	0.7+0.06[c]								
2008	1	0.9+0.07	1.2+0.08	0.8+0.07	1+0.07	1.2+0.08	0.9+0.07	1.3+0.08			0.9+0.07
		0.8+0.06[b]	1.1+0.08[c]								
	2	1.5+0.09	2+0.11	2.1+0.11	2.6+0.12	2.4+0.12	2.1+0.11	1.9+0.1			2.2+0.11
		1.6+0.09[b]	2+0.11[c]								

Table 5.7-14. Ambient Radon Gas Monitoring Results (Cont.)

Monitoring Period		Monitoring Location									
		AM-1	AM-2	AM-3	AM-4	AM-5	AM-6	AM-8	AM-9	AB-3 (AM-3)	AB-6 (AM-6)
Year	Half	Average Radon Concentration - x 10^{-9} μCi/ml (Accuracy x 10^{-9} μCi/ml)									
2009	1	0.2+0.02	0.4+0.04	0.2+0.03	0.4+0.04	0.6+0.05	0.3+0.03	0.5+0.05			0.3+0.03
		0.5+0.05[b]	0.4+0.04[c]								
	2	0.2+0.02	0.2+0.02	0.2+0.02	0.2+0.02	0.4+0.03	0.2+0.02	0.2+0.02			0.2+0.02
		0.2+0.02[b]	0.3+0.02[c]								
2010	1	0.4+0.04	0.5+0.04	0.3+0.03	0.3+0.03	0.5+0.04	0.3+0.03	0.4+0.04			0.3+0.03
		0.4+0.04[b]	0.7+0.06[c]								
	2	0.3+0.03	0.5+0.04	0.4+0.03	0.4+0.03	0.5+0.04	0.5+0.04	0.5+0.04			0.2+0.02
		0.4+0.03[b]	0.7+0.05[c]								
2011	1	0.2+0.02	0.2+0.02	0.2+0.03	0.2+0.02	0.4+0.03	0.2+0.02	0.2+0.02			0.2+0.02
		0.2+0.02[b]	0.2+0.02[c]								
	2	2.3+0.1	1.6+0.08	2.2+0.1	1.5+0.08	0.6+0.04	0.2+0.02	2.1+0.09			1.5+0.08
		2+0.09[b]	1.6+0.08[c]								
2012	1	0.2+0.02	0.3+0.03	0.2+0.03	0.3+0.03	0.6+0.05	0.2+0.02	0.3+0.03			0.2+0.02
		0.2+0.02[b]	0.2+0.02[c]								
	2	0.4+0.03	0.9+0.06	0.5+0.04	0.4+0.03	1+0.06	1.3+0.07	0.5+0.04			1.1+0.06
		0.6+0.04[b]	0.8+0.05[c]								
2013	1	0.6+0.05	0.2+0.02	0.6+0.05	1+0.06	1.1+0.07	1+0.06	0.9+0.06			1+0.07
		0.6+0.05[b]	0.2+0.02[c]								
	2	0.7+0.04	2.5+0.11	2.6+0.11	0.2+0.02	0.3+0.02	0.2+0.02	3+0.12			0.2+0.02
		0.6+0.04	2.9+0.12								
2014	1	0.2+0.02	0.2+0.02	0.2+0.02	0.2+0.02	0.2+0.02	0.2+0.02	0.2+0.02			
	2	0.3+0.03	0.6+0.05	0.3+0.03	0.4+0.04	0.5+0.04	0.4+0.04	0.4+0.04			
2015	1	0.2+0.02	0.2+0.02	0.2+0.02	0.2+0.02	0.2+0.02	0.2+0.02	0.3+0.03	0.3+0.03		
	2	0.3+0.03	0.5+0.04	0.3+0.03	0.3+0.03	0.6+0.05	0.3+0.03	0.5+0.04	0.6+0.05		
2016	1	0.2+0.02	0.4+0.04	0.2+0.02	0.3+0.03	0.2+0.02	0.3+0.04	0.4+0.04	0.4+0.04		
	2	0.3+0.04	0.4+0.05	0.3+0.04	0.3+0.04	0.4+0.05	0.3+0.04	0.3+0.04	0.3+0.04		
2017	1	0.2+0.04	0.3+0.04	0.3+0.04	0.4+0.04	0.3+0.04	0.2+0.04	0.3+0.04	0.3+0.04		
	2	0.3+0.04	0.4+0.04	0.2+0.04	0.3+0.04	0.3+0.04	0.2+0.04	0.3+0.04	0.3+0.04		
2018	1	0.3+0.04	0.5+0.05	0.3+0.04	0.3+0.04	0.2+0.04	0.2+0.04	0.2+0.04	0.2+0.04		
	2	0.2+0.04	0.2+0.04	0.2+0.03	0.3+0.04	0.3+0.04	0.2+0.04	0.2+0.04	0.2+0.04		
2019	1	0.1+0.03	0.1+0.02	0.1+0.02	0.1+0.02	0.1+0.02	0.1+0.03	0.1+0.03	0.1+0.02		
	2	0.3+0.04	0.2+0.03	0.1+0.03	0.2+0.03	0.2+0.04	0.2+0.03	0.2+0.03	0.2+0.03		

Table 5.7-14. Ambient Radon Gas Monitoring Results (Cont.)

Monitoring Period		Monitoring Location									
		AM-1	AM-2	AM-3	AM-4	AM-5	AM-6	AM-8	AM-9	AB-3 (AM-3)	AB-6 (AM-6)
Year	Half	Average Radon Concentration – x 10^{-9} µCi/ml (Accuracy x 10^{-9} µCi/ml)									
2020	1	[f]	[f]	[f]	[f]	[f]	[f]	[f]	[f]		
	2	0.2+0.04	0.2+0.03	0.2+0.03	0.2+0.04	0.2+0.03	0.2+0.04	0.2+0.03	0.2+0.03		
2021	1	0.1+0.03	0.2+0.03	0.2+0.03	0.2+0.03	0.2+0.04	0.2+0.03	0.2+0.03	0.2+0.03		
	2	0.2+0.03	0.2+0.03	0.1+0.03	0.2+0.03	0.2+0.04	0.2+0.03	0.1+0.03	0.2+0.03		
2022	1	0.2+0.04	0.1+0.02	0.1+0.03	0.2+0.03	0.1+0.03	0.1+0.03	0.2+0.03	0.2+0.03		
	2	0.3+0.07	0.3+0.06	0.2+0.06	0.2+0.06	0.3+0.07	0.3+0.07	0.2+0.05	0.2+0.05		
2023	1	0.2+0.05	0.2+0.05	0.2+0.06	0.2+0.06	0.2+0.05	0.2+0.05	0.2+0.06	0.1+0.04		
	2	0.2+0.05	0.3+0.08	0.2+0.06	0.3+0.07	0.3+0.09	0.3+0.07	0.2+0.06	0.2+0.07		

Notes:

Monitoring Locations AB-3 and AB-6 are co-located with stations AM-3 and AM-6 (duplicate sampling locations modified beginning in the second half of 2004).
Samples collected between the first half of 2014 and the first half of 2016 included 2 duplicate samples at each location. In the first half of 2016, CBR began taking 5 duplicate samples each at the background location (AM-6) and highest exposed member of the public location (AM-9). Results reported for locations having duplicate samples after the first half of 2014 are the average of all location samples including duplicates.

[a] Detector damaged/missing from cup – no data.
[b] AB-1 (AM-1 Duplicate)
[c] AB-2 (AM-2 Duplicate)
[d] AB-5 (AM-5 Duplicate)
[e] AB-8 (AM-8 Duplicate)
[f] Track etch data from the first half of 2020 could not be correlated to specific locations due to lab/CBR error. See First Half 2020 Radiological and Effluent Environmental Monitoring Report (ML20248H492).

Table 5.7-15. Annual Soil Sampling Program Results (2015-2023)

Year	AM-1	AM-2	AM-3	AM-4	AM-5	AM-6	AM-7	AM-8	AM-9
Uranium (pCi/g)									
2015	0.4	0.4	0.6	0.6	0.7	0.5	0.5	0.4	0.4
2016	0.57	0.56	0.92	1	1.3	0.74	0.8	0.78	0.57
2017	0.6	0.5	0.6	ND	0.8	0.7	0.6	0.7	0.6
2018	0.3	0.3	0.5	0.6	0.7	0.4	0.4	0.4	0.3
2019	0.6	0.8	0.6	0.8	0.7	0.6	0.6	0.7	0.6
2020	0.3	0.3	0.5	0.5	0.6	0.4	0.4	0.3	0.3
2021	0.6	0.5	0.7	0.8	0.8	0.7	0.7	0.6	0.6
2022	0.4	0.4	0.5	0.5	0.5	0.4	0.3	0.3	0.4
2023	0.3	0.3	0.5	0.7	0.6	0.4	0.4	0.4	0.3
Radium-226 (pCi/g)									
2015	0.4	0.5	1.2	0.6	0.9	0.6	0.7	0.7	0.4
2016	0.3	0.3	0.5	0.1	0.6	0.4	0.5	0.4	0.3
2017	0.7	0.7	1.2	0.9	1	1	1.2	1.2	0.7
2018	0.9	0.9	1	1	1.5	0.8	1	1.1	0.9
2019	1.4	1.1	1.3	0.9	1.2	1.2	1.5	1.5	1.4
2020	0.8	0.8	0.8	1.2	1.1	1	0.8	0.8	0.8
2021	1.1	0.9	1.2	1.1	1.2	1.1	1.4	1.3	1.1
2022	0.9	0.7	0.7	1	1.3	0.9	1.3	0.9	0.9
2023	1	0.6	1.3	1.2	1.1	1.1	1.2	1.2	1
Lead-210 (pCi/g)									
2015	0.4	0.4	1.3	0.7	0.5	1	0.8	0.6	0.4
2016	0.5	0.3	0.6	0.5	0.6	0.4	0.5	0.5	0.5
2017	1.2	1.4	1.6	1.2	2.1	2.2	1.8	1.8	1.2
2018	2.4	2.1	2.6	2.3	2.3	4.7	3.7	1.5	2.4
2019	1.3	1.4	1.4	2	2.3	1.4	1.2	1.2	1.3
2020	0.9	1.2	0.9	1.4	1.6	2.2	0.5	1.2	0.9
2021	1.1	1.1	1.5	1.2	1.5	ND	ND	1.1	1.1
2022	1.6	6.1	5.1	1.3	ND	ND	ND	ND	1.6
2023	1.2	ND	1	1	ND	ND	ND	ND	1.2

ND = below detection limit

Table 5.7-16. Annual Vegetation Sampling Program Results (1992 – 1997)

Sample Date	U-Natural µCi/kg	Ra-226 µCi/kg	Th-230 µCi/kg	Pb-210 µCi/kg	Po-210 µCi/kg
6/9/92	2.90 E-6	2.16 E-6	< 1.00 E-7	1.14 E-4	6.44 E-6
7/10/92	4.06 E-6	9.67 E-6	< 9.67 E-8	5.98 E-5	2.76 E-6
8/13/92	1.47 E-5	2.71 E-6	9.34 E-9	7.34 E-5	9.43 E-6
6/23/93	7.30 E-6	1.80 E-6	< 7.50 E-8	2.30 E-5	< 3.80 E-7
7/20/93	3.90 E-6	< 3.10 E-8	< 3.10 E-8	1.40 E-5	< 1.60 E-7
8/24/93	3.10 E-6	1.80 E-6	1.70 E-8	8.30 E-5	1.80 E-5
6/1/94	1.60 E-5	1.90 E-5	< 8.00 E-8	5.60 E-5	5.20 E-5
7/8/94	5.70 E-6	1.10 E-5	< 6.00 E-8	2.80 E-5	1.90 E-5
8/1/94	1.30 E-5	7.00 E-7	< 4.30 E-8	3.70 E-5	4.40 E-6
6/21/95	4.60 E-6	6.00 E-6	<0.20 E-7	33.0 E-6	3.80 E-6
7/21/95	4.01 E-6	1.02 E-5	<1,50 E-7	4.02 E-5	<7.30 E-7
8/23/95	1.60 E-5	53.0 E-7	30.0 E-7	50.0 E-6	18.0 E-6
6/19/96	9.90 E-6	3.20 E-6	1.29 E-6	10.0 E-6	<1.80 E-7
7/12/96	15.0 E-6	6.50 E-6	1.50 E-6	31.0 E-6	2.00 E-6
8/09/96	53.0 E-6	15.0 E-6	10.8 E-6	66.0 E-6	24.0 E-6
6/10/97	1.00 E-5	5.90 E-6	1.48 E-6	5.60 E-5	4.00 E-4
7/08/97	3.10 E-5	4.20 E-6	1.27 E-6	6.50 E-5	4.90 E-6
8/06/97	4.40 E-5	4.20 E-6	2.30 E-6	1.00 E-4	6.50 E-6

Table 5.7-17. Direct Radiation Area Monitoring Results

Year	Qtr	Cont	AM-1	AM-2	AM-3	AM-4	AM-5	AM-6	AM-8	AM-9	R&D	Well	Well	Comm
		mRem												
1991	1	23.8	30.2	30.6	28.2	31.2	33.0	30.0	28.0	-	29.2	31.8	34.0	-
	2	27.6	29.4	27.6	30.0	30.2	28.2	26.6	27.4	-	28.6	32.2	31.6	30.6
	3	23.8	30.8	27.2	30.8	30.2	29.2	25.8	23.2	-	29.6	34.4	31.4	29.0
	4	36.2	43.2	43.4	45.2	41.8	46.6	46.6	41.6	-	44.0	41.4	54.8	40.4
1992	1	26.6	30.0	31.8	-	34.2	35.0	30.6	41.8	-	29.8	34.0	34.0	32.2
	2	34.6	30.4	29.6	32.6	30.2	33.2	31.0	29.8	-	32.0	33.0	32.4	31.0
	3	35.8	31.4	32.6	36.2	31.6	30.6	30.0	27.4	-	31.2	30.4	33.4	33.0
	4	36.4	28.2	33.4	33.6	30.4	35.6	32.6	35.4	-	35.0	35.4	39.8	31.2
1993	1	42.6	38.4	34.0	32.4	36.8	36.8	33.6	33.2	-	37.0	35.8	40.6	33.6
	2	43.6	29.2	31.6	31.6	25.8	33.6	30.8	31.0	-	29.8	34.4	34.4	30.8
	3	39.8	29.0	27.2	31.4	30.0	28.0	27.6	26.4	-	31.6	29.8	32.8	26.4
	4	49.4	35.8	32.0	33.2	29.8	32.2	34.2	32.2	-	34.4	38.4	33.8	44.4
1994	1	46.8	33.0	32.6	40.2	16.4	39.4	42.2	36.2	-	32.2	27.2	40.0	35.4
	2	59.2	35.8	37.0	38.2	43.2	40.0	36.8	36.0	-	38.6	42.6	45.8	41.2
	3	57.2	29.8	29.4	36.8	35.8	39.2	39.6	32.2	-	38.8	16.0	32.8	37.2
1995	1	46.4	34.2	31.2	30.2	34.4	32.2	33.8	30.6	-	34.8	36.8	36.6	33.0
	2	43.2	30.0	29.8	21.4	25.8	27.0	27.8	23.4	-	28.0	32.4	32.2	25.4
	3	49.4	40.0	34.8	35.6	37.8	34.6	33.2	37.4	-	30.0	39.4	33.8	37.0
	4	40.8	24.6	24.6	25.4	23.2	26.2	25.0	24.6	-	12.0	26.4	28.0	24.2
1996	1	44.8	29.2	28.2	30.4	32.2	31.8	32.2	29.2	-	29.4	30.4	30.2	25.8
	2	46.2	35.0	31.2	34.2	30.6	31.2	33.0	30.6	-	33.2	36.8	35.8	32.2
	3	35.2	35.4	36.0	33.2	35.4	37.4	34.2	30.8	-	32.8	37.4	36.2	32.4
	4	51.8	32.6	31.4	30.0	33.6	30.0	32.6	31.6	-	28.6	40.6	0.0	34.2
1997	1	45.0	28.2	28.2	27.4	18.2	29.4	31.2	26.8	-	26.0	30.8	31.6	29.2
	2	50.0	40.2	29.0	29.6	29.4	30.0	31.0	28.2	-	30.6	32.8	32.6	31.6
	3	60.4	31.6	33.0	35.2	29.2	32.2	31.8	30.0	-	29.8	30.4	30.8	32.0
	4	56.8	34.4	32.0	34.8	34.0	36.6	29.6	32.2	-	32.8	37.2	32.8	30.6
1998	1	48.0	29.8	34.3	31.4	33.6	30.0	34.2	31.8	-	30.2	33.4	30.3	30.6
	2	63.4	34.6	36.0	38.0	34.4	35.4	37.4	36.2	-	-	-	-	-
	3	61.2	26.6	27.4	34.8	29.2	31.0	33.8	25.8	-	-	-	-	-
	4	67.6	33.8	35.8	35.0	34.4	29.0	35.2	38.0	-	-	-	-	-
1999	1	72.2	36.8	33.8	34.6	31.0	40.0	27.0	35.2	-	-	-	-	-
	2	53.8	29.4	29.4	28.8	25.0	29.2	27.0	29.2	-	-	-	-	-
	3	57.8	25.0	29.0	21.6	24.8	27.6	26.2	26.0	-	-	-	-	-
	4	52.2	28.0	32.2	32.4	30.0	32.6	28.6	31.2	-	-	-	-	-

Table 5.7-17. Direct Radiation Area Monitoring Results (Cont.)

Year	Qtr	Cont	AM-1	AM-2	AM-3	AM-4	AM-5	AM-6	AM-8	AM-9	R&D	Well	Well	Comm
		mRem												
2000	1	70.2	35.2	34.8	36.2	30.8	34.2	36.4	38.8	-	-	-	-	-
	2	67.8	29.6	32.2	32.8	30.2	29.4	31.4	36.4	-	-	-	-	-
	3	75.2	30.8	30.6	30.8	30.8	32.0	30.2	33.0	-	-	-	-	-
	4	54.2	32.6	26.0	-	27.4	29.4	27.4	28.6	-	-	-	-	-
2001	1	53.8	33.6	34.6	35.4	35.8	38.8	35.0	35.6	-	-	-	-	-
	2	77.6	55.4	54.6	57.2	55.6	58.0	55.0	59.4	-	-	-	-	-
	3	71.6	41.8	42.8	45.8	43.2	45.8	44.0	44.2	-	-	-	-	-
	4	81.2	47.4	47.6	45.2	45.2	47.0	45.0	48.4	-	-	-	-	-
2002	1	84.0	36.6	35.4	40.6	41.0	42.6	41.0	44.2	-	-	-	-	-
	2	41.8	49.2	49.2	52.8	52.0	51.0	51.4	51.4	-	-	-	-	-
	3	25.4	34.6	32.0	38.2	44.0	34.8	33.8	40.2	-	-	-	-	-
	4	44.2	49.0	47.4	49.6	50.8	52.0	49.0	51.6	-	-	-	-	-
2003	1	44.8	52.2	48.6	49.4	a	49.6	62.6	52.0	-	-	-	-	-
	2	37.4	42.0	43.0	45.0	43.8	47.0	44.2	46.8	-	-	-	-	-
	3	33.8	43.6	44.0	44.0	43.2	45.4	39.0	45.0	-	-	-	-	-
	4	40.6	51.0	49.6	49.0	48.6	48.2	46.4	51.0	-	-	-	-	-
2004	1	40.8	45.8	44.6	45.8	48.6	48.8	48.0	49.4	-	-	-	-	-
	2	34.2	42.2	42.6	41.4	43.8	45.4	43.0	43.8	-	-	-	-	-
	3	35.0	45.0	42.8	46.0	43.2	43.8	45.2	44.8	-	-	-	-	-
	4	40.0	52.4	49.0	49.0	49.2	51.2	49.0	49.8	-	-	-	-	-
2005	1	44.2	53.8	53.6	55.0	53.0	53.0	52.4	55.6	-	-	-	-	-
	2	25.6	36.4	33.4	36.6	36.4	39.4	40.6	36.4	-	-	-	-	-
	3	35.6	40.6	41.4	41.4	37.8	32.0	40.6	42.4	-	-	-	-	-
	4	33.6	41.6	40.0	41.2	42.2	42.4	b	40.6	-	-	-	-	-
2006	1	31.6	36.4	37.8	41.0	39.2	39.8	36.4	39.2	-	-	-	-	-
	2	28.4	35.0	35.2	38.0	32.0	35.8	35.8	36.8	-	-	-	-	-
	3	20.2	25.8	27.0	28.0	27.6	26.8	25.2	28.8	-	-	-	-	-
	4	27.2	34.8	31.8	35.0	32.6	35.4	33.0	35.0	-	-	-	-	-
2007	1	33.0	39.0	40.0	39.0	39.0	39.0	38.0	41.0	-	-	-	-	-
	2	24.0	29.0	30.0	29.0	28.0	27.0	30.0	29.0	-	-	-	-	-
	3	22.0	27.0	28.0	31.0	30.0	31.0	29.0	31.0	-	-	-	-	-
	4	24.0	29.0	30.0	31.0	29.0	30.0	29.0	31.0	-	-	-	-	-
2008	1	27.8	32.6	33.0	34.8	35.9	34.5	37.0	37.1	-	-	-	-	-
	2	35.1	41.3	44.0	43.3	38.5	38.9	44.0	42.5	-	-	-	-	-
	3	36.6	42.7	50.7	45.3	41.7	45.8	44.4	50.0	-	-	-	-	-
	4	27.8	32.6	33.0	34.8	35.9	34.5	37.0	37.1	-	-	-	-	-

Table 5.7-17. Direct Radiation Area Monitoring Results (Cont.)

Year	Qtr	Cont	AM-1	AM-2	AM-3	AM-4	AM-5	AM-6	AM-8	AM-9	R&D	Well	Well	Comm
		mRem												
2009	1	24.8	26.8	30.7	31.3	28.6	31.5	28.1	32.8	-	-	-	-	-
	2	23.6	32.1	31.2	34.0	31.0	35.5	31.8	34.0	-	-	-	-	-
	3	25.6	37.7	32.6	37.3	33.4	36.3	30.1	38.1	-	-	-	-	-
	4	26.9	32.6	32.4	33.8	31.7	34.9	35.0	36.4	-	-	-	-	-
2010	1	24.5	32.5	31.9	30.8	30.0	31.4	34.1	32.3	-	-	-	-	-
	2	29.6	37.8	38.9	39.4	34.2	37.7	37.0	39.7	-	-	-	-	-
	3	27	35.7	35.4	38.8	35.5	38.5	37.3	36.2	-	-	-	-	-
	4	24.1	38.3	30.0	33.9	33.8	35.7	37.3	32.6	-	-	-	-	-
2011	1	25.9	30.8	30.0	29.8	28.9	29.1	31.2	33.4	-	-	-	-	-
	2	26.6	34.3	30.9	34.3	32.8	35.1	33.5	38.8	-	-	-	-	-
	3	26.6	35.2	37.3	39.5	34.0	35.7	37.4	40.2	-	-	-	-	-
	4	27.1	37.1	35.8	36.8	38.2	37.5	33.6	37.8	-	-	-	-	-
2012	1	29.6	32.8	33.7	30.9	30.3	34.9	33.7	33.7	-	-	-	-	-
	2	30.8	36.8	38.6	41.9	37.6	39.1	37.5	45.3	-	-	-	-	-
	3	28.3	39.7	41.0	40.3	37.2	43.0	40.2	43.5	-	-	-	-	-
	4	27.5	35.2	36.9	37.8	33.6	35.9	36.5	40.6	-	-	-	-	-
2013	1	25.9	33.5	34.7	36.1	33.4	34.1	31.4	35.6	-	-	-	-	-
	2	30.8	36.8	38.6	41.9	37.6	39.1	37.5	45.3	-	-	-	-	-
	3	30.6	39.2	35.9	39.7	37.3	40.0	38.4	42.2	-	-	-	-	-
	4	26.0	34.9	34.8	35.6	32.0	34.5	34.3	37.3	-	-	-	-	-
2014	1	29.5	34.7	37.6	33.6	34.8	38.7	36.6	38.7	-	-	-	-	-
	2	31.5	38.1	41.6	41.7	39.3	41.6	40.4	40.5	-	-	-	-	-
	3	30	36.1	35.8	43.0	37.5	38.4	39.5	41.9	-	-	-	-	-
	4	32.1	43.0	45.9	42.9	41.2	42.6	41.8	45.3	-	-	-	-	-
2015	1	27.8	33.0	34.8	35.3	33.9	34.3	36.0	34.7	-	-	-	-	-
	2	31	37.8	39.6	40.5	35.0	39.1	37.6	40.4	-	-	-	-	-
	3	29.8	38.1	38.2	37.4	38.7	36.8	37.4	39.8	37.5	-	-	-	-
	4	30.7	40.7	38.3	39.7	40.6	41.6	41.6	42.3	39.3	-	-	-	-
2016	1	31.7	36.8	38.9	39.1	36.9	37.4	37.9	41.8	39.6	-	-	-	-
	2	35.2	41.7	42.5	41.8	42.3	44.0	41.4	45.2	45.1	-	-	-	-
	3	33.7	39.9	39.6	41.8	39.5	41.7	38.4	43.0	42.5	-	-	-	-
	4	40.0	48.0	45.6	50.2	44.8	45.7	44.0	49.3	44.5	-	-	-	-
2017	1	23	26.7	26.4	28.3	26.0	27.5	25.7	28.8	25.7	-	-	-	-
	2	34.5	40.2	39.0	42.3	40.6	41.4	40.2	41.9	43.0	-	-	-	-
	3	27.2	38.7	42.3	43.6	41.5	44.2	42.0	41.8	42.1	-	-	-	-
	4	25.8	39.2	43.8	39.1	39.7	41.6	37.9	43.2	43.8	-	-	-	-

Table 5.7-17. Direct Radiation Area Monitoring Results (Cont.)

Year	Qtr	Cont	AM-1	AM-2	AM-3	AM-4	AM-5	AM-6	AM-8	AM-9	R&D	Well	Well	Comm
		mRem												
2018	1	29.4	40.1	40.5	40.0	35.8	47.3	42.4	41.7	40.5	-	-	-	-
	2	25.5	36.0	42.5	37.9	37.9	42.4	39.7	45.3	39.1	-	-	-	-
	3	23.3	31.2	38.5	36.4	34.4	37.0	35.5	35.7	38.6	-	-	-	-
	4	25.6	38.2	34.8	40.0	35.3	38.6	37.5	38.8	39.4	-	-	-	-
2019	1	22.2	32.0	30.3	33.6	32.5	33.7	33.4	34.0	33.6	-	-	-	-
	2	26.9	28.7	37.7	40.3	37.2	40.4	39.7	38.8	37.3	-	-	-	-
	3	25.3	40.3	38.2	39.2	38.6	41.8	40.8	37.6	41.9	-	-	-	-
	4	27.3	42.8	39.6	47.1	42.6	42.2	40.4	43.2	38.2	-	-	-	-
2020	1	23.8	35.8	36.9	39.9	33.7	35.4	38.1	35.5	37.0	-	-	-	-
	2	26.5	38.3	38.0	40.8	37.2	38.3	37.1	40.6	39.5	-	-	-	-
	3	24.9	38.9	34.6	36.8	36.6	38.2	40.0	37.3	38.6	-	-	-	-
	4	23.7	37.8	37.3	41.4	37.0	37.0	38.7	38.7	37.8	-	-	-	-
2021	1	25.0	36.9	34.1	35.1	36.7	37.8	34.3	38.3	37.6	-	-	-	-
	2	19.4	32.8	34.0	34.8	34.2	34.1	33.3	36.6	32.2	-	-	-	-
	3	21.0	31.2	34.3	36.6	33.2	35.8	35.5	34.8	37.8	-	-	-	-
	4	23.4	36.8	39.0	38.3	34.2	39.6	36.7	42.6	38.6	-	-	-	-
2022	1	15.0	31.1	31.4	33.3	29.0	30.3	29.1	31.6	31.7	-	-	-	-
	2	25.3	35.9	38.9	38.6	36.8	39.5	37.5	40.0	40.1	-	-	-	-
	3	21.5	37.1	37.7	36.3	35.9	36.0	32.4	38.9	36.5	-	-	-	-
	4	25.6	40.3	33.1	40.4	41.2	41.1	38.5	45.0	36.6	-	-	-	-
2023	1	22.7	34.4	32.4	33.9	33.5	33.1	36.3	30.9	35.6	-	-	-	-
	2	29.3	40.3	41.3	42.2	39.5	41.5	37.6	38.3	42.8	-	-	-	-
	3	29.3	41.8	37.1	42.2	41.8	35.5	40.5	36.2	39.8	-	-	-	-
	4	22.7	38.0	36.2	36.7	34.1	36.9	34.3	40.9	33.2	-	-	-	-

Sample Locations: Cont: Control
R&D: R&D Pond Gate
Well: Wellfield
Well: Wellfield
Comm: Commercial Pond Gate

[a] Received damage by laboratory.
[b] Dosimeter not returned to laboratory.

Table 5.7-18. Annual Sediment Sampling Results

Year	S-1	S-2	S-3	S-5	E-1 & E-2 Composite	E-4	E-5	I-3	I-4	I-5
U-Natural (mg/L)										
1996	0.13	0.73	1.13							
1997	0.45	0.5	0.56							
1998	0.5	0.02		0.54		9.8				
1999	0.48	0.5		0.55	3.7	6.30				
2000	0.38	0.7		0.31	1.66	2.13				
2001	0.44	0.44		0.45	0.45	2.83				
2002	0.43	0.48		0.39	2.11		0.87	1.09	4.16	
2003	0.61	0.3		0.34	3.72		1.20	1.15	7.1	
2004	0.05	0.71		0.03	0.13		0.11	0.13	0.07	
2005	0.45	0.33		0.32	1.99		1.64	4.23	2.75	
2006	1.04	0.49		0.24	1.81		2.58	5.85	13.6	2.94
2007	7.21	0.39		1.56	2.95		4.29	5.33	17.5	2.11
2008	0.5	0.74		0.6	13		1.9	4.6	8.1	1
2009	0.9	0.03		0.7	7.1		1.7	3.2	0.2	0.9
2010	0.9	0.33		0.9	13		2	17	0.9	4.9
2011	0.6	0.57	Relocated	0.7	3.2		1.3	2.7	1.3	1.3
2012	0.7	1.78		ND	24.5	Relocated	ND	12.9	10.9	6.8
2013	0.7	0.7		ND	4.1		ND	2.8	1.5	1.4
2014	0.5	0.4		0.8	19		4.5	2.1	2	2.6
2015	0.7	0.7		0.7	5.3		5.3	1.7	0.5	1.9
2016	0.42	0.8		0.46	2.18		1.93	3.57	1.5	1.06
2017	1.5	ND		0.4	2		2	11.3	0.5	0.9
2018	0.5	ND		0.5	1.5		0.7	2.9	1.6	1.6
2019	1.6	1		0.7	8.7		2	2.1	0.8	2.2
2020	0.4	1		0.6	4.2		2.1	5	1.2	1.8
2021	0.5	0.37		0.5	4.5		1.5	10.3	1.9	0.7
2022	0.7	0.4		0.6	17.3		2	2.7	2.1	1
2023	0.6	0.4		0.7	2.2		1.8	1.9	1.7	1.8

Table 5.7-18. Annual Sediment Sampling Results (Cont.)

Year	S-1	S-2	S-3	S-5	E-1 & E-2 Composite	E-4	E-5	I-3	I-4	I-5
Radium-226 (pCi/g)										
1996	0.2	0.2	0.6							
1997	0.4	0.1	0.6							
1998	0.6	0.7	Relocated	0.5		1.3				
1999	0.37	0.4		0.39	0.85	0.64				
2000	0.31	0.4		0.37	0.63	0.35				
2001	0.61	0.4		0.51	0.62	0.53				
2002	0.4	0.4		0.2	0.7	Relocated	0.50	0.7	0.5	
2003	0.4	0.9		0.4	0.6		0.40	0.6	0.6	
2004	0.4	0.43		0.4	0.8		0.50	0.5	0.6	
2005	0.3	0.35		0.6	0.8		0.7	0.7	0.6	
2006	0.6	0.44		0.3	0.9		0.90	1.0	0.5	0.3
2007	2.8	0.4		0.4	0.7		0.4	0.5	1.4	0.5
2008	0.3	0.4		0.3	0.3		0.6	0.8	0.3	0.2
2009	0.3	0.4		0.5	1.0		0.4	0.7	1.1	0.7
2010	0.3	0.6		0.06	0.0		0.04	0.6	0.2	0.03
2011	0.5	0.5		0.5	0.9		0.6	0.6	0.4	0.7
2012	0.3	0.6		0.4	0.6		0.7	0.6	0.1	0.4
2013	0.6	ND		0.6	1.5		1.6	1.2	1.2	1.2
2014	0.7	0.5		0.8	0.8		0.8	1.4	0.9	1.2
2015	0.5	0.2		0.6	0.8		0.8	0.8	0.9	0.7
2016	0.3	0.5		0.3	0.7		0.9	0.5	0.5	0.6
2017	0.4	0.3		0.4	0.7		0.5	0.4	0.4	0.5
2018	0.8	0.4		0.8	1.1		1.4	1.2	0.9	0.6
2019	0.3	0.4		0.7	1.3		0.9	0.9	1	0.9
2020	0.4	0.5		1	1.5		0.9	0.8	1	0.6
2021	0.8	0.4		0.5	1.7		1.3	0.2	1.1	1
2022	0.5	0.3		1.1	1.4		1.1	1	1.4	1.1
2023	1	0.6		0.6	1.4		1.3	1.3	1.2	1.6

Table 5.7-18. Annual Sediment Sampling Results (Cont.)

Year	S-1	S-2	S-3	S-5	E-1 & E-2 Composite	E-4	E-5	I-3	I-4	I-5
Thorium-230 (pCi/g)										
1996	0.1	0.2	0.3							
1997	0.17	-	0.32							
1998	-	0.02	Relocated	-		-				
1999	-	0.4		-	-	-				
2000	-	0.3		-	-	-				
2001	-	0.2		-	-	-				
2002	-	0.22		-	-	Relocated	-	-	-	
2003	-	-		-	-		-	-	-	
2004	-	-		-	-		-	-	-	
2005	-	-		-	-		-	-	-	
2006	-	-		-	-		-	-	-	-
2007	-	-		-	-		-	-	-	-
2008	-	-		-	-		-	-	-	-
2009	-	-		-	-		-	-	-	-
2010	-	-		-	-		-	-	-	-
2011	-	-		-	-		-	-	-	-
2012	0.3	-		0.2	ND		0.5	0.4	ND	-
2013	0.6	-		0.4	ND		0.7	<0.2	ND	ND
2014	0.2	-		0.2	0.3		<0.2	0.3	0.5	<0.2
2015	<0.2	-		<0.2	<0.2		0.3	0.3	0.1	0.2
2016	0.4	-		0.2	0.1		0.2	0.2	0.3	0.4
2017	0.2	ND		0.2	0.2		0.3	0.2	0.3	0.2
2018	0.4	ND		0.6	0.6		0.6	0.3	0.8	1.3
2019	0.5	0.3		0.4	0.6		0.4	0.5	0.5	<0.2
2020	0.23	0.3		0.27	0.1		0.3	0.4	0.29	0.26
2021	0.2	0.2		0.2	0.5		0.5	0.23	0.8	0.2
2022	0.5	0.3		0.3	0.29		0.23	0.25	0.5	0.2
2023	ND	0.5		0.29	0.27		0.21	0.4	0.4	0.6

Table 5.7-18. Annual Sediment Sampling Results (Cont.)

Year	S-1	S-2	S-3	S-5	E-1 & E-2 Composite	E-4	E-5	I-3	I-4	I-5
Lead-210 (pCi/g)										
1996	0.1	0.6	0.7							
1997	0.5		0.8							
1998	0.4	0.3		0.4		1.5				
1999	0.05	1.9		0.05	1.4	1.32				
2000	0.05	0.1		0.05	0.05	0.05				
2001	0.87	0.1		0.48	0.44	0.45				
2002	ND	0.7		0.2	ND		ND	ND	ND	
2003	ND	0.05		0.5	ND		ND	ND	ND	
2004	ND	0.05		ND	ND		1.4	ND	ND	
2005	ND	0.05		ND	ND		1.4	ND	ND	
2006	1.3	ND		ND	0.4		1.0	1.6	1.6	2.4
2007	2.00	ND		0.6	1.0		0.8	1.1	3.2	1.2
2008	0.40	0.5		0.6	0.9		1.4	ND	1.3	0.4
2009	ND	ND		0.04	0.04		0.1	ND	0.04	ND
2010	ND	ND	Relocated	0.3	0.8		0.4	ND	0.3	ND
2011	0.7	0.3		0.3	1.3		0.6	0.6	0.4	0.7
2012	0.5	0.7		0.4	1	Relocated	0.5	2.2	1.6	0.7
2013	1.1	0.5		0.9	1.6		1.1	1.1	0.9	0.9
2014	0.5	0.03		0.8	1.6		2.1	0.6	0.8	0.5
2015	0.5	0.5		0.3	0.9		1.1	<0.2	0.2	0.6
2016	0.4	0.8		0.2	1.2		1.3	1.2	0.5	0.5
2017	0.4	0.6		0.3	1.1		1.7	1.4	0.7	0.6
2018	1.3	1.1		0.7	1.4		2.5	2.9	3.3	1.7
2019	1.2	0.5		1.1	2.1		2.5	1.6	0.8	0.8
2020	0.4	0.7		1.9	0.4		2	1	2.7	1.2
2021	1	0.6		1.1	1.7		1.2	2.4	1.4	1.2
2022	4.6	0.3		1.2	1.1		1.9	ND	1.1	7.2
2023	ND	1.5		ND	1.9		1.2	1.2	ND	1.2

Notes:
- Denotes that no analysis was done for the listed parameter.
ND – Non-detect [0.2 pCi/g – dry]

Table 5.7-19. Estimated Effluent Emissions (1995 – 2015)

Year	1995	1996	1997	1998	1999	2000	2001
1st Quarter [Leaching]	856	896	899	1,061	1,148	1,100	1,109
2nd Quarter [Leaching]	890	882	917	1,150	1,114	1,073	1,086
Startup	2.6	11	10	18	2	11	20
Semi-Annual Total • Leaching • Restoration Total	 1,749 -- 1749	 1,789 -- 1789	 1,826 201 2,027	 2,229 170 2,399	 2,264 79 2,343	 2,184 139 2,323	 2,215 129 2,344
3rd Quarter	895	926	951	1,100	1,105	1,110	1,076
4th Quarter	888	939	1,133	1,101	1,120	1,152	1,082
Startup	5	8	9	9	10	29	7.6
Semi-Annual Total • Leaching • Restoration Total	 1,788 -- 	 1,873 335 2,208	 2,093 55 2,148	 2,210 131 2,341	 2,235 96 2,331	 2,291 146 2,437	 2,166 123 2,289
Annual Total	3,537	3,997	4,175	4,740	4,674	4,760	4,633
Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
1st Quarter [Leaching]	1,066	1,089	1,048	1,057	1,046	1,069	987
2nd Quarter [Leaching]	1,113	1,086	1,059	1,063	1,107	1,106	946
Startup	15	08	14	9	13	11	15
Semi-Annual Total • Leaching • Restoration Total	 2,195 115 2,310	 2,183 136 2,319	 2,121 158 2,279	 2,129 205 2,334	 2,166 86 2,253	 2,186 133 2,318	 1,948 39 1,987
3rd Quarter	1,119	1,107	1,076	1,020	1,129	1,040	1,042
4th Quarter	1,098	1,083	1,094	1,036	1,110	1,087	1,273
Startup	20	21	17	16	09	12	13
Semi-Annual Total • Leaching • Restoration Total	 2,237 128 2,365	 2,211 85 2,296	 2,187 205 2,392	 2,072 111 2,183	 2,248 106 2,354	 2,139 47 2,186	 2,328 98 2,427
Annual Total	4,675	4,615	4,671	4,517	4,607	4,504	4,414
Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
1st Quarter [Leaching]	1,464	1,689	1,598	1,649	1,727	1,711	1,385
2nd Quarter [Leaching]	1,586	1,759	1,561	1,653	1,757	1,709	1,389
Startup	14	11	14	8	7	9	0
Semi-Annual Total • Leaching • Restoration Total	 3,064 127 3,191	 3,458 355 3,814	 3,173 289 3,462	 3,310 292 3,603	 3,492 425 3,917	 3,429 418 3,847	 2,774 309 3,083
3rd Quarter	1,772	1,794	1,677	1,557	1,746	1,668	1,420
4th Quarter	1,745	1,554	1,672	1,706	1,689	1,573	1,396
Startup	7	10	9	13	16	2	0
Semi-Annual Total • Leaching • Restoration Total	 3,525 219 3,744	 3,359 377 3,735	 3,359 298 3,657	 3,276 272 3,548	 3,452 373 3,825	 3,243 431 3,674	 2,815 388 3,203
Annual Total	6,935	7,549	7,119	7,151	7,742	7,521	6,286

Table 5.7-20. Estimated Effluent Emissions (2016 – 2023)

Reporting Period	Source	Radon Progeny (Ci)	Radon Gas (Ci)	Particulate (Ci)	Total by Source (Ci)	% by Source
1H16	Plant Floor Vents	0.23	1.27	3.70E-5	1.5	0.0%
	Wellhouses	0.13	1.52	6.09E-5	1.6	0.0%
	Wellheads	N/A	2.42E-5	N/A	2.42E-5	0.0%
	Plant Tanks/Vents	465.1	6,278.2	N/A	6,743	100%
	Spills	0	0	0	0	0.0%
	Deepwells	N/A	N/A	5.62E-7	5.62E-7	0.0%
	TOTAL	465	6281	9.79E-5	6,746.5	100%
2H16	Plant Floor Vents	0.21	1.43	1.10E-4	1.64	0.0%
	Wellhouses	0.11	2.57	1.32E-5	2.67	0.1%
	Wellheads	N/A	1.10E-4	N/A	1.10E-4	0.0%
	Plant Tanks/Vents	79.2	4,737.1	N/A	4,816.3	99.9%
	Spills	N/A	4.10E-3	N/A	4.10E-3	0.0%
	Deepwells	N/A	N/A	3.29E-7	3.29E-7	0.0%
	TOTAL	79.54	4,741.1	1.23E-4	4,820.61	100%
1H17	Plant Floor Vents	0.28	2.05	5.14E-5	2.33	0.0%
	Wellhouses	0.15	5.48	1.48E-5	5.63	0.1%
	Wellheads	N/A	0	N/A	0	0.0%
	Plant Tanks/Vents	81.8	4,720.0	N/A	4,801.8	99.8%
	Spills	N/A	1.18E-2	N/A	1.18E-2	0.0%
	Deepwells	N/A	N/A	4.50E-7	4.50E-7	0.0%
	TOTAL	82.20	4,727.55	6.67E-5	4809.75	100%
2H17	Plant Floor Vents	0.16	1.62	5.14E-5	1.78	0.0%
	Wellhouses	0.17	3.76	1.91E-5	3.94	0.1%
	Wellheads	N/A	0	N/A	0	0.0%
	Plant Tanks/Vents	73.7	4,152.0	N/A	4,225.7	99.9%
	Spills	N/A	7.33E-2	N/A	7.33E-2	0.0%
	Deepwells	N/A	N/A	5.81E-7	5.81E-7	0.0%
	TOTAL	73.99	4,157.5	7.11E-5	4,231.49	100%
1H18	Plant Floor Vents	0.12	1.53	3.66E-5	1.66	0.2%
	Wellhouses	0.07	1.96	1.66E-5	2.03	0.2%
	Wellheads	N/A	N/A	N/A	N/A	0.0%
	Plant Tanks/Vents	51.3	1,016.3	N/A	1,067.6	99.7%
	Spills	N/A	0	N/A	NA	0.0%
	Deepwells	N/A	N/A	9.18E-7	9.18E-7	0.0%
	TOTAL	51.46	1,019.78	5.42E-5	1,071.24	100%
2H18	Plant Floor Vents	0.17	2.96	3.66E-5	3.13	0.6%
	Wellhouses	0.09	1.67	5.80E-5	1.76	0.3%
	Wellheads	N/A	N/A	N/A	N/A	0.0%
	Plant Tanks/Vents	33.8	469.3	N/A	503.1	99.0%
	Spills	N/A	1.10E-3	N/A	1.10E-3	0.0%
	Deepwells	N/A	N/A	1.13E-6	1.13E-6	0.0%
	TOTAL	34.06	473.9	9.57E-5	507.95	100%
1H19*	Plant Floor Vents	0.12	2.05	5.74E-5	2.17	0.5%
	Wellhouses	0.14	3.95	2.43E-5	4.09	0.9%
	Plant Tanks/Vents	39.8	433.2	N/A	473.0	98.7%
	Spills	N/A	0	N/A	0	0.0%
	Deepwells	N/A	N/A	7.06E-7	7.06E-7	0.0%
	TOTAL	40.03	439.22	8.25E-5	479.25	100%

Table 5.7-20. Estimated Effluent Emissions (2016 – 2023) (Cont.)

Reporting Period	Source	Radon Progeny (Ci)	Radon Gas (Ci)	Particulate (Ci)	Total by Source (Ci)	% by Source
2H19	Plant Floor Vents	0.23	6.38	5.74E-5	6.61	2.0%
	Wellhouses	0.18	2.76	2.05E-5	2.94	0.9%
	Plant Tanks/Vents	23.7	293.7	N/A	317.4	97.1%
	Spills	N/A	2.8E-2	N/A	2.82E-2	0.0%
	Deepwells	N/A	N/A	9.35E-7	9.35E-7	0.0%
	TOTAL	24.10	302.9	7.89E-5	327.02	
1H20	Plant Floor Vents	0.25	2.05	1.49E-5	2.30	0.4%
	Wellhouses	0.17	0.00	1.50e-5	0.17	0.0%
	Plant Tanks/Vents	29.5	566.3	N/A	595.8	99.6%
	Spills	N/A	1.55E-1	N/A	1.55E-1	0.0%
	Deepwells	N/A	N/A	3.72E-7	3.72E-7	0.0%
	TOTAL	29.93	568.53	3.03E-5	598.46	
2H20	Plant Floor Vents	0.31	4.09	1.49E-5	4.40	1.0%
	Wellhouses	0.18	1.80	2.72E-5	1.98	0.4%
	Plant Tanks/Vents	23.5	427.2	N/A	450.7	98.6%
	Spills	N/A	2.82E-2	N/A	2.82E-2	0.0%
	Deepwells	N/A	N/A	5.22E-07	5.22E-7	0.0%
	TOTAL	23.98	433.1	4.26E-05	457.07	
1H21	Plant Floor Vents	0.25	2.53	3.86E-5	2.78	1.3%
	Wellhouses	0.20	1.41	2.75E-5	1.61	0.7%
	Plant Tanks/Vents	19.2	191.6	N/A	210.7	98.0%
	Spills	N/A	3.17E-5	N/A	3.17E-5	0.0%
	Deepwells	N/A	N/A	1.14E-6	1.14E-6	0.0%
	TOTAL	19.64	195.50	6.73E-5	215.14	100%
2H21	Plant Floor Vents	0.21	1.82	3.86E-5	2.03	0.4%
	Wellhouses	0.10	1.31	3.14E-5	1.41	0.3%
	Plant Tanks/Vents	28.0	452.1	N/A	480.1	99.3%
	Spills	N/A	3.33E-05	N/A	3.33E-2	0.0%
	Deepwells	N/A	N/A	1.07E-6	1.07E-6	0.0%
	TOTAL	28.27	455.3	7.11E-5	483.58	100%
1H22	Plant Floor Vents	0.18	2.24	2.78E-5	2.42	0.5%
	Wellhouses	0.10	0.94	2.86E-5	1.04	0.2%
	Plant Tanks/Vents	18.8	456.7	N/A	475.5	99.3%
	Spills	N/A	1.39E-4	N/A	1.39E-4	0.0%
	Deepwells	N/A	N/A	7.14E-7	7.14E-7	0.0%
	TOTAL	19.07	459.92	5.71E-5	478.98	100%
2H22	Plant Floor Vents	0.22	1.76	2.78E-5	1.98	0.7%
	Wellhouses	0.09	1.31	3.67E-5	1.40	0.5%
	Plant Tanks/Vents	20.4	273.7	N/A	294.1	98.9%
	Spills	N/A	2.95E-3	N/A	2.95E-3	0.0%
	Deepwells	N/A	N/A	7.52E-7	7.52E-7	0.0%
	TOTAL	20.67	276.8	6.53E-5	297.46	100%
1H23	Plant Floor Vents	0.17	1.43	1.25E-5	1.60	0.5%
	Wellhouses	0.08	1.33	1.95E-5	1.41	0.5%
	Plant Tanks/Vents	13.1	289.2	N/A	302.3	99.0%
	Spills	N/A	4.34E-3	N/A	4.34E-3	0.0%
	Deepwells	N/A	N/A	4.23E7	4.23E-7	0.0%
	TOTAL	13.32	291.97	3.24E-5	305.28	100%

Table 5.7-20. Estimated Effluent Emissions (2016 – 2023) (Cont.)

Reporting Period	Source	Radon Progeny (Ci)	Radon Gas (Ci)	Particulate (Ci)	Total by Source (Ci)	% by Source
2H23	Plant Floor Vents	0.20	1.30	1.25E-5	1.50	0.5%
	Wellhouses	0.15	1.45	2.95E-5	1.60	0.6%
	Plant Tanks/Vents	19.4	262.0	N/A	281.5	98.9%
	Spills	N/A	0	N/A	0	0.0%
	Deepwells	N/A	N/A	2.67E-7	2.67E-7	0.0%
	TOTAL	19.76	264.8	4.23E-5	284.55	100%

Note: * In the 1st Half of 2019, CBR stopped injecting oxygen into the injection stream. As a result no production wells became overpresssurized and required bleeding. Therefore, no radon samples have been collected from the wellheads since the 2nd Half of 2018.

Table 5.7-21. Maximum and Average Contribution of Annual Emissions

Source	Radon Progeny	RnP % Contribution to total	Radon Gas	RnP % Contribution to total	Particulate	Particulate % Contribution to total
Plant Maximum	0.56	0.066%	8.43	1.045%	1.15E-04	0.000%
Plant Average	0.40	0.040%	4.51	0.478%	5.34E-05	0.000%
Wellhouses Maximum	0.35	0.042%	9.25	0.832%	3.81E-05	0.000%
Wellhouses Average	0.25	0.025%	4.142222	0.336%	2.34E-05	0.000%
Tanks/Vents Maximum	544.37	11.586%	11015.25	98.129%	N/A	0.000%
Tanks/Vents Average	120.563	5.953%	2834.24	93.164%	N/A	N/A
Spills Maximum	N/A	N/A	1.83E-01	0.023%	N/A	N/A
Spills Average	N/A	N/A	4.69E-02	0.005%	N/A	N/A
Deepwells Maximum	N/A	N/A	N/A	N/A	2.21E-06	0.000%
Deepwells Average	N/A	N/A	N/A	N/A	1.36E-06	0.000%

Emissions in Ci/Year
Note: Wellheads were excluded due to lack of data.

Table 5.7-22. Total Tank Vent Effluent (RnP and RnG Emissions from Tank Vents) 2016-2024

Location	Average Percent RnG of Total	Average Percent RnP of Total	Maximum Percent RnG of Total	Maximum Percent RnP of Total
6 - Pond Water Treat. Fan	0.57%	0.06%	4.13%	0.32%
7 - Chem Mix Demister Fan	6.33%	3.00%	37.73%	0.15%
8 - Waste Tank Blower	4.85%	0.20%	26.25%	1.57%
10 - Precip Demister Fan	0.59%	0.01%	4.72%	0.13%
11 - Shaker Deck Blower	0.64%	0.13%	7.84%	2.02%
13 - Eluent Tank Blower	0.73%	0.02%	3.82%	0.14%
14 - Precip A Blower	0.00%	0.00%	0.00%	0.00%
15 - East Train, 16 - West Train, 17 - Backwash Tank Blower	50.17%	3.60%	50.17%	3.60%

Table 5.7-23. Crow Butte Project Excursion Summary

Monitor Well ID	Date On Excursion	Date Off Excursion	Causal Factor(s)
CM6-6	July 1, 1999	September 23, 1999	Excursion of mining solutions due to imbalance between wellhouses.
PR-15	January 13, 2000	March 23, 2000	Mine Unit 1 interior monitor well affected by adjacent groundwater restoration (unrelated to mining activities)
SM6-18	March 6, 2000	April 11, 2001	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
IJ-13	April 20, 2000	July 20, 2000	Mine Unit 1 interior monitor well affected by adjacent groundwater restoration (unrelated to mining activities)
SM7-23	April 27, 2000	November 27, 2001	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-28	May 25, 2000	June 22, 2000	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-13	May 25, 2000	July 20, 2000	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-12	September 8, 2000	November 2, 2000	Surface leak
SM6-13	March 1, 2001	April 12, 2001	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM7-23	December 4, 2001	January 9, 2004	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
CM6-7	April 4, 2002	April 25, 2002	Excursion of mining solutions
CM5-11	September 10, 2002	June 3, 2003	Excursion of mining solutions
IJ-13	December 26, 2002	March 29, 2011	Mine Unit 1 interior monitor well affected by adjacent groundwater restoration (unrelated to mining activities)
PR-8	December 23, 2003	July 27, 2010	Mine Unit 1 interior monitor well affected by adjacent groundwater restoration (unrelated to mining activities)
CM5-19	May 2, 2005	July 26, 2005	Excursion of mining solutions
SM6-28	June 16, 2005	July 5, 2005	High water table due to heavy spring rains (unrelated to mining activities)
SM6-12	June 27, 2005	July 26, 2005	High water table due to heavy spring rains (unrelated to mining activities)
CM9-16	August 4, 2005	November 8, 2005	Excursion of mining solutions
CM8-21	January 18, 2006	April 4, 2006	Excursion of mining solutions
PR-15	September 26, 2006	February 1, 2011	Mine Unit 1 interior monitor well affected by adjacent groundwater restoration (unrelated to mining activities)
CM9-5	May 15, 2008	June 24, 2008	Excursion of mining solutions
CM9-3	May 30,2008	July 15, 2008	Excursion of mining solutions
SM6-20	April 27, 2009	August 25, 2009	High water table due to heavy spring rains (unrelated to mining activities)
CM9-4	June 11, 2009	July 21, 2009	Excursion of mining solutions
SM8-6	April 13, 2010	August 31, 2010	High water table due to heavy spring rains (unrelated to mining activities)

Table 5.7-23. Crow Butte Project Excursion Summary (Cont.)

Monitor Well ID	Date On Excursion	Date Off Excursion	Causal Factor(s)
SM6-23	June 17, 2010	July 29, 2010	High water table due to heavy spring rains (unrelated to mining activities)
SM6-28	June 17, 2010	July 29, 2010	High water table due to heavy spring rains (unrelated to mining activities)
SM8-28	June 17, 2010	August 12, 2010	High water table due to heavy spring rains (unrelated to mining activities)
SM8-5	June 22, 2010	August 3, 2010	High water table due to heavy spring rains (unrelated to mining activities)
SM6-21	June 22, 2010	August 10, 2010	High water table due to heavy spring rains (unrelated to mining activities)
CM8-12	July 09, 2010	August 19, 2010	Excursion of mining solutions
CM8-8	March 16, 2011	June 29, 2011	Excursion of mining solutions
SM6-20	May 23, 2011	July 26, 2011	High water table due to heavy spring rains (unrelated to mining activities)
SM8-6	May 25, 2011	August 23, 2011	High water table due to heavy spring rains (unrelated to mining activities)
SM6-28	May 27, 2011	July 20, 2011	High water table due to heavy spring rains (unrelated to mining activities)
SM8-28	May 27, 2011	July 20, 2011	High water table due to heavy spring rains (unrelated to mining activities)
IJ13P	October 5, 2011	February 21, 2012	Excursion of mining solutions
CM11-10	September 11, 2013	November 5, 2013	Excursion of mining solutions
SM10-18	December 10, 2013	February 3, 2013	Operator error (unrelated to mining activities)
CM8-28	May 8, 2014	June 17, 2014	Excursion of mining solutions
SM8-6	May 20, 2014	July 8, 2014	High water table due to heavy spring rains (unrelated to mining activities)
SM10-18	July 22, 2014	September 16, 2014	Surface drainage issues (unrelated to mining activities)
CM11-3	February 11, 2015	March 31, 2015	Excursion of mining solutions
CM11-10	November 19, 2015	February 9, 2016	Excursion of mining solutions
SM6-23	May 21, 2015	July 9, 2015	High water table due to heavy spring rains (unrelated to mining activities)
SM6-24	August 13, 2015	September 3, 2015	High water table due to heavy spring rains (unrelated to mining activities)
SM6-28	May 21, 2015	August 3, 2015	High water table due to heavy spring rains (unrelated to mining activities)
SM8-5	June 3, 2015	July 28, 2015	High water table due to heavy spring rains (unrelated to mining activities)
SM8-6	May 19, 2015	July 7, 2015	High water table due to heavy spring rains (unrelated to mining activities)
SM8-21	May 28, 2015	June 17, 2015	High water table due to heavy spring rains (unrelated to mining activities)
SM8-21	July 9, 2015	July 29, 2015	High water table due to heavy spring rains (unrelated to mining activities)

Table 5.7-23. Crow Butte Project Excursion Summary (Cont.)

Monitor Well ID	Monitor Well ID	Monitor Well ID	Monitor Well ID
SM8-28	May 21, 2015	August 3, 2015	High water table due to heavy spring rains (unrelated to mining activities)
SM10-18	April 14, 2015	June 2, 2015	Operator error (unrelated to mining activities)
SM10-20	October 27, 2015	December 8. 2015	Operator error (unrelated to mining activities)
SM10-21	May 27, 2015	July 29, 2015	Operator error (unrelated to mining activities)
SM 10-21	October 29, 2015	February 18, 2016	Operator error (unrelated to mining activities)
SM 6-23	April 21, 2016	June 30, 2016	High water table due to heavy spring rains (unrelated to mining activities)
SM6-28	May 5, 2016	July 28, 2016	High water table due to heavy spring rains (unrelated to mining activities)
SM8-28	May 5, 2016	May 23, 2016	High water table due to heavy spring rains (unrelated to mining activities)
SM10-18	August 29, 2017	October 24. 2017	Operator error (unrelated to mining activities)
CM11-11	November 28, 2018	January 30, 2019	Excursion of mining solutions
SM8-28	June 1, 2018	July 19, 2018	High water table due to heavy spring rains (unrelated to mining activities)
SM6-23	May 2, 2019	August 20, 2019	High water table due to heavy spring rains (unrelated to mining activities)
SM6-28	May 2, 2019	January 28, 2020	High water table due to heavy spring rains (unrelated to mining activities)
SM8-21	June 5, 2019	July 17, 2019	High water table due to heavy spring rains (unrelated to mining activities)
SM8-25	March 27, 2019	September 4, 2019	High water table due to heavy spring rains (unrelated to mining activities)
SM8-28	April 22, 2019	August 21, 2019	High water table due to heavy spring rains (unrelated to mining activities)
SM10-17	April 9, 2019	May 21, 2019	High water table due to heavy spring rains (unrelated to mining activities)
SM10-28A	March 25, 2019	May 14, 2019	High water table due to heavy spring rains (unrelated to mining activities)
SM6-28	May 29, 2020	July 8, 2020	High water table due to heavy spring rains (unrelated to mining activities)
SM8-25	May 20, 2020	July 8, 2020	High water table due to heavy spring rains (unrelated to mining activities)

Notes: Impacts on groundwater quality are discussed in Section 7.2-6.

Table 5.7-24. Private Wells with 1-km of Wellfields Groundwater Monitoring Results - Uranium

Year	Qtr	Well #8	Well #11	Well #12	Well #24	Well #25	Well #26	Well #28	Well #38	Well #41	Well #61	Well #63	Well #66	Well #125	Well #129	Well #131	Well #133	Well #134	Well #135	Well #138	Well #140	Well #435	Well #445	Drinking Water Well
		(mg/L)																						
1991	1	-	-	-	-	0.0036	0.0045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	0.014	0.003	-	-	-	-	-	-	0.003	0.003	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	0.0049	0.0059	-	-	-	-	-	-	0.0059	0.0069	-	-	-	-	-	-	-	-	-
	4	-	-	-	-	0.0041	0.0062	-	-	-	-	-	-	0.0021	0.0052	-	-	-	-	-	-	-	-	-
1992	1	-	-	-	-	0.005	0.007	-	-	-	-	-	-	0.005	0.004	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	0.004	0.004	-	-	-	-	-	-	0.004	0.004	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	0.008	0.01	-	-	-	-	-	-	0.01	0.01	-	-	-	-	-	-	-	-	-
	4	-	-	-	-	0.02	0.008	-	-	-	-	-	-	<0.0003	<0.0003	-	-	-	-	-	-	-	-	-
1993	1	-	-	-	-	0.01	<0.0003	-	-	-	-	-	-	<0.0003	0.007	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	<0.0003	<0.0003	-	-	-	-	-	-	<0.0003	<0.0003	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	0.013	0.002	-	-	-	-	-	-	0.003	0.002	-	-	-	-	-	-	-	-	-
	4	-	-	-	-	0.008	0.012	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-
1994	1	-	-	-	-	0.025	0.007	-	-	-	-	-	-	0.007	0.005	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	0.005	0.007	-	-	-	-	-	-	0.005	0.014	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	0.003	0.008	-	-	-	-	-	-	0.005	0.004	-	-	-	-	-	-	-	-	-
	4	-	-	-	-	0.005	0.007	-	-	-	-	-	-	0.006	0.006	-	-	-	-	-	-	-	-	-
1995	1	-	-	-	-	0.01	0.01	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-
	2	-	0.008	-	0.005	0.006	0.009	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-
	3	-	0.0088	-	0.006	0.0058	0.0076	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-
	4	-	0.007	-	0.005	0.005	0.009	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-
1996	1	-	0.0091	-	0.0058	0.0058	0.0095	-	-	-	-	-	-	0.0067	0.0093	-	-	-	-	-	-	-	-	-
	2	-	0.0074	-	0.037	0.0037	0.008	-	-	-	-	-	-	0.0064	0.01	-	-	-	-	-	-	-	-	-
	3	0.02	0.009	-	0.006	0.007	0.01	-	-	-	-	-	-	0.008	0.01	-	-	-	-	-	-	-	-	-
	4	0.014	0.004	-	0.0047	0.0052	0.0027	-	-	-	-	-	-	0.0063	0.0024	-	-	-	-	-	-	-	-	-
1997	1	0.01	0.0065	-	0.0016	0.0036	0.0073	-	-	-	-	-	-	0.0062	0.0018	-	-	-	-	-	-	-	-	-
	2	0.011	0.0071	-	0.0012	0.0031	0.0054	-	-	-	-	-	-	0.003	0.0048	-	-	-	-	-	-	-	-	-
	3	0.019	0.0067	-	0.0052	0.0059	0.0078	-	-	-	-	-	-	0.0044	0.0067	-	-	-	-	-	-	-	-	-
	4	0.014	0.0078	-	0.0037	0.004	0.0084	-	-	-	-	-	-	0.0058	0.0082	-	-	-	-	-	-	-	-	-
1998	1	0.0139	0.0078	-	0.0041	0.51	0.0076	-	-	-	-	-	-	0.0057	0.0076	-	-	-	-	-	-	-	-	-
	2	0.016	0.0086	-	0.0047	0.0057	0.0078	0.0068	-	0.0086	-	0.0127	-	0.0063	0.0081	-	-	-	-	-	-	-	-	-
	3	0.023	0.01	-	0.0057	0.0062	0.0081	0.0073	-	0.0075	-	0.014	-	0.0067	0.01	-	-	-	-	-	-	-	-	-
	4	0.014	0.0085	-	0.0047	0.0057	0.0081	0.0064	-	0.0069	-	0.0133	-	0.0096	0.0067	-	-	-	-	-	-	-	-	-
1999	1	0.015	0.0085	-	0.0047	0.0054	0.0072	0.0063	-	0.0079	-	0.013	-	0.0062	0.0099	-	-	-	-	-	-	-	-	-
	2	0.014	0.0086	-	0.0046	0.0061	0.0076	0.0067	-	0.0062	-	0.012	-	0.0057	0.0085	-	-	-	-	-	-	-	-	-
	3	0.016	0.0087	-	0.0049	0.0057	0.0087	0.0075	-	0.0075	-	0.011	-	0.0061	0.0086	-	-	-	-	-	-	-	-	0.0076
	4	0.0043	0.0086	0.0042	0.0048	0.0057	0	0.0071	-	0.0069	-	0.013	-	0.0069	0.0089	-	-	-	-	-	-	-	-	0.0084
2000	1	0.02	0.0093	0.0039	0.0051	0.0062	0.0076	0	-	0.0086	-	0.015	-	0.0068	0.0094	-	-	-	-	-	-	-	-	0
	2	0.016	0.0092	0.0037	0.0055	0.0068	0.008	0	-	0.0097	-	0.016	-	0.0072	0.0093	-	-	-	-	-	-	-	-	0.0079
	3	0.017	0.0097	0.0047	0.0054	0.0057	0.0079	0.0066	-	0.0079	-	0.014	-	0.0067	0.01	-	-	-	-	-	-	-	-	0.0078
	4	0.02	0.0096	0.0044	0.0053	0.0061	0.0081	0	-	0.0075	-	0.013	-	0.0066	0.009	-	-	-	-	-	-	-	-	0.0082
2001	1	0.0162	0.01	0.0042	0	0.0067	0.0084	0.0082	-	0.01	-	0.016	-	0.0074	0.01	-	-	-	-	-	-	-	-	0.011
	2	0.019	0.0087	0.0033	0	0.0056	0.0071	0.0068	-	0.0097	-	0.019	-	0.0065	0.0076	-	-	-	-	-	-	-	-	0.0076
	3	0.0166	0.0099	0.0029	0.0049	0.0058	0.0075	0.0068	-	0.008	-	0.0155	-	0.0061	0.0081	-	-	-	-	-	-	-	-	0.0073
	4	0.017	0.0095	0.0047	0.0053	0.0058	0.0092	0.0073	-	0.0081	-	0.0154	-	0.007	0.009	-	-	-	-	-	-	-	-	0.0079
2002	1	0.0163	0.0085	0.0044	0.0046	0.0054	0.0076	WI	-	0.0116	-	0.0174	-	0.0079	0.0086	0.0046	-	-	-	-	-	-	-	0.0079
	2	0.0177	0.0098	WI	0.0051	0.0063	0.0078	WI	-	WI	-	0.0173	-	0.0078	0.0087	0.0053	-	-	-	-	-	-	-	0.0085
	3	0.0159	0.0159	0.0024	0.0041	0.0045	0.0057	0.0052	-	0.0061	-	0.012	-	0.006	0.0065	0.0038	-	0.0125	-	-	-	-	-	0.006
	4	0.0155	0.0091	0.0045	0.0046	0.0053	0.0082	0.0066	-	0.0073	-	0.0142	-	0.0063	0.0078	0.0046	0.0087	0.0114	-	-	-	-	-	0.0074
2003	1	0.0135	0.0092	0.0033	0.0045	0.0054	0.0066	0.0064	-	0.0072	-	0.0132	-	0.0073	0.0074	0.0045	0.009	0.0103	0.0211	-	-	-	-	0.0071
	2	0.014	0.0091	0.0035	0.0048	0.0057	0.0068	0.0067	-	0.0088	-	0.015	-	0.0072	0.0079	0.0049	0.0093	0.01	0.022	-	-	-	-	0.0077
	3	0.0177	WI	0.0042	0.0053	0.0056	0.0076	0.0065	-	0.0078	-	0.0155	-	0.0061	0.008	0.005	0.0092	0.01	0.0216	-	-	-	-	0.0071
	4	0.015	0.009	0.004	0.005	0.006	0.009	0.007	-	0.007	-	0.017	-	0.006	0.008	0.005	0.011	0.012	0.023	-	-	-	-	0.007

Table 5.7-24. Private Wells with 1-km of Wellfields Groundwater Monitoring Results – Uranium (Cont.)

Year	Qtr	Well #8	Well #11	Well #12	Well #24	Well #25	Well #26	Well #28	Well #38	Well #41	Well #61	Well #63	Well #66	Well #125	Well #129	Well #131	Well #133	Well #134	Well #135	Well #138	Well #140	Well #435	Well #445	Drinking Water Well
		(mg/L)																						
2004	1	0.0156	0.0089	0.0043	0.0046	0.0056	0.0077	WI	-	0.0072	-	0.0178	-	0.0072	0.0076	0.0046	0.0117	0.0107	0.0212	-	-	-	-	0.0078
	2	0.016	0.0086	0.0034	0.0047	0.0055	0.0069	WI	-	0.0081	-	0.017	-	0.0073	0.0071	0.0047	0.0091	0.0099	0.019	-	0.019	-	-	0.0061
	3	0.0132	0.0085	0.0036	0.0047	0.0053	0.0071	0.0057	-	WI	-	0.0164	-	0.0069	0.0073	0.0047	0.0085	0.0097	0.0174	0.0178	0.0096	-	-	0.0074
	4	0.012	0.0069	0.0035	0.0038	0.0045	0.0062	0.0054	-	WI	-	0.015	-	0.006	0.0071	0.0039	0.0076	0.0087	0.017	0.015	0.0091	-	-	0.006
2005	1	0.01	0.008	0.003	0.005	0.005	0.007	WI	-	WI	-	0.02	-	0.007	0.008	0.004	0.008	0.01	0.02	0.01	0.01	-	-	0.007
	2	0.01	WI	0.004	0.005	0.006	0.007	WI	-	WI	-	0.02	-	0.007	0.007	0.006	0.009	0.01	0.02	0.01	0.01	-	-	0.007
	3	0.016	WI	0.0043	0.0052	0.0056	0.0092	0.0067	-	0.0071	-	0.0189	-	0.0077	0.0075	0.0048	0.0093	0.0103	0.0183	0.0221	0.0111	-	-	0.0074
	4	0.015	0.0085	0.0043	0.0047	0.0054	0.0088	0.005	-	WI	-	0.017	-	0.0058	0.0065	0.0047	0.0091	0.0089	WI	0.014	0.0111	-	-	0.0066
2006	1	0.014	0.0087	0.0032	0.0048	0.0055	0.0077	WI	-	WI	-	0.017	-	0.005	0.0063	0.0052	0.0084	0.0093	0.018	0.014	0.0096	-	-	0.0067
	2	0.015	0.0092	0.0042	0.0047	0.0055	0.0077	0.0063	-	WI	-	0.018	-	0.0062	0.0071	0.0049	0.009	0.009	0.017	0.02	0.011	-	-	0.0078
	3	0.015	WI	0.0044	0.0051	0.0057	0.008	0.0067	-	0.0071	-	0.018	-	0.0073	0.0075	0.005	0.0093	0.011	0.019	0.026	0.0111	-	-	0.0086
	4	0.017	WI	0.0049	0.005	0.0056	0.0081	0.0066	-	0.007	-	0.018	-	0.0072	0.0077	0.005	0.0094	0.011	0.018	0.018	0.0111	-	-	0.0081
2007	1	0.016	0.0088	0.0035	WI	WI	0.0067	WI	-	0.0068	-	0.017	-	0.0063	0.0075	0.005	0.0092	0.0096	0.018	0.021	0	0.0075	-	0.0078
	2	0.016	0.0091	0.0043	WI	WI	0.0065	0.0064	-	0.0075	-	0.017	-	0.0069	0.0073	0.0061	0.0094	0.009	0.018	0.021	0.012	0.0083	-	0.0078
	3	0.021	0.009	0.004	-	-	0.007	0.007	-	0.007	-	0.018	-	0.007	0.007	0.005	0.009	0.011	0.018	0.024	0.011	0.008	-	0.008
	4	0.013	0.008	0.003	-	-	0.006	0.006	-	0.007	ND	0.014	0.018	0.006	0.006	0.004	0.008	0.010	0.015	0.017	0.011	0.007	-	0.006
2008	1	0.0156	0.0088	0.0036	-	-	0.0066	0.0066	-	0.0069	0.0003	0.0162	0.0186	0.0073	0.0072	0.0048	0.009	0.0116	0.0176	0.0167	0.0116	0.0072	-	0.0077
	2	0.0137	0.0087	0.0043	-	-	0.0063	0.0066	-	0.0083	ND	0.0163	0.0213	0.0062	0.0074	0.0050	0.0094	0.0090	0.0167	0.0158	0.0111	0.0076	-	0.0078
	3	0.0110	0.0070	0.0035	-	-	0.0049	0.0053	-	0.0061	ND	0.0140	0.0140	0.0048	0.0057	0.0040	0.0074	0.0071	0.0140	0.0180	0.0096	0.0063	-	0.0061
	4	0.0156	WI	WI	-	-	0.0057	0.0055	-	0.0062	ND	0.0071	0.0183	0.0050	0.0061	0.0039	0.0076	0.0085	0.0152	0.0162	0.0127	0.0066	-	0.0068
2009	1	0.0133	0.0078	WI	-	-	0.0057	0.0054	-	0.0054	ND	0.0126	0.0190	0.0055	0.0059	0.0041	0.0078	0.0078	0.0150	0.0150	0.0123	0.0058	-	0.0064
	2	0.0130	0.0081	0.0040	-	-	0.0063	0.0066	-	0.0096	ND	0.0150	0.0270	0.0068	0.0060	0.0049	0.0091	0.0100	0.0160	0.0150	0.0110	0.0072	-	0.0066
	3	0.0120	WI	0.0037	-	-	0.0063	0.0059	-	0.0074	ND	0.0140	0.0280	0.0056	0.0056	0.0051	0.0081	0.0081	0.0140	0.0140	0.0096	0.0066	-	0.0062
	4	0.0130	0.0079	0.0035	-	-	0.0069	0.0061	-	0.0065	ND	0.0140	0.0210	0.0057	0.0056	0.0043	0.0081	0.0089	0.0150	0.0160	0.0095	0.0067	-	0.0060
2010	1	0.0120	0.0080	0.0028	-	-	0.0067	0.0060	-	0.0074	ND	0.0150	0.0210	0.0060	0.0058	0.0045	0.0099	0.0082	0.0160	0.0120	0.0097	0.0079	-	0.0066
	2	0.0120	0.0082	0.0031	-	-	0.0072	0.0060	-	0.0090	ND	0.0170	0.0310	0.0051	0.0057	0.0050	0.0095	0.0096	0.0150	0.0310	0.0097	0.0077	-	0.0063
	3	0.0120	0.0068	0.0035	-	-	0.0060	0.0058	-	0.0068	ND	0.0180	0.0240	0.0054	0.0054	0.0050	0.0089	0.0072	0.0140	0.0200	0.0095	0.0073	-	0.0065
	4	0.0130	0.0066	0.0031	-	-	0.0068	0.0056	0.0029	0.0046	ND	0.0130	0.0210	0.0054	0.0052	0.0036	0.0065	0.0070	0.0130	0.0130	0.0080	0.0053	-	0.0055
2011	1	0.0100	0.0065	0.0023	-	-	0.0058	0.0048	0.0028	0.0049	ND	0.0140	0.0210	0.0062	0.0053	0.0036	0.0069	0.0078	0.0120	0.0110	0.0076	0.0054	-	0.0058
	2	0.0065	0.0042	0.0016	-	-	0.0032	0.0035	0.0017	0.0031	ND	0.0095	0.0214	0.0031	0.0035	0.0022	0.0043	0.0054	0.0083	0.0087	0.0055	0.0034	-	0.0034
	3	0.0137	0.0075	0.0034	-	-	0.0113	0.0058	0.0031	0.0100	ND	0.0157	0.0234	0.0059	0.0062	0.0040	0.0077	0.0094	0.0151	0.0131	0.0092	0.0067	-	0.0066
	4	0.0118	0.0077	0.0032	-	-	0.0100	0.0056	0.0029	0.0058	ND	0.0148	0.0196	0.0057	0.0058	0.0038	0.0076	0.0075	0.0146	WI	0.0091	0.0053	-	0.0062
2012	1	0.0122	0.0074	0.0025	-	-	0.0081	0.0054	0.0034	0.0068	ND	0.0148	0.0207	0.0060	0.0064	0.0042	0.0082	0.0079	0.0148	WI	0.0093	0.0074	-	0.0060
	2	0.0144	0.0082	0.0042	-	-	0.0075	0.0063	0.0034	0.0067	ND	0.0165	0.0195	0.0064	0.0066	0.0046	0.0086	0.0091	0.0178	0.0170	0.0091	0.0075	-	0.0070
	3	0.0161	WI	0.0038	-	-	0.0084	0.0062	0.0031	0.0064	ND	0.0139	0.0211	0.0061	0.0066	0.0047	0.0092	0.0090	0.0180	0.0207	0.0112	0.0069	0.0128	0.0059
	4	0.0160	0.0090	0.0042	-	-	0.0085	0.0064	0.0042	0.0064	ND	0.0181	0.0240	0.0058	0.0067	0.0047	0.0092	0.0096	0.0183	0.0183	0.0115	0.0054	0.0137	0.0061
2013	1	0.0149	0.0098	0.0042	-	-	0.0072	0.0066	0.0038	0.0070	ND	0.0130	0.0245	0.0066	0.0071	0.0052	0.0100	0.0111	0.0189	0.0180	0.0117	0.0074	0.0010	0.0081
	2	0.0134	WI	0.0051	-	-	0.0064	0.0068	0.0036	0.0074	ND	0.0168	0.0221	0.0065	0.0068	0.0049	0.0091	0.0086	0.0168	0.0141	0.0108	0.0075	0.0124	0.0070
	3	0.0131	WI	0.0044	-	-	0.0063	0.0030	0.0031	0.0066	ND	0.0143	0.0216	0.0052	0.0058	0.0047	0.0083	0.0078	0.0177	0.0184	0.0107	0.0061	0.0109	0.0078
	4	0.0154	WI	0.0038	-	-	0.0055	0.0068	0.0032	0.0058	ND	0.0161	0.0218	0.0064	0.0062	0.0045	0.0089	0.0090	0.0157	0.0137	0.0087	0.0064	0.0118	0.0070
2014	1	0.0134	0.0085	0.0032	-	-	0.0063	0.0070	0.0035	0.0079	ND	0.0271	0.0228	0.0091	0.0099	0.0078	0.0142	0.0108	0.0248	0.0141	0.0106	0.0075	0.0196	0.0119
	2	0.0109	WI	0.0036	-	-	0.0060	0.0059	0.0030	0.0087	ND	0.0136	0.0218	0.0060	0.0053	0.0043	0.0081	0.0072	0.0140	0.0334	0.0094	0.0065	0.0098	0.0006
	3	0.0141	WI	0.0040	-	-	0.0068	0.0068	0.0030	0.0069	ND	0.0157	0.0186	0.0058	0.0065	0.0046	0.0089	0.0081	0.0148	0.0147	0.0091	0.0076	0.0106	0.0069
	4	0.0132	WI	0.0040	-	-	0.0064	0.0062	0.0035	0.0073	ND	0.0170	0.0202	0.0061	0.0074	0.0540	0.0090	0.0089	0.0162	0.0148	0.0093	0.0079	0.0121	0.0062
2015	1	0.0134	0.0090	0.0031	-	-	0.0066	0.0068	0.0035	0.0089	ND	0.0164	0.0222	0.0060	0.0067	0.0047	0.0083	0.0081	0.0165	0.0147	0.0108	0.0078	0.0107	0.0079
	2	0.0129	WI	0.0030	-	-	0.0070	0.0054	0.0033	0.0078	ND	0.0182	0.0190	0.0054	0.0060	0.0051	0.0090	0.0081	0.0161	0.0150	0.0093	0.0072	0.0098	0.0073
	3	0.0152	WI	0.0029	-	-	0.0076	0.0075	0.0035	0.0109	ND	0.0182	0.0247	0.0067	0.0063	0.0052	0.0097	0.0093	0.0168	0.0157	0.0091	0.0082	0.0123	0.0074
	4	0.0161	WI	0.0040	-	-	0.0077	0.0072	0.0036	0.0079	ND	0.0202	0.0233	0.0059	0.0064	0.0047	0.0093	0.0088	0.0183	0.0151	0.0108	0.0076	0.0120	0.0069
2016	1	0.0148	0.0081	0.0028	-	-	0.0068	0.0063	0.0034	0.0084	ND	0.0188	0.0206	0.0060	0.0061	0.0046	0.0083	0.0096	0.0167	0.0138	ND	0.0074	0.0117	0.0071
	2	0.0134	0.0082	WI	-	-	0.0066	0.0061	0.0035	0.0086	0.0012	0.0189	0.0243	0.0061	0.0061	0.0047	0.0089	0.0087	0.0178	0.0184	0.0100	0.0073	0.0108	0.0072
	3	0.0150	0.0083	0.0036	-	-	0.0067	0.0064	0.0034	0.0070	0.0006	0.0193	0.0187	0.0063	0.0061	0.0048	0.0087	0.0084	0.0170	0.0188	0.0096	0.0073	0.0115	0.0075
	4	0.0156	0.0084	0.0037	-	-	0.0066	0.0067	0.0034	0.0076	0.0005	0.0186	0.0233	0.0062	0.0068	0.0050	0.0089	0.0086	0.0168	0.0170	0.0103	0.0072	0.0112	0.0068

Table 5.7-24. Private Wells with 1-km of Wellfields Groundwater Monitoring Results – Uranium (Cont.)

Year	Qtr	Well #8	Well #11	Well #12	Well #24	Well #25	Well #26	Well #28	Well #38	Well #41	Well #61	Well #63	Well #66	Well #125	Well #129	Well #131	Well #133	Well #134	Well #135	Well #138	Well #140	Well #435	Well #445	Drinking Water Well
		(mg/L)																						
2017	1	0.0149	0.0092	0.0032	-	-	0.0062	0.0063	0.0037	0.0093	ND	0.0178	0.0226	0.0058	0.0067	0.0047	0.0087	0.0085	0.0166	0.0153	ND	0.0079	0.0119	0.0071
	2	0.0266	WI	0.0049	-	-	0.0072	0.0069	0.0039	0.0097	ND	0.0212	0.0285	0.0069	0.0070	0.0054	0.0098	0.0099	0.0189	0.0166	0.0111	0.0082	0.0131	0.0076
	3	0.0167	WI	0.0025	-	-	0.0071	0.0069	0.0037	0.0074	0.0005	0.0205	0.0241	0.0070	0.0073	0.0053	0.0098	0.0094	0.0185	0.0150	0.0110	0.0078	0.0136	0.0078
	4	0.0130	WI	0.0029	-	-	0.0050	0.0057	0.0034	0.0059	0.0001	0.0169	0.0162	0.0061	0.0058	0.0040	0.0070	0.0076	0.0165	0.0133	0.0088	0.0068	0.0104	0.0057
2018	1	0.0122	0.0060	0.0028	-	-	0.0044	0.0050	0.0036	0.0072	<.0003	0.0148	0.0187	0.0046	0.0049	0.0043	0.0078	0.0094	0.0131	0.0086	<.0003	0.0082	0.0078	0.0062
	2	0.0142	0.0081	0.0033	-	-	0.0060	0.0070	0.0033	0.0074	<.0003	0.0175	0.0216	0.0054	0.0063	0.0049	0.0086	0.0086	0.0171	0.0175	0.0092	0.0078	0.0107	0.0062
	3	0.0129	WI	0.0031	-	-	0.0050	0.0048	0.0031	0.0067	<.0003	0.0158	0.0213	0.0049	0.0070	0.0039	0.0082	0.0096	0.0152	0.0167	0.0079	0.0074	0.0098	0.0065
	4	0.0116	0.0071	0.0037	-	-	0.0049	0.0055	0.0036	0.0064	<.0003	0.0171	0.0175	0.0048	0.0055	0.0041	0.0067	0.0070	0.0162	0.0108	0.0082	0.0062	0.0097	0.0062
2019	1	0.0133	WI	0.0031	-	-	0.0050	0.0073	0.0031	0.0072	WI	0.0159	0.0170	0.0049	0.0054	0.0053	0.0091	0.0074	0.0155	0.0111	0.0089	0.0062	0.0099	0.0066
	2	0.0149	WI	0.0038	-	-	0.0059	0.0061	0.0034	0.0119	<.0003	0.0167	0.0218	0.0063	0.0059	0.0052	0.0096	0.0070	0.0171	0.0154	0.0087	0.0075	0.0118	0.0067
	3	0.0159	WI	0.0037	-	-	0.0056	0.0057	0.0027	0.0071	<.0003	0.0176	0.0218	0.0055	0.0062	0.0043	0.0080	0.0076	0.0164	0.0115	0.0087	0.0059	0.0093	0.0069
	4	0.0165	0.0087	0.0037	-	-	0.0060	0.0061	0.0040	WI	0.0193	<.0003	0.0243	0.0058	0.0073	0.0550	0.0094	0.0084	0.0186	0.0143	0.0106	0.0075	0.0101	0.0082
2020	1	0.0124	0.0090	0.0039	-	-	0.0062	0.0058	0.0032	WI	<.0003	0.0183	0.0233	0.0070	0.0065	0.0058	0.0084	0.0085	0.0164	0.0128	0.0106	0.0069	0.0100	0.0075
	2	0.0133	0.0084	0.0035	-	-	0.0061	0.0051	0.0033	0.0088	<.0003	0.0188	0.0237	0.0061	0.0072	0.0057	0.0087	0.0085	0.0179	0.0129	0.0099	0.0740	0.0094	0.0077
	3	0.0125	0.0086	0.0033	-	-	0.0064	0.0051	0.0034	0.0061	<.0003	0.0189	0.0237	0.0062	0.0073	0.0057	0.0090	0.0086	0.0161	0.0130	0.0100	0.0070	0.0090	0.0076
	4	0.0134	0.0085	0.0036	-	-	0.0057	0.0061	0.0035	0.0066	<.0003	0.0172	0.0178	0.0073	0.0077	0.0057	0.0087	0.0089	0.0170	0.0123	0.0113	0.0070	0.0102	0.0079
2021	1	0.0136	0.0082	0.0037	-	-	0.0058	0.0055	0.0040	0.0075	<.0003	0.0186	0.0212	0.0066	0.0074	0.0060	0.0086	0.0103	0.0170	0.0140	0.0105	0.0073	0.0120	0.0085
	2	0.0152	0.0093	0.0038	-	-	0.0064	0.0064	0.0036	0.0074	<.0003	0.0167	0.0246	0.0760	0.0087	0.0067	0.0085	0.0096	0.0171	0.0137	0.0112	0.0080	0.0123	0.0088
	3	0.0126	0.0079	0.0038	-	-	0.0058	0.0059	0.0037	0.0067	<.0003	0.0195	0.0241	0.0074	0.0082	0.0061	0.0091	0.0089	0.0195	0.0149	0.0099	0.0070	0.0103	0.0086
	4	0.0145	0.0079	0.0035	-	-	0.0061	WI	0.0033	0.0059	<0.0003	0.0164	0.0234	0.0067	0.0081	0.0050	0.0084	0.0077	0.0183	0.0136	0.0099	0.0069	0.0110	0.0083
2022	1	0.0152	0.009	0.0036	-	-	0.0063	WI	WI	0.0081	<0.0003	0.0197	0.0251	0.0064	0.0087	0.0062	0.0097	0.0119	0.0194	0.0141	WI	0.0076	0.0126	0.0073
	2	0.0146	WI	0.0033	-	-	0.0051	0.0050	0.0035	0.0064	<0.0003	0.0176	0.0209	0.0054	0.0085	0.0049	0.0082	0.0078	0.0167	0.0150	0.0087	0.0063	0.0101	0.0070
	3	0.0121	WI	0.0031	-	-	0.0052	0.0052	0.0032	0.0068	<0.0003	0.0154	0.0184	0.0057	0.0067	0.0052	0.0085	0.0078	0.0171	0.0151	0.0092	0.006	0.01	0.0076
	4	0.0139	WI	0.0036	-	-	0.0059	0.0063	0.0035	0.0066	<0.0003	0.0174	0.0221	0.0065	0.008	0.0058	0.0098	0.0112	0.0197	0.0139	0.01	0.007	0.0115	0.0085
2023	1	WI	0.0073	WI	-	-	0.0049	0.0063	WI	0.0063	<0.0003	0.0171	0.0199	0.0053	0.0071	0.0051	0.0081	0.0098	0.0168	0.0127	WI	0.0072	0.0112	0.0068
	2	0.0132	0.0076	0.0032	-	-	0.0054	0.0051	WI	0.0072	<0.0003	0.0149	0.0191	0.0050	0.0066	0.0047	0.0077	0.0085	0.0160	0.0112	WI	0.0067	0.0104	0.0065
	3	0.135	WI	0.0034	-	-	0.0058	0.006	WI	0.00117	<0.0003	0.019	0.02	0.0053	0.0071	0.0053	0.0089	0.0081	0.0178	0.0116	0.0087	0.0085	0.0099	0.0076
	4	0.013	WI	0.0032	-	-	0.0063	0.0064	0.0042	0.0077	<0.0003	0.0164	0.0218	0.0059	0.0072	0.0052	0.0085	0.0081	0.0179	0.0117	0.0092	0.0072	0.0115	0.0075

Notes:
WI = Well Inoperable
ND = Non Detect
- = Sample not taken

Table 5.7-25. Private Wells with 1-km of Wellfields Groundwater Monitoring Results – Radium-226

Year	Qtr	Well #8	Well #11	Well #12	Well #24	Well #25	Well # 26	Well #28	Well #38	Well #41	Well #61	Well #63	Well #66	Well #125	Well #129	Well #131	Well #133	Well #134	Well #135	Well #138	Well #140	Well #435	Well #445	Drinking Water Well
		(pCi/L)																						
1991	1	-	-	-	-	2	3.2	-		-		-		-	-	-	-	-	-	-	-	-		-
	2	-	-	-	-	2.3	0.5	-		-		-		3.2	1.8	-	-	-	-	-	-	-		-
	3	-	-	-	-	1.3	0.9	-		-		-		1.7	0.9	-	-	-	-	-	-	-		-
	4	-	-	-	-	1.7	0.5	-		-		-		0.2	0.7	-	-	-	-	-	-	-		-
1992	1	-	-	-	-	0.7	0.5	-		-		-		<0.2	1	-	-	-	-	-	-	-		-
	2	-	-	-	-	<0.2	0.4	-		-		-		<0.2	<0.2	-	-	-	-	-	-	-		-
	3	-	-	-	-	0.7	1.6	-		-		-		0.5	0.9	-	-	-	-	-	-	-		-
	4	-	-	-	-	0.8	0.6	-		-		-		<0.2	0.4	-	-	-	-	-	-	-		-
1993	1	-	-	-	-	1.2	0.8	-		-		-		1.2	0.9	-	-	-	-	-	-	-		-
	2	-	-	-	-	2.7	0.6	-		-		-		0.3	<0.2	-	-	-	-	-	-	-		-
	3	-	-	-	-	0.5	0.4	-		-		-		0.8	0.8	-	-	-	-	-	-	-		-
	4	-	-	-	-	0.5	1.9	-		-		-		0	0	-	-	-	-	-	-	-		-
1994	1	-	-	-	-	0.3	0.9	-		-		-		3.4	0.4	-	-	-	-	-	-	-		-
	2	-	-	-	-	0.2	0.3	-		-		-		<0.2	0.7	-	-	-	-	-	-	-		-
	3	-	-	-	-	1.5	0.4	-		-		-		0.4	0.9	-	-	-	-	-	-	-		-
	4	-	-	-	-	<0.2	1.4	-		-		-		0.3	<0.2	-	-	-	-	-	-	-		-
1995	1	-	-	-	-	<0.2	0.4	-		-		-		0	0	-	-	-	-	-	-	-		-
	2	-	0.3	-	0.9	<0.2	1.2	-		-		-		0	0	-	-	-	-	-	-	-		-
	3	-	1	-	1.2	1.5	0.9	-		-		-		0	0	-	-	-	-	-	-	-		-
	4	-	<0.2	-	<0.2	0.4	0.2	-		-		-		0	0	-	-	-	-	-	-	-		-
1996	1	-	0.2	-	0.2	0.2	0.3	-		-		-		0.4	0.4	-	-	-	-	-	-	-		-
	2	-	0.3	-	0.2	0.4	0.9	-		-		-		0.3	4.3	-	-	-	-	-	-	-		-
	3	1.1	<0.2	-	1.1	0.9	0.8	-		-		-		<0.2	1	-	-	-	-	-	-	-		-
	4	0.4	0.4	-	1.9	0.7	0.7	-		-		-		0.5	<0.2	-	-	-	-	-	-	-		-
1997	1	<0.2	<0.2	-	0.5	<0.2	<0.2	-		-		-		<0.2	1	-	-	-	-	-	-	-		-
	2	<0.2	<0.2	-	<0.2	1.3	<0.2	-		-		-		<0.2	<0.2	-	-	-	-	-	-	-		-
	3	<0.2	<0.2	-	<0.2	1.9	0.5	-		-		-		<0.2	<0.2	-	-	-	-	-	-	-		-
	4	<0.2	<0.2	-	<0.2	<0.2	<0.2	-		-		-		0.8	<0.2	-	-	-	-	-	-	-		-
1998	1	<0.2	<0.2	-	<0.2	<0.2	<0.2	-		-		-		<0.2	<0.2	-	-	-	-	-	-	-		-
	2	1	0.3	-	<0.2	<0.2	<0.2	<0.2		<0.2		<0.2		<0.2	<0.2	-	-	-	-	-	-	-		-
	3	<0.2	<0.2	-	<0.2	<0.2	<0.2	<0.2		<0.2		<0.2		<0.2	<0.2	-	-	-	-	-	-	-		-
	4	<0.2	<0.2	-	<0.2	<0.2	<0.2	<0.2		<0.2		<0.2		<0.2	<0.2	-	-	-	-	-	-	-		-
1999	1	<0.2	<0.2	-	<0.2	<0.2	<0.2	<0.2		<0.2		<0.2		<0.2	<0.2	-	-	-	-	-	-	-		-
	2	<0.2	0.7	-	<0.2	<0.2	<0.2	<0.2		<0.2		<0.2		4.2	<0.2	-	-	-	-	-	-	-		-
	3	<0.2	<0.2	-	<0.2	<0.2	<0.2	0.9		<0.2		<0.2		<0.2	<0.2	-	-	-	-	-	-	-		<0.2
	4	<0.2	<0.2	0.5	<0.2	<0.2	0	0.4		<0.2		<0.2		0.3	<0.2	-	-	-	-	-	-	-		<0.2
2000	1	<0.2	0.7	<0.2	<0.2	<0.2	<0.2	0		<0.2		<0.2		<0.2	<0.2	-	-	-	-	-	-	-		0
	2	0.4	<0.2	<0.2	<0.2	<0.2	<0.2	0		<0.2		0.5		<0.2	<0.2	-	-	-	-	-	-	-		<0.2
	3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2		<0.2		<0.2		<0.2	<0.2	-	-	-	-	-	-	-		<0.2
	4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0		<0.2		<0.2		<0.2	<0.2	-	-	-	-	-	-	-		<0.2
2001	1	0.5	<0.2	<0.2	0	<0.2	<0.2	<0.2		<0.2		0.6		<0.2	<0.2	-	-	-	-	-	-	-		<0.2
	2	0.4	<0.2	<0.2	0	<0.2	<0.2	<0.2		<0.2		<0.2		<0.2	<0.2	-	-	-	-	-	-	-		<0.2
	3	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2		<0.2		<0.2		<0.2	<0.2	-	-	-	-	-	-	-		<0.2
	4	<0.2	ND	ND	ND	ND	ND	ND		ND		ND		ND	ND	-	-	-	-	-	-	-		ND
2002	1	0.4	ND	ND	ND	ND	ND	WI		ND		ND		ND	ND	ND	-	-	-	-	-	-		ND
	2	ND	ND	0	ND	ND	ND	WI		WI		ND		ND	ND	ND	-	-	-	-	-	-		ND
	3	0.3	0.3	ND	ND	ND	ND	ND		ND		ND		ND	ND	ND	-	0.5	-	-	-	-		ND
	4	0.7	ND	0.3	ND	ND	ND	0.3		0.4		ND		ND	ND	ND	ND	ND	-	-	-	-		ND
2003	1	0.4	ND	ND	ND	ND	ND	ND		ND		0.4		ND	ND	ND	0.3	ND	ND	-	-	-		ND
	2	0.6	ND	ND	ND	ND	ND	ND		ND		ND		ND	ND	ND	ND	ND	0.4	-	-	-		ND
	3	ND	0	ND	ND	ND	ND	ND		ND		ND		ND	ND	ND	ND	ND	0.3	-	-	-		ND
	4	ND	0.2	ND	0.2	0.3	ND	ND		0.3		0.6		ND	ND	0.2	0.6	ND	0.3	-	-	-		ND

Table 5.7-25. Private Wells with 1-km of Wellfields Groundwater Monitoring Results – Radium-226 (Cont.)

Year	Qtr	Well #8	Well #11	Well #12	Well #24	Well #25	Well # 26	Well #28	Well #38	Well #41	Well #61	Well #63	Well #66	Well #125	Well #129	Well #131	Well #133	Well #134	Well #135	Well #138	Well #140	Well #435	Well #445	Drinking Water Well
		(pCi/L)																						
2004	1	ND	ND	ND	ND	ND	ND	WI		ND		ND		ND	ND	ND	ND	0.5	ND	-	-	-		ND
	2	0.4	ND	ND	ND	ND	ND	WI		ND		ND		ND	ND	ND	ND	ND	ND	-	ND	-		ND
	3	ND	ND	ND	ND	ND	ND	ND		WI		ND		ND	ND	ND	ND	ND	ND	ND	ND	-		ND
	4	0.4	0.3	0.4	ND	0.3	0.3	0.4		WI		0.2		ND	ND	0.4	0.4	0.3	ND	0.4	0.3	-		ND
2005	1	ND	0.3	ND	ND	ND	ND	WI		WI		0.4		ND	ND	ND	ND	0.4	0.2	ND	ND	-		ND
	2	0.3	0	0.3	0.2	0.3	ND	WI		WI		0.2		ND	ND	ND	0.5	0.4	0.4	0.6	0.4	-		ND
	3	0.2	0	ND	0.2	ND	0.4	ND		0.4		0.8		0.4	ND	0.3	ND	0.3	0.4	0.8	ND	-		ND
	4	ND	ND	ND	ND	ND	ND	ND		WI		0.8		ND	ND	ND	ND	0.9	WI	1.3	1.3	-		ND
2006	1	ND	ND	ND	ND	ND	ND	WI		WI		ND		ND	ND	ND	ND	ND	ND	ND	ND	-		ND
	2	ND	ND	ND	ND	ND	ND	ND		WI		ND		ND	ND	ND	ND	ND	ND	ND	ND	-		ND
	3	1.4	0	ND	ND	ND	ND	ND		ND		ND		ND	ND	0.7	0.6	ND	ND	ND	0.59	-		ND
	4	ND	0	ND	ND	ND	ND	ND		ND		ND		ND	ND	ND	ND	ND	ND	ND	ND	-		ND
2007	1	0.6	ND	ND	0	WI	ND	WI		ND		ND		ND	ND	ND	ND	ND	ND	ND	0	ND		ND
	2	ND	ND	ND	0	WI	ND	ND		ND		ND		ND	ND	ND	ND	ND	ND	0.8	ND	ND		ND
	3	ND	ND	ND	WI	WI	ND	ND		ND	-	ND	-	ND	ND	ND	ND	ND	0.6	0.5	ND	ND		ND
	4	ND	ND	ND	WI	WI	ND	ND		ND	3.5	ND	ND	ND	ND	ND	ND	ND	0.6	0.6	ND	ND		ND
2008	1	ND	ND	ND	-	-	ND	ND		ND	3.1	0.19	ND	ND	ND	ND	ND	ND	ND	0.43	ND	ND		ND
	2	ND	0.2	ND			ND	ND		ND	3.5	ND	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND
	3	ND	0.25	ND			ND	ND		ND	3	0.24	0.44	ND	ND	ND	0.47	ND	ND	0.49	ND	ND		ND
	4	0.21	WI	WI			ND	0.260		3.1	0.21	ND	0.33	ND	ND	ND	ND	0.91	ND	0.33	0.26	ND		ND
2009	1	0.25	0.36	WI			ND	ND		0.16	3.4	0.18	ND	ND	ND	ND	ND	0.34	0.41	0.5	ND	ND		ND
	2	0.21	ND	ND			0.23	0.160		0.42	2.7	0.41	0.39	0.17	ND	ND	0.38	0.21	ND	ND	0.97	0.38		ND
	3	ND	WI	ND			ND	ND		ND	4.1	ND	0.32	ND	ND	ND	0.35	ND	0.18	0.21	ND	ND		ND
	4	ND	ND	ND			ND	ND		ND	3.2	ND	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND
2010	1	0.3	0.25	ND			0.17	0.170		0.16	3.6	ND	0.28	0.14	ND	ND	0.29	ND	ND	0.29	ND	0.16		ND
	2	ND	ND	ND			ND	0.230		0.33	ND	0.29	0.28	ND	ND	0.18	0.3	ND	0.24	0.62	0.17	0.22		ND
	3	0.28	0.18	ND			ND	0.19		ND	4.1	0.31	0.64	ND	ND	0.22	0.26	0.31	0.31	0.38	ND	0.33		0.18
	4	0.24	ND	ND			ND	0.15	ND	ND	3.1	0.17	0.24	ND	ND	ND	0.14	0.23	0.17	0.26	ND	ND		ND
2011	1	0.33	ND	ND			ND	ND	ND	ND	3.6	ND	0.31	ND	ND	ND	0.22	0.35	0.28	0.17	ND	ND		ND
	2	0.3	0.4	0.3			0.3	0.3	ND	0.3	3.6	0.4	0.6	ND	0.2	ND	0.3	0.4	0.4	0.5	0.3	0.3		ND
	3	ND	ND	ND			ND	ND	ND	ND	3.5	0.3	0.3	ND	ND	ND	ND	ND	ND	0.4	ND	ND		ND
	4	0.4	0.4	0.3			0.3	0.3	0.2	0.1	2.8	0.3	0.4	0.2	0.1	ND	0.3	0.2	0.3	WI	0.3	0.2		ND
2012	1	0.4	0.3	ND			ND	0.2	ND	0.3	4.0	0.3	0.4	ND	ND	ND	0.3	0.3	0.3	WI	ND	0.3		ND
	2	0.26	ND	ND			ND	0.3	ND	ND	2.7	ND	0.21	ND	ND	ND	0.2	ND	ND	0.3	0.21	ND		ND
	3	ND	WI	ND			ND	ND	ND	ND	3.1	ND	ND	ND	ND	ND	0.21	ND	ND	0.28	ND	ND	ND	ND
	4	0.4	ND	ND			ND	0.4	ND	ND	4.0	0.2	0.5	0.3	ND	ND	ND	0.4	ND	0.5	0.3	ND	ND	ND
2013	1	0.3	0.3	ND			ND	0.2	ND	ND	3.0	ND	0.3	0.2	ND	ND	ND	ND	0.2	0.2	ND	ND	ND	ND
	2	ND	WI	ND			ND	0.2	ND	ND	3.0	0.2	0.3	ND	ND	ND	0.3	ND	0.5	0.4	0.2	ND	ND	ND
	3	0.3	WI	ND			ND	0.3	ND	0.3	3.8	0.3	0.4	ND	ND	ND	0.3	0.2	<0.2	0.3	0.2	ND	ND	ND
	4	0.3	WI	ND			ND	0.2	ND	ND	3.3	0.3	0.3	ND	ND	ND	1	0.3	0.3	0.3	ND	ND	ND	ND
2014	1	0.4	0.2	ND			ND	0.3	ND	ND	3.5	0.3	0.2	ND	ND	ND	0.3	0.2	0.2	0.3	ND	0.3	ND	ND
	2	0.2	WI	0.2			0.2	ND	ND	ND	2.8	0.5	0.4	0.4	ND	0.2	0.3	0.2	ND	0.3	ND	0.2	ND	ND
	3	0.5	WI	0.3			0.9	0.3	ND	0.3	3.3	0.7	0.3	0.2	ND	ND	0.4	0.7	0.3	0.6	0.3	ND	0.4	ND
	4	0.3	WI	ND			0.1	ND	ND	ND	3.0	0.3	0.4	ND	0.2	ND	0.2	0.2	ND	0.3	ND	ND	ND	ND
2015	1	ND	ND	ND			0.3	0.3	ND	0.2	3.1	0.3	ND	ND	ND	ND	0.3	0.2	0.2	0.4	ND	0.3	ND	ND
	2	0.3	WI	1.6			ND	0.8	0.5	0.3	3.3	0.5	0.3	ND	0.4	0.2	0.5	0.6	0.4	0.4	0.3	0.2	ND	ND
	3	0.3	WI	ND			0.2	0.3	ND	ND	3.3	0.2	0.4	ND	ND	ND	0.3	ND	0.2	0.4	ND	ND	ND	ND
	4	0.3	WI	ND			ND	0.3	ND	0.3	3.6	ND	0.7	ND	0.2	0.3	0.3	0.2	0.3	0.3	0.2	0.3	ND	0.2
2016	1	0.2	0.2	0.2			0.1	0.2	0.1	0.2	3.3	0.3	0.2	0.003	0.2	0.1	0.3	0.3	0.1	0.3	0.3	0.03	0.1	0.1
	2	0.5	0.5	WI			0.4	0.4	0.4	0.3	6.2	0.4	0.5	0.4	0.2	0.5	0.5	0.4	0.4	0.6	0.3	0.2	0.3	0.1
	3	0.3	0.3	0.2			0.3	0.3	0.2	0.3	4.6	0.4	0.4	0.3	0.2	0.3	0.5	0.3	0.5	0.4	0.3	0.2	0.1	0.2
	4	0.7	0.3	0.3			0.3	0.3	0.2	0.3	3.9	0.3	0.6	0.2	0.2	0.5	0.3	0.2	0.5	0.6	0.4	0.3	0.2	0.2

Table 5.7-25. Private Wells with 1-km of Wellfields Groundwater Monitoring Results – Radium-226 (Cont.)

Year	Qtr	Well #8	Well #11	Well #12	Well #24	Well #25	Well # 26	Well #28	Well #38	Well #41	Well #61	Well #63	Well #66	Well #125	Well #129	Well #131	Well #133	Well #134	Well #135	Well #138	Well #140	Well #435	Well #445	Drinking Water Well
		(pCi/L)																						
2017	1	0.5	0.3	0.1			0.2	0.4	0.2	0.3	4.6	0.4	0.5	0.2	0.4	0.3	0.6	0.7	0.5	0.6	0.7	0.3	0.3	0.2
	2	0.3	WI	0.2			0.2	0.4	0.2	0.2	3.1	0.4	0.4	0.2	0.1	0.1	0.3	0.3	0.4	0.4	0.3	0.3	0.2	0.1
	3	0.3	WI	0.1			0.2	0.4	1.0	0.3	3.2	0.4	0.3	0.2	0.1	0.3	0.3	0.2	0.4	0.4	0.3	0.3	0.1	0.2
	4	0.3	WI	0.1			0.16	0.3	0.1	0.16	3.3	0.2	0.4	0.16	0.1	0.17	0.3	0.3	0.2	0.5	0.2	0.16	0.1	0.1
2018	1	0.3	0.2	<0.2			0.20	0.3	<0.2	0.20	3.3	0.4	0.3	0.40	<0.2	<0.2	0.3	0.2	0.3	0.3	0.3	0.20	<0.2	<0.2
	2	0.5	0.5	0.4			0.6	0.4	0.4	0.4	3.2	0.5	0.6	0.4	0.5	0.3	0.5	0.4	0.4	0.8	0.5	1.2	0.3	0.3
	3	0.3	WI	<0.2			0.2	<0.2	<0.2	0.2	3.0	0.3	0.4	<0.2	<0.2	<0.2	0.2	0.4	0.3	0.4	<0.2	<0.2	<0.2	<0.2
	4	0.8	0.5	0.4			0.5	0.3	1.3	0.3	2.8	0.3	0.3	0.2	<0.2	0.3	0.4	0.3	0.3	0.4	0.3	0.2	0.3	0.2
2019	1	0.4	WI	0.2			0.3	0.4	0.3	0.2	WI	0.4	0.2	<0.2	0.3	<0.2	0.3	0.3	0.4	0.4	0.3	0.2	<0.2	<0.2
	2	0.4	WI	11.9			1.6	2.3	5.9	0.6	3.2	0.7	0.4	0.3	0.2	1.0	0.5	0.4	0.4	1.0	0.3	0.4	0.5	9.6
	3	0.4	WI	<0.2			0.2	0.3	<0.2	<0.2	2.7	0.3	0.3	<0.2	<0.2	<0.2	0.3	<0.2	0.2	0.3	0.3	<0.2	<0.2	<0.2
	4	0.3	0.3	<0.2			0.3	0.3	<0.2	WI	0.4	2.9	0.4	<0.2	<0.2	<0.2	0.2	0.3	0.2	0.3	0.2	0.3	<0.2	0.2
2020	1	0.3	0.3	<0.2			0.2	<0.2	<0.2	WI	3.2	0.3	0.5	0.9	<0.2	0.2	0.4	0.2	0.2	0.5	0.2	<0.2	<0.2	1.0
	2	0.4	0.3	<0.2			0.3	0.3	<0.2	0.2	3.2	0.3	0.4	<0.2	<0.2	<0.2	0.3	0.2	0.3	0.5	<0.2	<0.2	<0.2	<0.2
	3	0.3	0.5	0.4			0.3	0.3	<0.2	<0.2	3.4	0.4	0.4	<0.2	0.7	<0.2	0.4	0.4	0.6	0.5	0.2	<0.2	0.2	0.2
	4	0.3	0.2	<0.2			<0.2	<0.2	<0.2	0.3	3.2	0.3	0.5	<0.2	<0.2	<0.2	0.3	0.3	0.3	0.3	0.2	<0.2	0.2	<0.2
2021	1	0.3	0.2	<0.2			0.3	<0.2	<0.2	<0.2	3.0	0.3	0.4	<0.2	<0.2	<0.2	0.3	<0.2	0.3	0.4	<0.2	0.2	<0.2	<0.2
	2	<0.2	0.3	<0.2			0.3	<0.2	<0.2	<0.2	3.4	0.2	0.4	<0.2	<0.2	<0.2	0.3	0.2	<0.2	0.4	0.2	<0.2	<0.2	<0.2
	3	0.3	<0.2	<0.2			0.3	<0.2	<0.2	<0.2	3.3	0.3	0.3	<0.2	<0.2	<0.2	0.4	0.3	0.2	0.4	<0.2	<0.2	<0.2	0.3
	4	0.6	<0.2	<0.2			<0.2	WI	<0.2	0.2	3.4	0.4	0.5	<0.2	<0.2	0.2	0.3	0.3	0.3	0.4	0.4	<0.2	0.2	<0.2
2022	1	0.6	0.3	0.2			0.3	WI	WI	0.3	3.2	0.4	0.4	0.2	<0.2	<0.2	0.4	0.3	0.2	0.3	WI	0.2	<0.2	<0.2
	2	0.6	WI	0.2			0.4	0.3	0.2	0.3	3.2	0.4	0.5	0.2	0.3	0.3	0.4	0.4	0.6	0.4	0.3	0.3	0.2	0.2
	3	0.6	WI	<0.2			0.4	0.4	0.2	0.2	3.3	0.6	0.6	0.5	0.3	0.4	0.5	0.4	0.3	0.4	0.2	0.3	<0.2	0.3
	4	0.6	WI	0.3			0.3	0.3	<0.2	0.5	3.1	0.4	0.6	0.3	<0.2	0.3	0.5	0.3	0.4	0.4	0.4	0.3	0.2	0.3
2023	1	WI	0.3	WI			0.2	0.3	WI	<0.2	3.4	0.3	0.3	<0.2	<0.2	<0.2	0.3	0.3	0.5	0.4	WI	<0.2	0.4	<0.2
	2	0.4	0.3	<0.2			<0.2	0.2	WI	0.3	3.2	0.3	0.3	<0.2	<0.2	0.5	0.5	0.7	0.7	0.7	WI	0.5	0.3	0.3
	3	0.5	WI	<0.2			0.3	0.3	WI	0.3	3.2	0.3	0.4	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.2	0.2	<0.2	0.3
	4	0.4	WI	<0.2			0.3	0.2	<0.2	0.3	3.8	0.2	0.3	<0.2	<0.2	<0.2	0.9	0.2	0.3	0.4	0.2	<0.2	0.2	<0.2

Notes:
WI = Well Inoperable
ND = Non Detect
- = Sample not taken

Table 5.7-26. Surface Water Monitoring Results – Uranium

Year	Qtr	S-1	S-2	S-5	E-1 & E-2 Combined	E-5	I-3	I-4	I-5
		(mg/L)							
1991	1	-	ND	-	-	-	-	-	-
	2	-	0.002	-	-	-	-	-	-
	3	-	0.002	-	-	-	-	-	-
	4	-	0.0031	-	-	-	-	-	-
1992	1	-	ND	-	-	-	-	-	-
	2	-	0.001	-	-	-	-	-	-
	3	-	0.005	-	-	-	-	-	-
	4	-	<0.0003	-	-	-	-	-	-
1993	1	-	ND	-	-	-	-	-	-
	2	-	<0.0003	-	-	-	-	-	-
	3	-	<0.0003	-	-	-	-	-	-
	4	-	0.001	-	-	-	-	-	-
1994	1	-	0.004	-	-	-	-	-	-
	2	-	0.006	-	-	-	-	-	-
	3	-	0.002	-	-	-	-	-	-
	4	-	0.003	-	-	-	-	-	-
1995	1	-	0.01	-	-	-	-	-	-
	2	-	0.004	-	-	-	-	-	-
	3	-	0.004	-	-	-	-	-	-
	4	-	0.005	-	-	-	-	-	-
1996	1	-	0.00525	-	-	-	-	-	-
	2	-	0.0047	-	-	-	-	-	-
	3	0.005	0.004	-	-	-	-	-	-
	4	0.0018	0.0051	-	-	-	-	-	-
1997	1	0.0012	0.0055	-	-	-	-	-	-
	2	0.0024	0.0024	-	-	-	-	-	-
	3	0.0047	0.0048	-	-	-	-	-	-
	4	0.0026	0.0038	-	-	-	-	-	-
1998	1	0.0047	0.0045	-	-	-	-	-	-
	2	0.0052	0.005	0.0054	0.035	-	-	-	-
	3	0.0043	0.004	0.0037	0.011	-	-	-	-
	4	0.0043	0.0043	0.0061	ND	-	-	-	-
1999	1	0.0048	0.0048	0.0042	0.02	-	-	-	-
	2	0.0041	0.004	ND	0.0086	-	-	-	-
	3	0.0036	ND	ND	ND	-	-	-	-
	4	0.0043	0.0042	0.0047	0.018	-	-	-	-
2000	1	0.0051	0.005	0.0055	0.015	-	-	-	-
	2	0.0059	0.0056	0.0057	ND	-	-	-	-
	3	0.0041	0.0041	ND	ND	-	-	-	-
	4	0.0048	0.0046	0.0058	ND	-	-	-	-
2001	1	0.0055	0.0054	0.0064	ND	-	-	-	-
	2	0.0052	0.0049	0.0055	ND	-	-	-	-
	3	0.0042	0.0044	0.0056	ND	-	-	-	-
	4	0.0042	0.0044	0.0054	ND	-	-	-	-
2002	1	0.0045	0.0052	0.008	ND	-	-	-	-
	2	0.0052	0.0049	0.0061	ND	-	-	-	-
	3	0.0032	Dry	Dry	ND	-	-	-	-
	4	0.0043	0.0043	0.0064	ND	-	-	-	-
2003	1	0.0047	Frozen	Frozen	ND	Frozen	Frozen	Frozen	-
	2	0.0046	0.004	0.0045	ND	0.0077	0.0411	0.0334	-
	3	0.004	Dry	Dry	ND	0.004	0.0009	0.0079	-
	4	0.005	0.004	0.006	ND	0.01	0.116	0.024	-

Table 5.7-26. Surface Water Monitoring Results – Uranium (Cont.)

Year	Qtr	S-1	S-2	S-5	E-1 & E-2 Combined	E-5	I-3	I-4	I-5
		(mg/L)							
2004	1	0.00521	0.0051	0.00578	ND	0.0118	Frozen	Frozen	-
	2	0.0044	0.0038	0.0049	ND	0.007	0.039	0.023	-
	3	0.0034	0.0034	0.0044	ND	0.0024	0.0133	0.0091	-
	4	0.0033	0.0033	0.0038	ND	0.0054	0.011	0.0097	-
2005	1	0.004	0.005	0.005	v	0.009	0.03	0.03	-
	2	0.004	0.0044	0.005	0.02	0.004	0.02	0.01	-
	3	0.0041	0.0041	0.0051	0.0123	0.0039	0.0066	0.00914	-
	4	0.0041	0.0042	0.0045	0.018	0.0066	0.074	0.015	-
2006	1	0.0041	0.0041	0.0046	0.037	0.0082	0.0095	0.0083	-
	2	0.014	0.0045	0.005	0.011	0.0017	0.004	0.015	-
	3	0.0041	Dry	Dry	0.011	0.0072	Dry	0.027	-
	4	0.0042	0.0044	Dry	0.055	0.0075	Dry	0.04	0.0095
2007	1	0.0046	0.0046	0.0057	0.019	0.013	0.11	0.13	0.012
	2	0.0043	0.0041	0.0045	0.011	0.0031	0.02	0.037	0.0048
	3	0.004	Dry	Dry	Dry	Dry	Dry	0.038	0.002
	4	0.004	0.005	Dry	Dry	0.017	Dry	Dry	0.017
2008	1	0.0046	0.0044	0.0056	0.088	0.0201	0.119	0.179	0.0142
	2	0.0041	0.0038	0.0045	0.0132	0.0027	0.0336	0.0105	0.0040
	3	0.0027	0.0026	Dry	0.0098	0.0047	0.0160	0.0180	0.0008
	4	0.0035	0.0035	0.0044	0.0189	0.0076	Dry	0.0690	0.0095
2009	1	0.0039	0.0036	0.0039	0.0340	0.0079	0.0560	0.0770	0.0081
	2	0.0041	0.0040	0.0043	0.0350	0.0044	0.0400	0.0240	0.0092
	3	0.0036	0.0035	0.0042	0.0110	0.0013	0.0032	0.0063	0.0024
	4	0.0033	0.0034	0.0037	0.0530	0.0048	0.0230	0.0110	0.0068
2010	1	0.0040	0.0037	0.0043	0.2300	0.0130	0.0460	0.0390	0.0160
	2	0.0042	0.0042	0.0054	0.0230	0.0074	0.0190	0.0160	0.0062
	3	0.0042	0.0041	0.0048	0.0120	0.0026	0.0050	0.0420	0.0035
	4	0.0035	0.0034	0.0039	0.0240	0.0110	0.0440	0.0320	0.0120
2011	1	0.0035	0.0035	0.0039	0.0220	0.0094	0.0490	0.0450	0.0080
	2	0.0050	0.0049	0.0048	0.0170	0.0077	0.0240	0.0290	0.0170
	3	0.0035	0.0036	0.0041	0.0104	0.0028	Dry	0.0468	0.0027
	4	0.0037	0.0039	0.0041	0.0623	0.0133	0.0522	0.0316	0.0132
2012	1	0.0044	0.0046	0.0043	0.0445	0.0111	0.0469	0.0387	0.0111
	2	0.0042	0.0049	0.0037	0.0097	0.0023	Dry	0.0279	0.0035
	3	0.0076	0.0051	Dry	0.0361	0.0044	Dry	Dry	0.0125
	4	0.0040	0.0042	Dry	0.2070	0.0072	Dry	Dry	0.0196
2013	1	0.0048	0.0048	0.0055	0.3640	0.0150	0.1520	0.1380	0.0193
	2	0.0043	0.0042	0.0045	0.0214	0.0033	0.0185	0.0384	0.0084
	3	0.0039	0.0045	Dry	0.0142	0.0066	Dry	Dry	0.0025
	4	0.0037	0.0039	0.0056	0.1020	0.0073	0.1070	0.0443	0.0109
2014	1	0.0042	0.0044	0.0050	0.0046	0.0183	0.0731	0.0667	0.0262
	2	0.0034	0.0036	0.0037	0.0158	0.0060	0.0109	0.0093	0.0065
	3	0.0041	0.0040	0.0045	0.0136	0.0021	0.0063	0.0043	0.0041
	4	0.0042	0.0041	0.0038	0.0616	0.0132	0.0326	0.0255	0.0119
2015	1	0.0040	0.0039	0.0048	0.0686	0.0103	0.0264	0.0275	0.0125
	2	0.0039	0.0039	0.0040	0.0535	0.0059	0.0212	0.0174	0.0099
	3	0.0044	0.0045	0.0056	0.0145	0.0026	0.0063	0.0062	0.0041
	4	0.0039	0.0037	0.0041	0.0352	0.0054	0.0205	0.0192	0.0081
2016	1	0.0041	0.0042	0.0045	0.0413	0.0170	0.0408	0.0365	0.0181
	2	0.0040	0.0040	0.0029	0.0129	0.0046	0.0057	0.0055	0.0021
	3	0.0040	0.0040	0.0051	0.0116	0.0036	0.0029	0.0069	0.0042
	4	0.0041	0.0039	0.0044	0.0119	0.0053	0.0064	0.0100	0.0067

Table 5.7-26. Surface Water Monitoring Results – Uranium (Cont.)

Year	Qtr	S-1	S-2	S-5	E-1 & E-2 Combined	E-5	I-3	I-4	I-5
		(mg/L)							
2017	1	0.0043	0.0041	0.0047	0.0267	0.0138	0.0264	0.0248	0.0172
	2	0.0042	0.0043	0.0050	0.0147	0.0031	0.0078	0.0035	0.0038
	3	0.0043	0.0043	0.0052	0.0106	0.0041		0.0033	0.0046
	4	0.0033	0.0031	0.0036	0.0187	0.0052	0.027	0.0162	0.0069
2018	1	0.0033	0.0032	0.0037	0.0486	0.0156	0.0386	0.0295	0.0177
	2	0.0046	0.0035	0.0042	0.0560	0.0037	0.0099	0.0095	0.0061
	3	0.0041	0.0040	0.0048	0.0104	0.0029	0.0050	0.0018	0.0040
	4	0.0038	0.0033	0.0038	0.0278	0.0119	0.0356	0.0290	0.0139
2019	1	0.0037	0.0031	0.0032	0.0204	0.0091	0.0274	0.0086	0.0090
	2	0.0048	0.0041	0.0032	0.0185	0.0041	0.0141	0.0084	0.0046
	3	0.0035	0.0031	0.0037	0.0100	0.0035	0.0094	0.0066	0.0051
	4	0.0041	0.0039	0.0049	0.0328	0.0137	0.0234	0.0229	0.0151
2020	1	0.0040	0.0044	0.0050	0.0474	0.0119	0.0222	0.0219	0.0145
	2	0.0041	0.0041	0.0044	0.0164	0.0025	0.0047	0.0027	0.0085
	3	0.0037	0.0035	0.0042	0.0135	0.0016	0.0017	0.0005	0.0028
	4	0.0042	0.0040	0.0048	0.0236	0.0114	0.0432	0.0346	0.0234
2021	1	0.0043	0.0042	0.0048	0.0436	0.0219	0.0367	0.0354	0.0231
	2	0.0042	0.0042	0.0046	0.0286	0.0056	0.0127	0.0092	0.0070
	3	0.0040	0.0039	0.0040	0.0181	0.0023	Dry	0.0069	0.0027
	4	0.0037	0.0037	0.0045	0.0196	0.0066	0.314	0.0171	0.0075
2022	1	0.0037	0.0037	0.0045	0.0196	0.0066	0.314	0.0171	0.0075
	2	0.0032	0.0040	0.0038	0.0168	0.0054	0.018	0.0131	0.0087
	3	0.0032	0.0040	0.0038	0.0168	0.0054	0.018	0.0131	0.0087
	4	0.0032	0.0040	0.0038	0.0168	0.0054	0.018	0.0131	0.0087
2023	1	0.0072	0.0040	0.0043	Dry	0.0124	0.094	0.0806	0.0106
	2	0.0040	0.0037	0.0039	0.8250	0.1720	0.061	0.0485	0.2430
	3	0.0040	0.0037	0.0039	0.8250	0.1720	0.061	0.0485	0.2430
	4	0.0040	0.0037	0.0039	0.8250	0.1720	0.061	0.0485	0.2430

Notes:

Dry = Surface water monitoring point was dry, no sample taken
Frozen = Surface water monitoring point was frozen, no sample taken
- = Sample not taken

Table 5.7-27. Surface Water Monitoring Results – Radium-226

Year	Qtr	S-1	S-2	S-5	E-1 & E-2 Combined	E-5	I-3	I-4	I-5
		(pCi/L)							
1991	1	-	ND	-	-	-	-	-	-
	2	-	0.002	-	-	-	-	-	-
	3	-	0.002	-	-	-	-	-	-
	4	-	0.0031	-	-	-	-	-	-
1992	1	-	ND	-	-	-	-	-	-
	2	-	0.001	-	-	-	-	-	-
	3	-	0.005	-	-	-	-	-	-
	4	-	<0.0003	-	-	-	-	-	-
1993	1	-	ND	-	-	-	-	-	-
	2	-	<0.0003	-	-	-	-	-	-
	3	-	<0.0003	-	-	-	-	-	-
	4	-	0.001	-	-	-	-	-	-
1994	1	-	0.004	-	-	-	-	-	-
	2	-	0.006	-	-	-	-	-	-
	3	-	0.002	-	-	-	-	-	-
	4	-	0.003	-	-	-	-	-	-
1995	1	-	0.01	-	-	-	-	-	-
	2	-	0.004	-	-	-	-	-	-
	3	-	0.004	-	-	-	-	-	-
	4	-	0.005	-	-	-	-	-	-
1996	1	-	0.00525	-	-	-	-	-	-
	2	-	0.0047	-	-	-	-	-	-
	3	0.005	0.004	-	-	-	-	-	-
	4	0.0018	0.0051	-	-	-	-	-	-
1997	1	0.0012	0.0055	-	-	-	-	-	-
	2	0.0024	0.0024	-	-	-	-	-	-
	3	0.0047	0.0048	-	-	-	-	-	-
	4	0.0026	0.0038	-	-	-	-	-	-
1998	1	0.0047	0.0045	-	-	-	-	-	-
	2	0.0052	0.005	0.0054	0.035	-	-	-	-
	3	0.0043	0.004	0.0037	0.011	-	-	-	-
	4	0.0043	0.0043	0.0061	ND	-	-	-	-
1999	1	0.0048	0.0048	0.0042	0.02	-	-	-	-
	2	0.0041	0.004	ND	0.0086	-	-	-	-
	3	0.0036	ND	ND	ND	-	-	-	-
	4	0.0043	0.0042	0.0047	0.018	-	-	-	-
2000	1	0.0051	0.005	0.0055	0.015	-	-	-	-
	2	0.0059	0.0056	0.0057	ND	-	-	-	-
	3	0.0041	0.0041	ND	ND	-	-	-	-
	4	0.0048	0.0046	0.0058	ND	-	-	-	-
2001	1	0.0055	0.0054	0.0064	ND	-	-	-	-
	2	0.0052	0.0049	0.0055	ND	-	-	-	-
	3	0.0042	0.0044	0.0056	ND	-	-	-	-
	4	0.0042	0.0044	0.0054	ND	-	-	-	-
2002	1	0.0045	0.0052	0.008	ND	-	-	-	-
	2	0.0052	0.0049	0.0061	ND	-	-	-	-
	3	0.0032	Dry	Dry	ND	-	-	-	-
	4	0.0043	0.0043	0.0064	ND	-	-	-	-
2003	1	0.0047	Frozen	Frozen	ND	Frozen	Frozen	Frozen	-
	2	0.0046	0.004	0.0045	ND	0.0077	0.0411	0.0334	-
	3	0.004	Dry	Dry	ND	0.004	0.0009	0.0079	-
	4	0.005	0.004	0.006	ND	0.01	0.116	0.024	-

Table 5.7-27. Surface Water Monitoring Results – Radium-226 **(Cont.)**

Year	Qtr	S-1	S-2	S-5	E-1 & E-2 Combined	E-5	I-3	I-4	I-5
		(mg/L)							
2004	1	0.00521	0.0051	0.00578	ND	0.0118	Frozen	Frozen	-
	2	0.0044	0.0038	0.0049	ND	0.007	0.039	0.023	-
	3	0.0034	0.0034	0.0044	ND	0.0024	0.0133	0.0091	-
	4	0.0033	0.0033	0.0038	ND	0.0054	0.011	0.0097	-
2005	1	0.004	0.005	0.005	-	0.009	0.03	0.03	-
	2	0.004	0.0044	0.005	0.02	0.004	0.02	0.01	-
	3	0.0041	0.0041	0.0051	0.0123	0.0039	0.0066	0.00914	-
	4	0.0041	0.0042	0.0045	0.018	0.0066	0.074	0.015	-
2006	1	0.0041	0.0041	0.0046	0.037	0.0082	0.0095	0.0083	-
	2	0.014	0.0045	0.005	0.011	0.0017	0.004	0.015	-
	3	0.0041	Dry	Dry	0.011	0.0072	Dry	0.027	-
	4	0.0042	0.0044	Dry	0.055	0.0075	Dry	0.04	0.0095
2007	1	0.0046	0.0046	0.0057	0.019	0.013	0.11	0.13	0.012
	2	0.0043	0.0041	0.0045	0.011	0.0031	0.02	0.037	0.0048
	3	ND	Dry	Dry	Dry	Dry	Dry	ND	ND
	4	ND	ND	Dry	Dry	ND	Dry	Dry	ND
2008	1	ND	ND	ND	ND	ND	ND	ND	ND
	2	ND	ND	ND	ND	ND	ND	ND	ND
	3	ND	ND	Dry	ND	ND	ND	ND	ND
	4	ND	ND	ND	0.58	ND	Dry	ND	ND
2009	1	ND	ND	ND	0.25	ND	0.22	ND	ND
	2	ND	ND	ND	0.15	0.12	ND	ND	ND
	3	ND	ND	ND	0.2	ND	ND	ND	ND
	4	ND	ND	ND	ND	ND	ND	ND	ND
2010	1	ND	ND	ND	0.41	ND	ND	ND	ND
	2	ND	ND	ND	0.34	0.34	0.21	ND	0.25
	3	0.3	0.19	0.27	0.52	ND	0.46	0.3	0.27
	4	ND	ND	ND	ND	ND	ND	ND	ND
2011	1	ND	ND	ND	0.27	ND	ND	ND	ND
	2	ND	ND	ND	ND	ND	ND	ND	ND
	3	ND	ND	ND	0.3	ND	Dry	ND	ND
	4	0.2	0.2	ND	0.6	0.2	0.3	0.3	0.2
2012	1	ND	ND	ND	0.3	ND	ND	ND	ND
	2	ND	ND	ND	0.4	ND	Dry	ND	ND
	3	0.32	ND	Dry	0.4	ND	Dry	Dry	ND
	4	0.2	0.2	Dry	0.5	0.2	Dry	Dry	0.3
2013	1	ND	ND	ND	0.5	0.2	ND	0.3	0.3
	2	ND	ND	ND	0.2	ND	ND	0.4	ND
	3	ND	ND	Dry	0.4	ND	Dry	Dry	ND
	4	ND	ND	ND	0.3	ND	0.2	ND	ND
2014	1	ND	ND	ND	0.3	ND	ND	ND	ND
	2	ND	ND	ND	0.3	ND	ND	0.2	ND
	3	ND	0.3	ND	0.3	ND	ND	0.4	ND
	4	ND	ND	ND	0.3	ND	ND	ND	ND
2015	1	ND	ND	ND	0.2	ND	ND	ND	ND
	2	0.3	0.4	ND	0.7	0.4	0.5	0.3	0.4
	3	ND	ND	ND	0.3	ND	ND	ND	ND
	4	0.2	0.2	0.2	0.5	0.3	0.3	0.2	0.2
2016	1	0.001	0.04	0.2	0.2	0.1	0.2	0.1	0.3
	2	0.1	0.2	0.2	0.4	0.2	0.5	0.4	0.2
	3	0.3	0.2	0.2	0.5	0.4	0.2	0.3	0.2
	4	0.1	0.1	0.1	0.6	0.1	0.3	0.2	0.1

Table 5.7-27. Surface Water Monitoring Results – Radium-226 **(Cont.)**

Year	Qtr	S-1	S-2	S-5	E-1 & E-2 Combined	E-5	I-3	I-4	I-5
		(mg/L)							
2017	1	0.1	0.3	0.1	0.4	0.1	0.3	0.3	0.3
	2	0.0	0.2	0.1	0.4	0.2	0.3	0.2	0.2
	3	0.2	0.2	0.3	0.3	0.2		0.1	0.3
	4	0.1	0.04	0.04	0.2	0.1	0.2	0.2	0.1
2018	1	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2
	2	0.3	0.3	0.3	0.5	0.2	0.4	<0.2	0.2
	3	<0.2	<0.2	<0.2	0.3	<0.2	0.3	0.2	<0.2
	4	0.3	0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2
2019	1	0.2	0.3	<0.2	0.5	<0.2	0.3	<0.2	<0.2
	2	15.4	2.4	1.6	0.7	0.3	0.7	1.2	1.9
	3	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2
	4	<0.2	<0.2	<0.2	0.3	<0.2	<0.2	<0.2	<0.2
2020	1	<0.2	0.2	0.4	0.2	0.2	0.2	0.2	<0.2
	2	<0.2	<0.2	<0.2	0.3	0.2	0.2	0.5	<0.2
	3	0.8	<0.2	<0.2	0.5	<0.2	0.3	0.6	<0.2
	4	<0.2	<0.2	<0.2	0.4	<0.2	<0.2	0.3	<0.2
2021	1	<0.2	<0.2	<0.2	0.3	0.5	<0.2	<0.2	<0.2
	2	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2
	3	<0.2	<0.2	<0.2	0.3	<0.2	Dry	<0.2	<0.2
	4	<0.2	<0.2	<0.2	0.4	<0.2	<0.2	<0.2	0.2
2022	1	<0.2	<0.2	<0.2	0.4	<0.2	<0.2	<0.2	0.2
	2	<0.2	<0.2	0.2	0.4	0.4	0.3	0.3	<0.2
	3	<0.2	<0.2	0.2	0.4	0.4	0.3	0.3	<0.2
	4	<0.2	<0.2	0.2	0.4	0.4	0.3	0.3	<0.2
2023	1	0.5	0.5	0.6	Dry	<0.2	<0.2	<0.2	0.3
	2	0.4	<0.2	<0.2	0.3	<0.2	0.3	0.2	<0.2
	3	0.4	<0.2	<0.2	0.3	<0.2	0.3	0.2	<0.2
	4	0.4	<0.2	<0.2	0.3	<0.2	0.3	0.2	<0.2

Notes:

Dry = Surface water monitoring point was dry, no sample taken

Frozen = Surface water monitoring point was frozen, no sample taken

- = Sample not taken

Table 5.7-28. Radiological Monitoring Program Summary

Type of Survey	Type of Area	Current Frequency	Proposed Frequency	Reg. Guide 8.30 Recommended Frequency
Airborne uranium	• Airborne radioactivity areas • Other indoor process areas • Special maintenance involving high airborne concentrations of yellowcake	• Weekly grab samples[1] • Monthly grab samples • Extra breathing zone grab samples	• Weekly grab samples[1] • Monthly grab samples • Extra breathing zone grab samples	• Weekly grab samples • Monthly grab samples • Extra breathing zone grab samples
Radon daughters	• Areas that exceed 0.08WL • Areas that exceed 0.03WL • Areas below 0.03WL	• Weekly radon daughter grab samples • Monthly radon daughter grab samples • Quarterly radon daughter grab samples	• Weekly radon daughter grab samples • Monthly radon daughter grab samples • Quarterly radon daughter grab samples	• Weekly radon daughter grab samples • Monthly radon daughter grab samples • Quarterly radon daughter grab samples
External radiation: gamma	• Throughout mill • Radiation areas	• Semiannually • Quarterly	• Semiannually • Quarterly	• Semiannually • Quarterly
External radiation: beta	• Where workers are in close contact with yellowcake	• Survey by operation done once plus whenever procedures change	• Survey by operation done once plus whenever procedures change	• Survey by operation done once plus whenever procedures change
Surface contamination	• Yellowcake areas • Eating rooms, change rooms, control rooms, office	• Daily walkthrough • Weekly	• Daily walkthrough • Weekly	• Daily • Weekly
Skin and personal clothing	• Yellowcake workers who shower • Yellowcake workers who do not shower	• Each exit from controlled area[2] • Each exit from controlled area[2]	• Each exit from controlled area[2] • Each exit from controlled area[2]	• Quarterly • Each day before leaving
Equipment to be released	• Equipment to be released that may be contaminated	• Detailed survey before release	• Detailed survey before release	• Once before release
Packages containing yellowcake	• Packages	• Detailed survey before release	• Detailed survey before release	• Spot check before release
Ventilation	• All areas with airborne radioactivity	• Daily walkthrough	• Daily walkthrough	• Daily
Respirators	• Respirator face pieces and hoods	• Before reuse	• Before reuse	• Before reuse

Notes:

[1] Increased sampling frequency based on administrative action level of 25 percent of the MPC or DAC; Sampling is performed in the dryer room during dryer operation.
[2] All employees required to survey upon exit; Quarterly spot checks of >25 percent process staff are also conducted.

Figure 5.1.1. Crow Butte Resources Organizational Chart

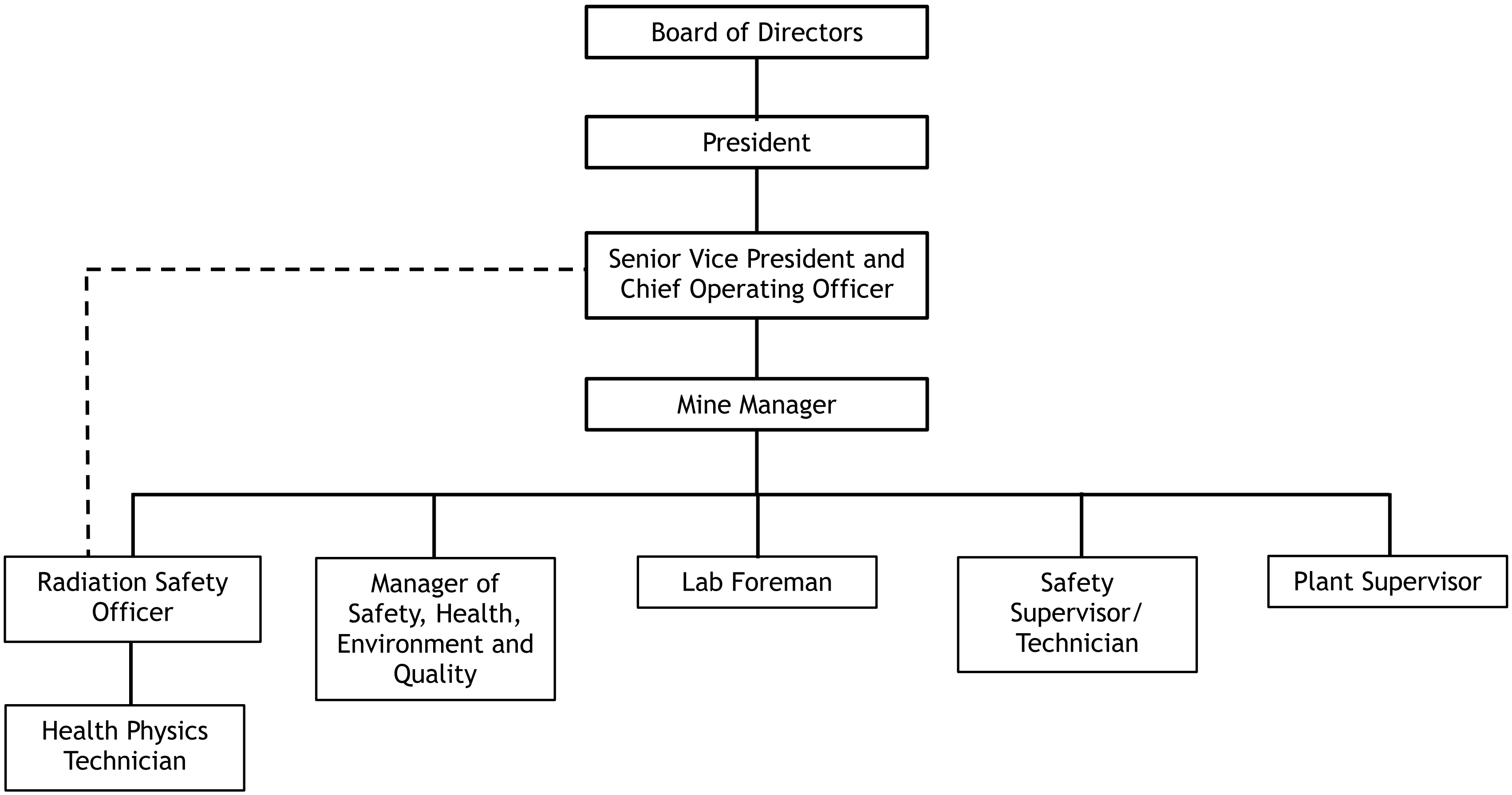
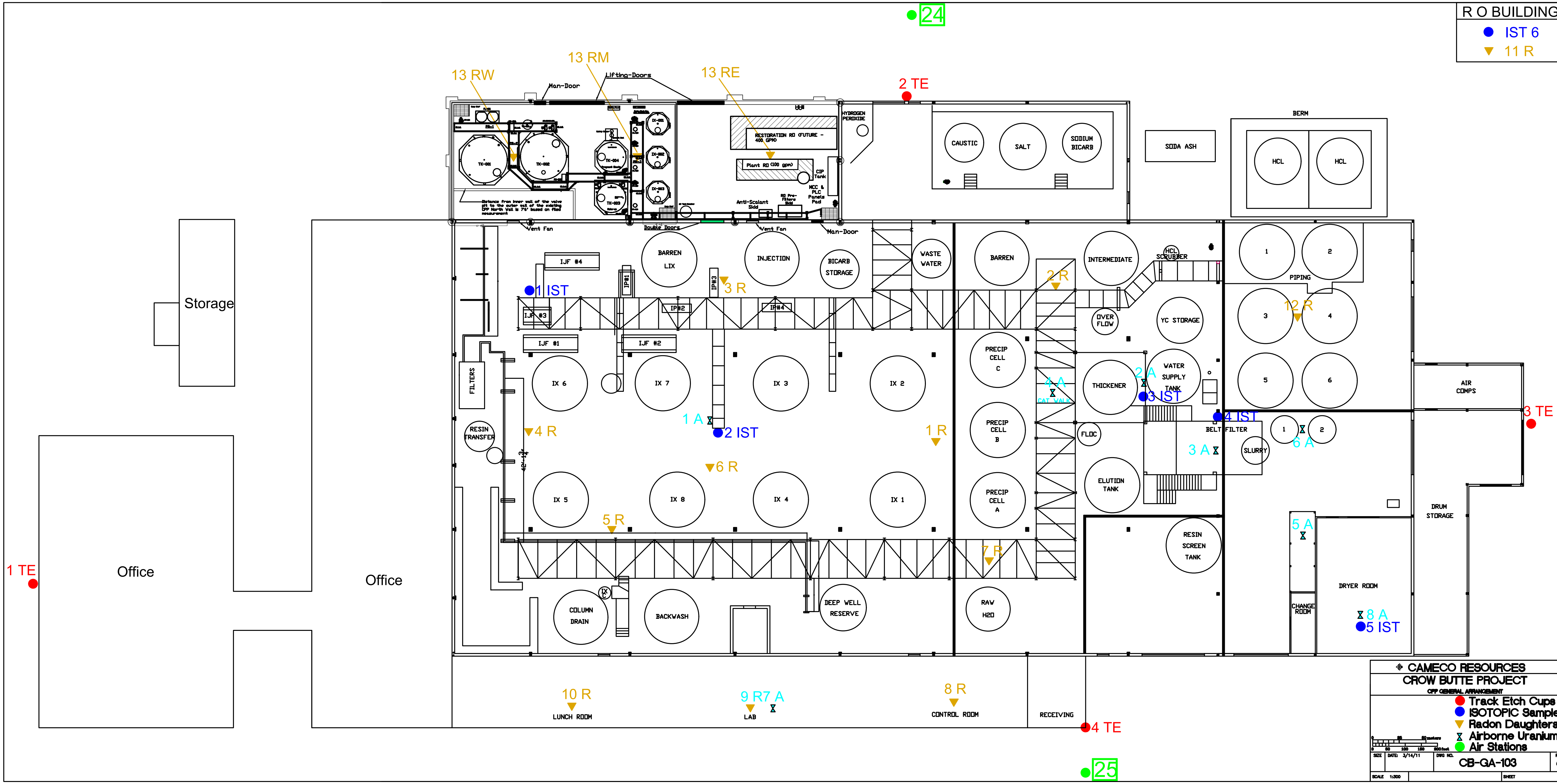
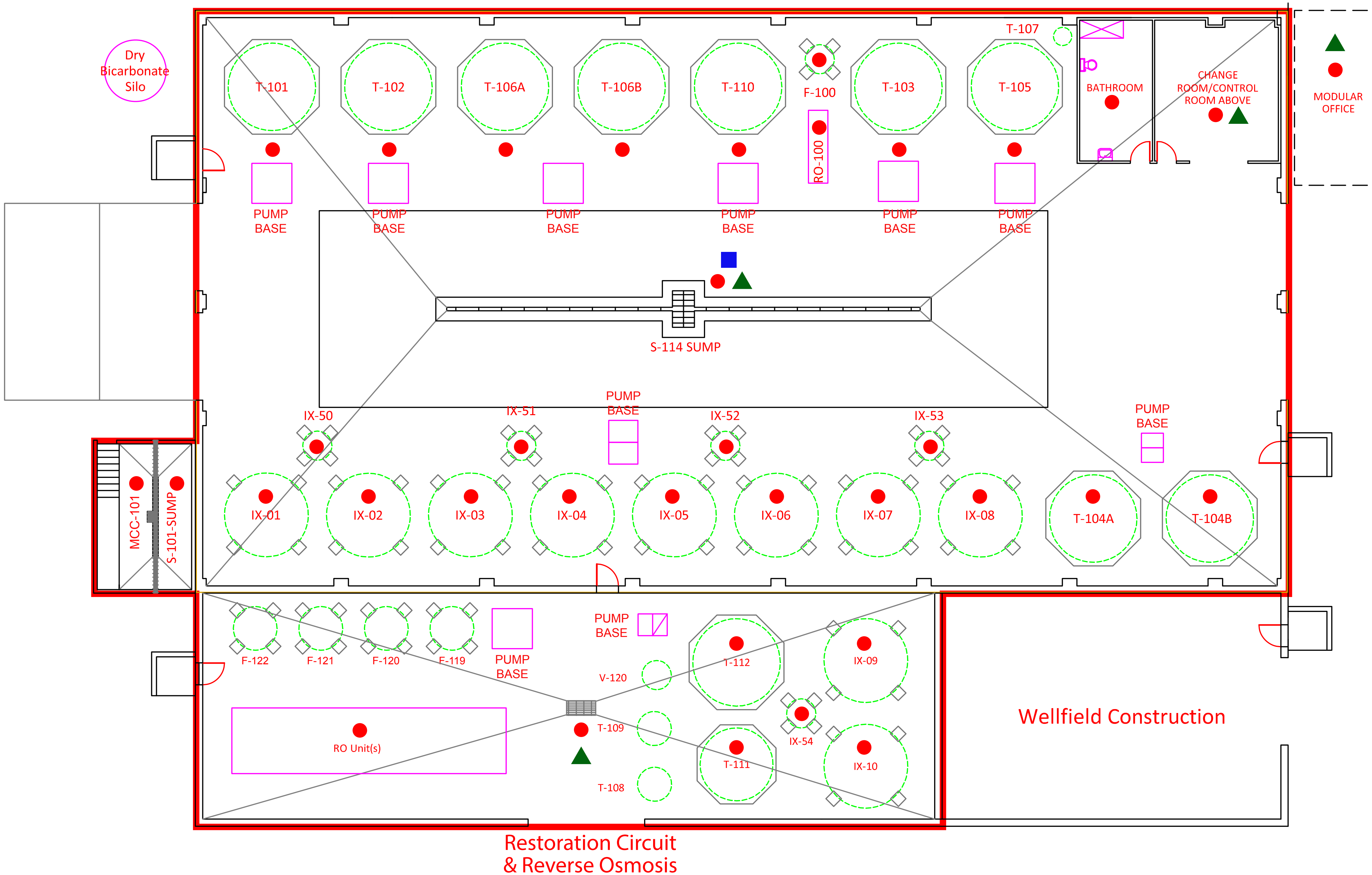


Figure 5.7-1
Crow Butte Project Radiological Monitoring Locations





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
F-119 through 122	RO Filter
V-120	Degaser
F-100	Sock filters
MCC-101	Injection pumps on trunk lines to wellfield
RO-100	RO Pump Base

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.

CROW BUTTE RESOURCES, INC.

FIGURE 5.7-2
PROPOSED OPERATIONAL RADIOLOGICAL MONITORING LOCATIONS FOR SATELLITE FACILITY

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: JEC

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 5.7-3. Average and Maximum External Exposure Analysis

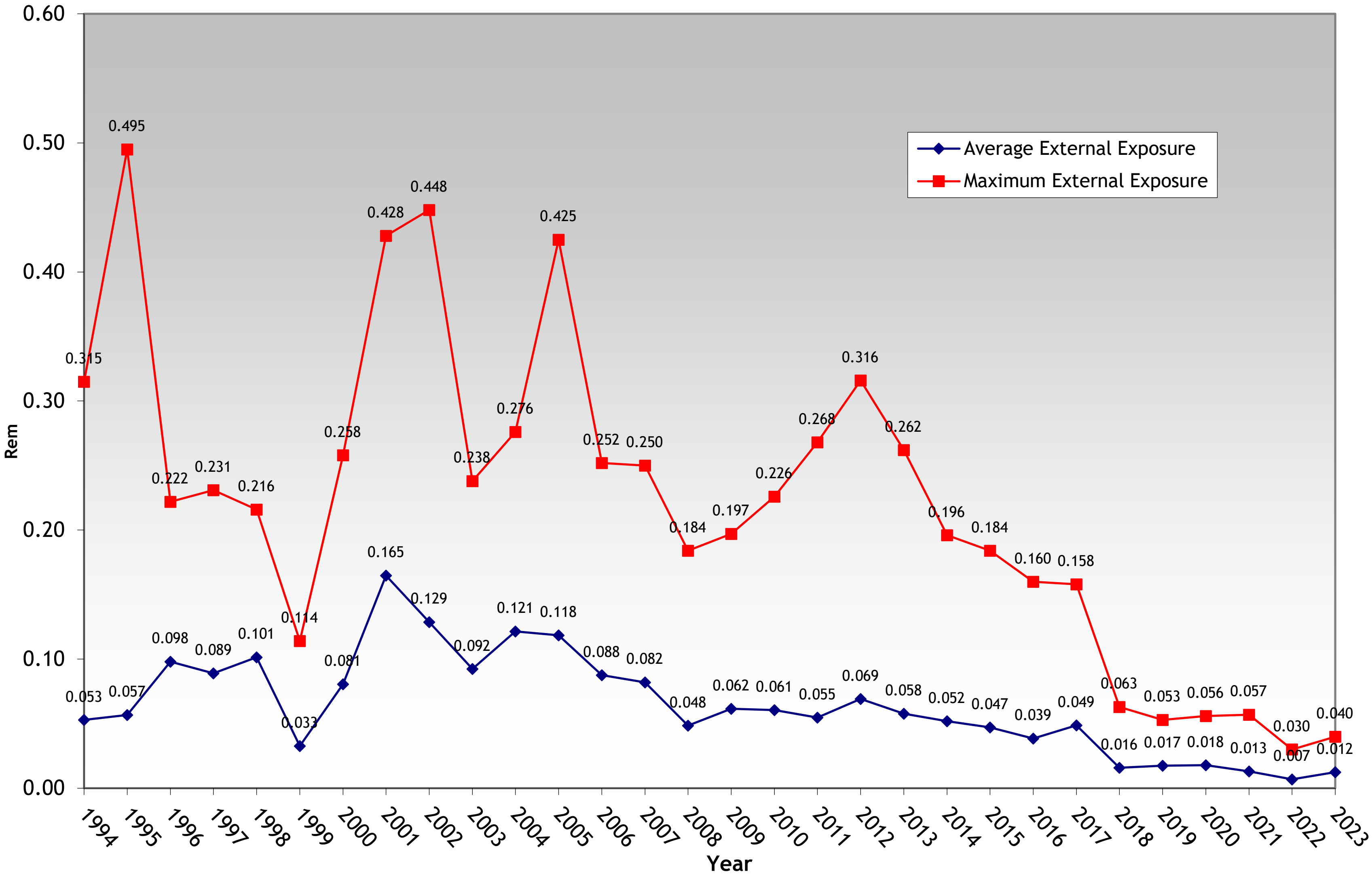


Figure 5.7-4. Combined External Exposure Analysis

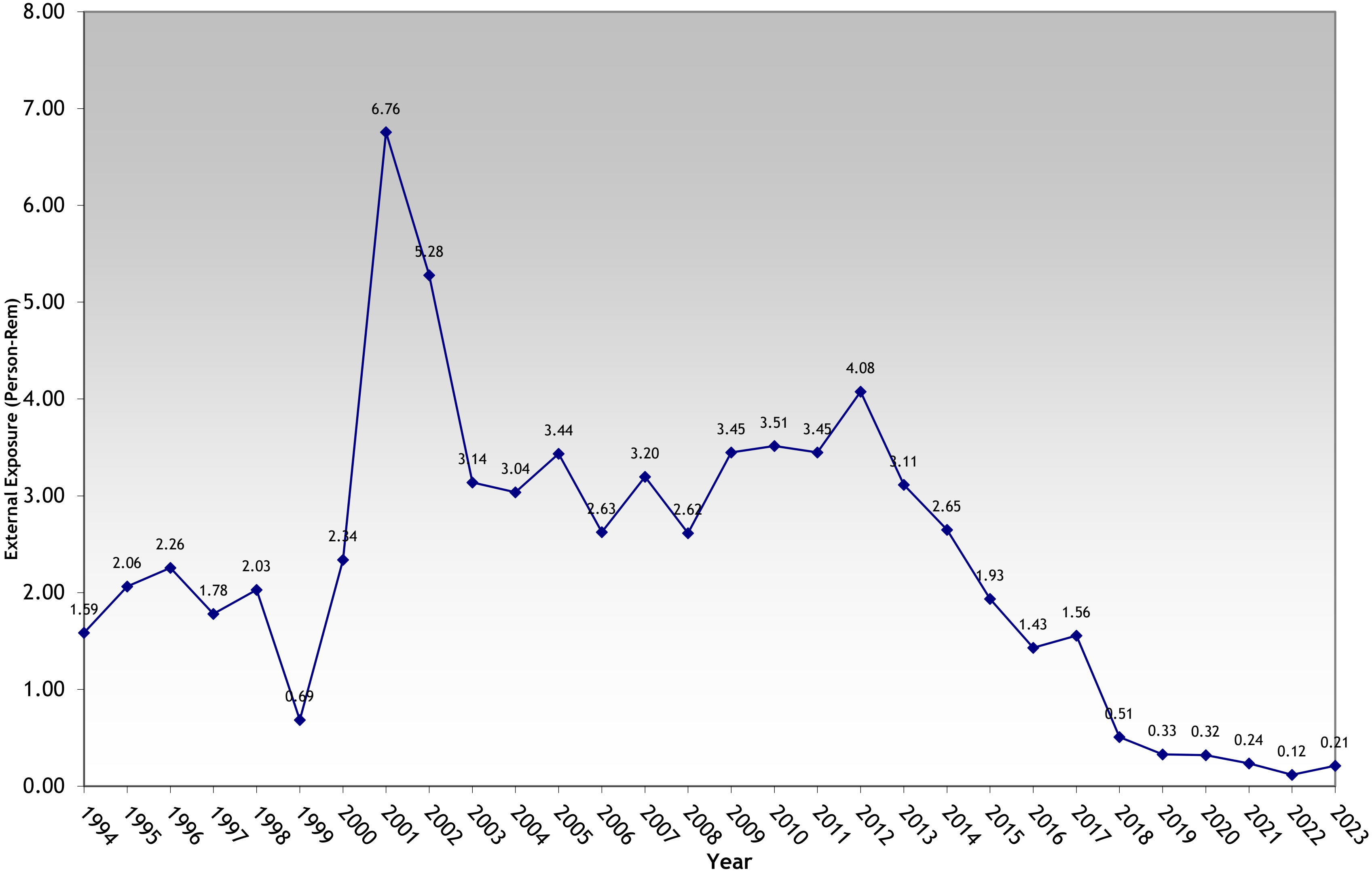


Figure 5.7-5. Average and Maximum Airborne Uranium Exposure

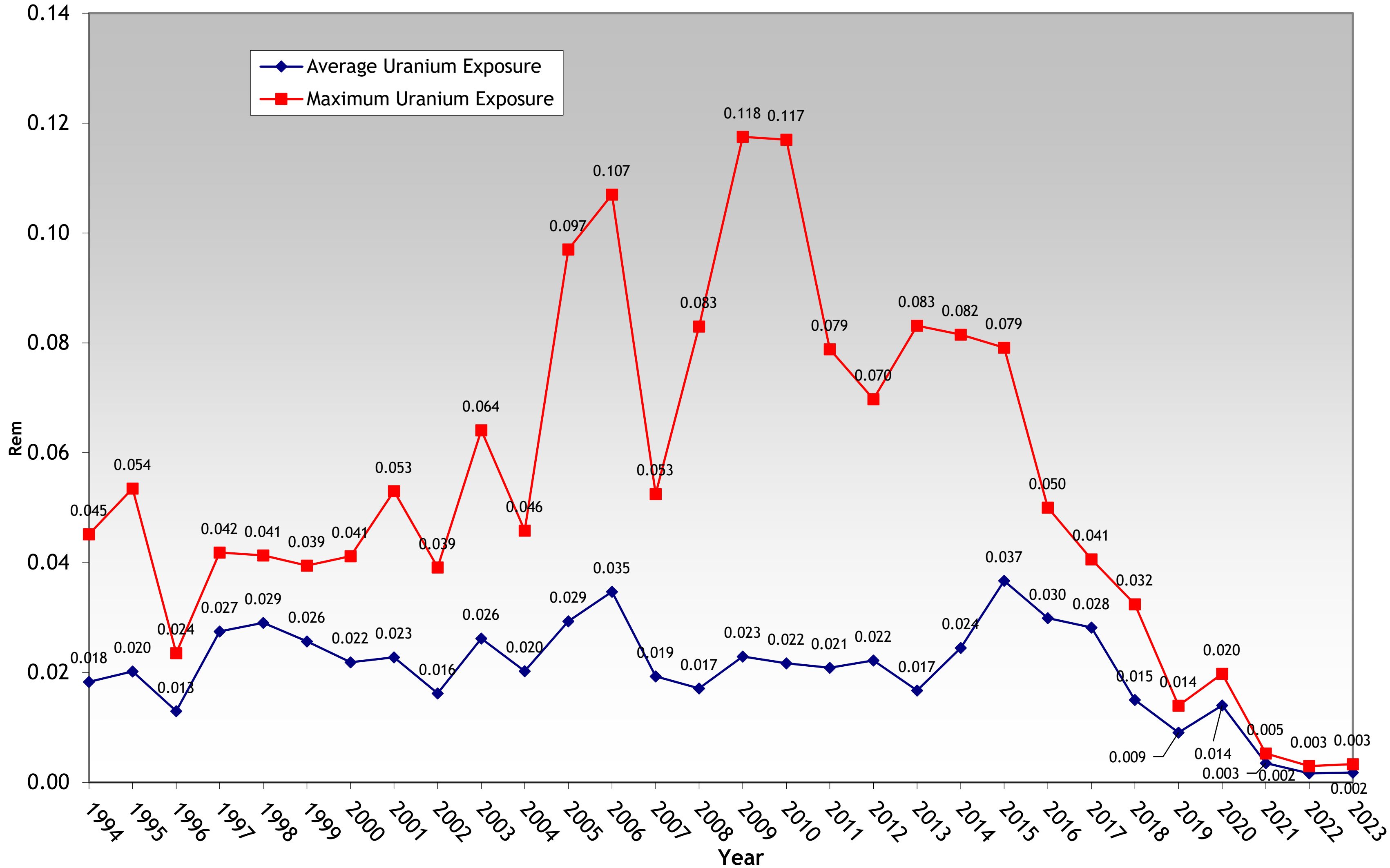


Figure 5.7-6. Combined Airborne Uranium Exposure Analysis

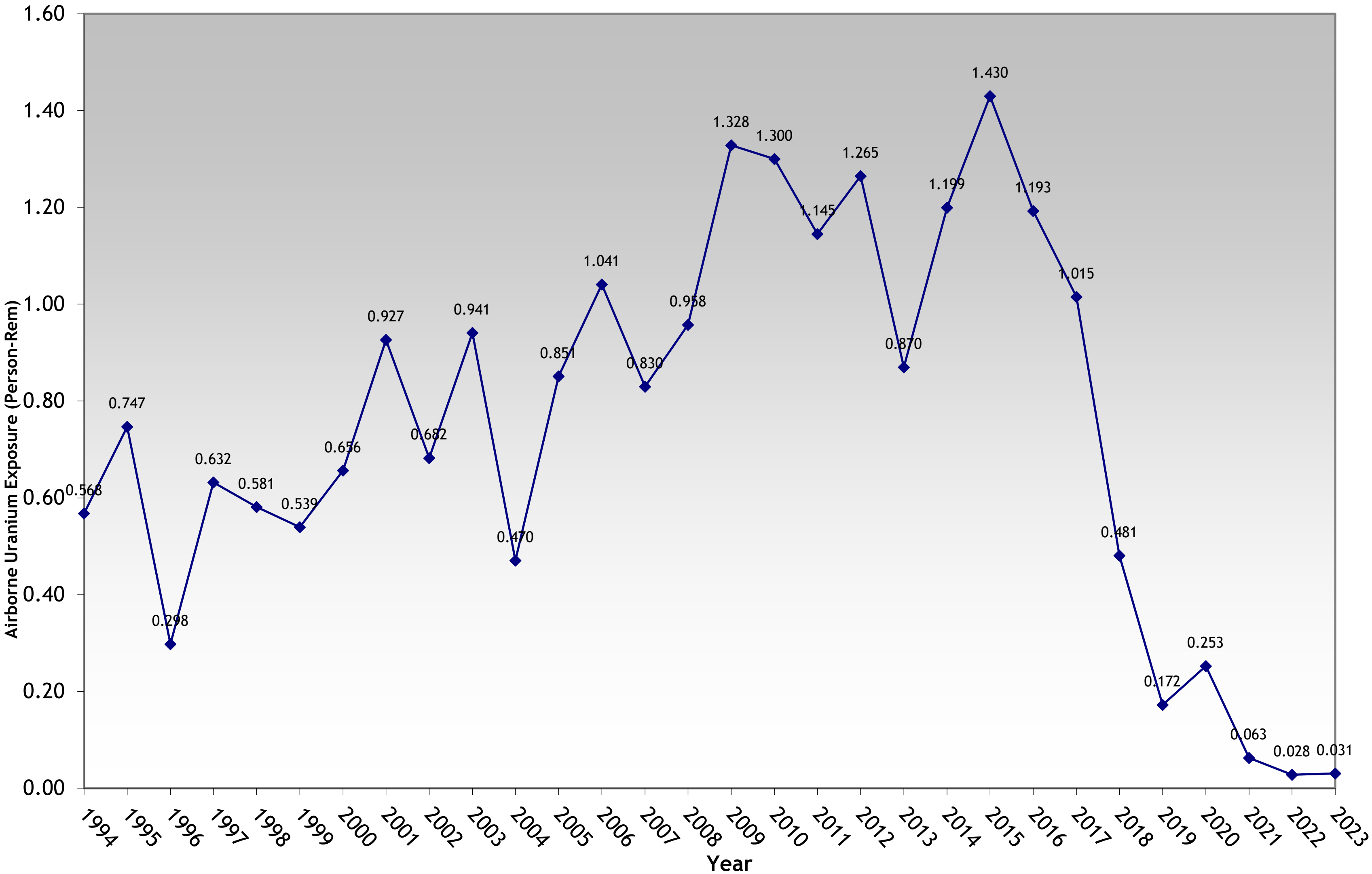


Figure 5.7-7. Average and Maximum Radon Exposure

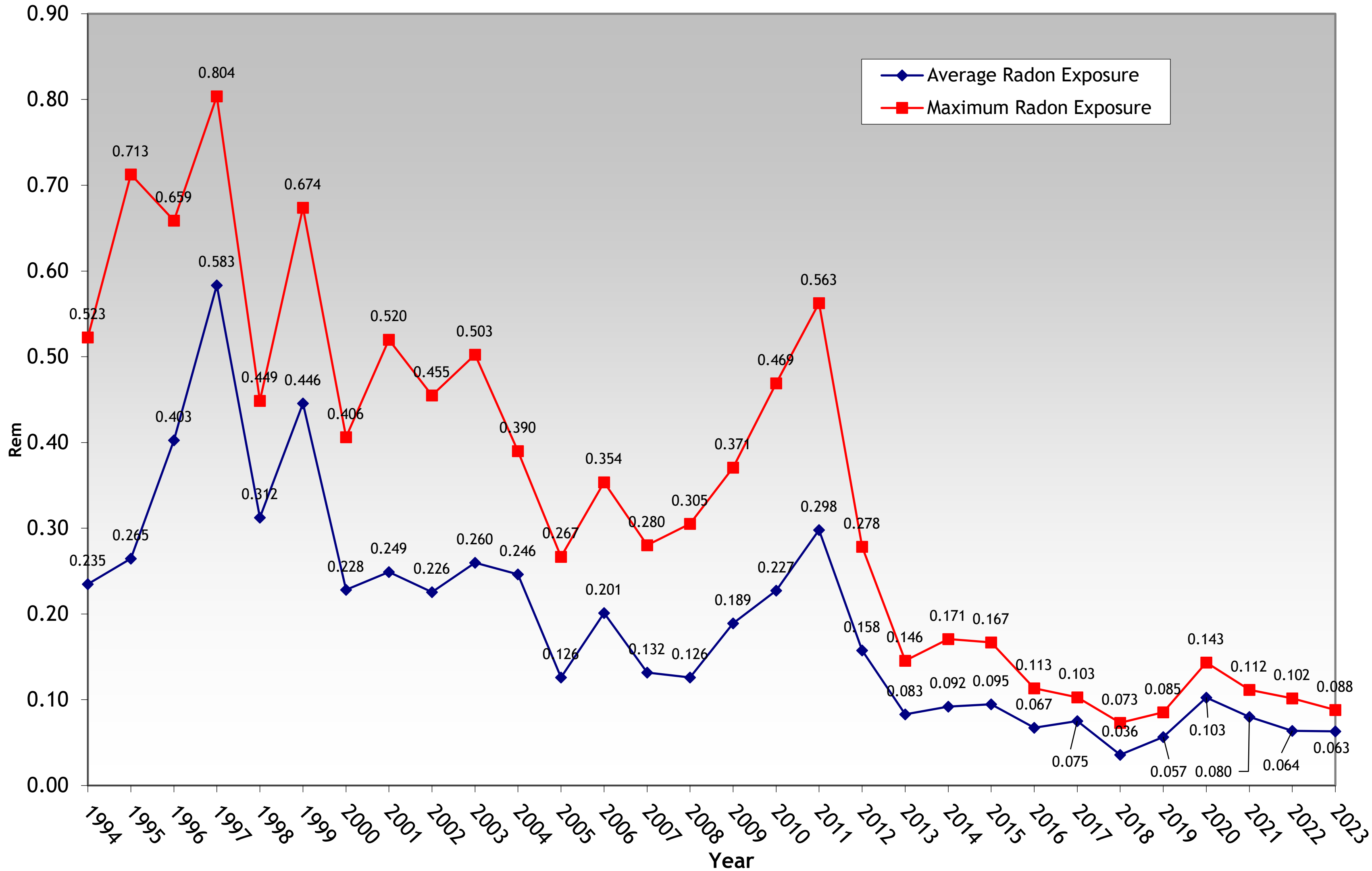
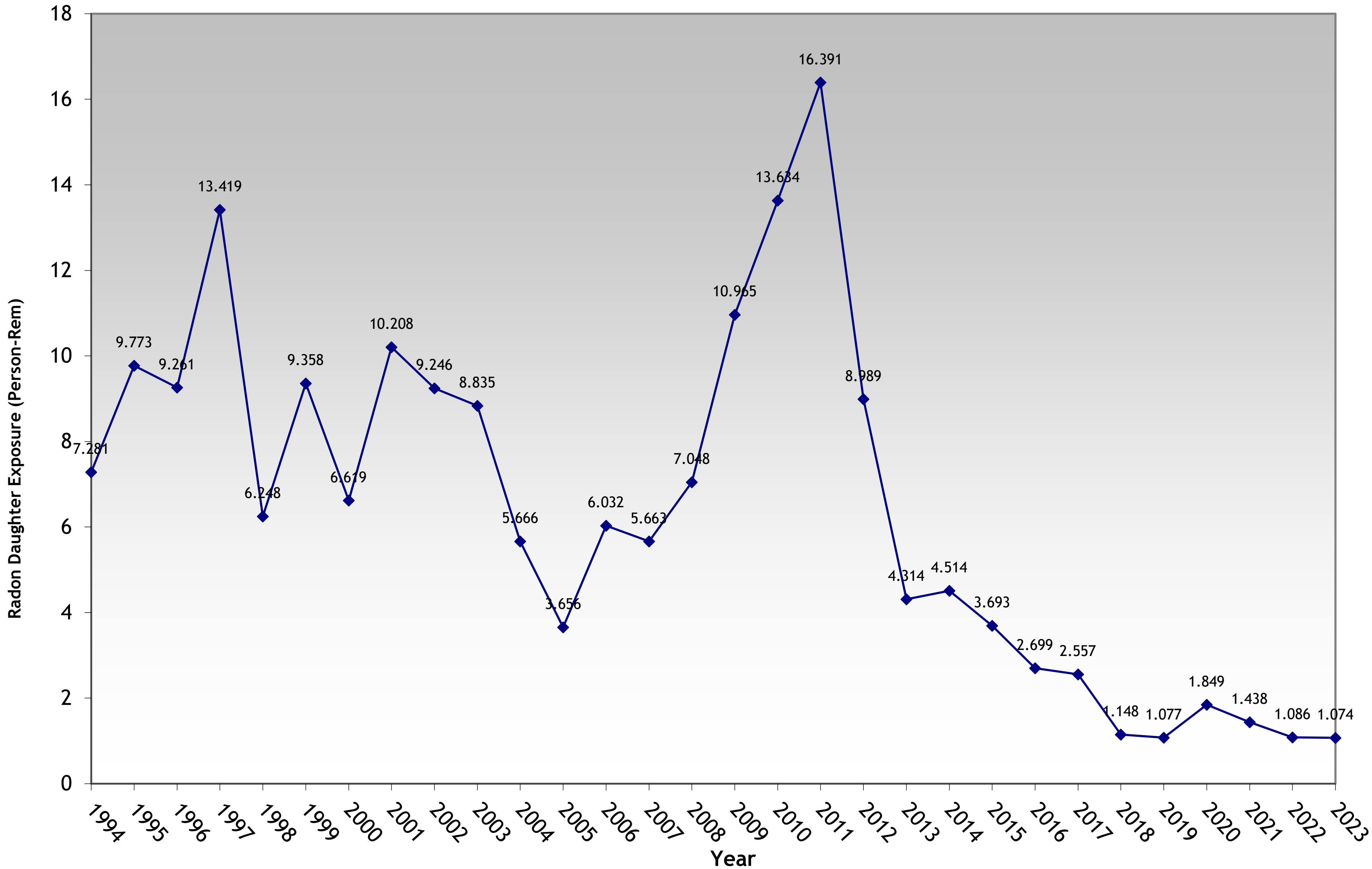


Figure 5.7-8. Combined Radon Daughter Exposure Trend Analysis



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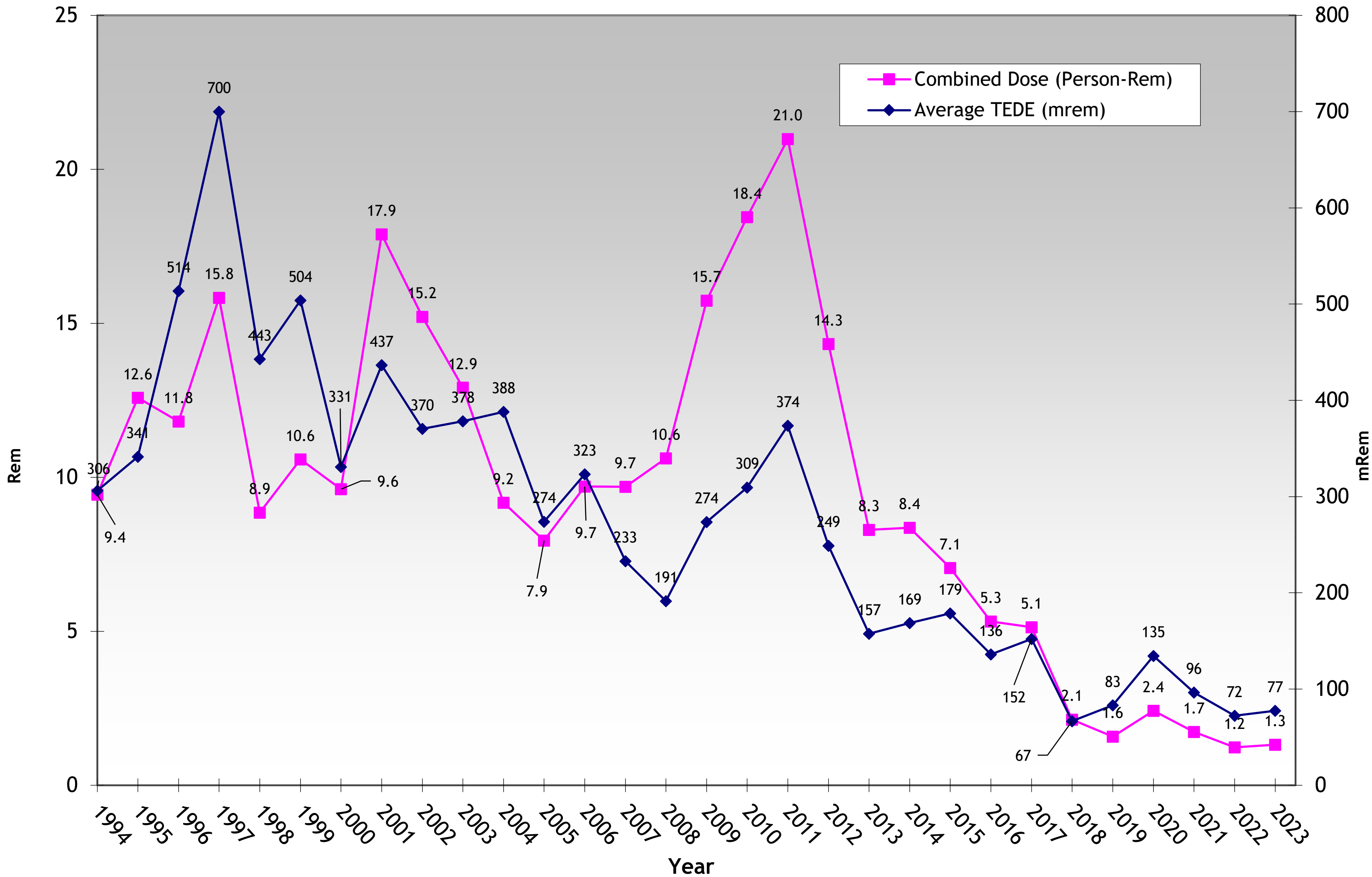

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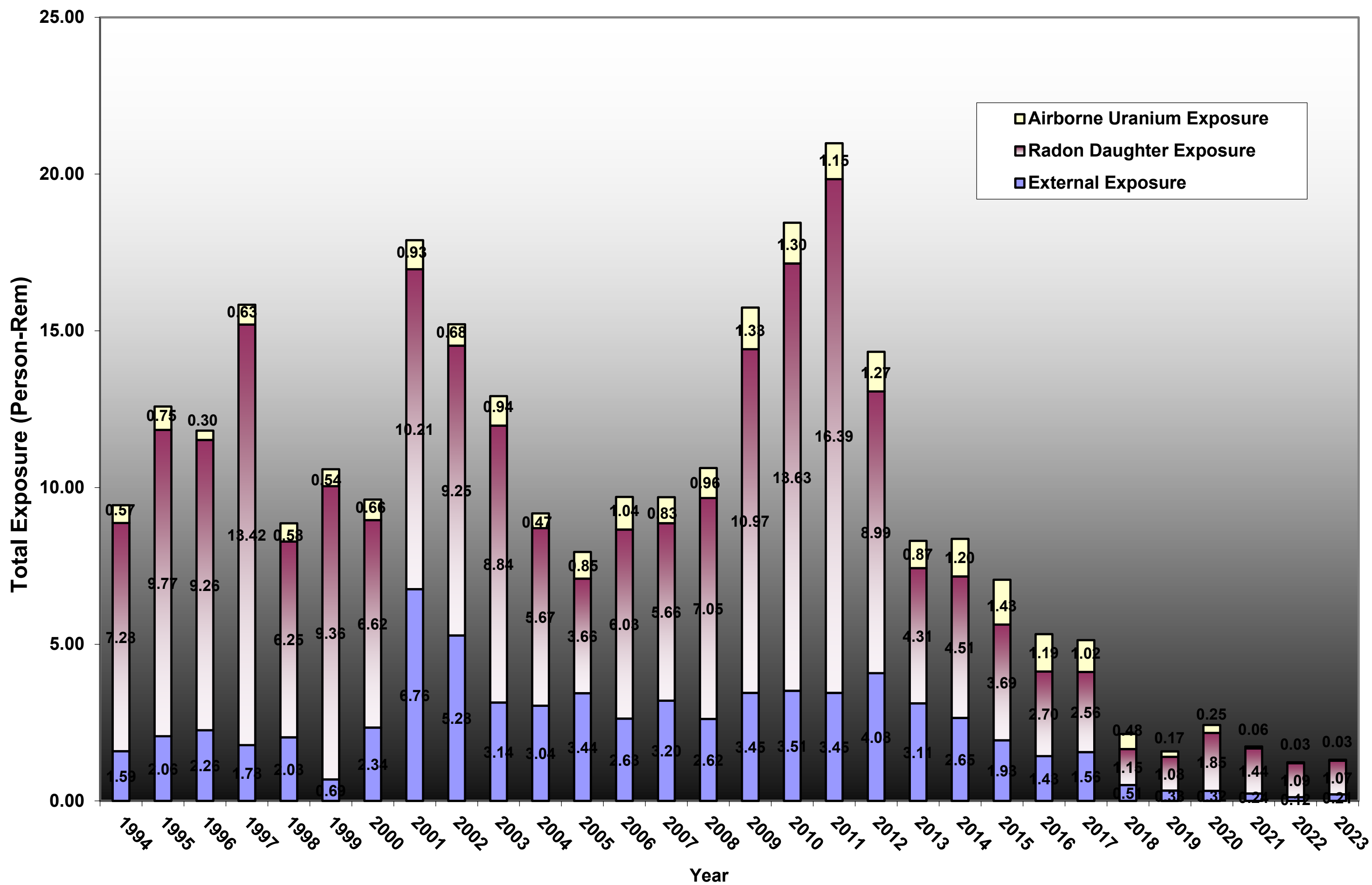

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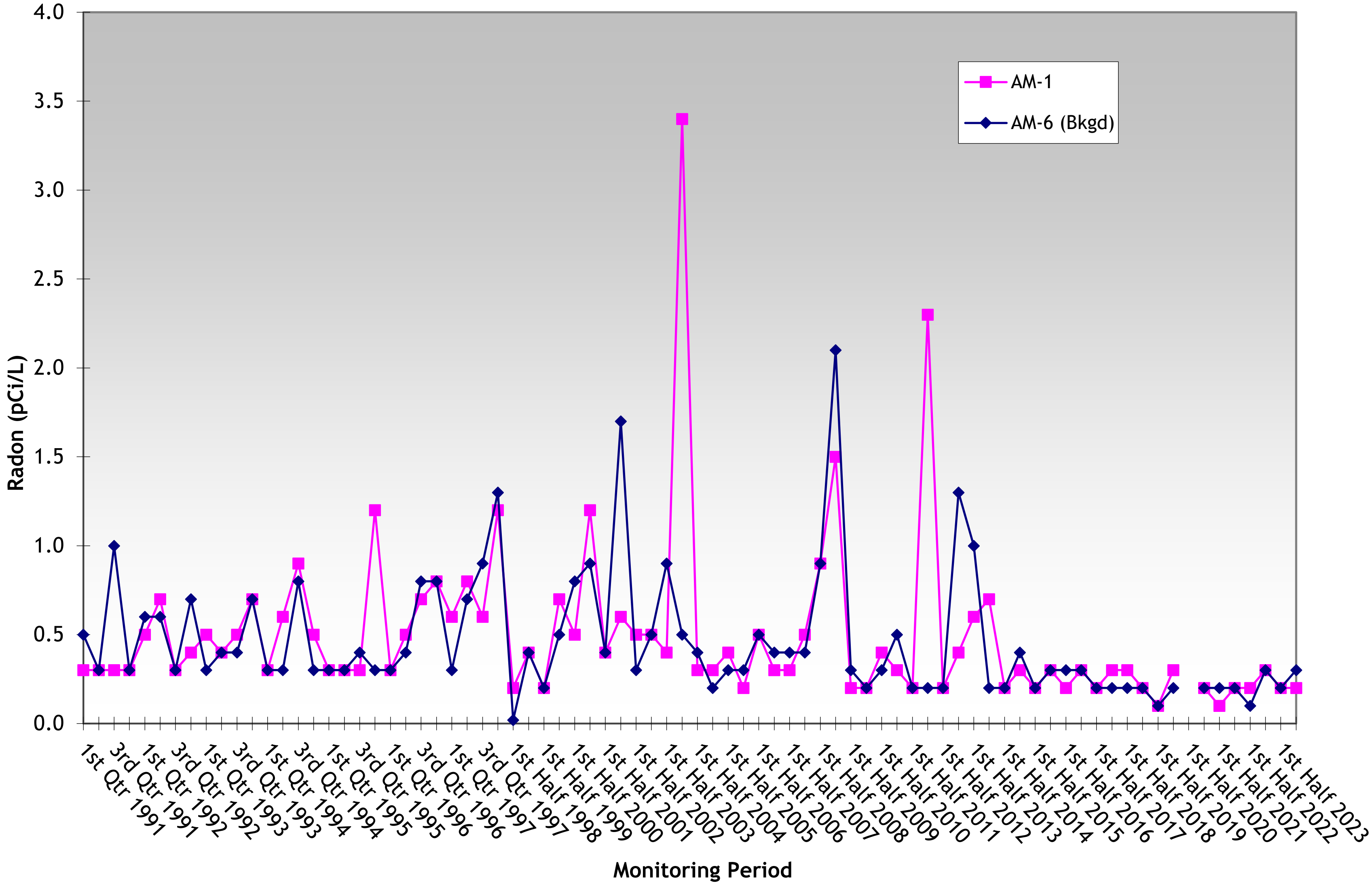

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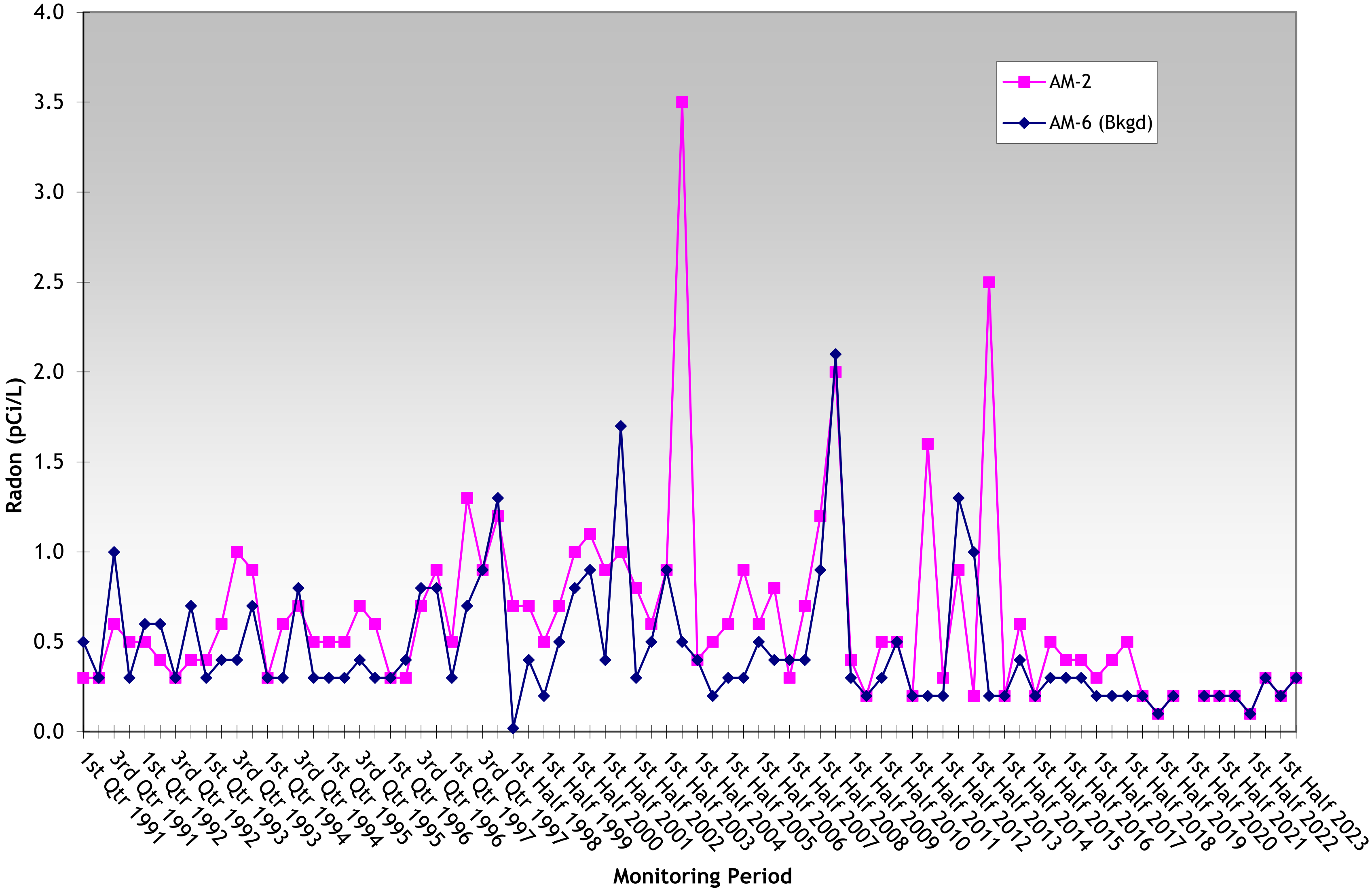

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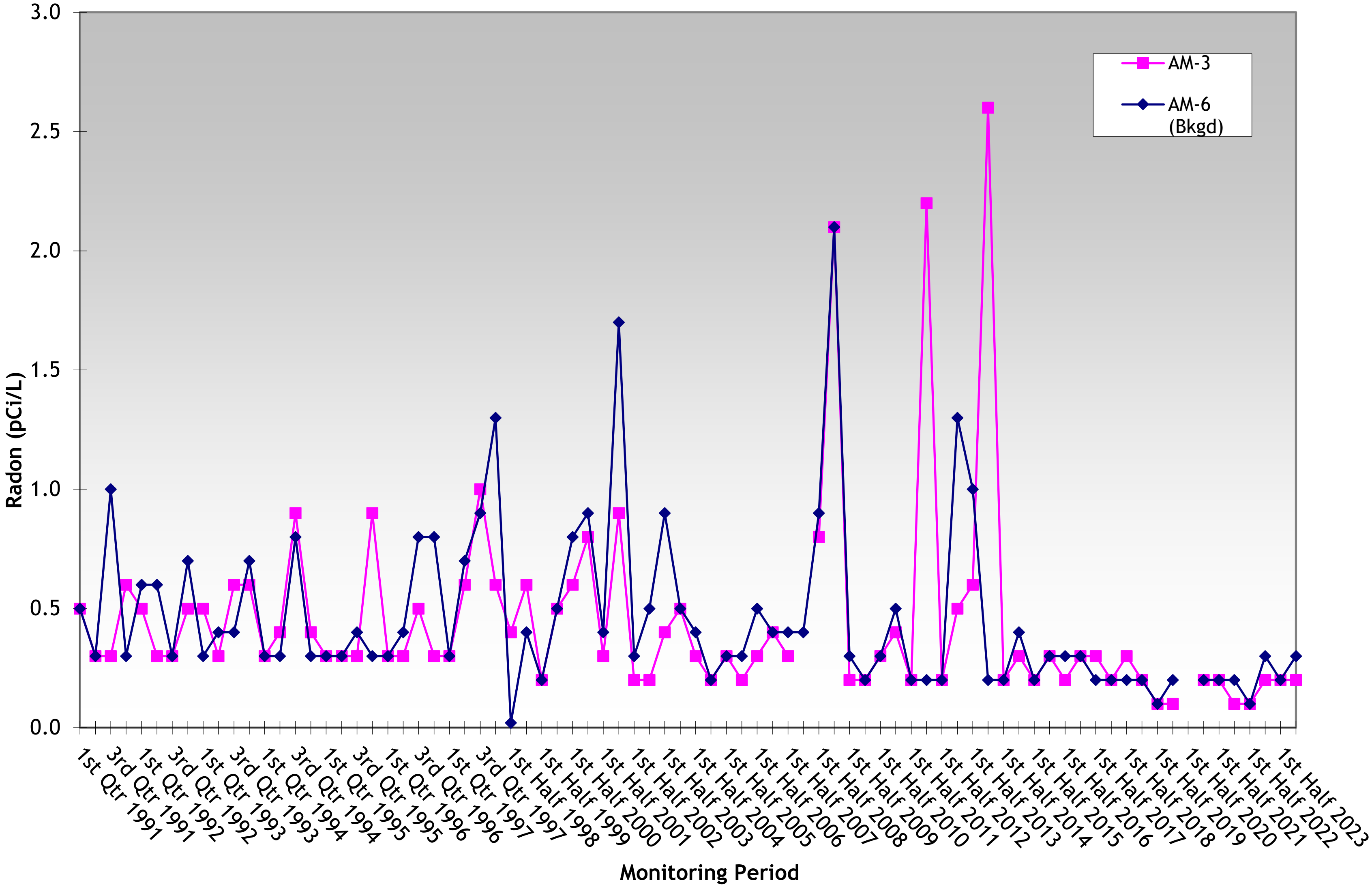

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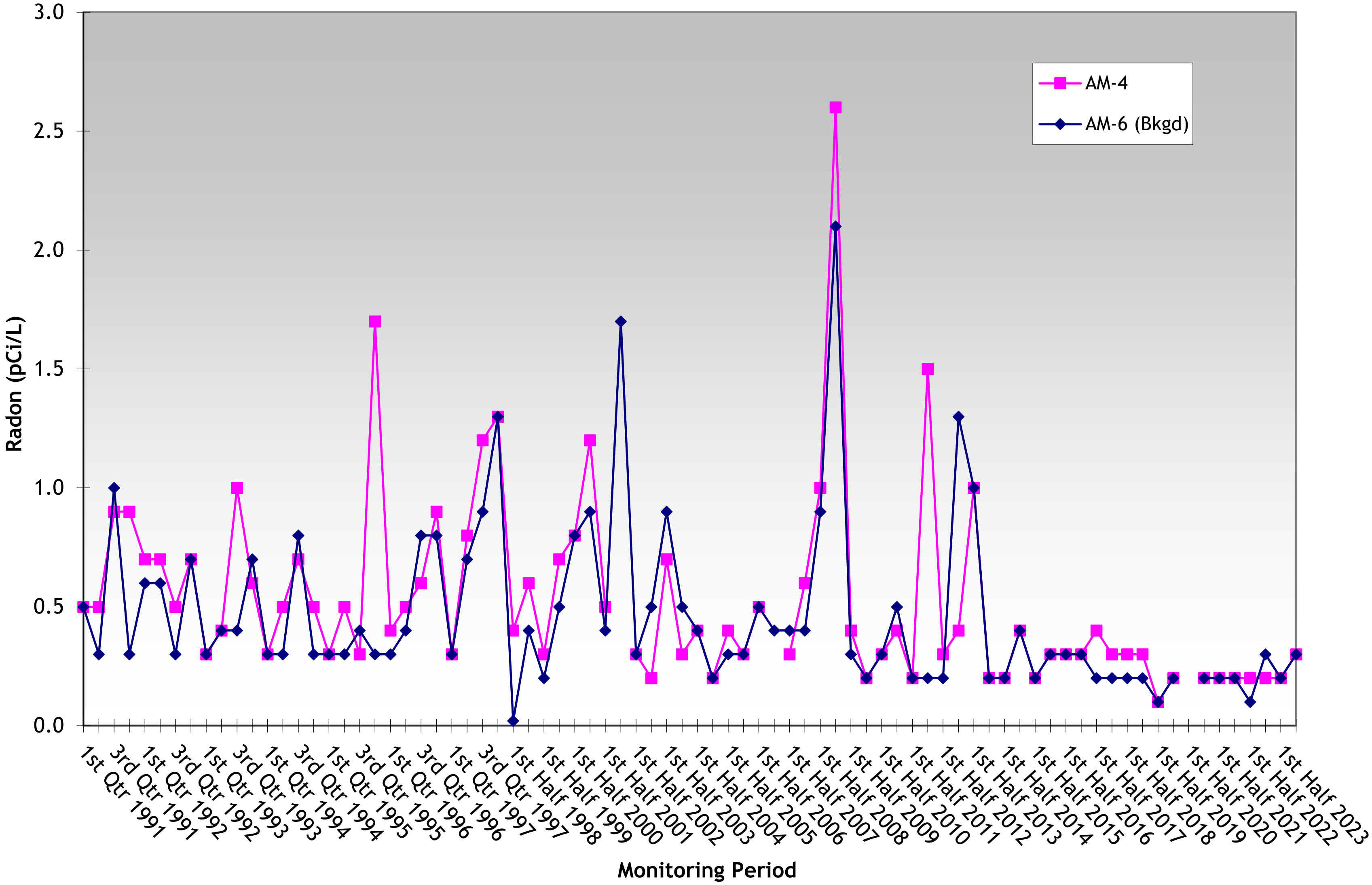

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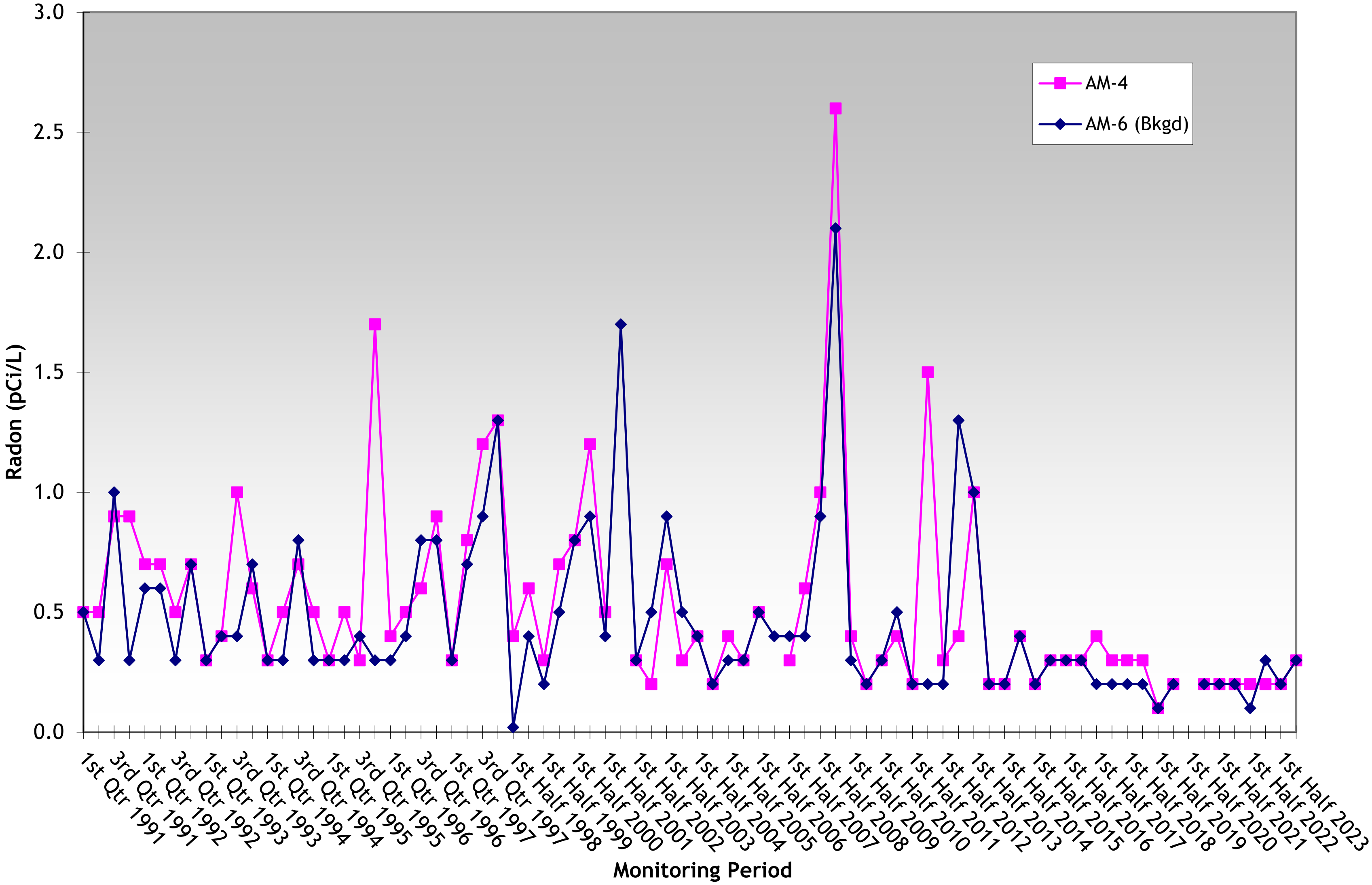

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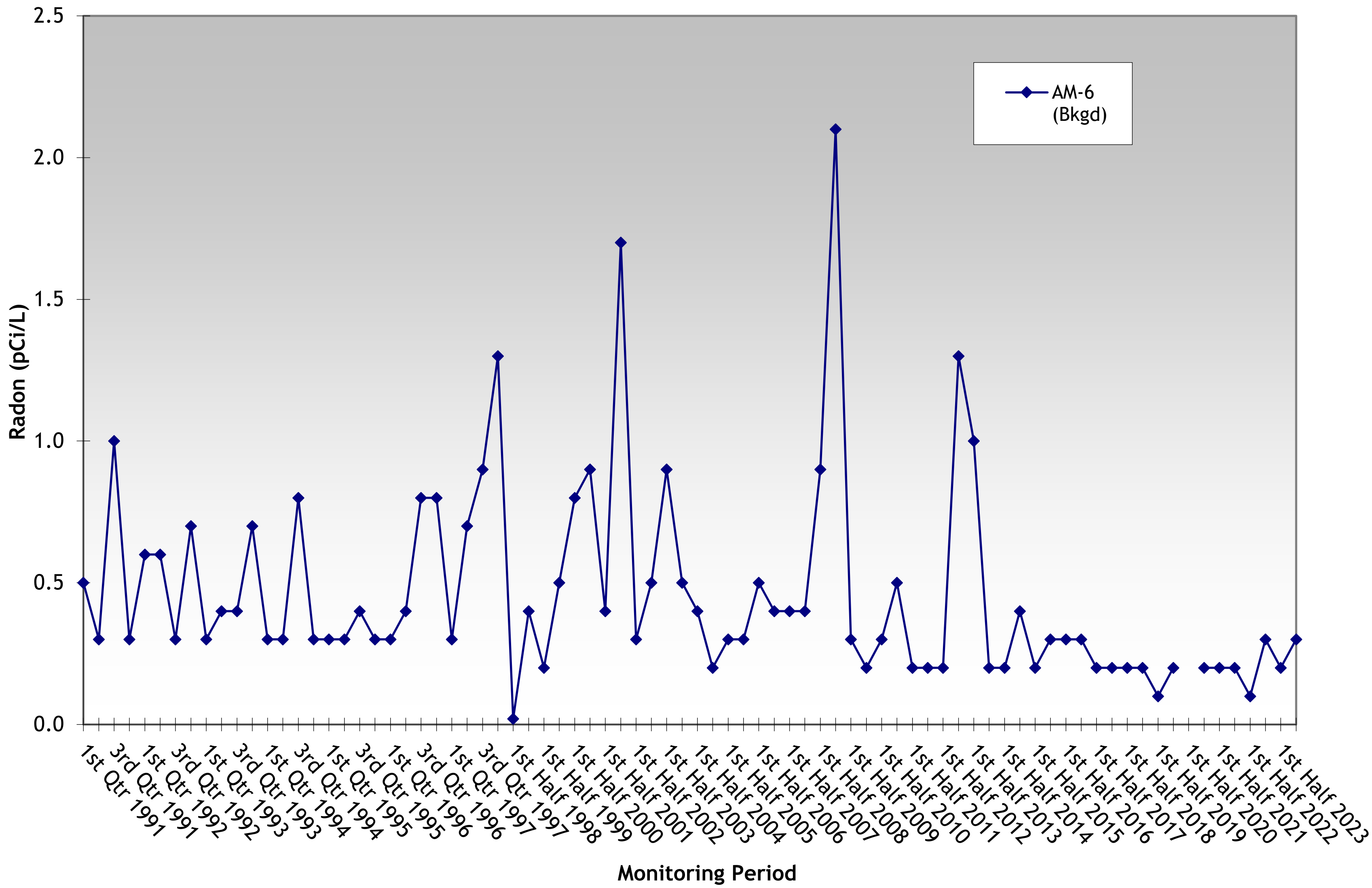

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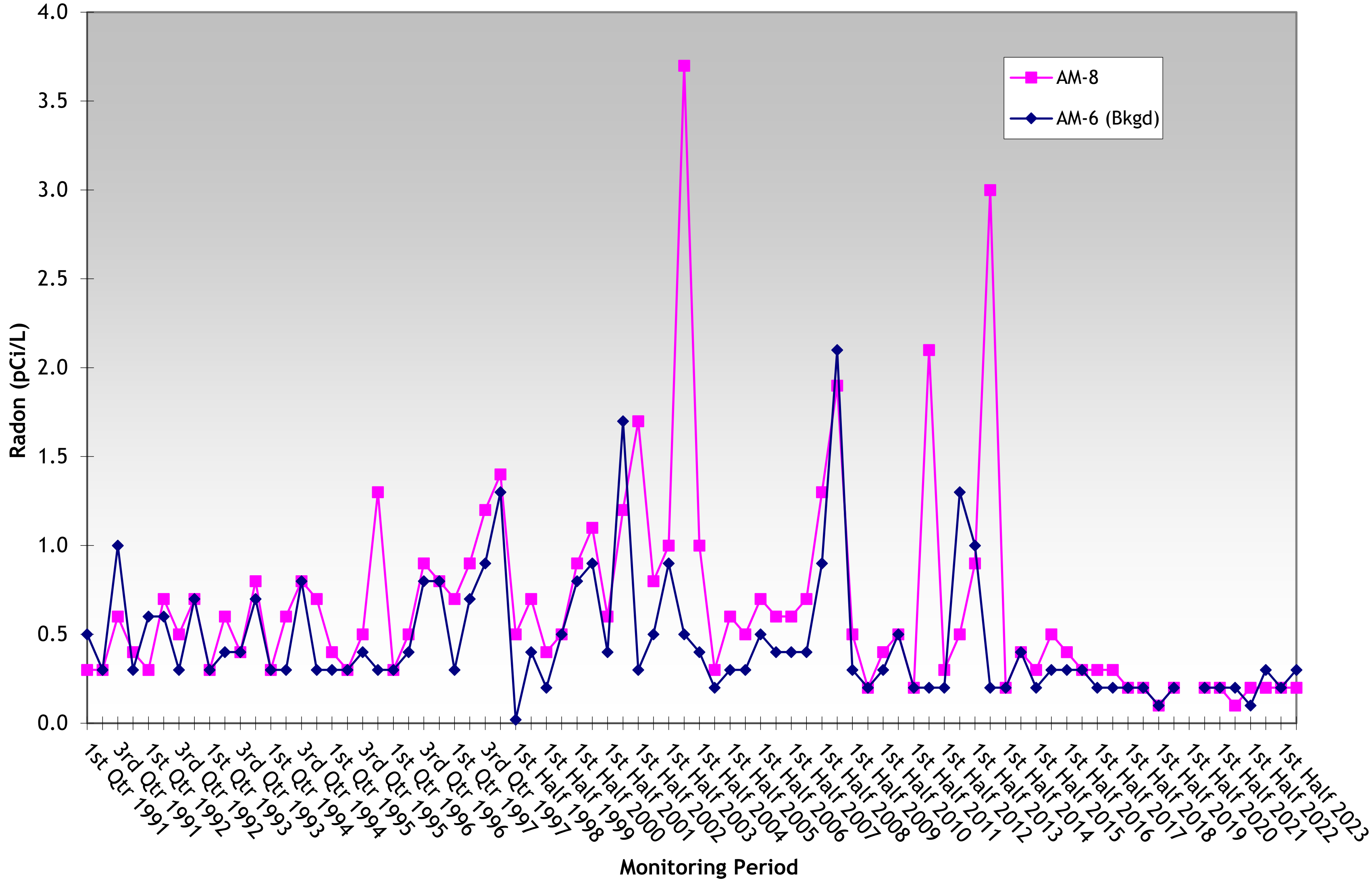

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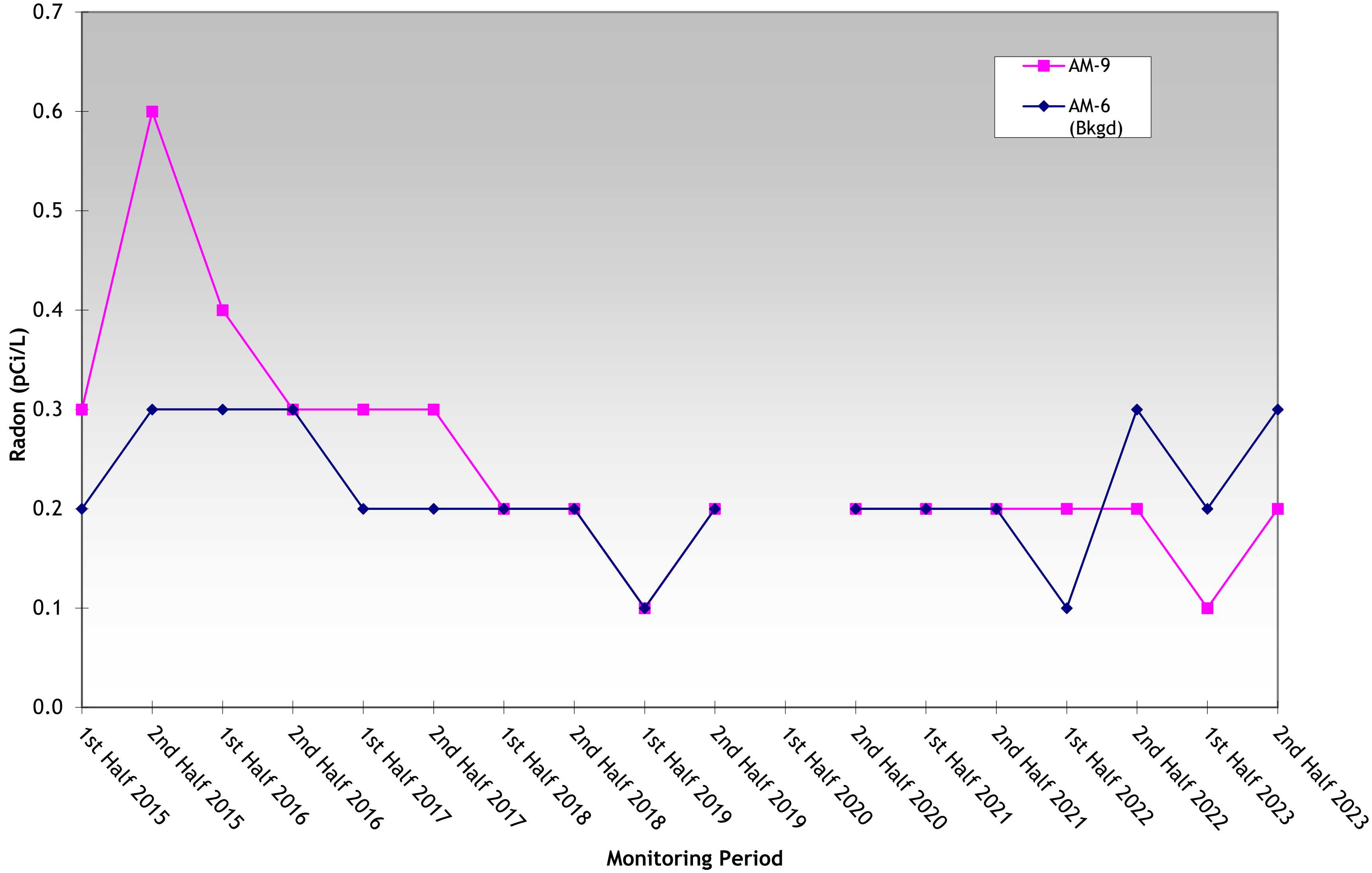

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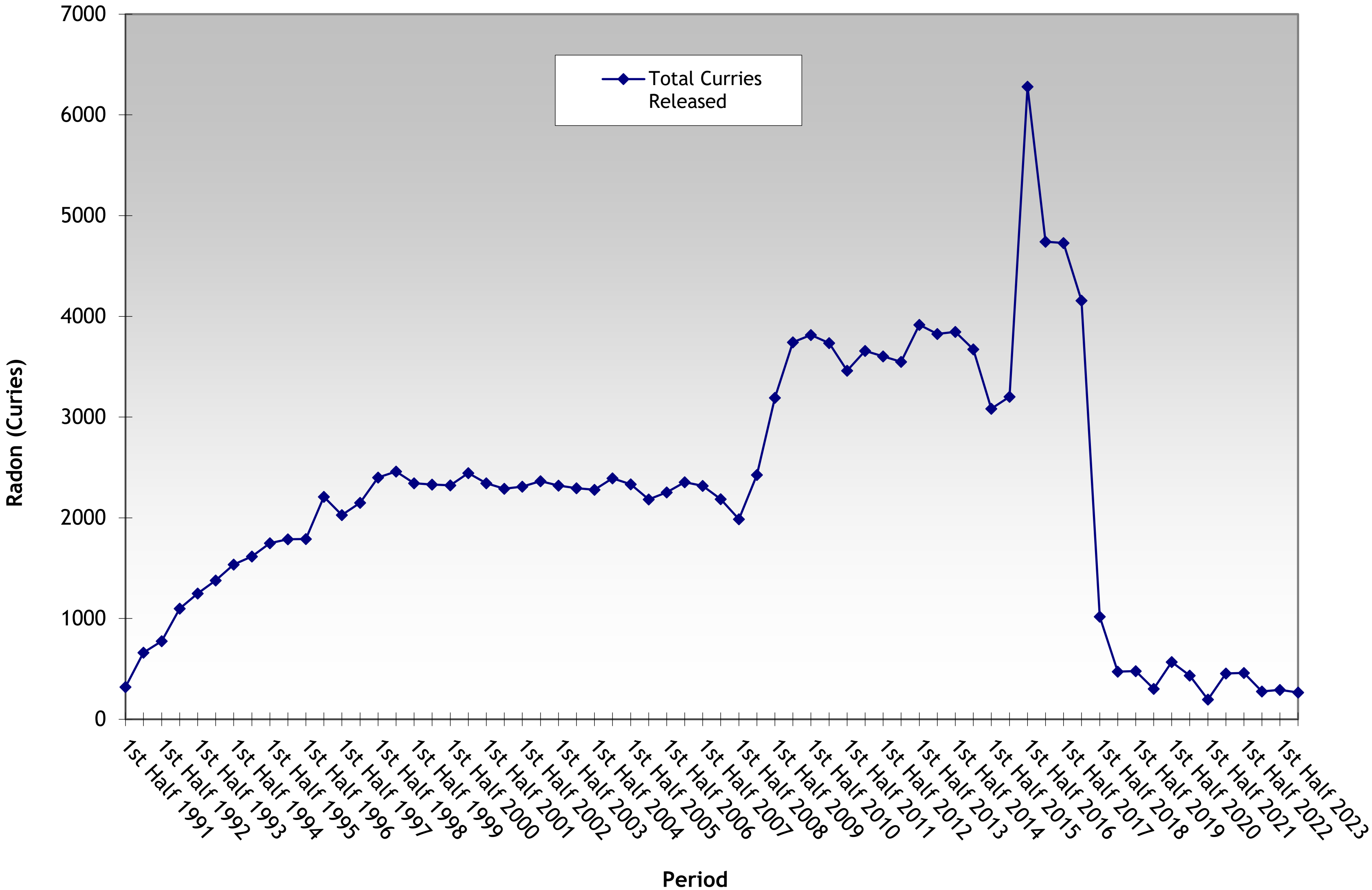

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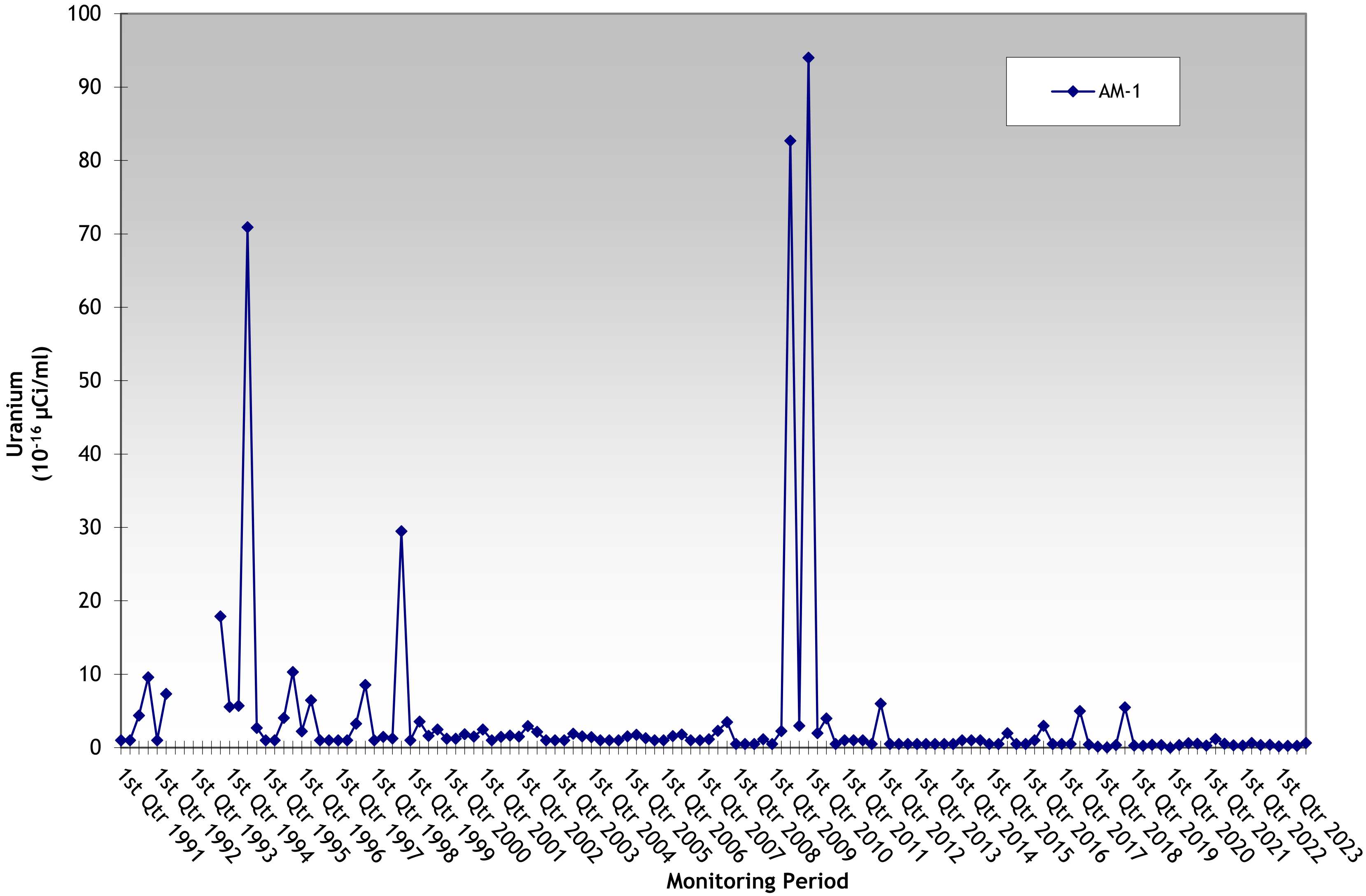

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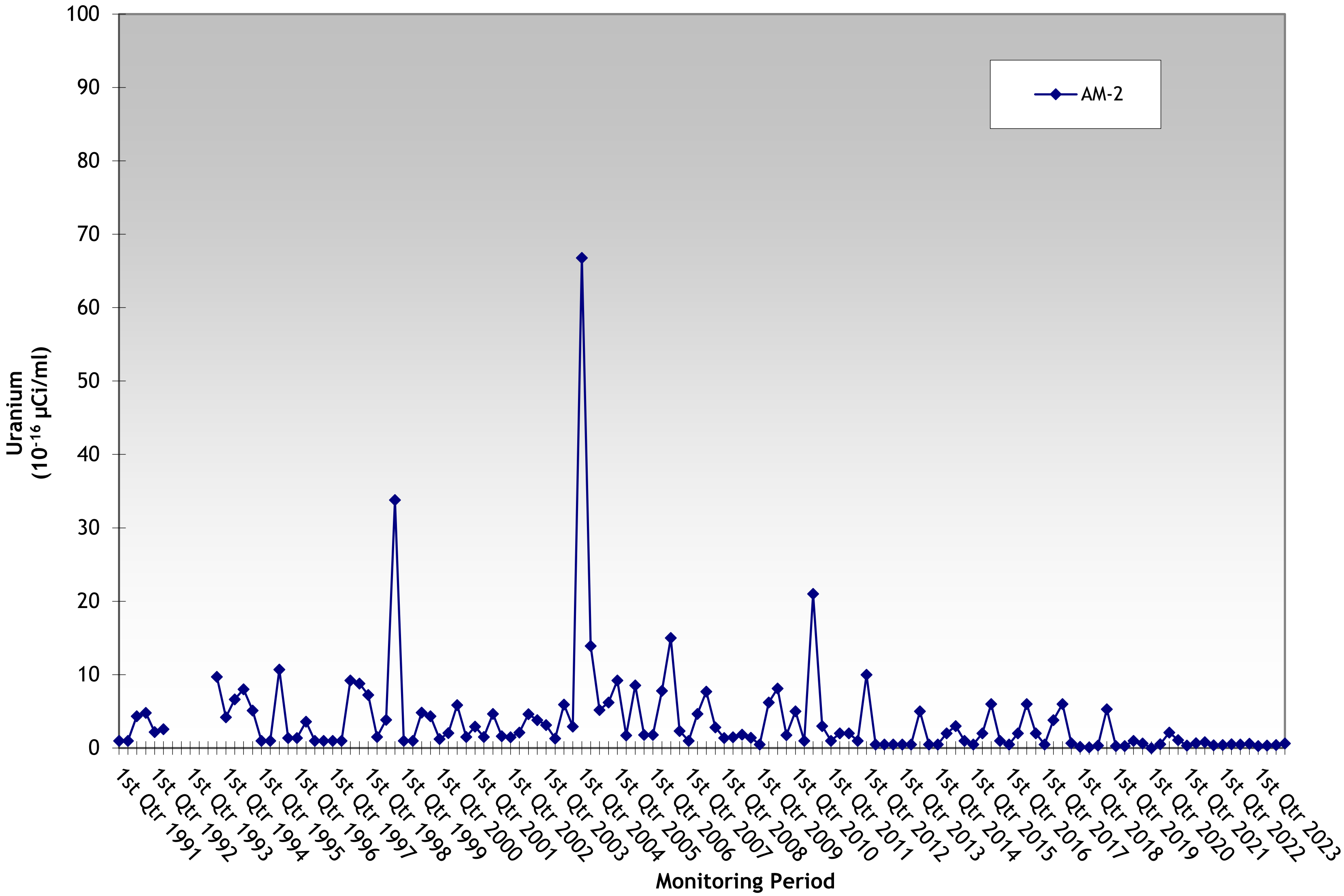

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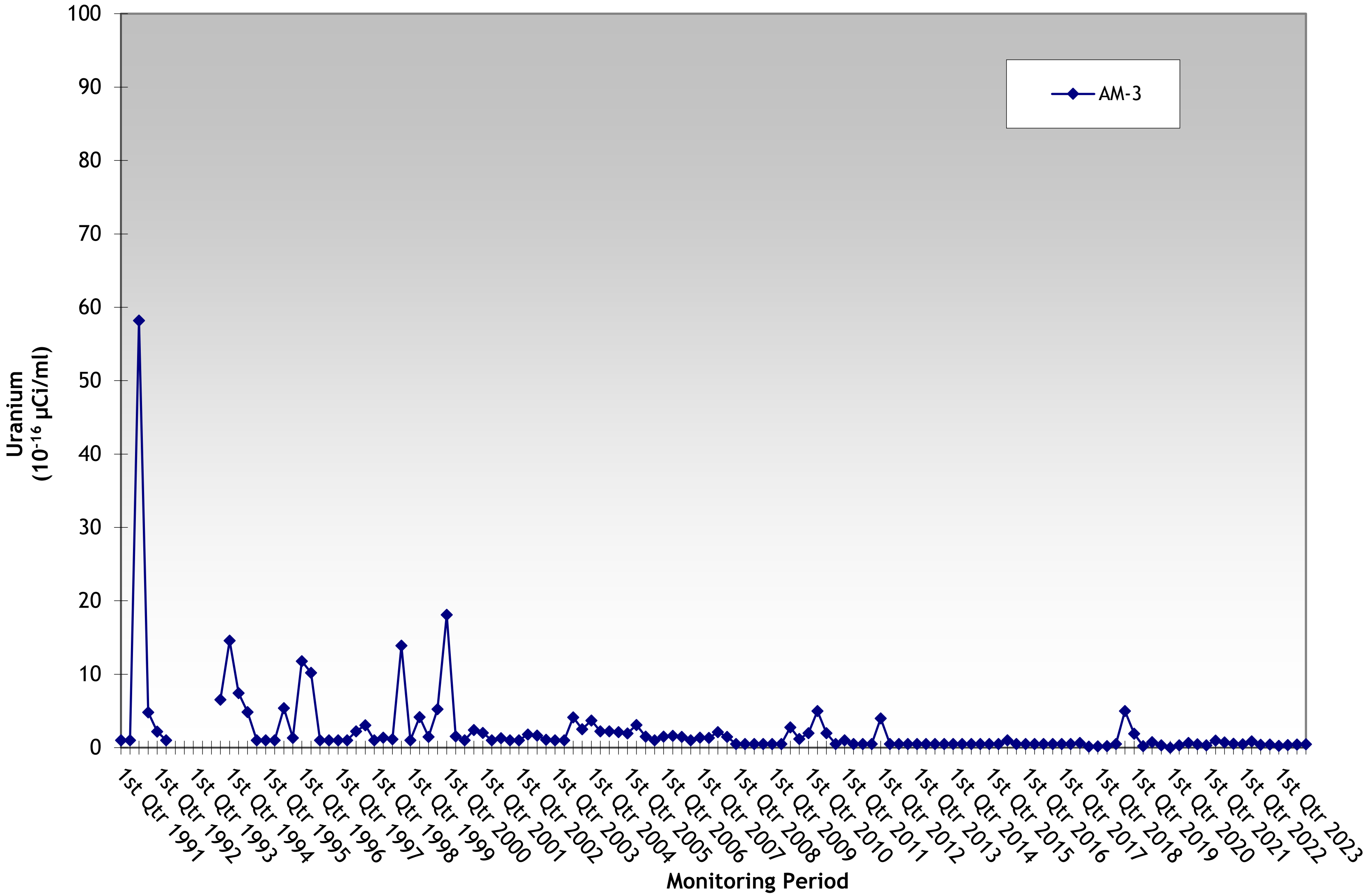

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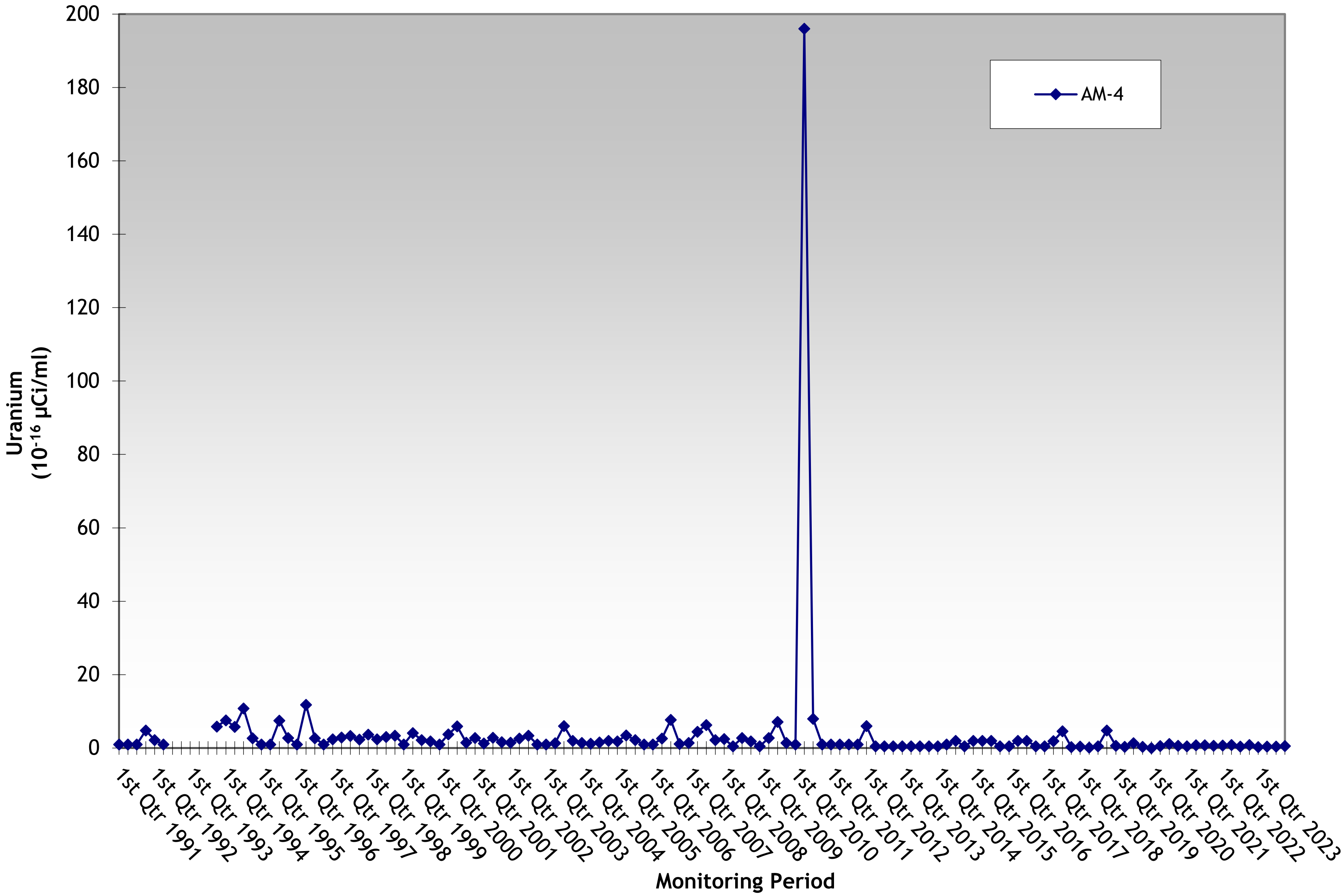

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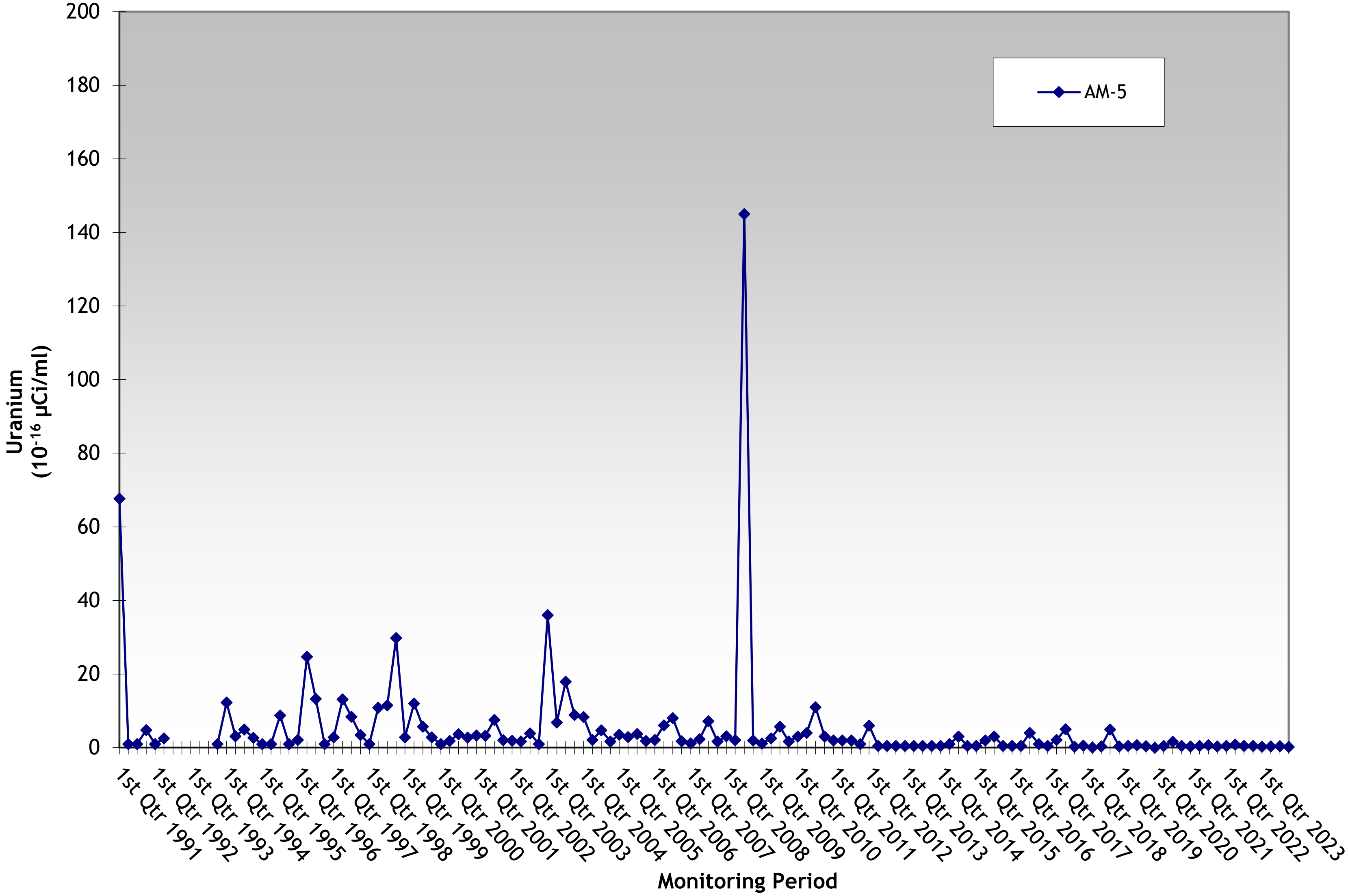

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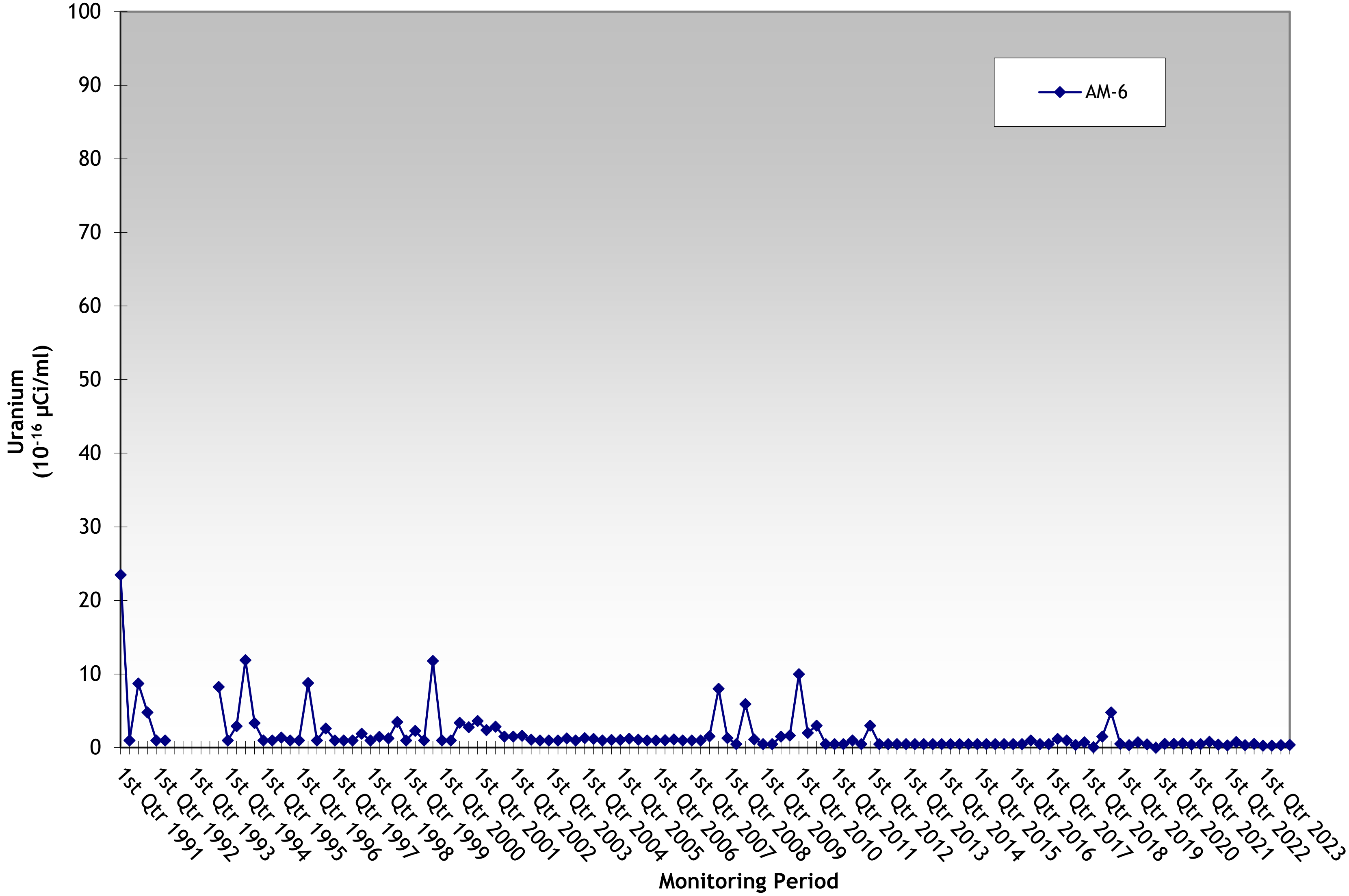

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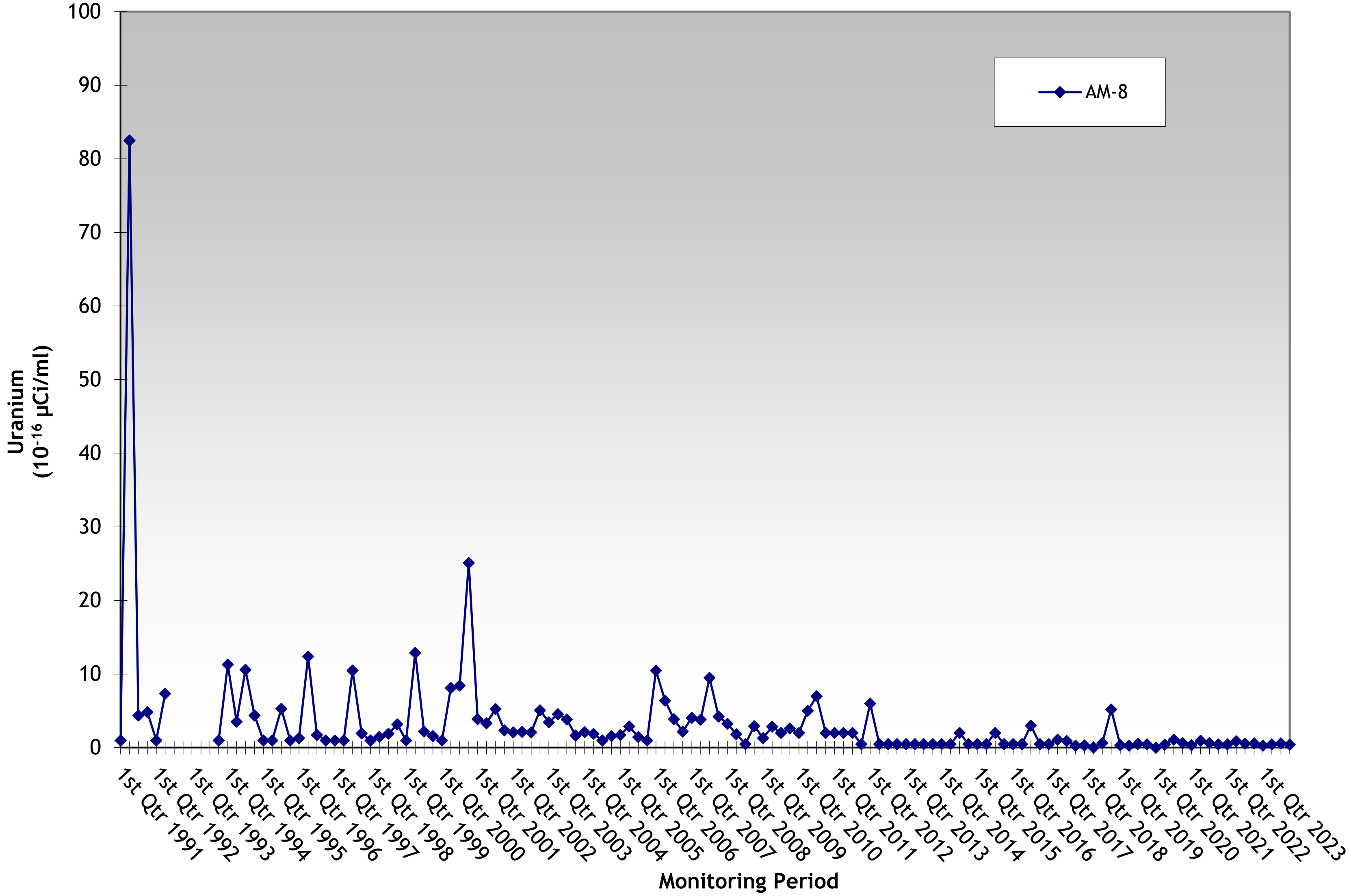

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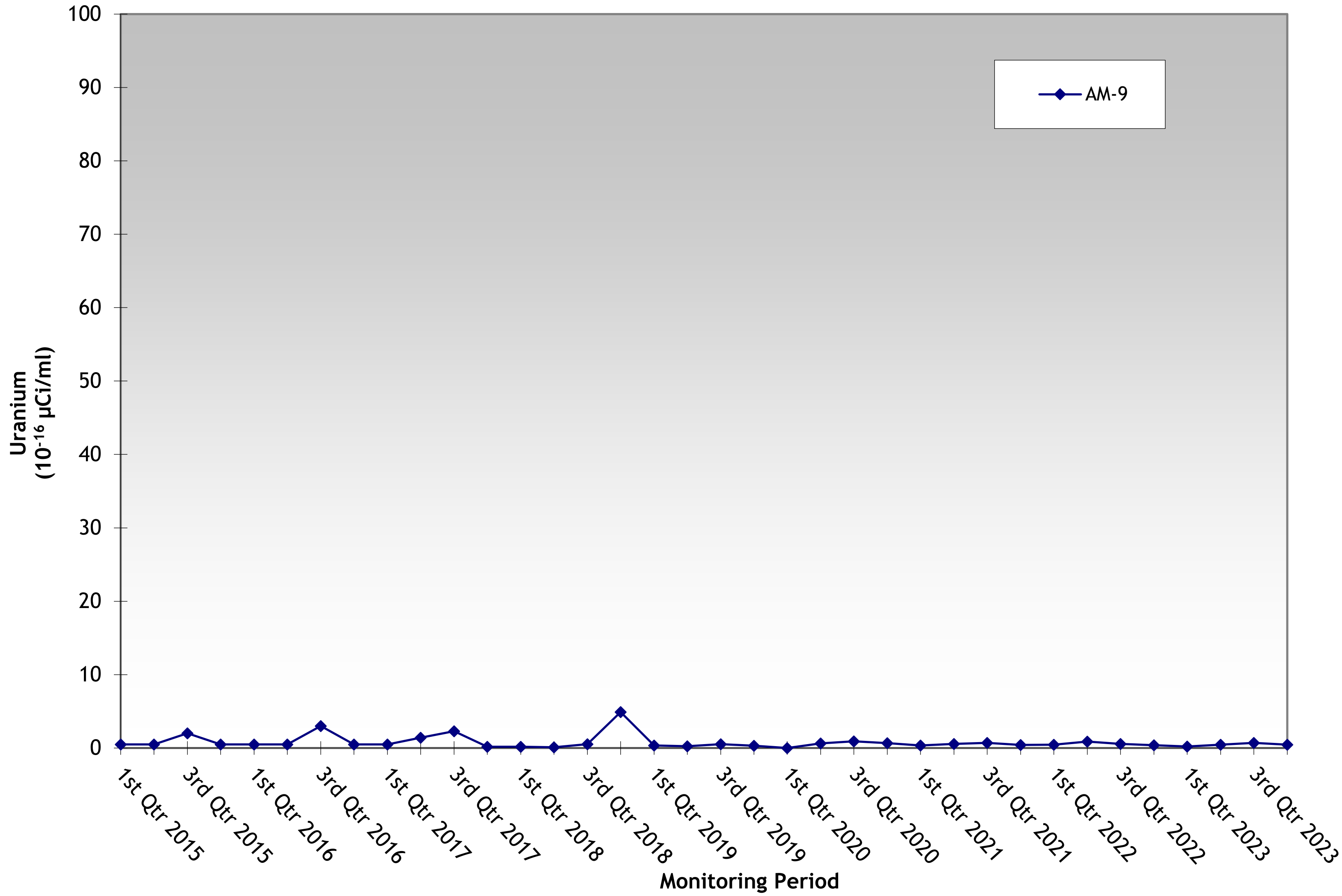

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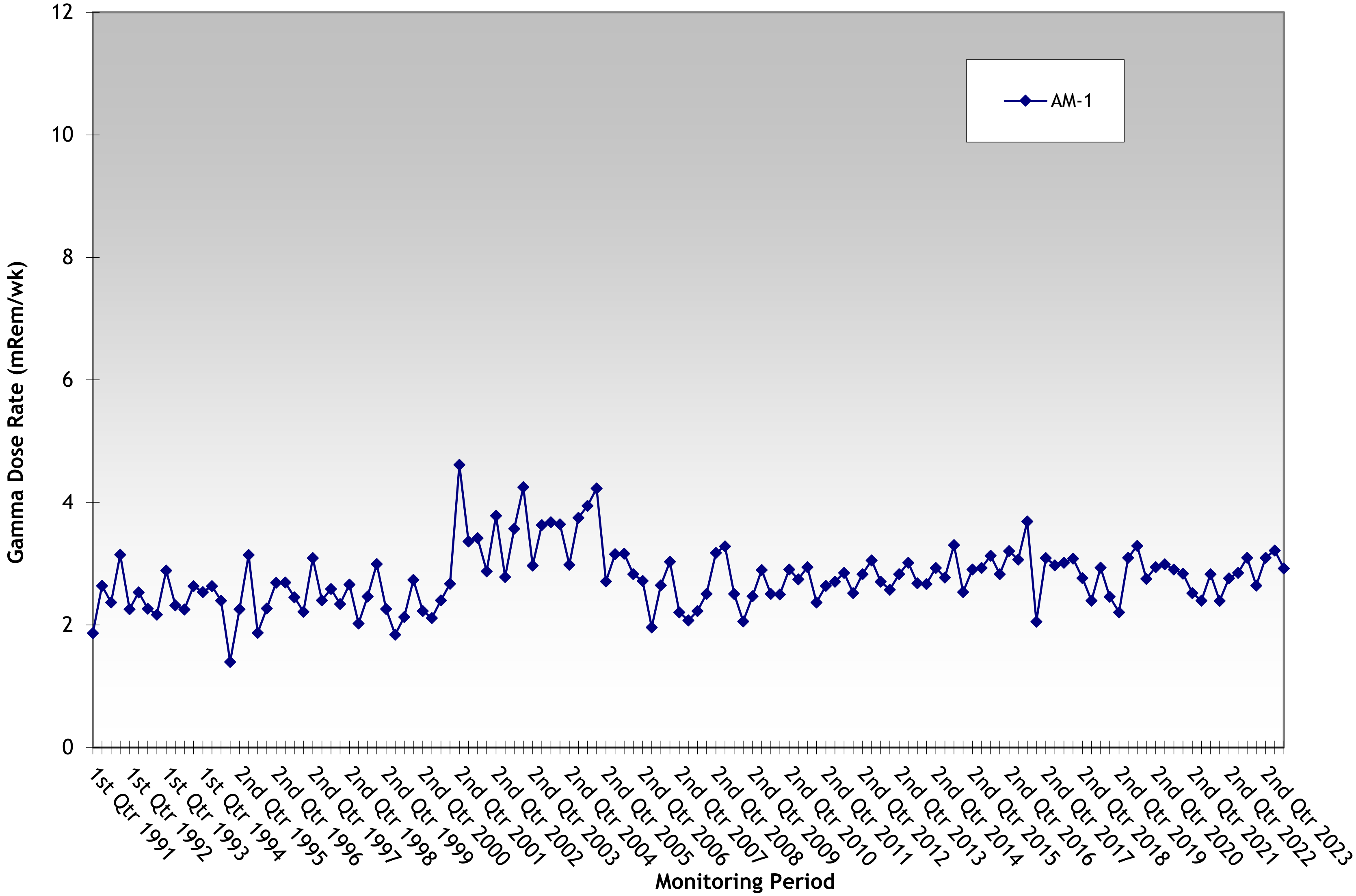

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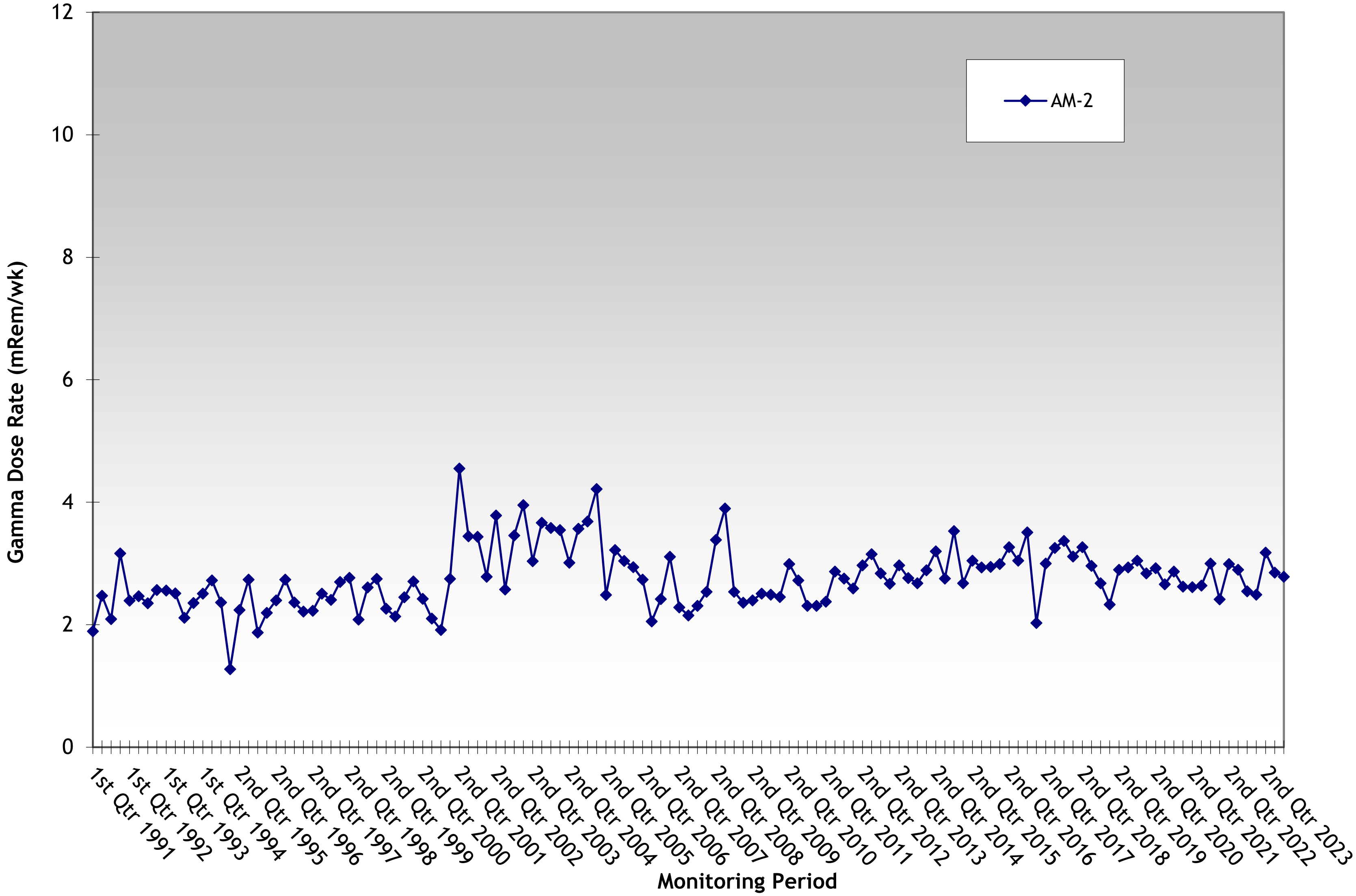

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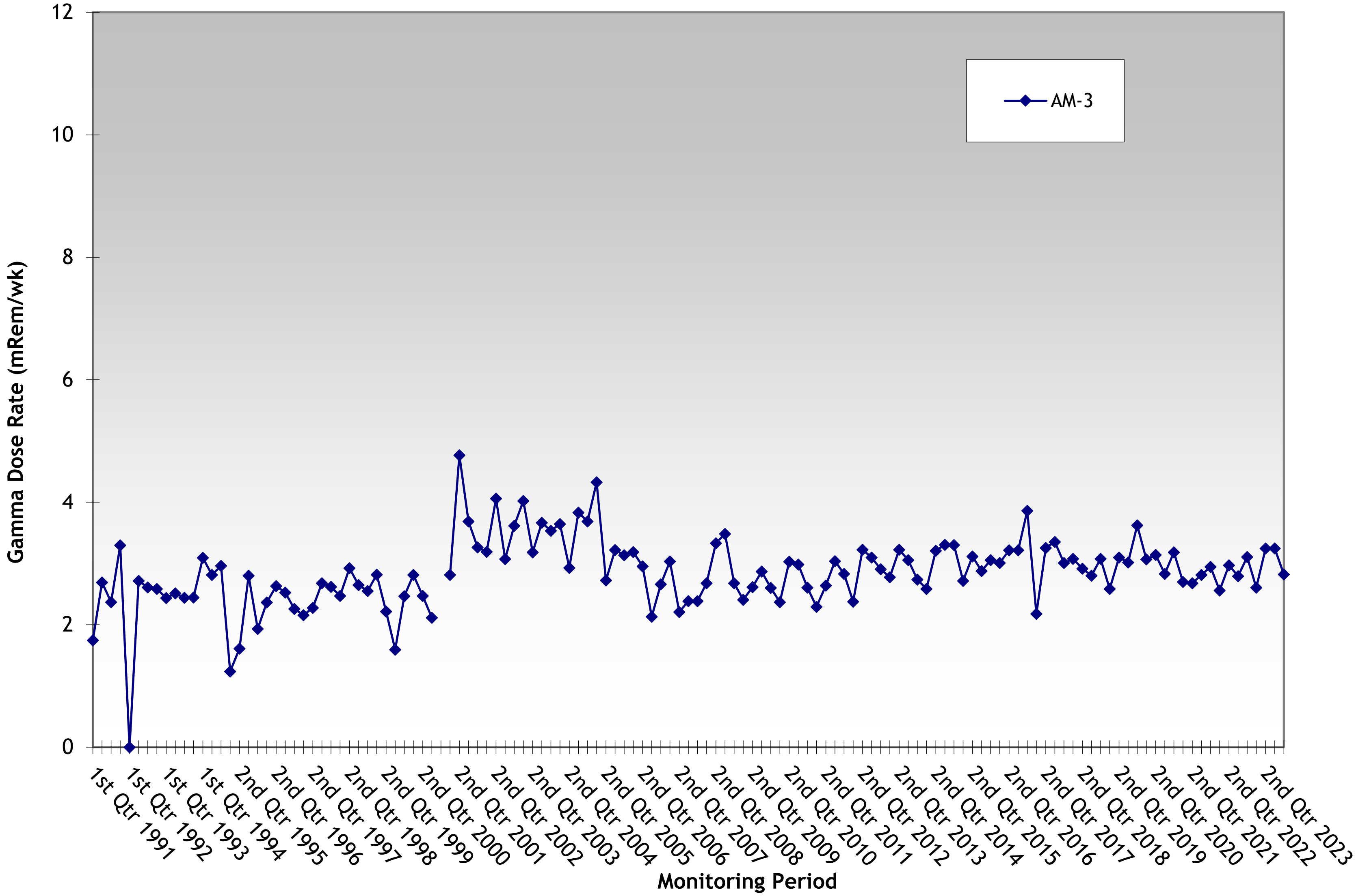

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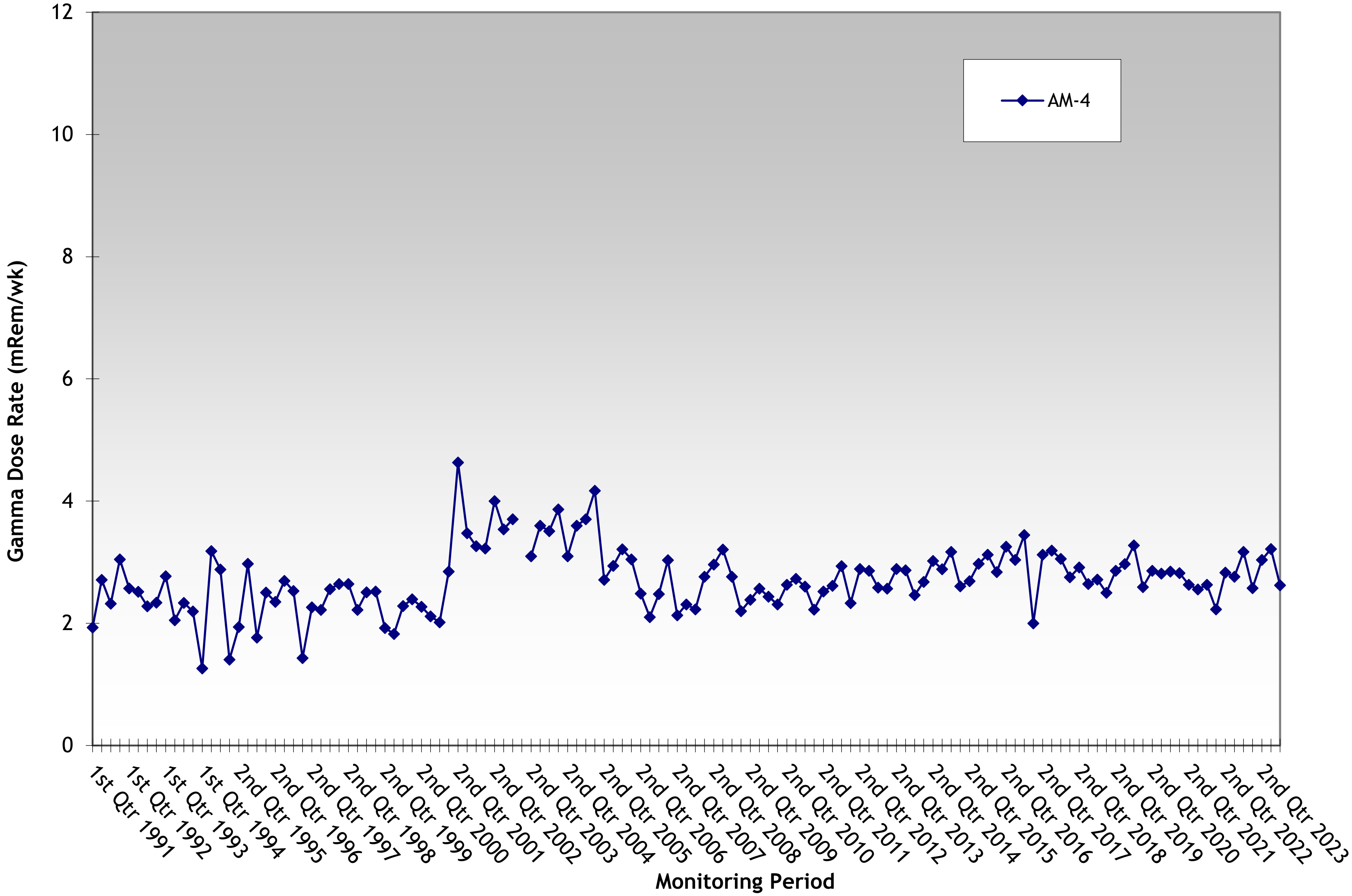

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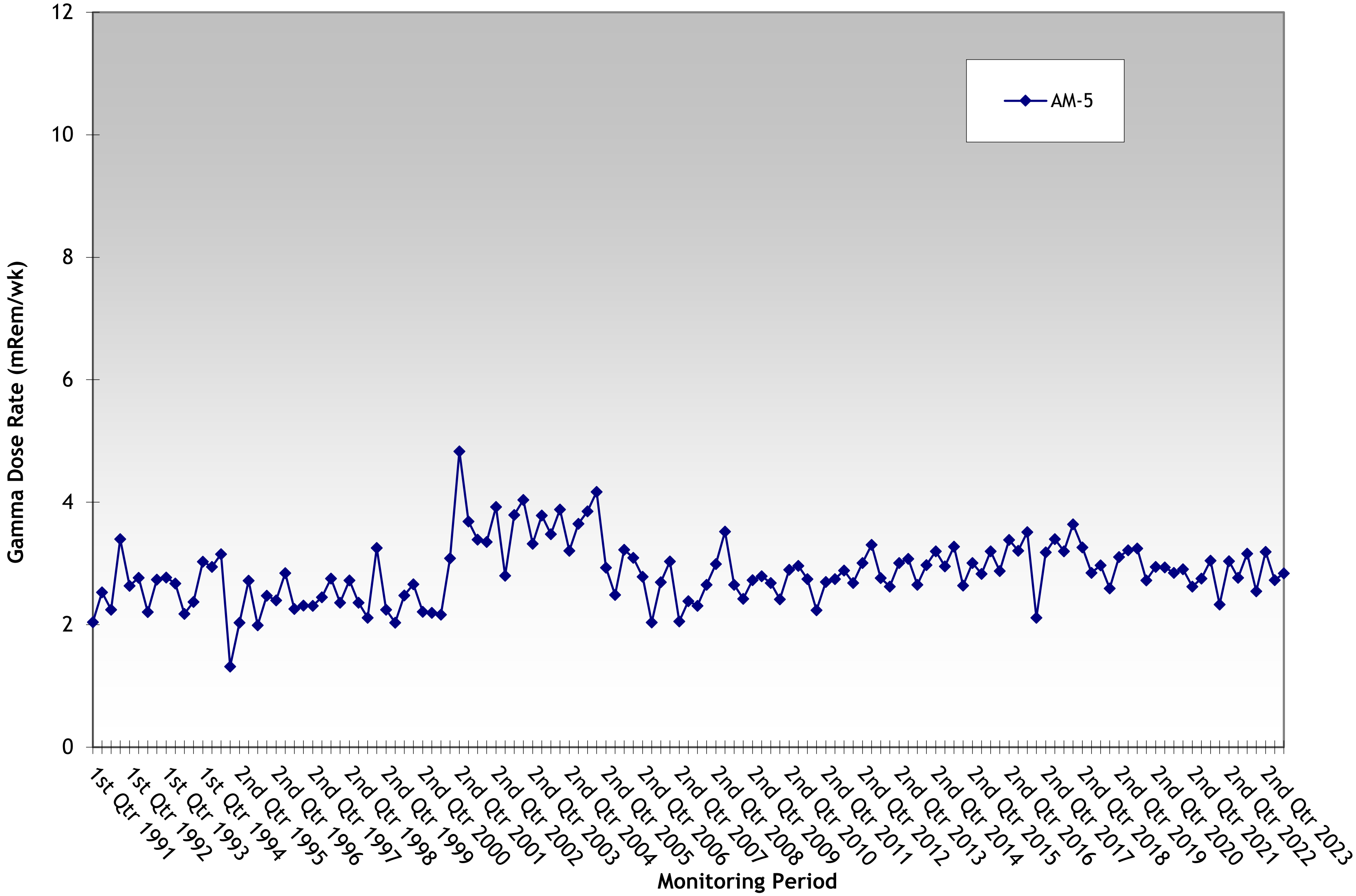

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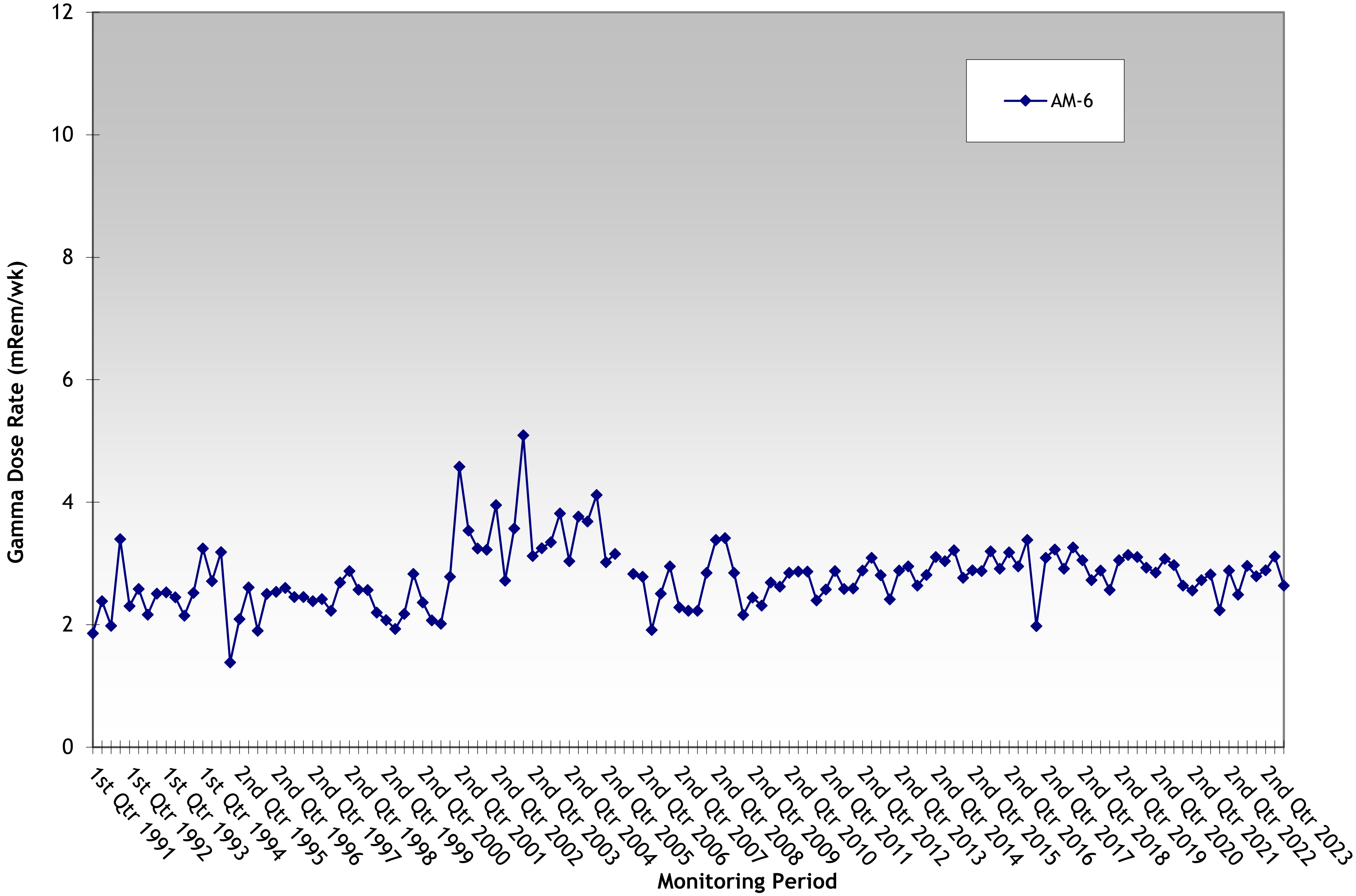

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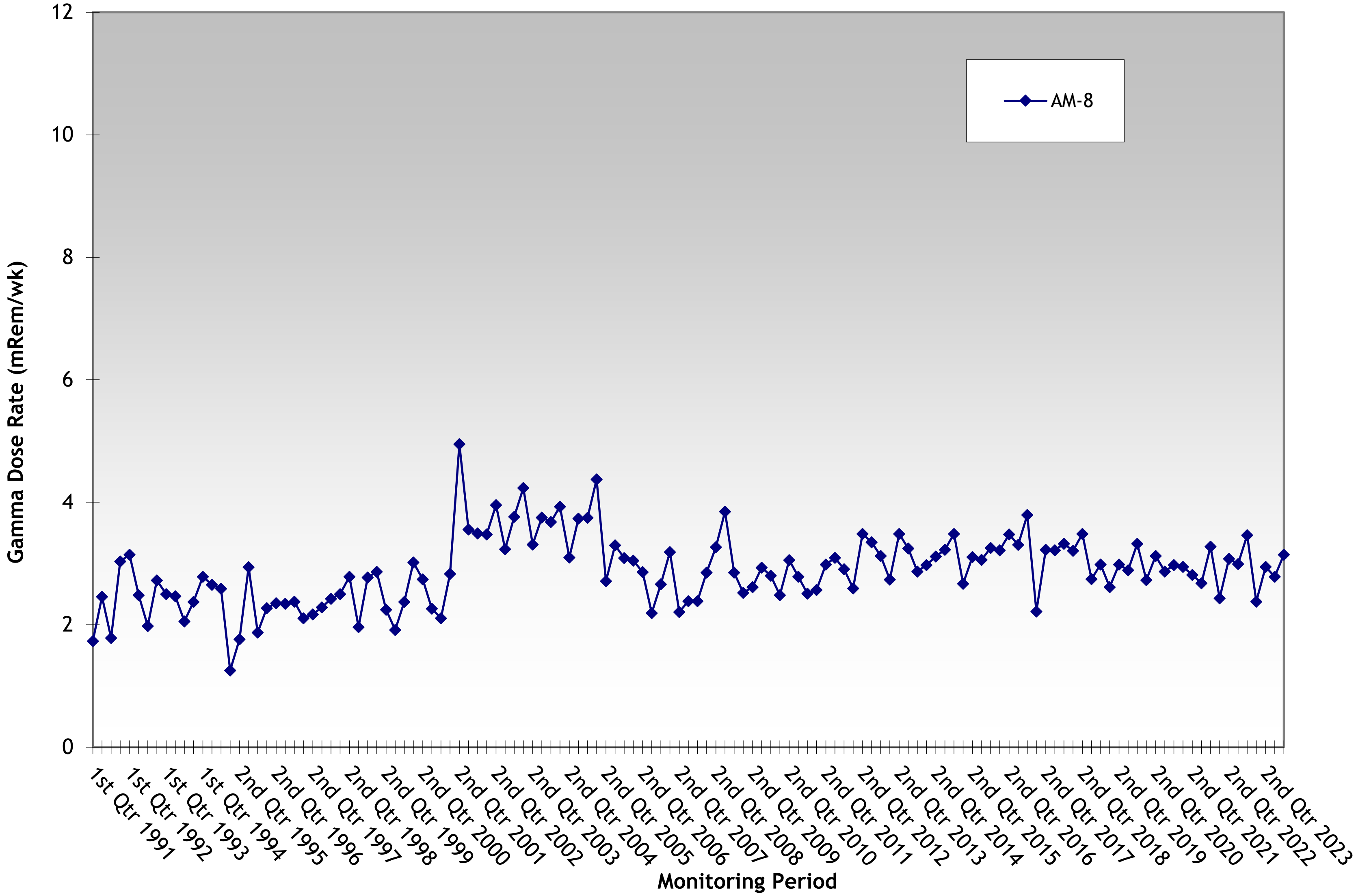

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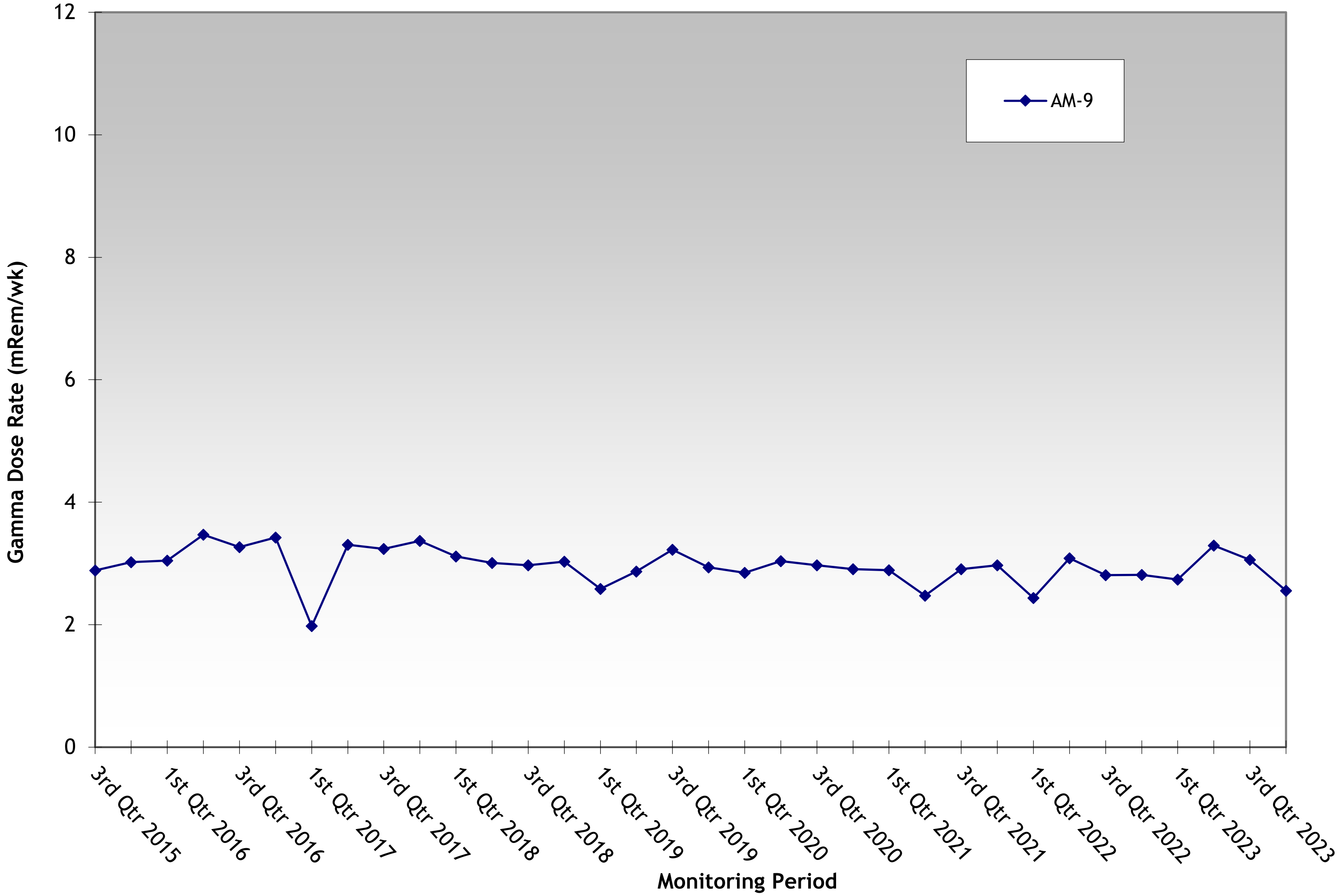

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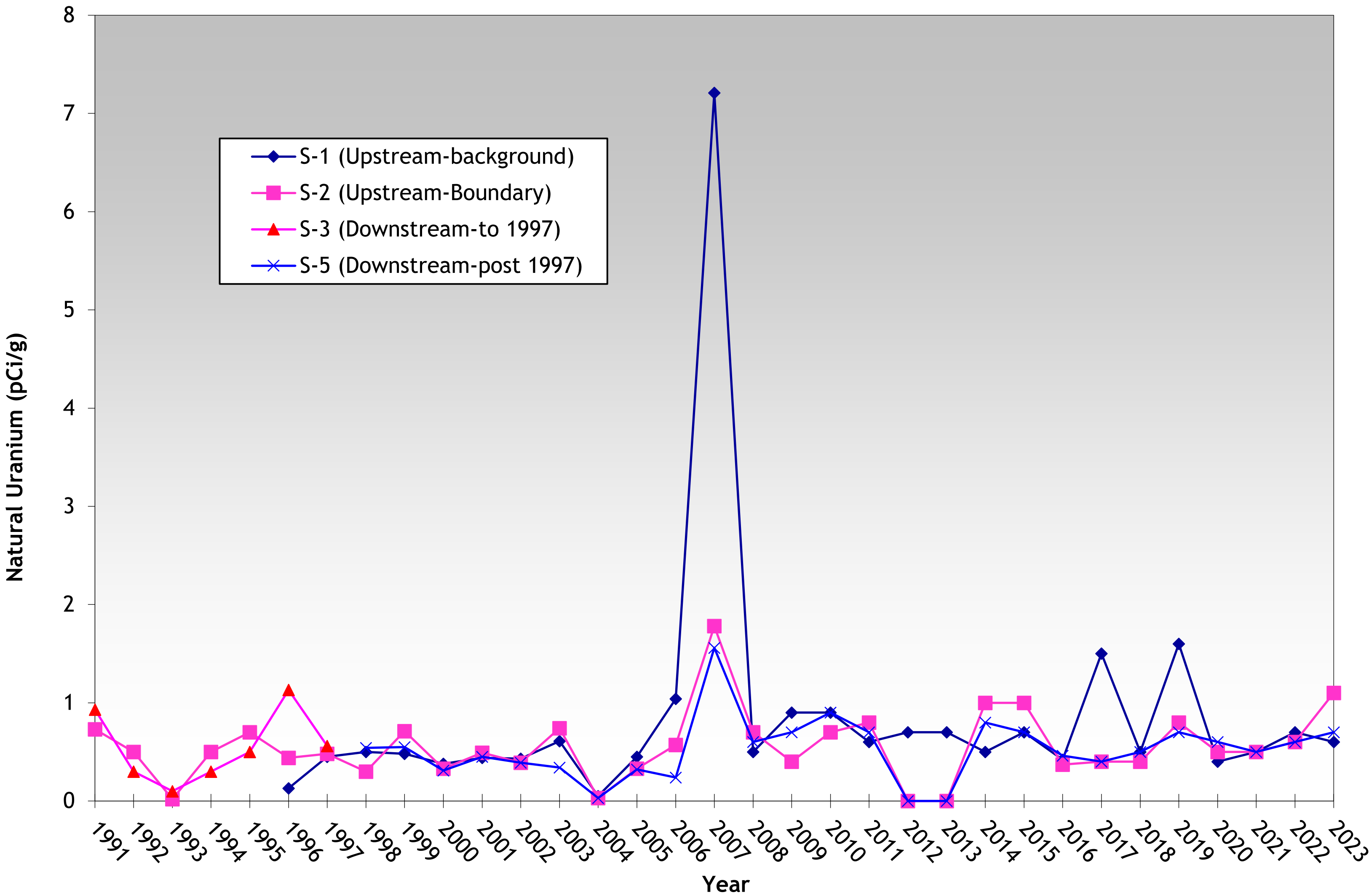

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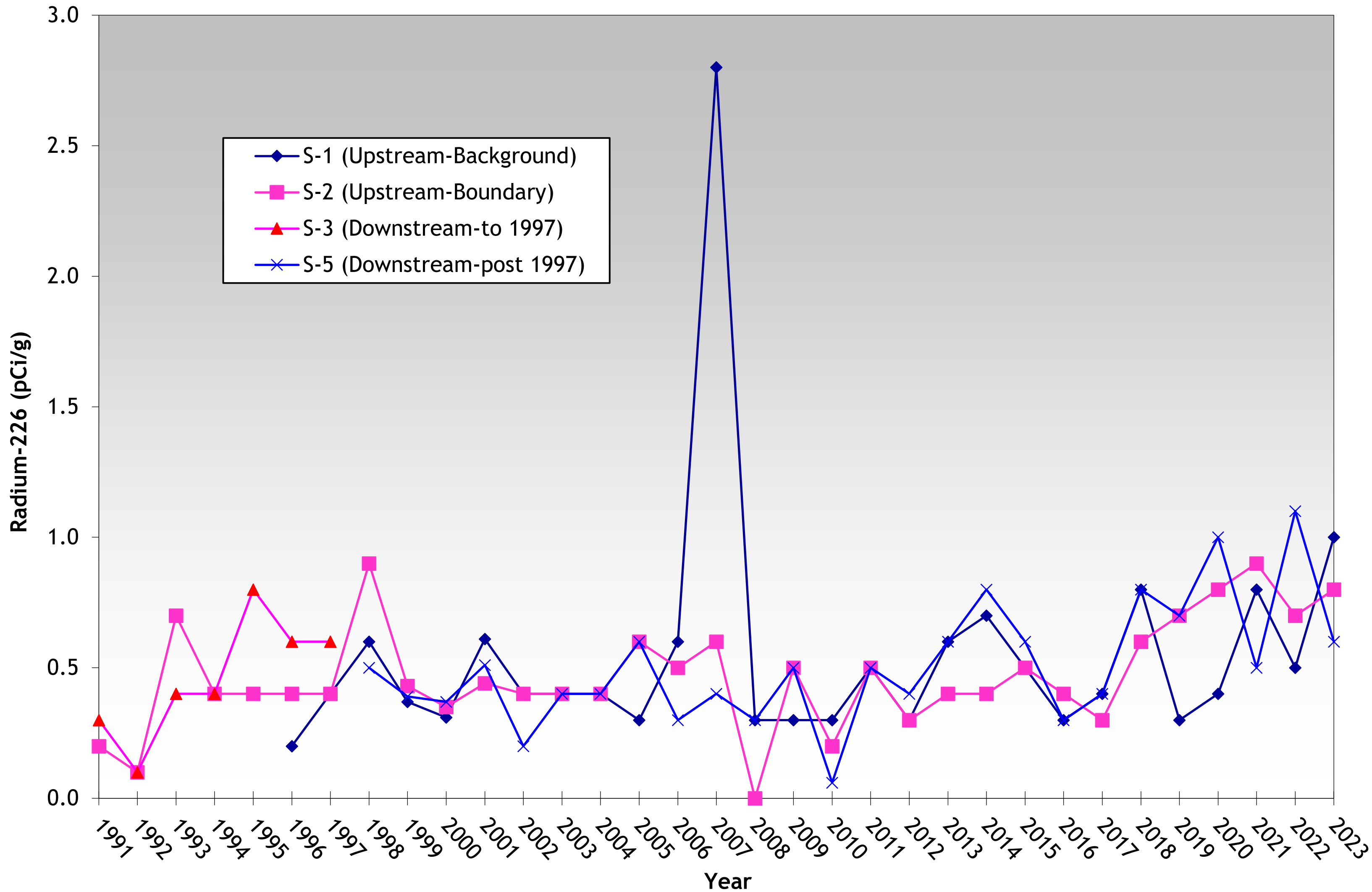

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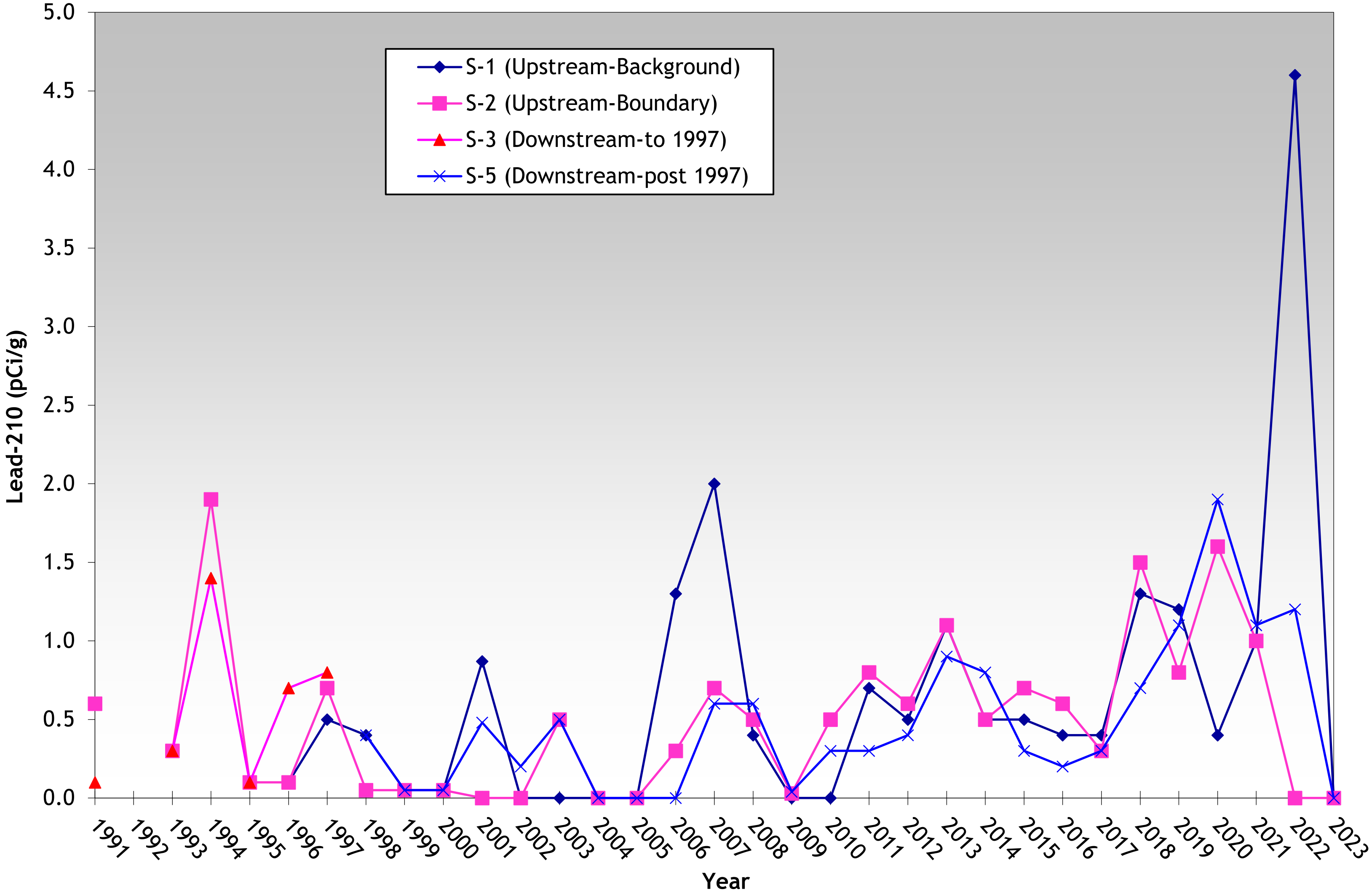

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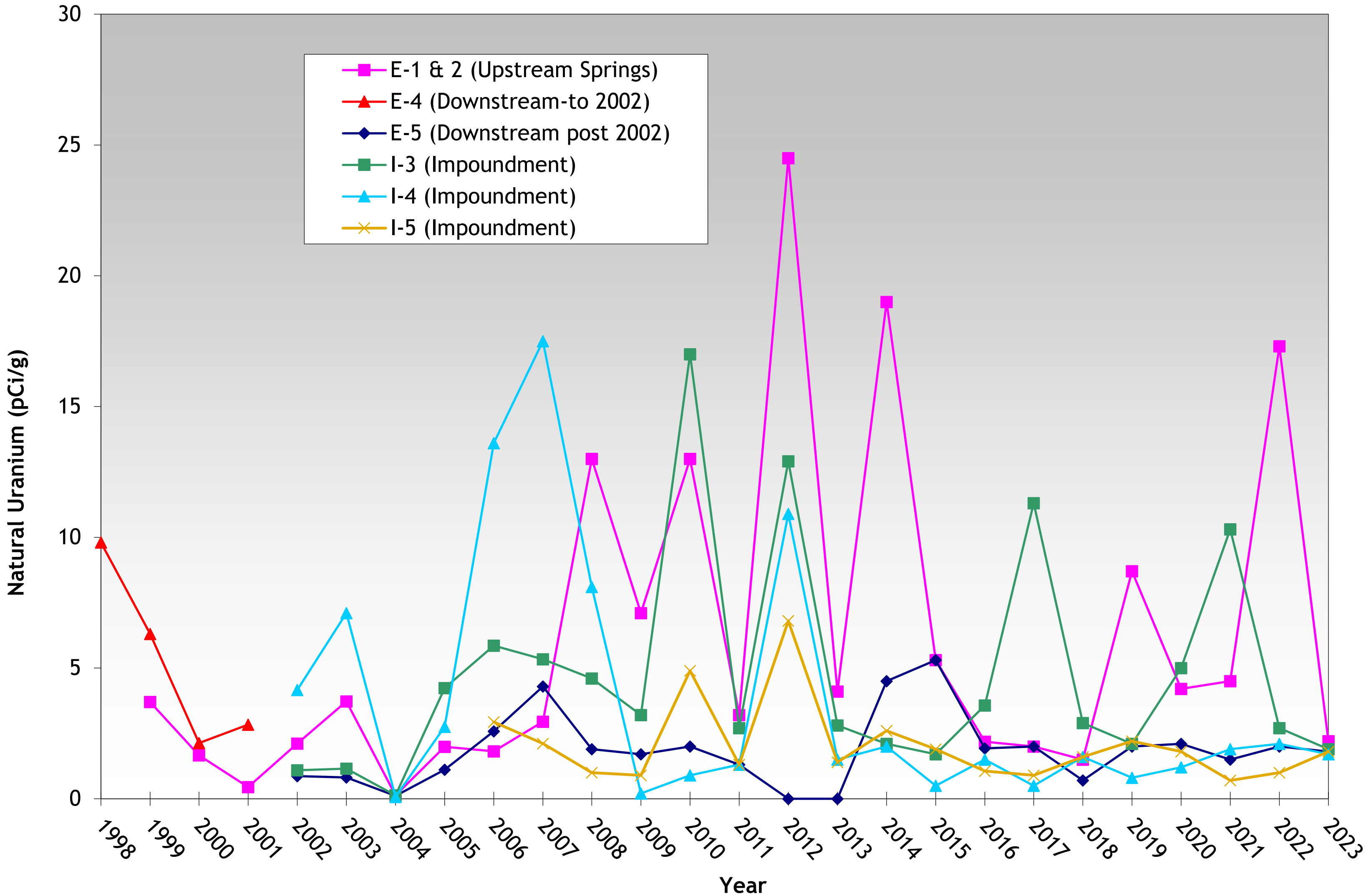

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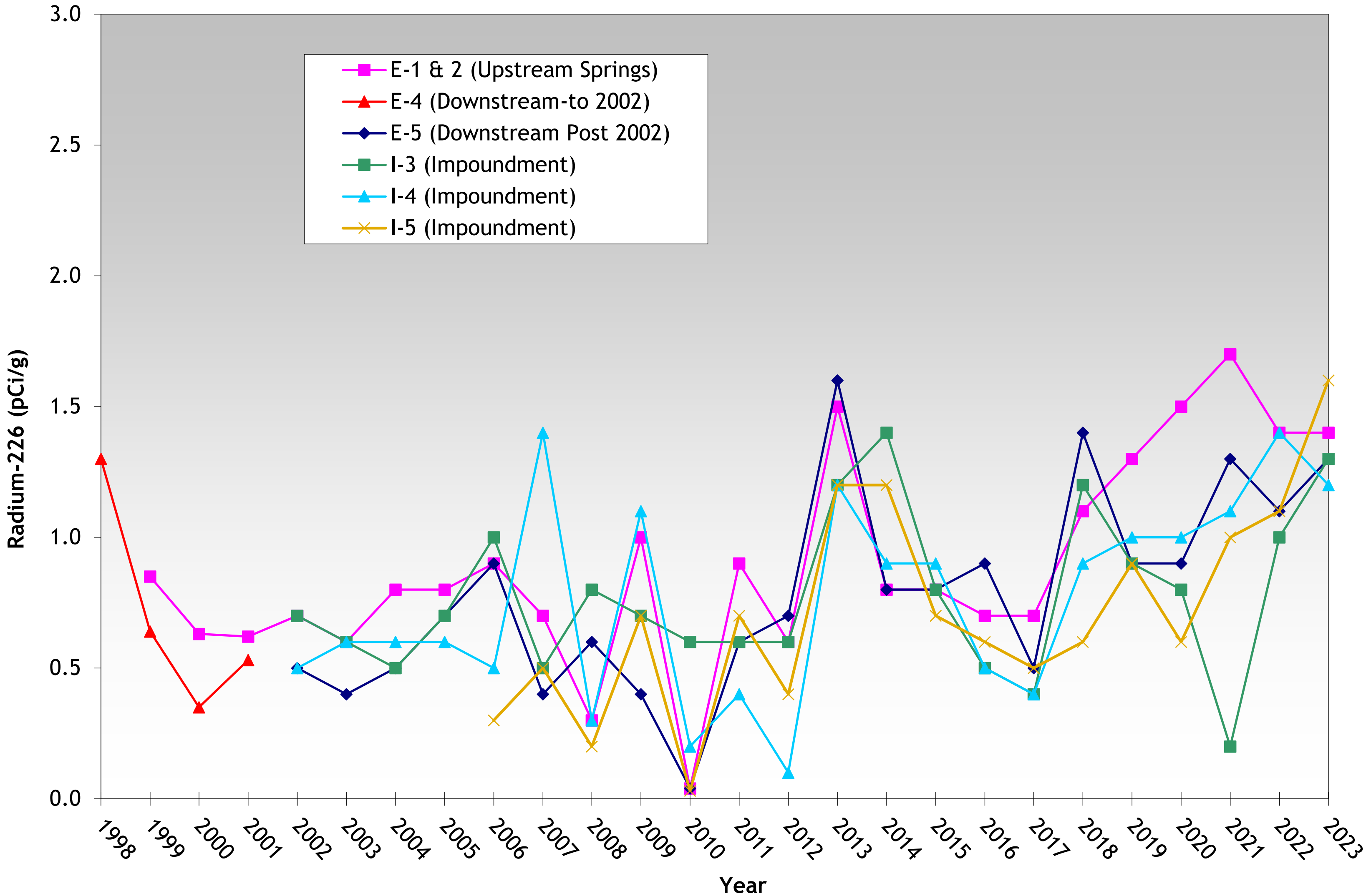

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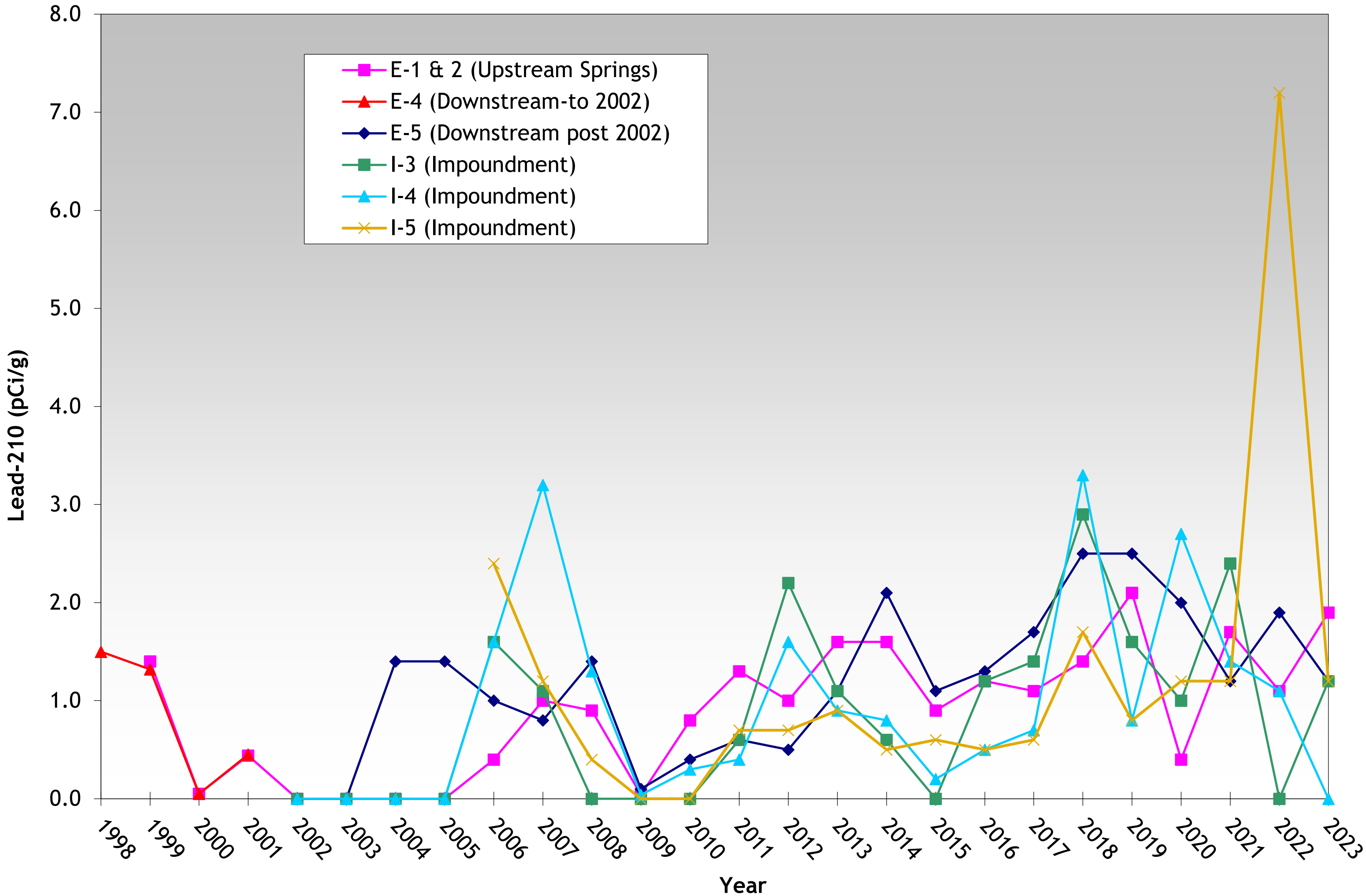

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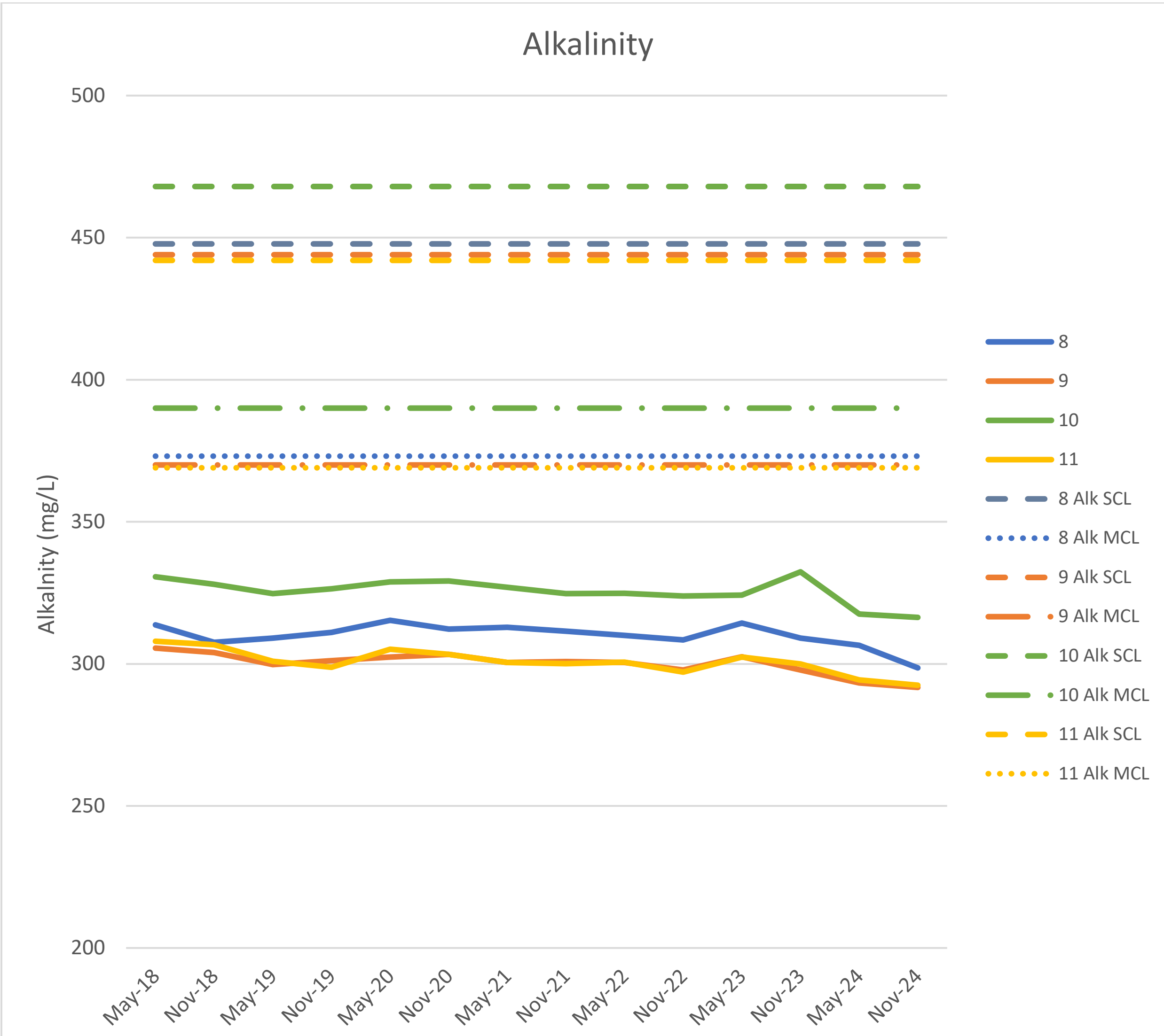

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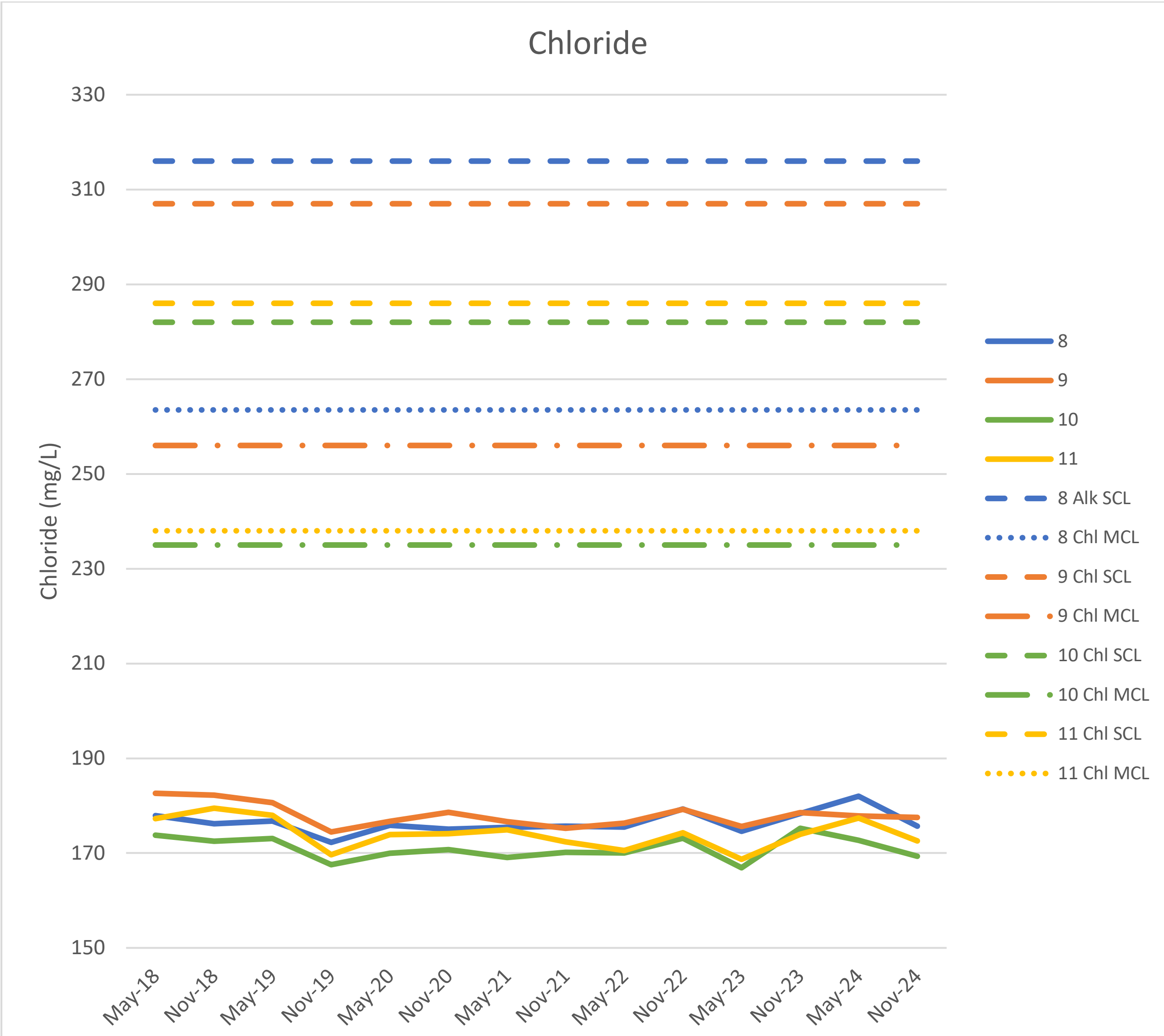

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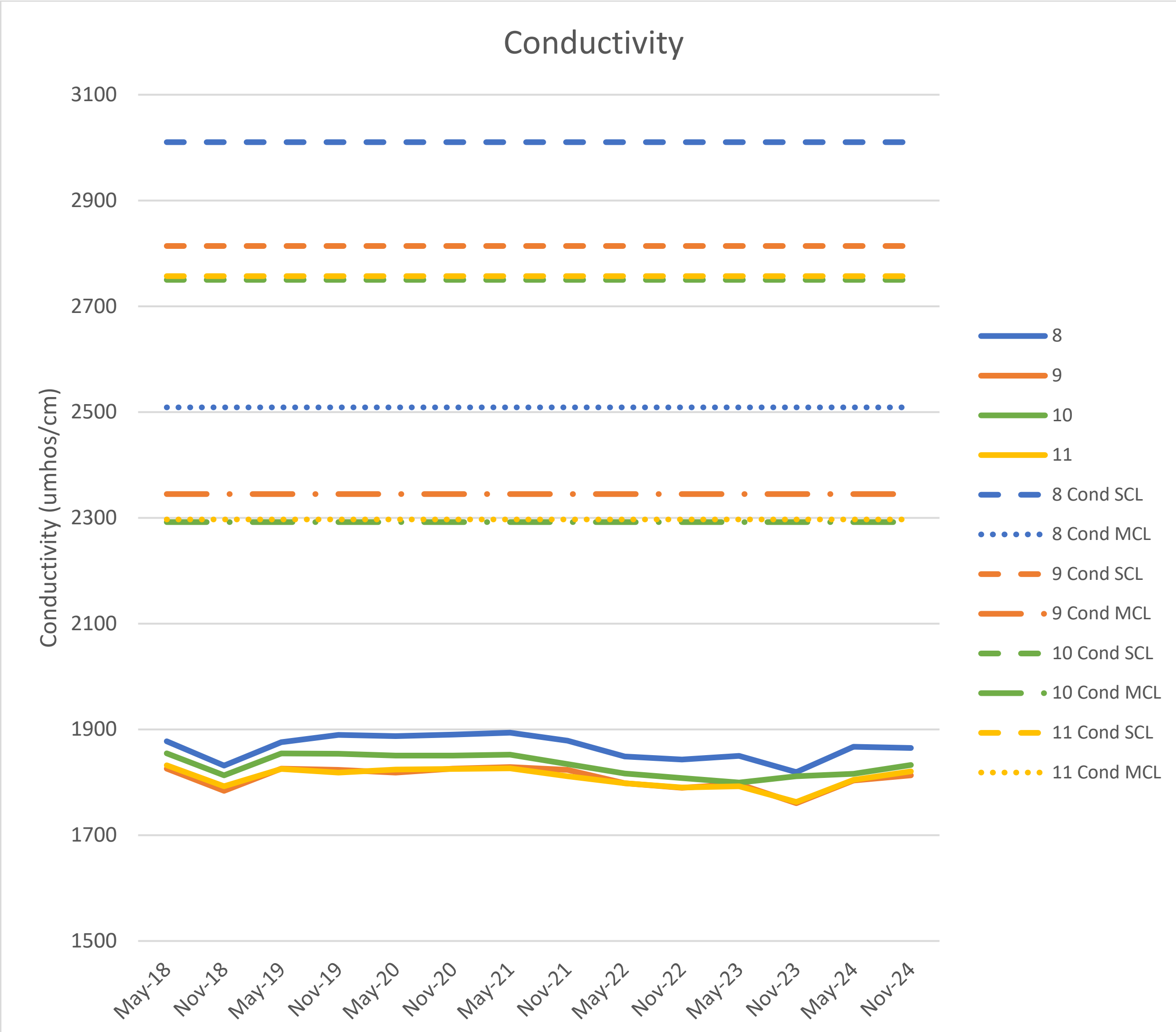

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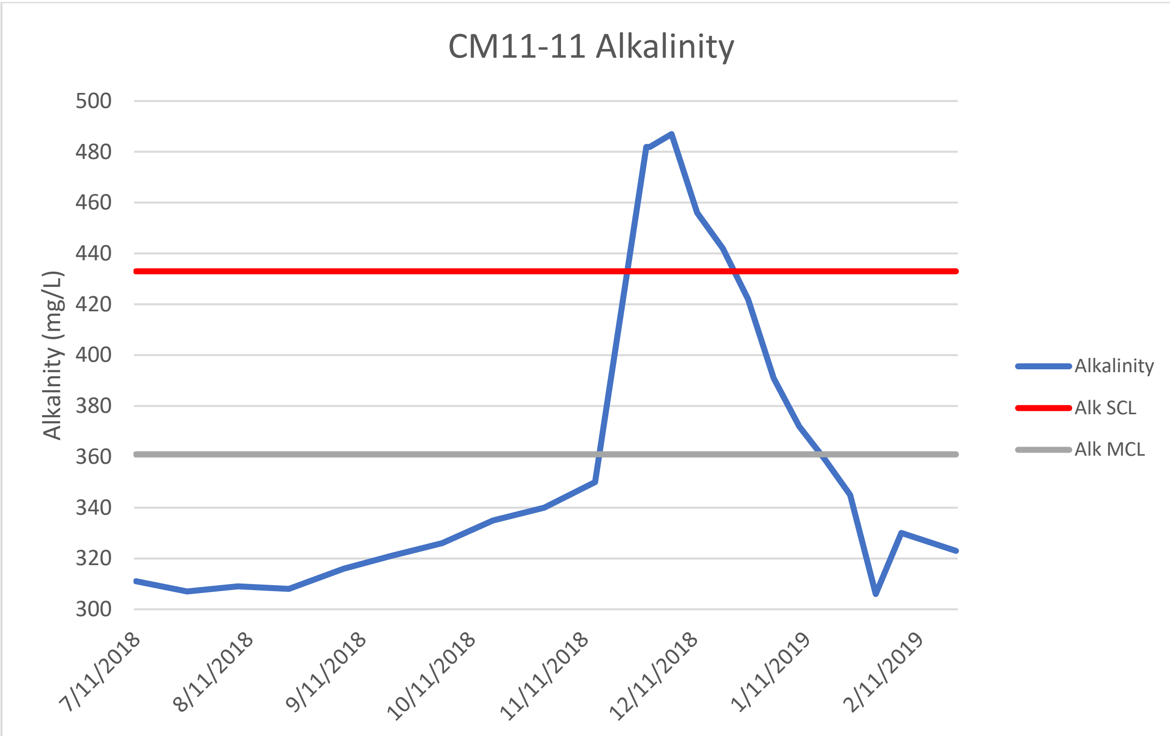

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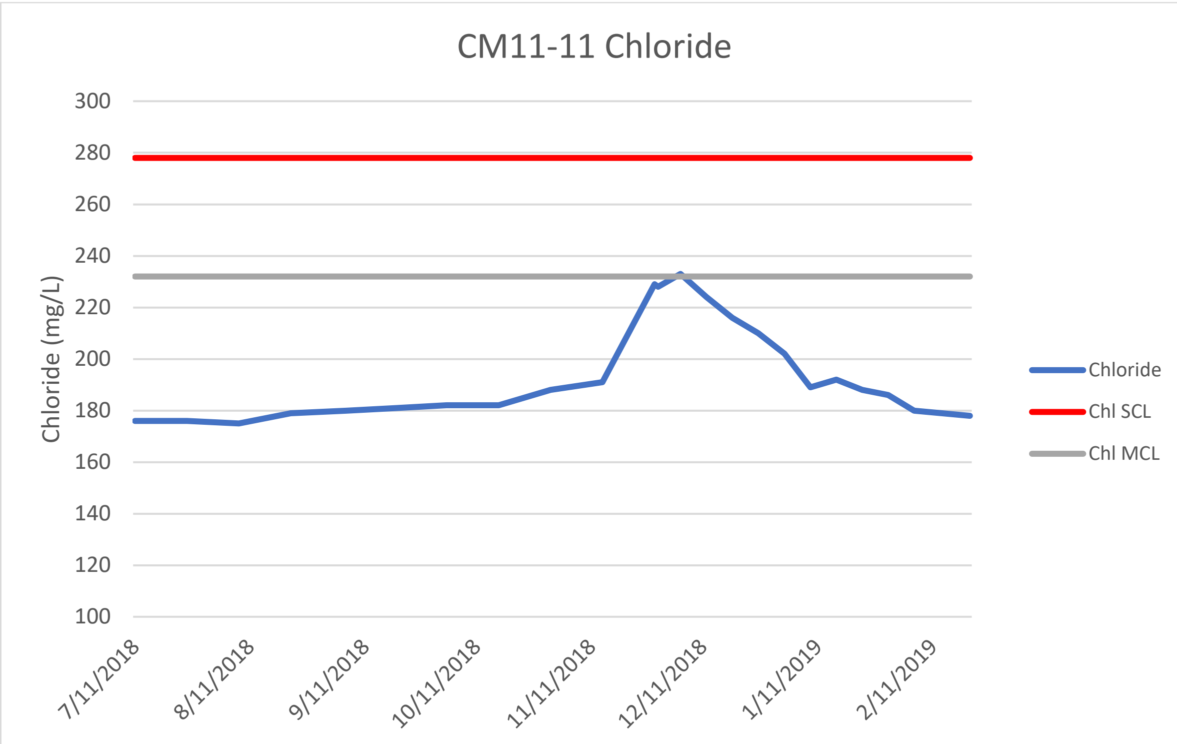

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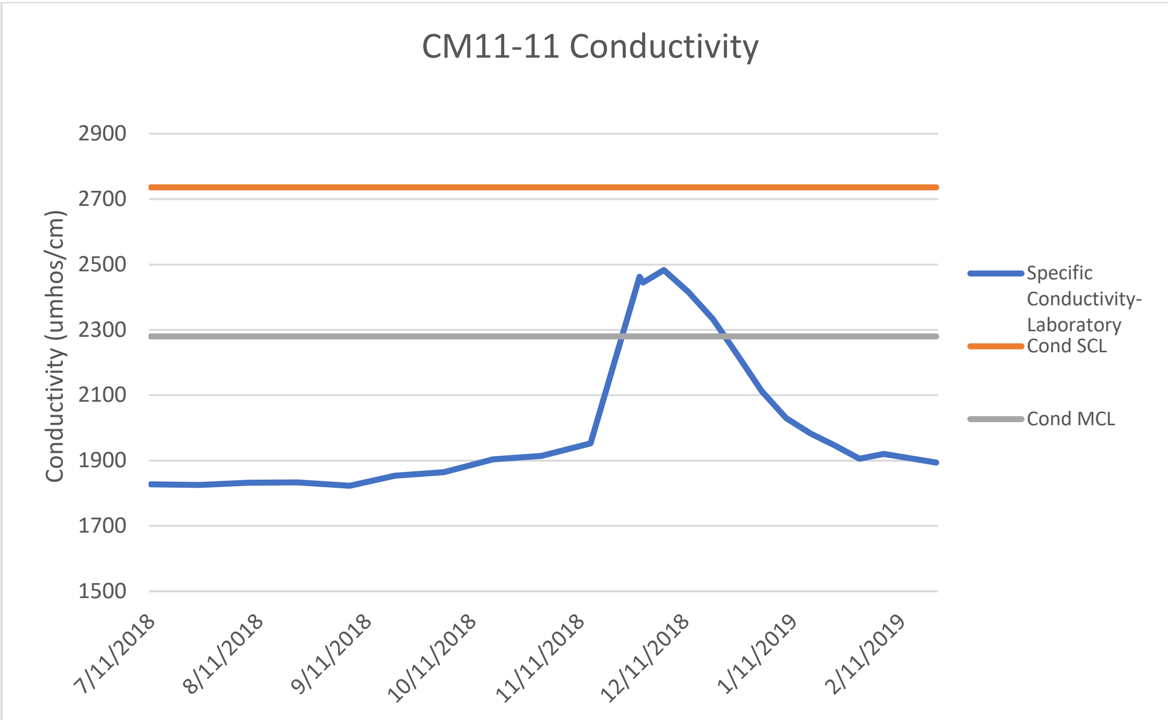

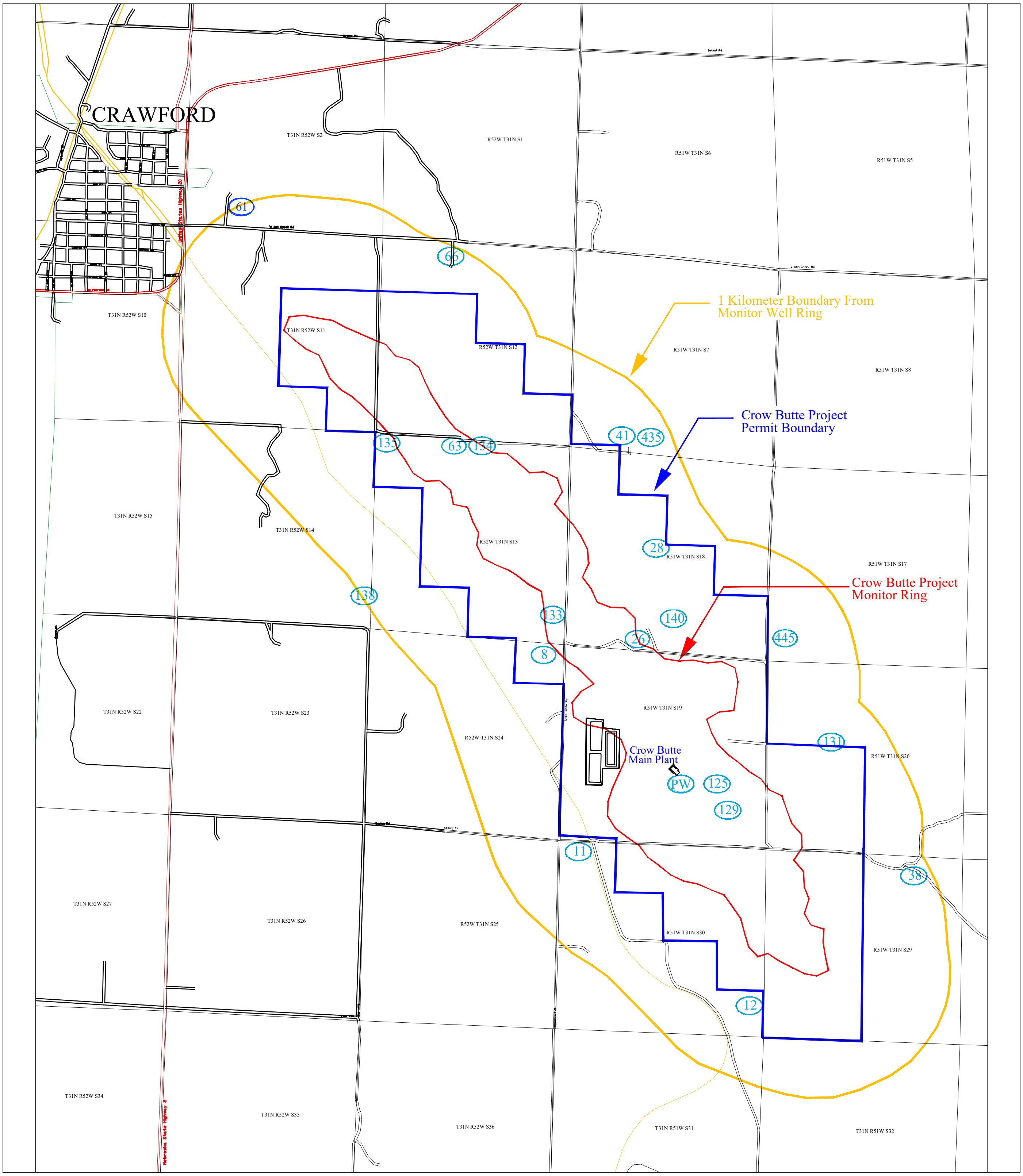

LEGEND

129	Water Supply Wells - Brule Formation
61	Water Supply Wells - Chadron Formation

0 2,000 4,000 8,000

SCALE IN FEET 1" = 4,000 FEET

N
W E

CROW BUTTE RESOURCES, INC.

FIGURE 5.7-48

Crow Butte Project Groundwater Monitoring Private Wells

DATE: APRIL 2025

BY: WWC CHECKED:

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6.0 GROUNDWATER QUALITY RESTORATION, SURFACE RECLAMATION, AND FACILITY DECOMMISSIONING

This chapter updates the restoration that has been completed to date at the Crow Butte Project and incorporates information on restoration, reclamation, and decommissioning from Chapter 6 of the MEA TR.

6.1 PLANS AND TIMELINES FOR GROUNDWATER RESTORATION

The objective of the Restoration and Reclamation Plan is to return the affected groundwater and land surface to conditions suitable for the uses for which they were suitable before mining. The methods to achieve this objective for both the affected groundwater and the surface are described in the following sections. Before discussing restoration methodologies, a discussion of the ore body genesis and chemical and physical interactions between the ore body and the lixiviant are provided.

6.1.1 Ore Body Genesis

The uranium deposit in the Crow Butte Project and MEA is a roll front deposit in a fluvial sandstone and is similar to those in the Wyoming basins such as the Gas Hills, Shirley Basin, and the Powder River Basin. The origin of the uranium in the deposit could lie within the host rock itself either from the feldspar or volcanic ash content of the Chadron Sandstone. The source of the uranium could also be volcanic ash of the Chadron Formation, which overlays the Chadron Sandstone. Regardless of the source of the uranium, it has precipitated in several long sinuous roll fronts. The individual roll fronts are developed within subunits of the Chadron Sandstone. The Chadron Sandstone is divided into local subunits by thin clay beds that confined the uranium bearing waters to several distinct hydrological subunits of the sandstone. These clay beds are laterally continuous for hundreds of feet but control the deposition of the uranium over greater distances as other clay beds exert vertical control when the locally controlling beds pinch out. Precipitation of the uranium resulted when the oxidizing water containing the uranium entered reducing conditions. These reducing agents are likely hydrogen sulfide (H_2S) and, to a lesser degree, organic matter and pyrite. More detailed discussions of the geochemical description of the mineralized zone are presented in Section 2.6.

Solution mining of the deposit is accomplished by reversing the natural processes that deposited the uranium. Oxidizing solution is injected into the mineralized portion of the Chadron Sandstone to oxidize the reduced uranium and to complex it with bicarbonates. Pumping from recovery wells draws the uranium bearing solution through the mineralized portion of the sandstone. The presence of reducing agents will increase oxidant requirements over that necessary to only oxidize the uranium.

Since the deposition of the uranium was controlled between clay beds within the Chadron Sandstone, the mining solutions will be confined to this portion of the sandstone by selectively screening these intervals. This will limit the contamination and thus the required restoration of unmineralized portions of the sandstone.

6.1.2 Chemical and Physical Interactions of Lixiviant with the Ore Body

The following discussion is based on a range of lixiviant conditions from 0.5 to 3.0 grams per liter (g/L) total carbonate and a pH from 6.5 to 9.0 standard units (s.u.). This represents the normal range of operating conditions for the Crow Butte Project and MEA ISR operations.

6.1.2.1 Ion Exchange

The principal ion exchange reaction is the exchange of sodium from the lixiviant onto exchangeable sites on ore minerals with the release into solution of calcium, magnesium and potassium. This reaction can be shown as follows:

$$Ca_{clay} + 2Na^{+}_{solution} = 2Na_{clay} + Ca^{++}_{solution}$$

Similar reactions can be written for magnesium and potassium. Due to higher solubility of their sulfate and carbonate compounds and their low concentrations in Chadron Sandstone and the ore, magnesium and potassium in solution have no impact. The limited solubility of calcium carbonate ($CaCO_3$), and to a lesser degree, calcium sulfate, may lead to the potential for calcium precipitation.

Laboratory tests have indicated that the maximum calcium IX capacity of the ore in a sodium lixiviant with 3.0 g/L total carbonate strength is 1.21 milliequivalents of calcium per 100 grams of ore. This equates roughly to 0.5 pound of calcium or about 1.2 pounds of calcium carbonate per ton of ore that could potentially precipitate. Not all of this calcium, however, will be realized since laboratory testing is run in such a way as to indicate the maximum amount of calcium that can be exchanged. Somewhat less than this amount will be released and only a portion of that precipitated. There is no way to directly control the buildup of calcium in the lixiviant circuit. In practice, the lixiviant carbonate concentration and the lixiviant pH is controlled. The formation characteristics dictate an equilibrium calcium concentration in the lixiviant system and ion exchange and/or precipitation will occur until the equilibrium is satisfied. The production bleed represents a departure from this equilibrium and as such has some effect on the amount of calcium exchanged. If the bleed is kept generally small, on the order of 0.5 percent, the effect of the bleed on the ion exchange is small.

6.1.2.2 Precipitation

In the presence of carbonate ions and bicarbonate ions in the lixiviant system, calcium ions will precipitate provided the limit of saturation has been reached. Calcium precipitation is a function of total carbonate, pH and temperature. For example, at 15 °C, a pH of 7.5 s.u., and 1 g/L carbonate in lixiviant, the equilibrium solubility of calcium is approximately 40 to 100 ppm. Some uncertainty is seen in these numbers due to the effect of ionic strength and supersaturation considerations. However, these figures illustrate the effect of carbonate concentration and pH on the equilibrium solubility of calcium.

The amount of calcium produced depends on the ion exchange that is taking place, while the precipitation of calcium is a function of the lixiviant chemistry, and the degree of supersaturation that is observed in the system. As a first approximation, the proportion of calcium precipitation occurring above ground and underground will occur in the ratio of the residence times. In other words, if the residence time is much longer underground than it is above ground, as is the case for most ISR operations including the Crow Butte Project and the MEA, then more of the calcium will precipitate underground than above ground. The calcium precipitation is a function of turbulence in the solution, changes in dissolved carbon dioxide (CO_2) partial pressure or pH, and the presence of surface area. The most likely places for calcium to precipitate are underground where the ore provides abundant surface area for precipitation, at or near the injection or production wellbore where changes in pressure, turbulence and CO_2 partial pressure are all observed, and on the surface in the filters, in pipes, and in tanks. If all the calcium were to precipitate (based on 1.2 pounds of $CaCO_3$ per ton of ore) the precipitate would occupy about 0.15 percent of the void space in that ton of ore.

Calcium may be removed from the system in two ways:

- Filters will be routinely backwashed to the evaporation ponds and periodically acid cleaned, if necessary, to remove precipitated calcium carbonate from the filter housing or filter media; and
- The solution bleed (approximately 0.5 to 1.0 percent) taken to create overproduction and a hydrologic sink in the mining area serves to eliminate some calcium from the system.

Should precipitation of calcium carbonate at or near the wellbore of the wellfield wells become a problem, these wells may be air lifted, surged, water jetted, or acidified to remove the precipitated calcium. Any water recovered from these wells containing dissolved calcium carbonate or particulate calcium carbonate is collected and placed into the waste disposal system. A liquid seal is maintained on any calcium carbonate in the evaporation ponds. Upon decommissioning, calcium carbonate from the plant equipment and pond residues will be disposed of in either a licensed tailings pond or a commercial disposal site.

The other possible precipitating species that has been identified is iron, which could precipitate as either hydroxide or carbonate, causing some fouling. Such fouling is usually evidenced by a reduction in the ion exchange capacity of the resin in the extraction circuit. Should this fouling become a serious problem, the resin can be washed and the wash solution disposed of in the waste disposal system. Due to the small amount of iron present in the Chadron Sandstone, iron precipitation has not been a problem in mining operations to date.

6.1.2.3 Hydrolysis

Hydrolysis reactions, which involve minerals and hydrogen or hydroxide ions, do not play an important role in the ore/lixiviant interaction. In the pH range of 6.5 to 9.0 s.u., the concentration of hydrogen and hydroxide ions is so small that these types of reactions do not occur to any great degree. The only potential impact would be a small increase in the dissolved silica content of the lixiviant system and a possible small increase in the cations associated with the siliceous minerals. The hydrolysis reaction does not have a significant effect on operations.

6.1.2.4 Oxidation

The oxidant consumers in the Chadron Sandstone are hydrogen sulfide in the groundwater, uranium, vanadium, iron pyrite, and other trace and heavy metals. The impact of these oxidant consumers on the operation of the plant is a general increase in the oxidant consumption over that which would be required for uranium alone. The second effect is a release of iron and sulfate into solution from the oxidation of pyrite. A third effect is an increase in the levels of some trace metals such as arsenic, vanadium and selenium into solution. As mentioned previously, the iron solubilized will most likely be precipitated as hydroxide or carbonate, depending on its oxidation state. Any vanadium that is oxidized along with the uranium will be solubilized by the lixiviant, recovered with the uranium and could potentially contaminate the precipitated yellowcake product. Hydrogen peroxide precipitation of uranium is used to reduce the amount of vanadium precipitated in the product. Oxidation will also solubilize arsenic and selenium. The restoration program will return these substances to acceptable levels. A final potential oxidation reaction is the partial oxidation of sulfur species, increasing the concentrations of compounds such as polythionates, which can foul IX resins. In ISR operations with chemistries similar to the Crow Butte Project and MEA, these sulfur species are completely oxidized to sulfate, which poses no problems.

6.1.2.5 Organics

Organic materials are generally not present in the Crow Butte Project and MEA ore bodies at levels greater than 0.1 to 0.2 percent. Where present organic materials effectively increase the oxidant consumption and reduce uranium leaching. On longer flow paths, organic material could potentially re-precipitate uranium should all of the oxidant be consumed and conditions become reducing. Another potential impact of mobilized organics could be the coloring and fouling of leach solutions. As the aquifer is maintained in the pH range of 6.5 to 9.0 s.u., mobilization of the organics and coloring of the leach solution is avoided.

6.1.3 Basis of Restoration Goals

The primary goal of the groundwater restoration program is to restore the groundwater consistent with 10 CFR Part 40, Appendix A, Criterion 5B(5). The secondary goal of the groundwater restoration program is to return the groundwater to the restoration values set by the NDEE in the Class III UIC Permit.

In accordance with LC 10.1.5 of SUA-1534, hazardous constituents in the groundwater must be restored to the numerical groundwater protection standards as required by 10 CFR Part 40, Appendix A, Criterion 5B(5). Criterion 5B(5) requires that each parameter be restored to one of the following levels:

a. The Commission approved background concentration of that constituent in the ground water or,

b. The respective value given in Table 5C, 10 CFR 40, Appendix A, if the constituent is listed in the table and if the background level of the constituent is below the value listed, or

c. An alternate concentration limit (ACL) established by the Commission in accordance with Criterion 5B(6).

If the restoration activities are unable to achieve the background (Criterion a above) or maximum contaminant levels (Criterion b above), whichever is greater, after diligent application of the best practicable technology (BPT) available, CBR will submit a license amendment application for ACLs pursuant to Criterion 5B(6).

The secondary restoration values ensure that the groundwater is returned to a quality consistent with the use, or uses, for which the water was suitable prior to ISR mining. The secondary restoration values are approved by the NDEE in the individual Notice of Intent (NOI) for each mine unit based on the permit requirements and the results of the baseline monitoring program.

6.1.3.1 Establishment of Baseline Water Quality

Prior to injection of lixiviant for each mine unit, the background groundwater quality in the ore zone and overlying aquifers is determined in accordance with LC 11.1.3 of SUA-1534. The background groundwater quality is used to define the background groundwater protection standards required to be met in 10 CFR Part 40, Appendix A, Criterion 5B(5) for the ore zone aquifer and surrounding aquifers.

A minimum of one baseline production or injection well for each four acres is sampled to establish the mine unit baseline water quality in the ore zone. In the upper aquifer, a minimum of one monitoring well per five acres is sampled and all perimeter monitoring wells are sampled. In all cases, CBR will collect four samples from each well with each sample collected at least 14 days apart. The samples are analyzed for the parameters listed in Table 6.1-1. Representative background concentrations are established on a parameter-by-parameter basis using either the mine unit or well-specific mean value or other NRC-approved statistically valid analysis.

6.1.3.2 Establishment of Restoration Goals

The baseline data are used to establish the restoration standards for each mine unit. Since ISR operations alter the groundwater geochemistry, it is unlikely that restoration efforts will return the groundwater to the precise water quality that existed before operations.

Restoration goals are established by NDEE to ensure that, if baseline water quality is not achievable after diligent application of BPT, the groundwater is suitable for any use for which it was suitable before mining. NRC considers these NDEE restoration goals as the secondary goals. The NDEE restoration values are established for each mine unit and are approved with the Notice of Intent to Operate submittals according to the following analysis:

- For parameters that have numerical groundwater standards established in Title 118 (NDEE 2023), the restoration goal is based on the Title 118 maximum contaminant level (MCL).
- If the baseline concentration exceeds the applicable MCL, the standard is set as the mine unit baseline average plus two standard deviations.
- If there is no MCL for an element (e.g., vanadium), the restoration value is based on wellfield average of the baseline sampling data. Normal statistical procedures will be used to obtain the average.

- The restoration values for the major cations (Ca, Mg, K, and Na) allow the concentrations of these cations to vary by as much as one order of magnitude as long as the TDS restoration value is met. The total carbonate restoration criterion allows for the total carbonate to be less than 50 percent of the TDS. The TDS restoration value is set at the baseline mine unit average plus one standard deviation.

The current NDEE restoration standards are listed in Table 6.1-1.

Under the provisions of the performance-based license, the CBR SERP reviews and approves the establishment of restoration standards using the review procedures discussed in Chapter 5. Table 6.1-1 lists the 27 parameters used at the Crow Butte Project and MEA to determine groundwater quality. The current MCLs from Title 118 are listed as well as the restoration standards from the Class III UIC Permit. The restoration value for each mine unit is based on the current Title 118 standard at the time the NOI is approved by the NDEE.

Proposals for ACLs will include consideration of factors listed under Criterion 5B(6) of 10 CFR Part 40, Appendix A and approval by the Commission pursuant to Criterion 5B(5)(c).

Mine Unit restoration values are contained in Table 6.1-2 through Table 6.1-12 as follows:

- Mine unit averages and secondary goals for MUs 1 through 5 are given in Table 6.1-2 through Table 6.1-6. These restoration values were approved by NRC based on submittals before operation of the Mine Unit.
- The mine unit average and NDEE restoration values for MU6 are given in Table 6.1-7. The CBR SERP determined these restoration values on March 4, 1998.
- The mine unit average and NDEE restoration values for MU7 are given in Table 6.1-8. The CBR SERP determined these restoration values on July 9, 1999.
- The mine unit average and NDEE restoration values for MU8 are given in Table 6.1-9. The CBR SERP determined these restoration values on July 10, 2002.
- The mine unit average and NDEE restoration values for MU9 are given in Table 6.1-10. The CBR SERP determined these restoration values on October 23, 2003.
- The mine unit average and NDEE restoration values for MU10 are given in Table 6.1-11. The CBR SERP determined these restoration values on April 10, 2007.
- The mine unit average and NDEE restoration values for MU11 are given in Table 6.1-12. The CBR SERP determined these restoration values on November 8, 2010.

NDEE Permit Number NE0122611 requires that a mine unit be returned to a wellfield average of these restoration values. These concentrations were approved by the NDEE with the Notice of Intent to Operate submittals. Post mining water quality for MU1 can be found in Table 6.1-13.

CBR operated a R&D Pilot Facility starting in July 1986 and initiated restoration activities of its Wellfield No. 2 in February 1987. Wellfield No. 1 was incorporated into MU1, thus no restoration took place in that area. The techniques used during that program are the basis for the commercial restoration program outlined in this section. CBR utilizes IX columns, a RO unit and reductant addition equipment similar to those used in the R&D restoration during commercial restoration operations.

6.1.4 Groundwater Restoration Methods

6.1.4.1 Introduction

Restoration activities in the Crow Butte Project have proven that the groundwater can be restored to the appropriate standards following commercial mining activities. As shown in Table 1.7-1, MUs 2 through 6 have completed restoration and are currently in stability monitoring. MUs 7 and 8 are currently undergoing restoration. On February 12, 2003, the NRC issued the final approval of groundwater restoration in MU1 at the Crow Butte Project. This approval was the culmination of 3 years of agency reviews including a license amendment to accept the NDEE restoration standards as the approved secondary goals. MU1 consisted of 40 patterns installed in 9.3 acres immediately adjacent to the CPF. Included within the boundaries of MU1 were five wells originally mined beginning in 1986 as part of the R&D pilot plant operation. Commercial mining activities began in 1991 and were completed in 1994. MU1 was successfully restored to the approved primary or secondary restoration standards for all parameters.

The approved CBR restoration plan consists of four steps:

a. Groundwater transfer

b. Groundwater sweep

c. Groundwater treatment

d. Wellfield recirculation

A reductant may be added at anytime during the restoration stage to lower the oxidation potential of the mining zone. A sulfide or sulfite compound will be added to the injection stream in concentrations sufficient to reduce the mobilized species.

The stabilization stage consists of monitoring the restoration wells following successful completion of the restoration stage. Stabilization begins once restoration activities have returned the average concentration of restoration parameters to acceptable levels. Following the stabilization phase, CBR provides a restoration report to the appropriate regulatory agencies. A cone of depression (inward hydraulic gradient) is not maintained during stabilization.

During mining, until the start of stabilization, a hydrologic bleed will be maintained within the perimeter monitor well ring to prevent lateral migration of mining lixiviant. If a proper hydrologic bleed is not maintained, it is possible for water with chemistry similar to that in Table 2.7-18 column “Typical Water Quality During Mining at CSA” to begin migrating toward the monitor well ring. If mobile ions such as chloride and carbonate are detected at the monitor well ring, adjustments will be made to reverse the trend.

The maintenance of a hydrologic bleed and the close proximity of the monitor well ring, less than 300 feet from the mining patterns, will ensure there is negligible migration of mining fluid. Vertical migration of fluids is less of a concern than lateral migration due to the underlying and overlying aquitards. The ubiquitous Chadron Formation clays, which cap the Lower Chadron Formation ore body, have hydraulic conductivities on the order of 10^{-11} cm/sec as outlined in Section 2.7.2.2 of this LRA. Likewise, the underlying Pierre Shale is over 1,200 feet thick and acts as a significant aquitard. The vastly different piezometric heads between the Lower and Middle Chadron as well as the results of the pumping test support the conclusion that the Lower Chadron is vertically isolated.

6.1.4.2 Restoration Process

Restoration activities include four steps that are designed to optimize restoration equipment used in treating groundwater and to minimize the number of pore volumes circulated during the restoration stage. CBR will monitor the quality of selected wells during restoration to determine the efficiency of the operations and to determine if additional or alternate techniques are necessary.

The number of pore volumes that are displaced during groundwater restoration is as follows: three pore volumes through the IX treatment; six pore volumes through RO treatment; and two pore volumes of recirculation. There were nine pore volumes used for MU1 at the current CBR operations. For the remainder of the mine units (MUs 2 through 11) at the Crow Butte Project and the six proposed mine units at the MEA, 11 pore volumes will be used.

The pore volumes (in gallons) affected by the extraction process within the Crow Butte Project ore body water bearing zone are provided in Table 6.1-14. Because the final layout of the MEA mine units has not been defined, as assumed pore volume for the MUs was calculated based on the potential wellfield area, average underream interval of approximately 25 feet, and assumed open pore space value of 29 percent, and an assumed flare factor of 20 percent. As an example, the calculated pore volume for a 75-acre MEA wellfield will be approximately 177,193,095 gallons. A 75-acre wellfield is the maximum area allowed by the State of Nebraska.

Groundwater Transfer

During the groundwater transfer step, water may be transferred between the mine unit commencing restoration and a mine unit commencing mining operations. Baseline quality water from the mine unit starting mining may be pumped and injected into the mine unit in restoration. The higher TDS water from the mine unit in restoration is recovered and injected into the mine unit commencing mining. The direct transfer of water will act to lower the TDS in the mine unit being restored by displacing water affected by the mining with baseline quality water.

The goal of the groundwater transfer step is to blend the water in the two mine units until they become similar in conductivity. The recovered water may be passed through IX columns and filtration during this step if suspended solids are sufficient in concentration to present a problem with blocking the injection well screens.

For the groundwater transfer step to occur, a newly constructed mine unit must be ready to commence mining. If a mine unit is not available to accept transferred water, groundwater sweep or other activity will be utilized as the first step of restoration. The advantage of using the groundwater transfer technique is that it reduces the amount of water that must ultimately be sent to the wastewater disposal system during restoration activities.

Groundwater Sweep

During groundwater sweep, water is pumped without injection from the wellfield, causing an influx of baseline quality water from the perimeter of the mining unit, which sweeps the affected portion of the aquifer. The cleaner baseline quality water has lower ion concentrations that act to strip off the cations that have attached to the clays during mining. The affected water near the edge patterns of the wellfield is also drawn into the boundaries of the mine unit. The number of pore volumes transferred during groundwater sweep, if any, is dependent upon the presence of other active mine units along the mine unit boundary, the capacity of the wastewater disposal system, and the success of the groundwater transfer step in lowering TDS.

Groundwater Treatment

Following the groundwater sweep step, water will be pumped from production wells to treatment equipment and then re-injected into the wellfield. IX, RO, and/or Electro Dialysis Reversal (EDR) treatment equipment is generally used during this stage as shown on the generalized restoration flow sheet on Figure 6.1-1.

Water recovered from restoration that contains a significant amount of uranium is passed through the IX system. The IX columns exchange the majority of the contained soluble uranium for chloride or sulfate. Once the solubilized uranium is removed, a small amount of reductant may be metered into the restoration wellfield injection to reduce any pre-oxidized minerals. The concentration of reductant injected into the formation is determined by the concentration and type of trace elements encountered. The goal of reductant addition is to reduce minerals solubilized by carbonate complexes to prevent the buildup of dissolved solids, which would increase the time for restoration to be completed.

A portion of the restoration recovery water can be sent to the RO unit. The use of a RO unit 1) reduces the TDS in the contaminated groundwater, 2) reduces the quantity of water that must be removed from the aquifer to meet restoration limits, 3) concentrates the dissolved contaminates in a smaller volume of brine to facilitate waste disposal, and 4) enhances the exchange of ions from the formation due to the large difference in ion concentration.

The RO unit contains membranes that pass about 60 to 75 percent of the water through, leaving 60 to 90 percent of the dissolved salts in the water that will not pass the membranes. Table 6.1-15 shows typical RO manufacturers specification data for removal of ion constituents. The clean water, called “permeate”, will be re-injected, sent to storage for use in the mining process, or to the wastewater disposal system. The 25 to 40 percent of water that is rejected, called “brine”, contains the majority of dissolved salts that contaminate the groundwater and is sent for disposal in the waste system. Make-up water may be added to the wellfield injection stream to control the amount of “bleed” in the restoration areas.

The reductant (either biological or chemical) added to the injection stream during the groundwater treatment stage will scavenge any oxygen and reduce the oxidation-reduction potential (Eh) of the aquifer. During mining operations, certain trace elements are oxidized. By adding a reductant, the Eh of the aquifer is lowered, thereby decreasing the solubility of these elements. Hydrogen sulfide (H_2S), sodium sulfide (Na_2S), or a similar compound will be added as a reductant. CBR typically uses sodium sulfide due to the chemical safety issues associated with proper handling of hydrogen sulfide. A comprehensive safety plan regarding reductant use is implemented.

The number of pore volumes treated and re-injected during the groundwater treatment stage is dependent on the efficiency of the RO in removing TDS and the reductant in lowering the uranium and trace element concentrations.

Wellfield Recirculation

At the completion of the groundwater treatment stage, wellfield recirculation may be initiated. In order to homogenize the aquifer, pumping from the production wells and re-injecting the recovered solution into injection wells may be performed to blend solutions.

The sequence of the activities will be determined by CBR based on operating experience and wastewater system capacity. Not all phases of the restoration stage will be used if deemed unnecessary by CBR.

Once the restoration activities are completed, CBR will sample the restoration wells and determine if the mining unit has achieved the restoration values, on a mine unit average basis. If so, CBR will notify the regulatory agencies that it is initiating stability monitoring and will submit supporting documentation that the restoration parameters are at or below the restoration standards. If at the end of restoration activities the parameters are not at or below the approved values, CBR will either re-initiate certain steps of the restoration plan or submit documentation to the agencies that the best practical technology has been used in restoration. The documentation will include a justification for alternate parameter value(s) including available water quality data and a narrative of the restoration techniques used.

6.1.5 Stabilization Phase

Upon completion of restoration, all groundwater extraction and injection ceases. In accordance with LC 10.1.6 of SUA-1534, CBR is no longer required to maintain an inward hydraulic gradient once stability monitoring is initiated. Restoration stability monitoring is outlined in LC 10.1.5 of SUA-1534 and includes sampling the restoration wells and any monitor wells on excursion status during mining operations and analyzing the samples for the parameters listed in Table 6.1-1.

Although CBR's Class III UIC Permit requires a minimum of a 6-month period for stability monitoring of a mine unit to demonstrate the success of restoration activities (stabilization), for purposes of this license, the specified ore zone monitoring wells will be sampled at a frequency of once each quarter. The monitoring on a quarterly basis will continue until the data from the most recent four consecutive quarters indicate no statistically significant increasing trend for all constituents of concern, at which point will be deemed complete, subject to approval.

Throughout restoration and stabilization, excursion monitoring, consistent with Section 5.7.8.2, will continue until NRC determines that groundwater stabilization has been demonstrated.

6.1.6 Reporting

During the restoration process CBR will perform daily, weekly, and monthly analyses as needed to track restoration progress. These analyses will be summarized and discussed in the Semiannual Radiological Effluent and Environmental Monitoring Report submitted to NRC. This information will also be included in the final report on restoration.

In the unlikely event that a well goes on excursion during restoration, the process described in LC 11.1.5 of SUA-1534 will be followed. Excursion monitoring operational procedures will include corrective action and notification plans in the event of an excursion. The NRC will be notified within 24 hours by telephone and within 7 days in writing from the time an excursion is verified. A written report describing the excursion event, corrective actions taken, and the corrective action results will be submitted to the NRC within 60 days of the excursion confirmation. If any of the wells are still on excursion status when the report is submitted, the report will also contain a timeline for submittal of future reports describing the excursion event, corrective actions taken, and results obtained. In the event of a vertical excursion, the report will contain a projected completion date for the extent of the vertical excursion would be completed.

During stabilization, all designated restoration wells will be sampled in accordance with the respective agencies' sampling requirements for the constituents listed in Table 6.1-1. At the end of each agencies' stabilization period, CBR will compile all water quality data obtained during restoration and stabilization and submit a final report. If the analytical results continue to meet the appropriate standards for the mine unit and do not exhibit significant increasing trends, CBR would request the mine unit be declared restored. Following agency approval, wellfield reclamation and plugging and abandonment of wells will be performed as described in Section 6.2.

6.2 PLANS FOR RECLAIMING DISTURBED LANDS

The following section addresses the final decommissioning methods of disturbed lands including wellfields, CPF, satellite facilities, evaporation ponds, and diversion ditches that will be used on the project sites. The section discusses general procedures to be used during final decommissioning as well as the decommissioning of a particular phase or production unit area.

Decommissioning of wellfields and process facilities, once their usefulness has been completed in an area, will be scheduled after agency approval of groundwater restoration and stability. Decommissioning will be accomplished in accordance with an approved decommissioning plan and the most current applicable NDEE and NRC rules and regulations, permit and license stipulations and amendments in effect at the time of the decommissioning activity.

The following is a list of general decommissioning activities:

- Plug and abandon all wells as detailed in Section 6.2.4.
- Determination of appropriate cleanup criteria for structures (Section 6.3) and soils (Section 6.4).

- Radiological surveys and sampling of all facilities, process related equipment and materials on site to determine their degree of contamination and identify the potential for personnel exposure during decommissioning.
- Removal from the site of all contaminated equipment and materials to an approved licensed facility for disposal or reuse, or relocation to an operational portion of the mining operation as discussed in Section 6.3.
- Decontamination of items to be released for unrestricted use to levels consistent with the requirements of NRC.
- Survey excavated areas for contamination and remove contaminated materials to a licensed disposal facility.
- Perform final site soil radiation surveys.
- Backfill and recontour all disturbed areas.
- Establish permanent revegetation on all disturbed areas.

The following sections describe in general terms the planned decommissioning activities and procedures for the Crow Butte Project and MEA facilities. In accordance with LC 10.1.10 of SUA-1534, CBR will submit to the NRC a detailed Decommissioning Plan for review and approval at least 12 months before planned commencement of final decommissioning. The Decommissioning Plan will also be provided to NDEE for review and approval. As required by 10 CFR §40.36(f), records of information important to decommissioning will be maintained in the office of the on-site RSO. Such information shall meet the criteria of 10 CFR §40.42(g) (4) and (5).

6.2.1 General Surface Reclamation Procedures

The primary surface disturbances associated with solution mining are the sites containing the CPF and associated facilities, satellite facilities, and evaporation ponds. Surface disturbances also occur during the well drilling program, pipeline installation, and road construction. These more superficial disturbances, however, involve relatively small areas or have short-term impacts.

The principal objective of the surface reclamation plan is to return disturbed lands to production compatible with the post-mining land use of equal or better quality than the pre-mining condition. For the Crow Butte Project and the MEA, the reclaimed lands should be capable of supporting livestock grazing and providing stable habitat for native wildlife species. Soils, vegetation, wildlife and radiological baseline data will be used as guidelines for the design, completion and evaluation of surface reclamation. Final surface reclamation will blend affected areas with adjacent undisturbed lands so as to re-establish original slope and topography and present a natural appearance. Surface reclamation efforts will strive to limit soil erosion by wind and water, sedimentation and re-establish natural trough drainage patterns.

The following sections provide reclamation procedures for the facility sites, wellfield production units, evaporation ponds, and access and haul roads. Reclamation schedules for wellfield production units will be discussed separately because they are dependent upon the progress of mining and the successful completion of groundwater restoration. Cost estimates for bonding calculations are discussed in Section 6.6 and include all activities that are anticipated to complete groundwater restoration, decontamination, decommissioning, and surface reclamation of wellfield and satellite plant facilities installed. These cost estimates are updated annually to cover work projected for the next year of mining activity.

6.2.1.1 Topsoil Handling and Replacement

In accordance with NDEE requirements, topsoil is salvaged from building sites (including CPF and satellite buildings) and pond areas. Conventional rubber-tired, scraper-type earth moving equipment is typically used to accomplish such topsoil salvage operations. The exact location of topsoil salvage operations is determined by wellfield pattern emplacement and designated wellfield access roads within the wellfields, which are determined during final wellfield construction activities.

As described in Section 2.6, topsoil thickness varies within the Crow Butte Project and MEA. The topsoil thickness is usually greatest in and along drainages where material has been deposited and deep soils have developed. Therefore, topsoil stripping depths may vary in depth, depending on location and the type of structure being constructed. In cases where it is necessary to strip topsoil in relatively large areas, such as a major road or building site, field mapping and Soil Conservation Service Soil Surveys will be utilized to determine approximate topsoil depths.

Salvaged topsoil is stored in designated topsoil stockpiles. These stockpiles are generally located on the leeward side of hills to minimize wind erosion. Stockpiles are not located in drainage channels. The perimeter of large topsoil stockpiles may be bermed to control sediment runoff. Topsoil stockpiles are seeded as soon as possible after construction with the permanent seed mix to promote stability and minimize erosion.

During mud pit excavation associated with well construction, exploration drilling and delineation drilling activities, topsoil is separated from subsoil with a backhoe. When use of the mud pit is complete, all subsoil is replaced and topsoil is applied. Mud pits generally remain open a short time. The success of revegetation efforts at the Crow Butte Project show that these procedures adequately protect topsoil and result in vigorous vegetation growth.

6.2.1.2 Contouring of Affected Areas

Due to the relatively minor nature of disturbances created by ISR mining, there are only a few areas disturbed to the extent to which subsoil and geologic materials are removed, causing significant topographic changes that need backfilling and recontouring. Generally speaking, solar evaporation pond construction results in redistribution of sufficient amounts of subsurface materials, which requires replacement and contour blending during reclamation. The existing contours will only be interrupted in small, localized areas. Because approximate original contours will be achieved during final surface reclamation, no post mining contour maps have been included in this application.

Changes in the surface configuration caused by construction and installation of operating facilities will be only temporary, during the operating period. These changes will be caused by topsoil removal and storage along with the relocation of subsoil materials used for construction purposes. Restoration of the original land surface, which is consistent with the pre- and post-mining land use, the blending of affected areas with adjacent topography to approximate original contours and the reestablishment of drainage patterns will be accomplished by returning the earthen materials moved during construction to their approximate original locations.

Drainage channels that have been modified by the mine plan for operational purposes such as road crossings will be reestablished by removing fill materials, culverts and reshaping to as close to pre-operational conditions as practical. Surface drainage of disturbed areas that have been located on terrain with varying degrees of slope will be accomplished by final grading and contouring appropriate to each location so as to allow for controlled surface run off and eliminate depressions where water could accumulate.

6.2.1.3 Revegetation Practices

Revegetation practices are conducted in accordance with NDEE requirements. During mining operations the topsoil stockpiles, and as much as practical of the disturbed wellfield and pond areas, will be seeded with vegetation to minimize wind and water erosion. After placement of topsoil and contouring for final reclamation, an area will normally be seeded with a seed mixture developed in consultation with the Natural Resource Conservation Service as required by the NDEE.

6.2.2 Process Facility Reclamation

Following removal of structures as discussed in Section 6.3, subsoil and stockpiled topsoil will be replaced on the disturbances from which they were removed during construction, within practical limits. Areas to be backfilled will be scarified or ripped prior to backfilling to create an uneven surface for application of backfill. This will provide a more cohesive surface to eliminate slipping and slumping. The less suitable subsoil and unsuitable topsoil, if any, will be backfilled first so as to place them in the deepest part of the excavation to be covered with more suitable reclamation materials. Subsoils will be replaced using paddle wheel scrapers, bulldozers or other appropriate equipment to transfer the earth from stockpile locations or areas of use and to spread it evenly on the ripped disturbances. Grader blades may be used to even the spread of backfill materials. Topsoil replacement will commence as soon as practical after a given disturbed surface has been prepared. Topsoil will be picked up from storage locations by paddle wheel scrapers or other appropriate equipment and distributed evenly over the disturbed areas. The final grading of topsoil materials will be done so as to establish adequate drainage and the final prepared surface will be left in a roughened condition.

6.2.3 Evaporation Pond Decommissioning

6.2.3.1 Disposal of Pond Water

The volume of water remaining in the lined evaporation ponds after restoration as well as its chemical and radiological characteristics will be considered to determine the most practical disposal program. Disposal options for the pond liquid include evaporation sprays, treatment and disposal in the deep well, or transportation to another licensed facility or disposal site.

Currently, there are no plans for treating and discharging the pond water under an NPDES permit.

6.2.3.2 *Pond Sludge and Sediments*

Pond sludges and sediments will contain mining process chemicals and radionuclides. Wind blown sand grains and dust blown into the ponds during their active life also add to the bulk of sludges. This material will be contained within the pond bottom and kept in a dampened condition at all times, especially during handling and removal operation to prevent the spread of airborne contamination and potential worker exposure through inhalation. Dust abatement techniques will be used as necessary. The sludge will be removed from the ponds and loaded into roll off containers, dump trucks or drums and transported to an NRC licensed disposal facility.

6.2.3.3 *Disposal of Pond Liners and Leak Detection Systems*

Pond liners will be kept washed down and intact as much as practical during sludge removal so as to confine sludges and sediments to the pond bottom. Pond liners will be cut into strips and transported to an NRC licensed disposal facility or will be decontaminated for release to an unrestricted area. After removal of the pond liners, the pond leak detection system piping will be removed. Materials involved in the leak detection system will be surveyed and released for unrestricted use if not contaminated or transported to an NRC licensed facility for disposal. The earthen material in the pond bottom and leak detection system trenches will be surveyed for soil contamination. Any contaminated soil in excess of the cleanup criteria discussed in Section 6.4.1 will be removed and disposed at an NRC licensed disposal facility.

Following the removal of all pond materials and the disposal of any contaminated soils, surface preparation will take place prior to reclamation.

6.2.3.4 *On Site Burial*

At the present time, on site burial of contaminants is not anticipated; however, depending upon the availability of a NRC licensed disposal site at the time of decommissioning, on site burial may become a potential alternative. Should this occur, pond locations would be considered initially as the onsite disposal locations for contaminated materials. Appropriate licensing with the regulatory agencies would be obtained prior to any on site disposal of contaminated wastes.

6.2.4 Wellfield Decommissioning

Surface reclamation in the wellfield production units will vary in accordance with the development sequence and the mining/reclamation timetable. Final surface reclamation of each wellfield production unit will be completed after approval of groundwater restoration stability and the completion of well abandonment activities discussed below. Surface preparation will be accomplished as needed so as to blend any disturbed areas into the contour of the surrounding landscape.

Wellfield decommissioning will consist of the following steps:

- The first step of the wellfield decommissioning process will involve the removal of surface equipment. Surface equipment primarily consists of the injection and production feed lines, wellhouses, electrical and control distribution systems, well boxes, and wellhead equipment. Wellhead equipment such as valves, meters or control fixtures will be salvaged.
- Removal of buried wellfield piping.
- Wells will be plugged and abandoned according to the procedures described below.
- The wellfield area may be recontoured, if necessary, and a final background gamma survey conducted over the entire wellfield area to identify any contaminated earthen materials requiring removal to disposal.
- Final revegetation of the wellfield areas will be conducted according to the revegetation plan.
- All piping, equipment, buildings, and wellhead equipment will be surveyed for contamination prior to release in accordance with the USNRC guidelines for decommissioning.

It is estimated that a significant portion of the equipment will meet release limits, which will allow disposal at an unrestricted area landfill. Other materials that are contaminated will be acid washed or decontaminated with other methods until they are releasable. If the equipment cannot be decontaminated to meet release limits, it will be disposed of at an NRC licensed disposal facility.

Wellfield decommissioning will be an independent ongoing operation throughout the mining sequence. Once a production unit has been mined out and groundwater restoration and stability have been accepted by the regulatory agencies, the wellfield will be scheduled for decommissioning and surface reclamation.

6.2.4.1 Well Plugging and Abandonment

Cased Mining and Restoration Wells

All wells no longer useful to continue mining or restoration operations will be abandoned. These include all injection and production wells, monitor wells, and any other wells within the production unit used for the collection of hydrologic or water quality data or incidental monitoring purposes. The only known exception at this time may be a shallow well that could be transferred to the landowner for domestic or livestock use.

The objective of the CBR well abandonment program is to seal and abandon all wells in such a manner as to assure the groundwater supply is protected and to eliminate any potential physical hazard.

Prior to abandoning a well, data are gathered (static water level, under-ream interval, casing depth) for use in a well abandonment spreadsheet that accounts for formation pressures, mining injection pressures, static water level, casing depth, materials used and weight of material used. Based on that information, adjustments can be made to the amount of bentonite chips to be used to plug the well screens, and also to calculate the minimum weight (lbs/gallon) of abandonment mud to be used to fill the hole to the surface and keep formation and mining pressures from allowing water to rise in the borehole. A prepackaged bentonite-filled tube currently is used for plugging the well screens. These tubes are placed into the screens by filling the well to the surface with water from a water truck, and then dropping the bentonite tubes down the well. The water is allowed to run while the tubes make their descent into the screens. The drill rig then trips drill pipe into the well and tags the bentonite to verify it has reached the targeted depths. The drill stem is raised approximately 10 feet and a plug-gel abandonment mud is mixed. If the weight of the abandonment mud needs to be increased, an amount of barite may be added to increase the weight. Likewise, a drilling additive (Dris-pac) may be added to improve the ability of the abandonment mud to carry the barite. In situations where it appears that the operating pressure and formation pressure are great enough to make it difficult to mix heavy mud, cement slurry may be substituted to fill the casing to the surface. All abandoned wells will remain above the surface until the wellfield is reclaimed. This allows for the continuation of monitoring and observation of the integrity of the abandonment fluid. If needed, additional abandonment fluids are added. The plugging method is approved by the NDEE and is generally as summarized below:

- A mechanical plug may be placed above the screened interval.
- Thirty to fifty feet of coarse bentonite chips will be added to provide a grout seal.
- A plug gel or cement grout will be placed by tremie pipe from the chips to the top of the casing. The weight of the gel or grout plus the weight of the bentonite chips will be enough to exceed the local Chadron formation pressure plus the maximum injection pressure allowed (100 psi).
- The tremie pipe will be removed (when possible) and the casing will be filled to the surface.
- An approved hole plug will be installed.
- The well casing will be cut off below ground level, capped with cement, and the surface disturbance will be smoothed and contoured.
- The hole will be backfilled and the area revegetated.

Records of abandoned wells will be tabulated and reported to the appropriate agencies after decommissioning. CBR must submit a notarized affidavit to the NDEE detailing the significant data and the procedure used in connection with each well plugged. The NDNR also requires filing a well abandonment notice for all registered wells.

Exploratory Holes

Plugging and abandonment of exploratory holes (including core holes) is conducted in compliance with the State of Nebraska Title 135 Mineral Exploration Permit that requires NDEE approval. The Mineral Exploration Permit allows for exploratory holes within the boundaries of the permit and includes a surety bond to cover abandonment and reclamation costs in the event the permit holder does not complete the abandonment and reclamation.

6.2.4.2 Buried Trunklines, Pipes, and Equipment

Buried process-related piping, such as injection and production lines, will be removed from the mine unit undergoing decommissioning. Salvageable lines will be held for use in ongoing mining operations. Lines that are not reusable may either be assumed to be contaminated and disposed of at a licensed disposal site or may be surveyed and, if suitable for release to an unrestricted area, may be sent to a sanitary landfill.

6.3 REMOVAL AND DISPOSAL OF STRUCTURES, WASTE MATERIALS, AND EQUIPMENT

In accordance with LC 10.1.10 of SUA-1534, CBR will submit a final, detailed decommissioning plan for structures and equipment to the NRC for review and approval at least 12 months before the planned commencement of decommissioning of such structures and equipment. This final decommissioning plan will describe structures and equipment to be decommissioned, planned decommissioning activities, methods that will be implemented to ensure protection of workers and the environment against radiation hazards, the planned final radiation survey, and provide an updated detailed cost estimate.

The procedures to be used for removing and disposing of structures, waste materials and equipment will meet the following criteria:

- A written program is in place to control residual contamination on structures and equipment.
- Measurements of radioactivity on the interior surface of pipes, drain lines, and duct work would be determined by conducting measurements at all traps and other appropriate access points, provided that such contamination is likely to be representative of contamination on the interior of the pipes, drain lines and ductwork.
- Any surfaces of premises, equipment, or scrap that would likely be contaminated, but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement, would be presumed to be contaminated in excess of the limits.
- Prior to the release of structures for unrestricted use, a comprehensive radiation survey would be made to establish that contamination is within the limits specified in NRC Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material (NRC 1993) and NRC approval would be obtained.
- A contract between CBR and a waste disposal operator would be in place to dispose of 11e.(2) byproduct material.

6.3.1 Preliminary Radiological Surveys and Contamination Control

Prior to CPF and satellite plant decommissioning, a preliminary radiological survey will be conducted to characterize the levels of contamination on structures and equipment and to identify any potential hazards. The survey will support the development of procedures for dealing with such hazards prior to commencement of decommissioning activities. In general, the contamination control program used during mining operations (as discussed in Section 5.7 of this LRA) will be appropriate for use during decommissioning of structures.

Based on the results of the preliminary radiological surveys, gross decontamination techniques will be employed to remove loose contamination before decommissioning activities proceed. This gross decontamination will generally consist of washing all accessible surfaces with high-pressure water. In areas where contamination is not readily removed by high-pressure water, a decontamination solution (e.g., dilute acid) may be used.

6.3.2 Removal of Process Buildings and Equipment

The majority of the process equipment in the process buildings will be reusable, as well as the buildings themselves. Alternatives for the disposition of buildings and equipment are discussed in this section.

All process or potentially contaminated equipment and materials at the process facility including tanks, filters, pumps, piping, etc., will be inventoried, listed and designated for one of the following removal alternatives:

- Removal to a new location within the CBR sites for further use or storage;
- Removal to another licensed facility for either use or permanent disposal; or
- Decontamination to meet unrestricted use criteria for release, sale or other non-restricted use by others.

It is most likely that process buildings will be decontaminated, dismantled and released for use at another location. If decontamination efforts were unsuccessful, the material would be sent to a permanent licensed disposal facility. Cement foundation pads and footings will be broken up and trucked to a licensed disposal site or properly licensed facility if contaminated.

6.3.2.1 Building Materials, Equipment and Piping to be Released for Unrestricted Use

Salvageable building materials, equipment, pipe and other materials to be released for unrestricted use will be surveyed for alpha contamination in accordance with LC 9.6 in SUA-1534 and applicable NRC guidance.

The CBR release limits for alpha radiation are as follows:

- Removable of 1,000 dpm/100 cm^2
- Average total of 5,000 dpm/100 cm^2 over an area no greater than one square meter
- Maximum total of 15,000 dpm/100 cm^2 over an area no greater than 100 cm^2

Monitoring for beta contamination is a current license requirement. This requirement has been eliminated in subsequent ANSI standards, including ANSI/HPS N13.12 (ANSI 2013). In addition, CBR has routinely made these measurements but has never found them limiting.

Decontamination of surfaces will comply with CBR's ALARA policy, to reduce surface contamination as far below the limits as practical.

Non-salvageable contaminated equipment, materials, and dismantled structural sections will be sent to an NRC-licensed facility for disposal. In most cases, the byproduct material will be shipped as Low Specific Activity (LSA-I) material, UN2912, pursuant to 49 CFR §173.427.

6.3.2.2 *Disposal at a Licensed Facility*

If facilities or equipment are to be moved to a facility licensed for disposal of 11e.(2) byproduct material, the following procedures may be used.

- Flush inside of tanks, pumps, pipes, and other components with water or acid to reduce interior contamination as necessary for safe handling.
- Survey the exterior surfaces of process equipment for contamination. If the surfaces are found to be contaminated, the equipment will be washed down and decontaminated to permit safe handling.
- Disassemble the equipment only to the degree necessary for transportation. All openings, pipe fittings, vents, and other components, will be plugged or covered prior to moving equipment from the satellite building.
- Equipment in the building, such as large tanks, may be transported on flatbed trailers. Smaller items, such as links of pipe and ducting material, may be placed in lined roll-off containers or covered dump trucks or drummed in barrels for delivery to the receiving facility.
- Contaminated buried process trunk lines and sump drain lines will be excavated and removed for transportation to a licensed disposal facility.
- All other miscellaneous contaminated material will be transported to a licensed disposal facility.

6.3.2.3 *Release for Unrestricted Use*

If a piece of equipment or structure is to be released for unrestricted use, it will be appropriately surveyed before leaving the licensed area. Both interior and exterior surfaces will be surveyed to detect potential contamination. Radioactivity levels are determined on the interior surfaces of pipes, drain lines or duct work by making measurements in all traps and other appropriate access points, provided that contamination at these locations is expected to be representative of contamination on the interior of the pipes, drain lines or duct work. If the shape, size, or presence of inaccessible surfaces prevents an accurate and representative survey, the material will be assumed contaminated and properly disposed of. Appropriate decontamination procedures will be used to clean any contaminated areas and the equipment resurveyed and documentation of the final survey retained to show that unrestricted use criteria were met prior to releasing the equipment or materials from the site. The current release criteria are based on NRC guidelines. The criteria used for release to unrestricted use will be the appropriate NRC guidelines at that time. Release surveys will be based on the release methods discussed in Section 5.7.6 of this LRA.

If a process building is left on site for unrestricted use by a landowner, the following basic decontamination procedures will be used. Actual corrective procedures will be determined by field requirements as defined by radiological surveys.

After the building has been emptied, the interior floors, ceiling and walls of the building and exterior surfaces at vent and stack locations will be checked for contamination. Any remaining removable contamination will be removed by washing. Areas where contamination was noted will be resurveyed to ensure removal of all contamination to appropriate levels.

Process floor sumps and drains will be washed out and decontaminated using water and, if necessary, acid solutions. If the appropriate decontamination levels cannot be achieved, it may be necessary to remove portions of the sump and floor to disposal.

Excavations necessary to remove trunklines or drains will be surveyed for contaminated earthen material. Earthen material that is found to be contaminated will be removed to a licensed disposal facility prior to backfilling the excavated areas.

The parking and storage areas around the building will be surveyed for surface contamination after all equipment has been removed.

Decontamination of these areas will be conducted as necessary to meet the standards for unrestricted use.

6.3.3 Waste Transportation and Disposal

Materials, equipment, and structures that cannot be decontaminated to meet the appropriate release criteria will be disposed of at a disposal site licensed by the NRC or an Agreement State to receive 11e.(2) byproduct material. CBR currently maintains agreements with two such facilities located in the states of Utah and Wyoming for disposal of 11e.(2) byproduct materials generated by mining operations. A contract for disposal at a minimum of one facility will be maintained current as required in LC 9.9 of SUA-1534.

Transportation of all contaminated waste materials and equipment from the site to the approved licensed disposal facility or other licensed sites will be handled in accordance with the Department of Transportation (DOT) Hazardous Materials Regulations (49 CFR Part 173) and the NRC transportation regulations (10 CFR Part 71).

6.4 METHODOLOGIES FOR CONDUCTING POST-RECLAMATION AND DECOMMISSIONING RADIOLOGICAL SURVEYS

6.4.1 Cleanup Criteria

Surface soils will be cleaned up in accordance with the requirements of 10 CFR Part 40, Appendix A, including a consideration of ALARA goals and the chemical toxicity of uranium. The proposed limits and ALARA goals for cleanup of soils are summarized in Table 6.4-1.

The existing radium-226 criterion in 10 CFR Part 40, Appendix A, was used to derive a dose criterion (Benchmark Approach) for the cleanup of byproduct materials. The Benchmark Dose was modeled using NRC's Residual Radioactivity (RESRAD) computer code. RESRAD Version 6.22 was used to model the Crow Butte Project and calculate the annual dose from the current radium cleanup standard. The results show that a concentration of 537 pCi/g for natural uranium in the top 15 cm layer of soil for the resident farmer scenario is equivalent to the Benchmark Dose derived from a concentration of 5 pCi/g of radium-226. RESRAD Version 7.0 was used to model the MEA (Appendix N of the MEA Technical Report). The results show that a concentration of 600 pCi/g for natural uranium in the top 15 cm layer of soil for the resident farmer scenario is equivalent to the Benchmark Dose derived from a concentration of 5 pCi/g of radium-226.

ALARA considerations require that an effort be made to reduce contaminants to ALARA levels. The ALARA goals are normally based on a cost-benefit analysis. For the cleanup of gamma-emitting radionuclides, the cost of cleanup becomes excessively high as soil concentrations and/or gamma emission rates become indistinguishable from background.

Cleanup of uranium mill sites has demonstrated that conservatively derived gamma action levels along with appropriate field survey and sampling procedures result in near background radium-226 concentrations for the site. In addition, the presence of a mixture of radium-226 and uranium will tend to drive the cleanup to even lower radium-226 concentrations. It is therefore believed that no specific ALARA goal is required for surface radium-226.

The uranium concentration should be limited to, at most, 230 pCi/g for all soil depths because of chemical toxicity concerns. Using the most conservative daily limit corresponding to the National Primary Drinking Water Standard, a soil limit of 230 pCi/g corresponds to the EPA intake limit from drinking water with a uranium concentration of 0.06 mg/day.

CBR desires to reduce subsurface concentrations to a maximum of two-thirds of the proposed limit of 15 pCi/g radium-226. The subsurface uranium goal has not been reduced since it has not been demonstrated that these levels can be detected with readily available field instruments.

Section 2.5 of Appendix E to the Environmental Report supporting the license amendment application for the North Trend Expansion Area “Wellfield Decommissioning Plan for Crow Butte Uranium Project” demonstrates that spills of process solutions at the Crow Butte Project are not likely to contain substantial amounts of thorium-230. CBR believes that developing soil cleanup criteria for thorium-230 is not appropriate at this time. In the unlikely event that thorium-230 is present in significant quantities, cleanup criteria will be developed using the radium-226 benchmark approach and submitted to the NRC for approval prior to final site decommissioning.

6.4.2 Excavation Control Monitoring

Hand-held and GPS-based gamma surveys will be used to guide soil remediation efforts. Field personnel will monitor excavations with hand-held detection systems to guide the removal of contaminated material to the point where there is high probability that an area meets the cleanup criteria. Support will be provided by GPS-based gamma surveys periodically to more accurately assess the progress of excavation.

6.4.3 Surface Soil Cleanup Verification and Sampling Plan

Cleanup of surface soils will be restricted to a few areas where there are known spills and, potentially, small spills near wellheads. Final GPS-based gamma surveys will be conducted in potentially contaminated areas, including 10 m buffer zones.

CBR will divide the area systematically into 100 m^2 grid blocks and sample all grid blocks containing gamma count rates exceeding the gamma action level. The samples will be five-point composites and analyzed at an offsite laboratory for radium-226 and natural uranium.

CBR will sample the remaining grid blocks with average gamma count rates ranking in the top 10 percent.

If any grid blocks within the top 10 percent fail the cleanup criteria, CBR will sample the second ten percent of grid blocks. This will continue until all grid blocks pass within a 10 percent grouping. To meet the cleanup criterion, each of the sampled grid blocks must satisfy the following inequality,

$$\sum \frac{C_i}{Cc} < 1$$

where C_i is the concentration of the constituent and C_c is the concentration of the constituent that is equivalent to the Benchmark Dose.

CBR will remediate the grid blocks failing this inequality or propose alternatives consistent with Appendix A of 10 CFR Part 40.

After all sampled grids have met the inequality, an EPA-recommended statistical test will be done to determine whether the mean of the equality defined above for all grid blocks is 1 or less at the 95 percent confidence level, using Equation 8-13 of draft NUREG/CR-5849 (NRC 1992). If the mean of the sample concentrations is less than the criterion but the data fail the statistical test, CBR will follow procedures similar to those recommended in Section 8.6 of draft NUREG/CR-5849.

6.4.4 Subsurface Soil Cleanup Verification and Sampling Plan

For subsurfaces, CBR will adopt different survey and sample protocols, depending on the type and size of excavation. CBR will rely more on sampling and radium-226 and natural uranium analysis over surveying, to verify cleanup of subsurface excavations. The protocols are summarized in site procedures.

6.4.5 Temporary Ditches and Impoundments Cleanup Verification and Sampling Plan

CBR will adopt survey and sample protocols for temporary ditches and surface impoundments on a case-by-case basis. Ditches and impoundments can extend from the surface to the subsurface. For the purpose of decommissioning, the surfaces will be considered as part of adjacent soil surfaces. The subsurfaces will be surveyed and sampled systematically, based on their size and geometry. As with other subsurfaces, CBR will rely more on sampling and radium-226 and uranium analysis over surveying to verify cleanup of ditches and impoundments.

Surveying is applicable in larger impoundments, however, wherein the effects of geometry are not as pronounced, particularly in areas not influenced by adjacent walls.

6.4.6 Quality Assurance

Verification soil samples will be sent to a commercial laboratory for analysis of radium-226 and natural uranium. The criteria that CBR will use to select the commercial laboratory will follow the guidance published in the Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP) (NRC 2004). The commercial laboratory will adhere to a well-defined quality assurance program that addresses the laboratory’s organization and management, personal qualifications, physical facilities, equipment and instrumentation, reference materials, measurement traceability and calibration, analytical method validation, SOPs, sample receipt, handing, storage, records, and appropriate licenses.

The analytical work performed by the commercial laboratory will adhere to CBR-defined Data Quality Objectives (DQOs). Part of the DQO process is specific analytical sensitivities required by CBR. The minimum sensitivity required for each sample will be 0.5 pCi/g dry weight for each analyte, with an estimated overall error of ± 0.5 pCi/g.

CBR will expect the reporting equivalent of an EPA Contract Laboratory Program Level 3 data package from the commercial laboratory.

CBR will maintain a laboratory QA file that will include, at a minimum, the laboratory’s Quality Assurance Manual (QAM) and audit reports.

6.5 DECOMMISSIONING HEALTH PHYSICS AND RADIATION SAFETY

The health physics and radiation safety program for decommissioning will ensure that occupational radiation exposure levels are kept ALARA during decommissioning. This program will ensure that contamination and any use of the premises, equipment or scrap will not result in an unacceptable risk to the health and safety of the public or the environment. The Radiation Safety Officer, Health Physics Technician or designee will be on site during any decommissioning activities where a potential radiation exposure hazard exists. In general, the radiation safety program discussed in Chapter 5 will be used as the basis for development of the decommissioning health physics program. Health physics surveys conducted during decommissioning will be guided by applicable sections of RG 8.30 or other applicable standards at the time.

6.5.1 Records and Reporting Procedures

At the conclusion of site decommissioning and surface reclamation, a report containing all applicable documentation will be submitted to the NRC and NDEE. Records of all contaminated materials transported to a licensed disposal site will be maintained for a period of five years or as otherwise required by applicable regulations at the time of decommissioning.

6.6 FINANCIAL ASSURANCE

6.6.1 Bond Calculations

Cost estimates for the purpose of bond calculations are made annually for the Crow Butte Project. The cost assessment includes groundwater restoration, decontamination and decommissioning and surface reclamation costs for all areas to be affected by the installation and operation of the mine plan. The detailed calculations utilized in determining the bonding requirements for the Crow Butte Project are submitted annually.

6.6.2 Financial Surety Arrangements

CBR maintains an NRC-approved financial surety arrangement consistent with 10 CFR 40, Appendix A, Criterion 9 to cover the estimated costs of reclamation activities. CBR is currently operating under the NRC surety amount of $62,605,869, which was approved by NRC in a letter dated August 22,2024. CBR maintains an Irrevocable Standby Letter of Credit issued by the Royal Bank of Canada (New York Branch) in favor of the State of Nebraska.

The surety amount is revised annually in accordance with the requirements of LC 9.5 of SUA-1534. The surety amount will be revised to reflect the estimated costs of reclamation activities for the MEA as development activities proceed.

6.7 REFERENCES

American National Standard Institute (ANSI), 2013, Surface and Volume Radioactivity Standards for Clearance ANSI/HPS N13.12.

NDEE, 2023, Title 118, Ground Water Quality Standards and Use Classification. Effective Date: September 20, 2023. Available on the internet as of July 2024 at: http://dee.ne.gov/RuleAndR.nsf/Title_118.xsp

U.S. Nuclear Regulatory Commission (NRC), 1992, Manual for Conducting Radiological Surveys in Support of License Termination – Draft Report for Comment. NRC Accession No. ML090640319. Available on the internet as of July 2024 at: https://www.nrc.gov/docs/ML0906/ML090640319.pdf

U.S. Nuclear Regulatory Commission (NRC), 1993, Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material. NRC Accession No. ML030590505. Available on the internet as of July 2024 at: https://www.nrc.gov/docs/ML0305/ML030590505.pdf

U.S. Nuclear Regulatory Commission (NRC), 2004, Multi-Agency Radiological Laboratory Analytical Protocols Manual (NUREG-1576). Available on the internet as of July 2024 at: https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1576/index.html

Table 6.1-1: NDEE Groundwater Restoration Standards

Parameter	NDEE Title 118 Groundwater Standard	NDEE Restoration Standard[1]
Ammonium (mg/L)	Not Listed	10.0
Arsenic (mg/L)	0.010	0.010
Barium (mg/L)	2.0	2.0
Cadmium (mg/L)	0.005	0.005
Chloride (mg/L)	250	250
Copper (mg/L)	1.3	1.3
Fluoride (mg/L)	4.0	4.0
Iron (mg/L)	0.3	0.3
Mercury (mg/L)	0.002	0.002
Manganese (mg/L)	0.05	0.05
Molybdenum (mg/L)	(Reserved)	1.0
Nickel (mg/L)	(Reserved)	0.15
Nitrate (mg/L)	10.0	10.0
Lead (mg/L)	0.015	0.015
Radium (pCi/L)	5.0	5.0
Selenium (mg/L)	0.05	0.05
Sodium (mg/L)	(Reserved)	Note 2
Sulfate (mg/L)	250	250
Uranium (mg/L)	0.030	0.030
Vanadium (mg/L)	(Reserved)	0.2
Zinc (mg/L)	5.0	5.0
pH (Std. Units)	6.5 - 8.5	6.5 – 8.5
Calcium (mg/L)	N/A	Note 2
Total Carbonate (mg/L)	N/A	Note 3
Potassium (mg/L)	N/A	Note 2
Magnesium (mg/L)	N/A	Note 2
TDS (mg/L)	500	Note 4

1 NDEE Restoration Standard based on groundwater standard (MCL) from Title 118. For parameters where the baseline concentration exceeds the applicable MCL, the standard is set as the mine unit baseline average plus two standard deviations.
2 One order of magnitude above baseline is used as the restoration value for some parameters due to the ability of some major ions to vary one order of magnitude depending on pH.
3 Total carbonate shall not exceed 50% of the total dissolved solids value.
4 The restoration value for TDS shall be the baseline mean plus one standard deviation.
Source: NDEE Class III UIC Permit Number NE0122611

Table 6.1-2: Baseline and Restoration Values for Mine Unit 1

Parameter	Groundwater Standard	MU1 Baseline	MU1 Standard Deviation	MU1 NDEE Restoration Value
Ammonium (mg/L)	10.0	<0.372	N/A	10.0
Arsenic (mg/L)	0.05	<0.00214	N/A	0.05
Barium (mg/L)	1.0	<0.1	N/A	1.0
Cadmium (mg/L)[1]	0.01	<0.00644	N/A	0.005[1]
Chloride (mg/L)	250.0	203.9	38	250.0
Copper (mg/L)	1.0	<0.017	N/A	1.0
Fluoride (mg/L)	4.0	0.686	0.04	4.0
Iron (mg/L)	0.3	<0.0441	N/A	0.3
Mercury (mg/L)	0.002	<0.001	N/A	0.002
Manganese (mg/L)	0.05	<0.011	N/A	0.05
Molybdenum (mg/L)	1.0	<0.0689	N/A	1.0
Nickel (mg/L)	0.15	<0.0340	N/A	0.15
Nitrate (mg/L)	10.0	<0.050	N/A	10.0
Lead (mg/L)	0.05	0.0315	N/A	0.05
Radium (pCi/L)	5.0	229.7	177.1	584.0
Selenium (mg/L)	0.01	<0.00323	N/A	0.05
Sodium (mg/L)	N/A	412	19.2	4120
Sulfate (mg/L)	250.0	356.2	9.4	375
Uranium (mg/L)	5.0	0.0922	0.089	5.0
Vanadium (mg/L)	0.2	<0.0663	N/A	0.2
Zinc (mg/L)	5.0	<0.036	N/A	5.0
pH (Std. Units)	6.5 - 8.5	8.46	0.2	6.5 – 8.5
Calcium (mg/L)	N/A	12.5	3.2	125.0
Total Carbonate (mg/L)	N/A	351	31.1	585
Potassium (mg/L)	N/A	12.5	1.5	125.0
Magnesium (mg/L)	N/A	3.2	0.8	32.0
TDS (mg/L)	N/A	1170.2	47.6	1170.2

[1] Standard for cadmium lowered in modification to UIC permit dated March 9, 2001 following NDEQ approval of MU1 restoration.
N/A = Not Applicable

Table 6.1-3: Baseline and Restoration Values for Mine Unit 2

Parameter	Groundwater Standard	MU2 Baseline	MU2 Standard Deviation	MU2 NDEE Restoration Value
Ammonium (mg/L)	10.0	0.37	0.07	10.0
Arsenic (mg/L)	0.05	<0.001	N/A	0.05
Barium (mg/L)	1.0	<0.1	N/A	1.0
Cadmium (mg/L)	0.005	<0.007	N/A	0.005
Chloride (mg/L)	250.0	208.6	30.8	250.0
Copper (mg/L)	1.0	<0.013	N/A	1.0
Fluoride (mg/L)	4.0	0.67	0.04	4.0
Iron (mg/L)	0.3	<0.045	N/A	0.3
Mercury (mg/L)	0.002	<0.001	N/A	0.002
Manganese (mg/L)	0.05	<0.01	N/A	0.05
Molybdenum (mg/L)	1.0	<0.073	N/A	1.0
Nickel (mg/L)	0.15	<0.037	N/A	0.15
Nitrate (mg/L)	10.0	<0.039	N/A	10.0
Lead (mg/L)	0.05	<0.035	N/A	0.05
Radium (pCi/L)	5.0	234.5	411.8	1058.0
Selenium (mg/L)	0.05	<0.001	N/A	0.05
Sodium (mg/L)	N/A	410.8	18.2	4108
Sulfate (mg/L)	250.0	348.2	10.3	369.0
Uranium (mg/L)	5.0	0.046	0.037	5.0
Vanadium (mg/L)	0.2	<0.07	N/A	0.2
Zinc (mg/L)	5.0	<0.026	N/A	5.0
pH (Std. Units)	6.5 - 8.5	8.32	0.2	6.5 – 8.5
Calcium (mg/L)	N/A	13.4	2.4	134.0
Total Carbonate (mg/L)	N/A	366.9	13.3	585.0
Potassium (mg/L)	N/A	12.6	2.5	126.0
Magnesium (mg/L)	N/A	3.5	0.4	35.0
TDS (mg/L)	N/A	1170.4	41	1170.4

N/A = Not Applicable

Table 6.1-4: Baseline and Restoration Values for Mine Unit 3

Parameter	Groundwater Standard	MU3 Baseline	MU3 Standard Deviation	MU3 NDEE Restoration Value
Ammonium (mg/L)	10.0	<0.329	N/A	10.0
Arsenic (mg/L)	0.05	<0.001	N/A	0.05
Barium (mg/L)	1.0	<0.1	N/A	1.0
Cadmium (mg/L)	0.005	<0.01	N/A	0.005
Chloride (mg/L)	250.0	197.6	16.7	250.0
Copper (mg/L)	1.0	<0.0108	N/A	1.0
Fluoride (mg/L)	4.0	0.719	0.05	4.0
Iron (mg/L)	0.3	<0.05	N/A	0.3
Mercury (mg/L)	0.002	<0.001	N/A	0.002
Manganese (mg/L)	0.05	<0.01	N/A	0.05
Molybdenum (mg/L)	1.0	<0.1	N/A	1.0
Nickel (mg/L)	0.15	<0.05	N/A	0.15
Nitrate (mg/L)	10.0	<0.0728	N/A	10.0
Lead (mg/L)	0.05	<0.05	N/A	0.05
Radium (pCi/L)	5.0	165	222.5	611.0
Selenium (mg/L)	0.05	<0.00115	N/A	0.05
Sodium (mg/L)	N/A	428	27.6	4280
Sulfate (mg/L)	250.0	377.0	13.4	404.0
Uranium (mg/L)	5.0	0.115	0.158	5.0
Vanadium (mg/L)	0.2	<0.1	N/A	0.2
Zinc (mg/L)	5.0	<0.0131	N/A	5.0
pH (Std. Units)	6.5 - 8.5	8.37	0.3	6.5 – 8.5
Calcium (mg/L)	N/A	13.3	3.1	133.0
Total Carbonate (mg/L)	N/A	358.7	24.8	592.0
Potassium (mg/L)	N/A	13.9	4.0	139.0
Magnesium (mg/L)	N/A	3.5	0.9	35.0
TDS (mg/L)	N/A	1183.0	47.4	1183.0

N/A = Not Applicable

Table 6.1-5: Baseline and Restoration Values for Mine Unit 4

Parameter	Groundwater Standard	MU4 Baseline	MU4 Standard Deviation	MU4 NDEE Restoration Value
Ammonium (mg/L)	10.0	0.288	0.08	10.0
Arsenic (mg/L)	0.05	<0.00209	N/A	0.05
Barium (mg/L)	1.0	<0.1	N/A	1.0
Cadmium (mg/L)	0.005	<0.01	N/A	0.005
Chloride (mg/L)	250.0	217.5	34.9	250.0
Copper (mg/L)	1.0	<0.0114	N/A	1.0
Fluoride (mg/L)	4.0	0.745	0.05	4.0
Iron (mg/L)	0.3	<0.0504	N/A	0.3
Mercury (mg/L)	0.002	<0.001	N/A	0.002
Manganese (mg/L)	0.05	<0.01	N/A	0.05
Molybdenum (mg/L)	1.0	<0.1	N/A	1.0
Nickel (mg/L)	0.15	<0.05	N/A	0.15
Nitrate (mg/L)	10.0	<0.114	N/A	10.0
Lead (mg/L)	0.05	<0.05	N/A	0.05
Radium (pCi/L)	5.0	154.3	171.5	496.0
Selenium (mg/L)	0.05	<0.00244	N/A	0.05
Sodium (mg/L)	N/A	416.6	27.8	4166
Sulfate (mg/L)	250.0	337.2	19.3	375.0
Uranium (mg/L)	5.0	<0.122	N/A	5.0
Vanadium (mg/L)	0.2	<0.0984	N/A	0.2
Zinc (mg/L)	5.0	<0.0143	N/A	5.0
pH (Std. Units)	6.5 - 8.5	8.68	0.3	6.5 – 9.28
Calcium (mg/L)	N/A	11.2	2.9	112.0
Total Carbonate (mg/L)	N/A	374.4	28	610.0
Potassium (mg/L)	N/A	16.7	4.7	167.0
Magnesium (mg/L)	N/A	2.8	0.8	28.0
TDS (mg/L)	N/A	1221.1	73.5	1221.1

N/A = Not Applicable

Table 6.1-6: Baseline and Restoration Values for Mine Unit 5

Parameter	Groundwater Standard	MU5 Baseline	MU5 Standard Deviation	MU5 NDEE Restoration Value
Ammonium (mg/L)	10.0	0.28	0.05	10.0
Arsenic (mg/L)	0.05	<0.001	N/A	0.05
Barium (mg/L)	1.0	<0.10	N/A	1.0
Cadmium (mg/L)	0.005	<0.01	N/A	0.005
Chloride (mg/L)	250.0	191.9	7.9	250.0
Copper (mg/L)	1.0	<0.01	N/A	1.0
Fluoride (mg/L)	4.0	0.64	0.07	4.0
Iron (mg/L)	0.3	<0.05	N/A	0.3
Mercury (mg/L)	0.002	<0.001	N/A	0.002
Manganese (mg/L)	0.05	<0.01	N/A	0.05
Molybdenum (mg/L)	1.0	<0.10	N/A	1.0
Nickel (mg/L)	0.15	<0.05	N/A	0.15
Nitrate (mg/L)	10.0	<0.1	N/A	10.0
Lead (mg/L)	0.05	<0.05	N/A	0.05
Radium (pCi/L)	5.0	166.0	184.6	535.0
Selenium (mg/L)	0.05	<0.002	N/A	0.05
Sodium (mg/L)	N/A	397.6	14.4	3976
Sulfate (mg/L)	250.0	364.5	10.5	385.0
Uranium (mg/L)	5.0	0.072	0.056	5.0
Vanadium (mg/L)	0.2	<0.10	N/A	0.2
Zinc (mg/L)	5.0	<0.02	N/A	5.0
pH (Std. Units)	6.5 - 8.5	8.5	0.1	6.5 – 8.5
Calcium (mg/L)	N/A	12.6	1.8	126.0
Total Carbonate (mg/L)	N/A	372	13.0	590.0
Potassium (mg/L)	N/A	11.5	1.2	115.0
Magnesium (mg/L)	N/A	3.4	0.4	34.0
TDS (mg/L)	N/A	1179.5	22.5	1202.0

N/A = Not Applicable

Table 6.1-7: Baseline and Restoration Values for Mine Unit 6

Parameter	Groundwater Standard	MU6 Baseline	MU6 Standard Deviation	MU6 NDEE Restoration Value
Ammonium (mg/L)	10.0	0.32	0.05	10.0
Arsenic (mg/L)	0.05	0.002	N/A	0.05
Barium (mg/L)	1.0	0.100	N/A	1.0
Cadmium (mg/L)	0.005	0.009	N/A	0.005
Chloride (mg/L)	250.0	206	15.4	250.0
Copper (mg/L)	1.0	0.012	N/A	1.0
Fluoride (mg/L)	4.0	0.65	0.03	4.0
Iron (mg/L)	0.3	0.050	N/A	0.3
Mercury (mg/L)	0.002	0.001	N/A	0.002
Manganese (mg/L)	0.05	0.010	N/A	0.05
Molybdenum (mg/L)	1.0	0.102	N/A	1.0
Nickel (mg/L)	0.15	0.050	N/A	0.15
Nitrate (mg/L)	10.0	0.1	N/A	10.0
Lead (mg/L)	0.05	0.050	N/A	0.05
Radium (pCi/L)	5.0	80.6	121.9	325
Selenium (mg/L)	0.05	0.001	N/A	0.05
Sodium (mg/L)	N/A	400	12.8	4000
Sulfate (mg/L)	250.0	361	14.6	390
Uranium (mg/L)	5.0	0.133	0.212	5.0
Vanadium (mg/L)	0.2	0.098	N/A	0.2
Zinc (mg/L)	5.0	0.011	N/A	5.0
pH (Std. Units)	6.5 - 8.5	8.6	0.2	6.5 – 9.0
Calcium (mg/L)	N/A	12.8	2.3	128
Total Carbonate (mg/L)	N/A	367.1	22.9	596
Potassium (mg/L)	N/A	11.9	1.7	119
Magnesium (mg/L)	N/A	3.2	0.7	32
TDS (mg/L)	N/A	1192	28.1	1220

N/A = Not Applicable

Table 6.1-8: Baseline and Restoration Values for Mine Unit 7

Parameter	Groundwater Standard	MU7 Baseline	MU7 Standard Deviation	MU7 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.42	0.08	10.0
Arsenic (mg/L)	0.05	0.001	N/A	0.05
Barium (mg/L)	1.0	0.10	N/A	1.0
Cadmium (mg/L)	0.005	0.007	N/A	0.005
Chloride (mg/L)	250.0	198	22.6	250.0
Copper (mg/L)	1.0	0.01	N/A	1.0
Fluoride (mg/L)	4.0	0.70	0.05	4.0
Iron (mg/L)	0.30	0.05	N/A	0.30
Mercury (mg/L)	0.002	0.001	N/A	0.002
Manganese (mg/L)	0.05	0.01	N/A	0.05
Molybdenum (mg/L)	1.00	0.10	N/A	1.00
Nickel (mg/L)	0.15	0.05	N/A	0.15
Nitrate (mg/L)	10.0	0.1	N/A	10.0
Lead (mg/L)	0.05	0.05	N/A	0.05
Radium (pCi/L)	5.0	142	148.0	438
Selenium (mg/L)	0.05	0.004	N/A	0.05
Sodium (mg/L)	N/A	387	21.6	3,870
Sulfate (mg/L)	250.0	346	20.1	386
Uranium (mg/L)	5.0	0.110	0.138	5.0
Vanadium (mg/L)	0.2	0.10	N/A	0.2
Zinc (mg/L)	5.0	0.01	N/A	5.0
pH (Std. Units)	6.5 - 8.5	8.6	0.3	6.5 – 9.2
Calcium (mg/L)	N/A	12.2	2.6	122
Total Carbonate (mg/L)	N/A	356	N/A	588
Potassium (mg/L)	N/A	12.9	3.0	129
Magnesium (mg/L)	N/A	3.2	0.7	32
TDS (mg/L)	N/A	1,176	40.7	1,217

N/A = Not Applicable

Table 6.1-9: Baseline and Restoration Values for Mine Unit 8

Parameter	Groundwater Standard	MU8 Baseline	MU8 Standard Deviation	MU8 NDEE Restoration Value
Ammonium (mg/L)	10.0	0.682	0.222	10.0
Arsenic (mg/L)	0.05	0.002	0.001	0.05
Barium (mg/L)	1.0	0.099	0.005	1.0
Cadmium (mg/L)	0.005	0.005	N/A	0.005
Chloride (mg/L)	250	196	53.8	250
Copper (mg/L)	1.0	0.01	N/A	1.0
Fluoride (mg/L)	4.0	0.638	0.048	4.0
Iron (mg/L)	0.30	0.135	0.086	0.30
Mercury (mg/L)	0.002	0.001	N/A	0.002
Manganese (mg/L)	0.05	0.01	N/A	0.05
Molybdenum (mg/L)	1.0	0.093	0.023	1.00
Nickel (mg/L)	0.15	0.049	0.003	0.15
Nitrate (mg/L)	10.0	0.2	N/A	10.0
Lead (mg/L)	0.05	0.049	0.003	0.05
Radium (pCi/L)	5.0	124.4	151.8	428
Selenium (mg/L)	0.05	0.004	N/A	0.05
Sodium (mg/L)	N/A	416.8	41.8	4,168
Sulfate (mg/L)	250	312	33	378
Uranium (mg/L)	5.0	0.188	0.140	5.0
Vanadium (mg/L)	0.2	0.127	0.122	0.2
Zinc (mg/L)	5.0	0.013	0.008	5.0
pH (Std. Units)	6.5 - 8.5	8.67	0.37	6.5 – 9.41
Calcium (mg/L)	N/A	12.3	3.5	123
Total Carbonate (mg/L)	N/A	377	15.6	569
Potassium (mg/L)	N/A	11.8	3.2	117.8
Magnesium (mg/L)	N/A	2.7	0.92	27.1
TDS (mg/L)	N/A	1,137	97.4	1,234

N/A = Not Applicable

Table 6.1-10: Baseline and Restoration Values for Mine Unit 9

Parameter	Groundwater Standard	MU9 Baseline	MU9 Standard Deviation	MU9 NDEE Restoration Value
Ammonium (mg/L)	10.0	0.40	0.05	10.0
Arsenic (mg/L)	0.05	0.001	0.000	0.05
Barium (mg/L)	1.0	0.1	0.0	1.0
Cadmium (mg/L)	0.005	0.005	0.000	0.005
Chloride (mg/L)	250	203	13	250
Copper (mg/L)	1.0	0.01	0.00	1.0
Fluoride (mg/L)	4.0	0.8	0.0	4.0
Iron (mg/L)	0.3	0.04	0.01	0.3
Mercury (mg/L)	0.002	0.001	0.000	0.002
Manganese (mg/L)	0.05	0.01	0.00	0.05
Molybdenum (mg/L)	1.0	0.1	0.0	1.0
Nickel (mg/L)	0.15	0.05	0.00	0.15
Nitrate (mg/L)	10.0	0.06	0.01	10.0
Lead (mg/L)	0.05	0.05	0.00	0.05
Radium (pCi/L)	5.0	164	238	640
Selenium (mg/L)	0.05	0.003	0.001	0.05
Sodium (mg/L)	N/A	380	11	3,800
Sulfate (mg/L)	250	320	15	350
Uranium (mg/L)	5.0	0.1	0.24	5.0
Vanadium (mg/L)	0.2	0.1	0.0	0.2
Zinc (mg/L)	5.0	0.01	0.00	5.0
pH (Std. Units)	6.5 - 8.5	8.35	0.30	6.5 – 9.41
Calcium (mg/L)	N/A	13.6	4.6	136
Total Carbonate (mg/L)	N/A	383	14	595
Potassium (mg/L)	N/A	13.9	3.0	139
Magnesium (mg/L)	N/A	3.5	1.2	35.0
TDS (mg/L)	N/A	1,152	38	1,190

N/A = Not Applicable

Table 6.1-11: Baseline and Restoration Values for Mine Unit 10

Parameter	Groundwater Standard	MU10 Baseline	MU10 Standard Deviation	MU10 NDEE Restoration Value
Ammonia (mg/L)	10.0	0.34	0.07	10.0
Arsenic (mg/L)	0.010	0.001	0.001	0.010
Barium (mg/L)	2.0	0.1	0.0	2.0
Cadmium (mg/L)	0.005	0.005	0.000	0.005
Calcium (mg/L)	N/A	11.8	2.6	118.0
Chloride (mg/L)	250	185	14	250
Copper (mg/L)	1.3	0.01	0.01	1.3
Fluoride (mg/L)	4.0	0.72	0.10	4.0
Iron (mg/L)	0.3	0.03	0.01	0.3
Lead (mg/L)	0.015	0.001	0.0	0.015
Magnesium (mg/L)	N/A	3.4	0.7	34.0
Manganese (mg/L)	0.05	0.01	0.0	0.05
Mercury (mg/L)	0.002	0.001	0.0	0.002
Molybdenum (mg/L)	1.0	0.1	0.0	1.0
Nickel (mg/L)	0.15	0.05	0.0	0.15
Nitrite + Nitrate as N[1] (mg/L)	10.0	0.1	0.0	10.0
pH (Std, Units)	6.5 - 8.5	8.51	0.19	6.5 - 8.89
Potassium (mg/L)	N/A	10.1	1.6	101
Radium-226 (mg/L)	5.0	87.3	161.0	409.3
Selenium (mg/L)	0.05	0.003	0.002	0.05
Sodium (mg/L)	N/A	388	12	3880
Sulfate (mg/L)	250.0	329	25	379
Total Carbonate[2] (mg/L)	N/A	394	15	550.5
TDS (mg/L)	N/A	1101	26	1127
Uranium (mg/L)	0.03	0.0378	0.0351	0.108
Vanadium (mg/L)	0.2	0.1	0.0	0.2
Zinc (mg/L)	5.0	0.01	0.01	5.0

1 Nitrate was reported by the lab as NO_3 + NO_2 instead of NO_3 as required in the permit. However, only two samples, well 4024 collected 6/09/06 and well CM8-6 collected 5/02/02, were above the detection limits. The restoration value is 10.0 mg/L while the average is 0.1 mg/L. Therefore, including NO_2 has no bearing on determining the restoration value. Nitrite, NO_2, was also analyzed for and all samples were below the detection limit of 0.10 mg/L.

2 Total carbonate = alkalinity as $CaCO_3$ x 1.2

Standard formulas were used to calculate the average and standard deviation but the true values, especially for the standard deviation, are most likely significantly smaller than shown. This results in a conservative estimate of the standard deviation.

N/A = Not Applicable

Table 6.1-12: Baseline and Restoration Values for Mine Unit 11

Parameter	Groundwater Standard	MU11 Baseline	MU11 Standard Deviation	MU11 NDEE Restoration Value
Ammonia (mg/L)	10.0	0.33	0.05	10
Arsenic (mg/L)	0.010	0.001	0	0.010
Barium (mg/L)	2.0	<0.1	0	2
Cadmium (mg/L)	0.005	<0.005	0.000	0.005
Calcium (mg/L)	N/A	14.9	4	149
Chloride (mg/L)	250	186	16	250
Copper (mg/L)	1.3	<0.01	0	1.3
Fluoride (mg/L)	4.0	0.69	0.05	4.0
Iron (mg/L)	0.3	0.04	0.01	0.3
Lead (mg/L)	0.015	0.001	0.001	0.015
Magnesium (mg/L)	N/A	3.4	0.9	34.0
Manganese (mg/L)	0.05	0.01	0.0	0.05
Mercury (mg/L)	0.002	0.001	0.0	0.002
Molybdenum (mg/L)	1.0	<0.1	0.0	1.0
Nickel (mg/L)	0.15	<0.05	0.0	0.15
Nitrite + Nitrate as N[1] (mg/L)	10.0	0.09	0.0	10.0
pH (Std, Units)	6.5 - 8.5	8.27	0.21	6.5-8.5
Potassium (mg/L)	N/A	13.1	2.9	131
Radium-226 (mg/L)	5.0	90.3	107.2	304.7
Selenium (mg/L)	0.05	0.003	0.001	0.05
Sodium (mg/L)	N/A	407.5	18	4075
Sulfate (mg/L)	250.0	320	11	342
Total Carbonate[2] (mg/L)	N/A	304	11	565
TDS (mg/L)	N/A	1130	37	1167
Uranium (mg/L)	0.03	0.035	0.037	0.109
Vanadium (mg/L)	0.2	<0.1	0.0	0.2
Zinc (mg/L)	5.0	0.02	0.01	5.0

N/A = Not Applicable

Table 6.1-13: Post Mining Water Quality for Mine Unit 1 Restoration Well Sampling

Parameter	PM-1	PM-4	PM-5	PT-5	IJ-6	IJ-13	IJ-25	IJ-28	IJ-45	PR-8	PR-15	PR-19
Ca (mg/L)	87.9	87.1	80.8	87.9	87.6	93.9	89.4	89.6	89.9	85.4	86.7	98.3
Mg (mg/L)	22.6	20.6	22.7	23.8	21.4	23.9	22.5	23.1	24.8	23.2	23.1	23.8
Na (mg/L)	1154	942	1054	1144	1054	1174	1177	1182	1126	1144	1172	1083
K (mg/L)	32.7	26.3	30	30	27.2	31.3	30	31.3	32.7	30	30	28.6
CO_3 (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0
HCO_3 (mg/L)	1099	900	972	981	1057	1086	1111	1207	1104	1170	1170	959
SO_4 (mg/L)	1109	959	1115	1240	1031	1209	1119	1112	1134	1115	1115	1283
Cl (mg/L)	598	455	586	594	544	598	594	619	607	603	603	590
NH_4 (mg/L)	0.33	0.67	0.14	0.33	0.44	0.07	< 0.05	< 0.05	0.33	0.27	0.15	0.49
NO_2 (mg/L)	< 0.01	0.02	0.09	< 0.01	0.11	< 0.01	< 0.01	< 0.01	0.04	0.05	< 0.01	0.05
NO_3 (mg/L)	1.06	< 0.1	0.97	0.99	1.29	0.74	0.86	1.3	1.25	1.46	1.6	0.46
F (mg/L)	0.37	0.26	0.54	0.45	0.45	0.37	0.38	0.45	0.43	0.43	0.4	0.35
SiO_2 (mg/L)	25.7	18.2	35.3	24.7	33.3	34.3	26.4	31.6	28.3	33.2	30	22.2
TDS (mg/L)	3694	3121	3756	3851	3515	3899	3751	3886	3873	3820	3807	3765
Conductivity (μmho/cm)	5843	4841	5590	5964	5445	6012	5807	6025	5916	5819	5940	5819
$CaCO_3$ (mg/L)	901	738	797	804	866	890	911	989	905	959	959	786
pH (Std. units)	7.65	6.87	6.85	7.28	7.16	7.35	7.65	7.81	7.37	7.46	7.78	6.92
Trace Metals												
Al (mg/L)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.29
As (mg/L)	0.018	0.007	0.018	0.017	0.031	0.028	0.02	0.028	0.023	0.028	0.024	0.011
Ba (mg/L)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
B (mg/L)	1.17	1.44	1.09	1.36	1.06	1.26	1.13	1.19	1.15	1.23	1.25	1.17
Cd (mg/L)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cr (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cu (mg/L)	< 0.01	< 0.01	0.05	< 0.01	0.02	< 0.01	< 0.01	< 1	< 0.01	< 0.01	< 0.01	< 0.01
Fe (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.38
Pb (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mn (mg/L)	0.02	0.11	0.05	0.04	0.14	0.15	0.08	0.06	0.06	0.02	< 0.01	0.16
Hg (mg/L)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Mo (mg/L)	0.6	0.2	0.42	0.53	0.47	0.5	0.56	0.54	0.53	0.59	0.53	0.37
Ni (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.12	0.12	0.12	< 0.05	< 0.05	< 0.05	< 0.05
Se (mg/L)	0.139	0.012	0.129	0.24	0.112	0.122	0.1	0.138	0.149	0.154	0.148	0.041
V (mg/L)	1	0.1	0.38	1.15	1.12	1.18	1.03	1.24	1.29	1.23	1.56	0.28
Zn (mg/L)	< 0.01	0.14	0.11	0.01	0.11	0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Radionuclides												
U (mg/L)	8.63	6.29	54.52	9.3	13.9	9.31	9.9	2.52	14.83	5.24	5.18	6.78
Ra-226 (pCi/l)	370	126	329	1139	1113	1558	1258	1147	681	417	109	1182

Table 6.1-14. Crow Butte Project Restoration Pore Volumes

Pore Volume = Area x Thickness x Pore Space x Gallons per Cubic Foot					
Mine Unit	Actual Area	Effected Thickness	Porosity Factor	Gallons per Cubic Foot	Pore Volume Gallons
MU1	403,712	19.6	0.29	7.481	17,164,000
MU2	509,600	16.3	0.29	7.481	18,018,000
MU3	586,188	12.5	0.29	7.481	15,894,000
MU4	1,033,405	12.9	0.29	7.481	28,917,000
MU5	1,383,005	14.6	0.29	7.481	43,800,000
MU6	1,507,647	15.4	0.29	7.481	50,364,000
MU7	2,222,190	12.3	0.29	7.481	59,291,000
MU8	2,522,911	16.4	0.29	7.481	89,752,000
MU9	2,132,355	16.4	0.29	7.481	75,858,000
MU10	3,319,003	18.8	0.29	7.481	135,370,224
MU11	1,834,174	21.6	0.29	7.481	85,951,198

Table 6.1-15: Typical Reverse Osmosis Membrane Rejection

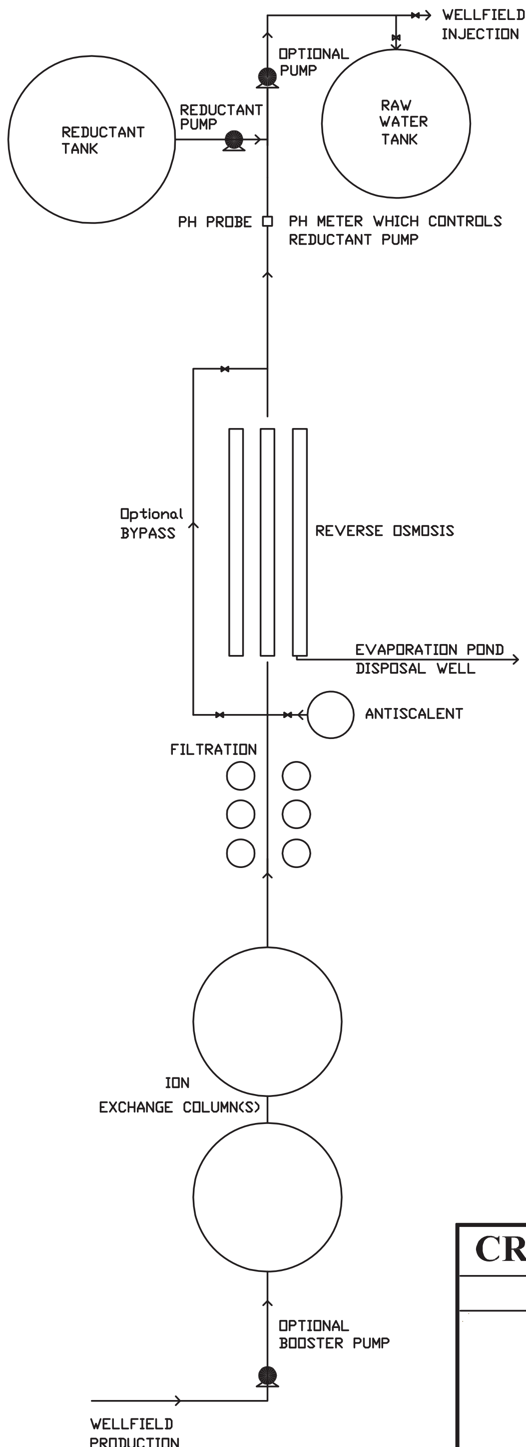
Name	Symbol	Percent Rejection
Cations		
Aluminum	Al^{+3}	99+
Ammonium	NH_4^{+1}	88-95
Cadmium	Cd^{+2}	96-98
Calcium	Ca^{+2}	96-98
Copper	Cu^{+2}	98-99
Hardness	Ca and Mg	96-98
Iron	Fe^{+2}	98-99
Magnesium	Mg^{+2}	96-98
Manganese	Mn^{+2}	98-99
Mercury	Hg^{+2}	96-98
Nickel	Ni^{+2}	98-99
Potassium	K^{+1}	94-96
Silver	Ag^{+1}	94-96
Sodium	Na^{+}	94-96
Strontium	Sr^{+2}	96-99
Zinc	Zn^{+2}	98-99
Anions		
Bicarbonate	HCO_3^{-1}	95-96
Borate	$B_4O_7^{-2}$	35-70
Bromide	Br^{-1}	94-96
Chloride	Cl^{-1}	94-95
Chromate	CrO_4^{-2}	90-98
Cyanide	CN^{-1}	90-95
Ferrocyanide	$Fe(CN)_6^{-3}$	99+
Fluoride	F^{-1}	94-96
Nitrate	NO_3^{-1}	95
Phosphate	PO_4^{-3}	99+
Silicate	SiO_2^{-1}	80-95
Sulfate	SO_4^{-2}	99+
Sulfite	SO_3^{-2}	98-99
Thiosulfate	$S_7O_3^{-2}$	99+

Source: Osmonics, Inc.

Table 6.4-1. Soil Cleanup Criteria and Goals

Layer Depth	Radium-226 (pCi/g)		Natural Uranium (pCi/g)	
	Limit	Goal	Limit	Goal
Surface (0-15 cm)	5	5	230	150
Subsurface (15 cm layers)	15	10	230	230

FIGURE 6.1-1
Restoration Process Flow Diagram



CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

Restoration Process Flow Diagram

Prepared By : JD

Drawn By: JD **Date: 3/30**

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7.0 ENVIRONMENTAL EFFECTS

The objective of the mining and environmental monitoring program is to conduct an operation that is economically viable and environmentally responsible. The environmental monitoring programs that are used to ensure that the potential sources of land, water and air pollution are controlled and monitored are presented in Section 5.7 of this LRA.

This section discusses and describes the degree of unavoidable environmental impacts, the short and long-term impacts associated with operations and the consequences of possible accidents at the Crow Butte Project and the MEA.

Environmental impacts that have occurred since the approval of the Crow Butte Project 2008 LRA are summarized for well excursions and effluent releases as measured at groundwater monitoring, stream monitoring, air monitoring, and stream and sediment sampling. In addition, potential environmental impacts at the MEA are incorporated into this chapter from Chapter 4 of the MEA Environmental Report and the 2018 MEA EA.

7.1 POTENTIAL IMPACTS DURING CONSTRUCTION

7.1.1 Land Use Impacts

The primary surface disturbances associated with solution mining are the sites containing the processing plants and associated facilities including satellite facilities and evaporation ponds. Surface disturbances also occur during the well drilling program, pipeline installation, and road construction. These more superficial disturbances, however, involve relatively small areas or have short-term impacts.

7.1.1.1 Crow Butte Project

Major facilities have already been constructed at the Crow Butte Project. The site layout for the commercial operation and ancillary facilities (Figure 3.1-4) currently includes:

- The original R&D process building housing the RO unit which is utilized for groundwater restoration activities. This area also includes two wellfields, two solar evaporation ponds and access roads.
- A nominal 120' by 300' process building (CPF) which is used for uranium extraction, precipitation, drying and packaging, offices, laboratories and change rooms.
- An office complex (75' x 75').
- Three commercial solar evaporation ponds.
- Deep well injection buildings.
- Maintenance, electrical and storage buildings located north of the main process facility.
- Drilling supply storage buildings.
- Commercial wellfields. Wellfield development includes a number of wellfield houses for each mine unit.

- Access roads.

Due to the relatively minor nature of disturbances created by ISR mining, there are only a few areas disturbed to the extent to which subsoil and geologic materials are removed, causing significant topographic changes that need backfilling and recontouring. Solar evaporation pond construction has resulted in redistribution of sufficient amounts of subsurface materials, which requires replacement and contour blending during reclamation. Overall, the existing contours have only been interrupted in small, localized areas.

Construction

In addition, all of the wellfields at the Crow Butte Project have been constructed with no additional wellfields planned. The principal land use for the Crow Butte Project is livestock grazing on rangeland, as discussed in Section 2.2. Within the Crow Butte Project, rangeland and cropland accounted for 55.7 and 29.9 percent of the land use in the license area and the review area, respectively. Because all major facilities at the Crow Butte Project have been constructed there are no longer any potential impacts to land use at the Crow Butte Project due to construction activities.

7.1.1.2 MEA

As described in Section 1.2.1, CBR submitted an application to NRC in 2012 to amend SUA-1534 to authorize construction and operation of the MEA satellite facility. The NRC amended license SUA-1534 in May 2018 (Amendment 3) to include the MEA. No construction or operation has occurred at the MEA to date. The MEA satellite facility will be located approximately 12 miles southwest of the CPF.

CBR estimates that a total of approximately 1,754 acres could be affected over the life of the MEA project. Approximately 592 acres will be required for the currently planned facilities, which consist of the satellite building and associated facilities (1.8 acres), the DDWs (0.79 acres), access roads to the satellite facility and DDW's (1.7 acres) and 11 MUs (587.6 acres). The number of acres associated with roadways located within the MUs is included in the total MU acreage estimates.

The initial site preparation and construction associated with the MEA satellite facility will include the following:

- Construction of a satellite process facility that will contain IX and associated equipment capable of processing 5,400 gpm of production flow and 1,550 gpm of restoration flow.
- Placement of a modular office building.
- Construction of chemical storage facilities, and other support facilities.
- Construction of DDWs for disposal of wastewater.
- A deep well injection building and associated facilities.
- Access roads, as required.

The principal land use for the MEA and vicinity is livestock grazing on rangeland, as discussed in Section 2.2. Within the MEA, rangeland accounts for approximately 73 percent of the license area and the review area.

Construction

At the MEA the primary surface disturbances will be associated with the construction of sites containing the processing facilities, associated facilities, and the DDWs. These surface impacts are unavoidable and last for the duration of the project until final decommissioning. Due to the lack of evaporation ponds in the MEA, no areas will be disturbed to the extent that subsoil and geologic materials will be removed, causing significant topographic changes that need backfilling and recontouring. Surface disturbance will also occur during well drilling, pipeline installation, and road construction. These more superficial disturbances involve relatively small areas or have short-term impacts.

The unavoidable impact of site preparation and construction are the exclusion of cattle and crop production from the areas that are under development. As a result of site preparation and construction, cattle production will be excluded from the areas that are under development. The total estimated area that will be impacted at the MEA is 491 acres (mixed-grass prairie and degraded rangeland) associated with the satellite facility, wellfield, DDWs and roads. The exclusion of agricultural activities from active mining areas is an unavoidable impact that will last for the duration of the project.

7.1.2 Transportation Impacts

The Crow Butte Project and MEA are located in a rural area of Nebraska with low traffic.

7.1.2.1 Crow Butte Project

There would be no additional construction activities at the Crow Butte Project so transportation would not be impacted.

7.1.2.2 MEA

As stated in Section 9.2.2.2, the MEA will require 10 to 12 full-time employees, 4 to 7 full-time contractor employees, and 10 to 15 part-time employees and short-term contractors for construction activities. Most MEA employees are expected to live in Dawes County. Those traveling from the city of Crawford would use Nebraska Highway 2/71, which intersects with Dodge Road/ Nebraska Highway 2 about 8.5 miles to the south of the MEA. Workers may also travel from the village of Hemingford, 11.9 miles east of the MEA. Chadron, the county seat and another potential source of employees, is located about 23 miles to the northeast of Crawford along U.S. Route 20, at the intersection with U.S. Route 385.

In addition, during the construction phases transportation impacts would occur from construction equipment and materials being transported to and from the MEA. The 2018 MEA EA estimated the number of shipments based on information provided in the ISR GEIS. During construction, it is estimated that there will be one shipment monthly for wellfield construction materials and one truck per working day for fuel and process chemicals. This would not likely have an impact on local or regional transportation networks.

The increase in employment and equipment transportation would have the potential to increase traffic on local roads. In addition, the increased traffic my result in degradation of public and local gravel road surfaces. These impacts are expected to be minimal because the additional traffic is not significant in comparison with current traffic levels (see Section 2.2.7).

7.1.3 Geology and Soils Impacts

7.1.3.1 Geologic Impacts

7.1.3.1.1 Crow Butte Project

No additional construction is expected to occur at the Crow Butte Project. Therefore, no geologic impacts due to construction will occur.

7.1.3.1.2 MEA

Geologic impacts at the MEA are expected to be minimal, if any. No significant matrix compression or ground subsidence is expected, as the net withdrawal of fluid from the basal sandstone of the Chadron Formation will be on the order of 1 percent or less, and the anticipated drawdown over the life of the project is expected to be on the order of 10 percent of the available head or less. Impacts to paleontological resources are expected to be minimal.

7.1.3.2 Soil Impacts

7.1.3.2.1 Crow Butte Project

Because no additional construction is expected to occur at the Crow Butte Project there were no potential impacts to soils due to construction.

7.1.3.2.2 MEA

The severity of soil impacts is dependent on the number of acres disturbed and the type of disturbance. Potential impacts include soil loss, sedimentation, compaction, salinity, loss of soil productivity, and soil contamination. Effects to soils results from the clearing of vegetation, excavating, leveling, stockpiling, compacting, and redistributing soils during construction and reclamation. Disturbance related to the construction and operation will continue until the area is revegetated.

Wind erosion is possible at the MEA. Various soils meet the criteria for high wind erosion hazard (SCS 1977). These soils include one or more major fine sand or sandy loam constituents that can easily be picked up and spread by wind. Vegetation removal presents the greatest threat to soils with potential for wind erosion. Wind erosion will be controlled by removing vegetation only where necessary, avoiding clearing and grading on erosive areas, surfacing roads with locally obtained gravel, and timely reclamation.

Water erosion is also possible at the MEA, especially in areas disturbed by road and wellfield construction. Various soils meet the criteria for severe water erosion hazard (SCS 1977). These soils have low permeability and high K-factors, making them susceptible to water erosion. The K-factor describes soil erodibility; it represents both the susceptibility of soil to erosion and the rate of runoff. It is calculated from soil texture, organic matter, and soil structure. Construction and operation increase soil loss through water erosion. Removal of vegetation for any activity exposes soils to increased erosion. Excavation could break down soil aggregates, increasing runoff and promoting gully formation. Soil loss will be reduced substantially by avoiding construction in highly erosive areas such as badlands and steep drainages. Locating roads in areas where cuts and fills would not be required, surfacing roads with gravel, installing drainage controls, and reseeding and installing water bars across reclaimed areas will also aid in reducing soil loss due to water erosion.

Sedimentation in streams and rivers at the MEA could result from soil loss. Sedimentation could alter water quality and the fluvial characteristics of area drainages. Installation of appropriate erosion control measures as required by the CBR Construction Stormwater NPDES authorization and avoidance of erosive soils have aided, and will continue to aid, in reducing sedimentation.

Activity on the site has the potential to compact soils. Soils sensitive to compaction (e.g., clay loams) do exist on the sites and compaction of the soils could decrease infiltration and promote higher runoff. If compaction occurs, reduced infiltration capacity could persist for over 50 years in some soils. Construction and traffic have been and will continue to be minimized where possible and soils will be loosened prior to reseeding during reclamation to control the effects of soil compaction.

Any soil on the site can be saline depending on site-specific soil conditions, such as permeability, clay content, quality of nearby surface waters, plant species, and drainage characteristics. Saline soils are extremely susceptible to soil loss caused by development. Soil erosion in areas with high salt content would contribute to salinity in the White River and Niobrara River basins. Reclamation of saline soils can be difficult, and no method that works in all situations has yet been found.

Satellite facility development would displace topsoil, which would adversely affect the structure and microbial activity of the soil. Loss of vegetation would expose soils and could result in a loss of organic matter in the soil. Excavation could cause mixing of soil layers and breakdown of the soil structure. Removal and stockpiling of soils for reclamation could result in mixing of soil profiles and loss of soil structure. Compaction of the soil could decrease pore space and cause a loss of soil structure as well. This would result in a reduction of natural soil productivity.

A number of erosion and productivity problems resulting from Crow Butte Project and the MEA may cause a long-term declining trend in soil resources. Long-term impacts to soil productivity and stability would occur as a result of large-scale surface grading and leveling until successful reclamation. Reduction in soil fertility levels and reduced productivity would affect diversity of reestablished vegetative communities. Moisture infiltration would be reduced, creating droughty soil conditions. Vegetation would undergo physiological drought reactions.

Surface spillage of hazardous materials could occur at the sites. If not remediated quickly, these materials have the potential to adversely impact soil resources. To minimize potential impacts from spills, a Spill Prevention, Control, and Countermeasure (SPCC) Plan has been implemented. The SPCC plan includes accidental discharge reporting procedures, spill response, and cleanup measures.

Soil Impact Mitigation Measures

BMPs have been included in the project description and will be followed to control erosion, minimize disturbance, and facilitate reclamation. The following mitigation measures will help reduce the effects to soil resources. BMPs and mitigation measures relevant to soil resources are also discussed in the water quality and reclamation sections of this document. Fundamentally, efforts will be made to preserve existing vegetation where practical.

Sediment Control

- Divert surface runoff from undisturbed areas around the disturbed area.
- Retain sediment within the disturbed area.
- Surface drainage shall not be directed over the unprotected face of the fill.
- Operations and disturbance on slopes greater than 40 percent need special sediment controls and should be designed and implemented appropriately.
- Avoid continuous disturbance that provides continuous conduit for routing sediment to streams.
- Inspect and maintain all erosion control structures.
- Repair significant erosion features, clogged culverts, and other hydrological controls in a timely manner.
- If BMPs do not result in compliance with applicable standards, modify or improve such BMPs to meet the controlling standard of surface water quality.

Topsoil

- Topsoil should be removed prior to any development activity to prevent loss or contamination.
- When necessary to substitute for or supplement available topsoil, use overburden that is equally conducive to plant growth as topsoil.
- To the extent possible, directly haul (live handle) topsoil from the site of salvage to concurrent reclamation sites.
- Avoid excessive compaction of topsoil and overburden used as plant growth medium by limiting the number of vehicle passes, handling soil while saturated, and scarifying compacted soils.
- Time topsoil redistribution so seeding or other protective measures can be readily applied to prevent compaction and erosion.

Roads

- Restrict the length and grade of roadbeds.
- Surface roads with durable material (i.e., locally obtained native gravel).
- Create cut and fill slopes that are stable.
- Revegetate the entire road prism including cut and fill slopes.
- Create and maintain vegetative buffer strips and construct sediment barriers (e.g., straw bales, wire-backed silt fences, check dams) during the useful life of roads.

Regraded Material

- Design regraded material to control erosion using activities that may include slope reduction, terracing, silt fences, chemical binders, seeding, mulching, and other activities.
- Divert all surface water above regraded material away from the area and into protected channels.
- Shape and compact regraded material to allow surface drainage and ensure long-term stability.
- Concurrently reclaim regraded material to minimize surface runoff.

Implementation of the above BMPs, SPCCs, and SWPPPs will minimize effects to soils associated with the construction of the satellite facility.

7.1.4 Water Resource Impacts

7.1.4.1 <u>Surface Water</u>

When stormwater drains off a construction site, it typically carries sediment and other pollutants that can harm lakes, streams and wetlands. EPA estimates that 20 to 150 tons of soil per acre is lost every year to stormwater runoff from construction sites. For this reason, stormwater runoff is controlled by NDEE NPDES regulations.

7.1.4.1.1 Crow Butte Project

Construction activities at the Crow Butte Project to date have had a minimal impact on the local hydrological system. CBR conducts construction activities under NDEE permitting regulations for control of construction stormwater discharges contained in Title 119. CBR is required by NDEE General Construction Stormwater NPDES Permit NER920000 to implement procedures that control runoff and the deposition of sediment in surface water features during construction activities. These procedures are contained in SHEQMS Volume VI, *Environmental Manual*, and require active engineering measures, such as berms, and administrative measures, such as work activity sequencing to control runoff and sedimentation of surface water features. CBR must annually submit a construction plan for the coming year and obtain authorization from the NDEE under the general permit.

7.1.4.1.2 MEA

Administrative and engineering controls implemented by CBR during initial site preparation and construction of the satellite facility and related facilities are expected to ensure that surface water impacts are minimal.

7.1.4.2 Groundwater

7.1.4.2.1 Crow Butte Project

The Crow Butte Project currently has 11 mine units in various phases as presented in Table 1.7-1. Mine Unit 1 has been restored, Mine Units 2 through 6 are undergoing stability monitoring, Mine Units 7 and 8 are in restoration, and Mine Units 9 through 11 are in standby. CBR has no further wellfields planned for development so construction would be limited to installing additional wells for improving restoration or capturing excursions. No additional construction activities are anticipated at the Crow Butte Project. Based on this, impacts on groundwater from construction at the Crow Butte Project would be negligible.

7.1.4.2.2 MEA

Construction activities that would have the potential to impact groundwater at the MEA include consumptive use of groundwater during mine unit construction and aquifer testing. In addition, groundwater may be used for dust control, drilling support, and cement mixing). All of these construction activities would have a minimal impact on groundwater at the MEA.

7.1.5 Ecological Resources Impacts

7.1.5.1 Vegetation

7.1.5.1.1 Crow Butte Project

At the Crow Butte Project, an estimated 1,265 acres of cultivated agricultural fields have been affected by surface-disturbing production facilities. No additional construction is anticipated at the Crow Butte Project and therefore there are no potential impacts to vegetation from construction.

7.1.5.1.2 MEA

The MEA will disturb up to 1,753 acres, with the majority of the disturbance occurring on areas dominated by mixed-grass prairie and degraded rangeland. Direct impacts associated with project development include the short-term loss of vegetation (modification of structure, species composition, and areal extent of cover types) from soil disturbance and grading. Potential indirect impacts include the short-term and long-term increased potential for non-native species invasion, establishment, and expansion; exposure of soils to accelerated erosion; shifts in species composition or changes in vegetative density; reduction of wildlife habitat; and changes in visual aesthetics. Vegetation removal and soil handling associated with the construction and installation of wellfields, pipelines, access roads, and satellite facilities would affect vegetation resources both directly and indirectly. However, because most project-related infrastructure will be constructed within cultivated agricultural fields, vegetation impacts will be negligible. If the mixed-grass prairie vegetation community were to be developed, direct impacts would include the short-term loss of vegetation (modification of structure, species composition, and areal extent of cover types). Indirect impacts would include the short-term and long-term increased potential for non-native species invasion, establishment, and expansion; exposure of soils to accelerated erosion; shifts in species composition or changes in vegetative density; reduction of wildlife habitat; reduction in livestock forage; and changes in visual aesthetics.

Construction activities, increased soil disturbance, and higher traffic volumes could stimulate the introduction and spread of undesirable and invasive, non-native species within the project area. Non-native species invasion and establishment has become an increasingly important result of previous and current disturbance in western states. These species often out-compete desirable species, including special-status species, rendering an area less productive as a source of forage for livestock and wildlife. Additionally, sites dominated by invasive, non-native species often have a different visual character that may negatively contrast with surrounding undisturbed vegetation. Currently, the MEA is relatively free of noxious and other unwanted invasive, non-native species.

7.1.5.2 Wetlands

7.1.5.2.1 Crow Butte Project

As described in Section 2.7, no wetlands have been identified within the Crow Butte Project area.

7.1.5.2.2 MEA

As described in Section 2.7, one wetland was identified within the MEA area but is located outside the disturbance boundary. Based on this, no impacts to wetlands are anticipated. If wells cannot be placed outside of areas within the wellfield deemed to carry moderate to high erosion risks, mitigation measures (e.g., berms) will be implemented to minimize the potential for flooding and erosion. The mitigation measures will be defined during final engineering and prior to any construction.

7.1.5.3 Terrestrial Ecology

7.1.5.3.1 Crow Butte Project

No impacts to terrestrial ecology at the Crow Butte Project due to construction are anticipated because no further construction is expected.

7.1.5.3.2 MEA

The effects on wildlife associated with construction include displacement of some individuals of some wildlife species, loss of wildlife habitats, and an increase in the potential for collisions between wildlife and motor vehicles. Other potential effects include a rise in the potential for illegal kill, harassment, and disturbance of wildlife because of increased human presence primarily associated with increased vehicle traffic. The magnitude of impacts to wildlife resources would depend on a number of factors, including the time of year, type and duration of disturbance, and species of wildlife present.

7.1.5.3.2.1 Small Mammals and Birds

The direct disturbance of wildlife habitat in the MEA likely would reduce the availability and effectiveness of habitat for a variety of common small mammals, birds, and their predators. The initial phases of surface disturbance and increased noise would result in some direct mortality to small mammals and would displace some bird species from disturbed areas. In addition, a slight increase in mortality from increased vehicle use of roads in the project area would be expected.

The temporary disturbances that occurs during the construction period would tend to favor generalist wildlife species such as ground squirrels and horned larks and would have more impact on specialist species such as western meadowlarks, lark buntings, and grasshopper sparrows. Overall, the long-term disturbance within both project areas would have a low effect on common wildlife species. Songbirds that may be affected by the reduction in cultivated fields would be horned larks, sage sparrows, sage thrashers, and vesper sparrows. Although there is no way to accurately quantify these changes, the impact is likely to be low in the short term and be reduced over time as reclaimed areas begin to provide suitable habitats.

Because of the high reproductive potential of these species, they would rapidly repopulate reclaimed areas as habitats become suitable. Birds are highly mobile and would disperse into surrounding areas and utilize suitable habitats to the extent that they are available. The primary small mammals found on the project area include, but are not limited to, eastern cottontail, deer mice, thirteen-lined ground squirrel, white-footed mouse, meadow jumping mouse, and northern pocket mouse. The initial phases of surface disturbance would result in some direct mortality and displacement of small mammals from construction sites. Quantifying these changes is not possible because population data are lacking. However, the impact is likely to be low, and the high reproductive potential of these small mammals would enable populations to quickly repopulate the area once reclamation efforts are initiated.

7.1.5.3.2.2 Big Game Mammals

The principal wildlife impacts likely to be associated within the MEA include: (1) a direct loss of certain wildlife habitat; (2) the displacement of some wildlife species; (3) an increase in the potential for collisions between wildlife and motor vehicles; and, (4) an increase in the potential for the illegal kill and harassment of wildlife.

In general, direct removal of habitat used by big game mammals is expected to be minimal, as the project areas are predominantly used for agricultural production. The capacity of the MEA to support big game populations should remain essentially unchanged from current conditions.

In addition to the direct removal of habitat because of the development of wells and associated satellite facilities, disturbances from drilling activities and traffic would affect utilization of the habitat immediately adjacent to these areas; however, big game mammals are adaptable and may adjust to non-threatening, predictable human activity. It is envisioned that most big game mammal responses will consist of avoidance of areas proximal to the operational facilities, with most individuals carrying out normal activities of feeding and bedding within adjacent suitable habitats. In addition, the magnitude of displacement would decrease over time as: (1) the animals have more time to adjust to the operational circumstances; and, (2) the extent of the most intense activities such as drilling and road building diminishes and the wellfields are put into production. By the time the wellfields are under full production, construction will have ceased, and traffic and human activities in general would be greatly reduced. As a result, this impact would be minimal and it is unlikely that big game mammals would be significantly displaced under full field development. The level of big game mammal use of the project area is more likely to be determined by the quantity and quality of forage available.

The potential for vehicle collisions with big game mammals would increase as a result of increased vehicular traffic associated with the presence of construction crews and would continue (although at a reduced rate) throughout all phases of the wellfield operations. Development of new roads would allow greater access to more areas and may lead to an increased potential for poaching of big game animals; however, because of the proximity to Crawford and locations of farm residences in the project area, the incidence of vehicle collision impacts to big game mammals is anticipated to occur infrequently and no long-term adverse effects are expected.

Based on the foregoing, long-term adverse effects are not expected for any local big game mammal populations.

7.1.5.3.2.3 Passerine and Upland Game Birds

Impacts to passerines would include short- and long-term habitat loss, primarily for birds using mixed-grass prairie habitat, and an effective loss of habitat extending beyond the disturbed areas if birds avoid the project facilities due to noise or activity. Generalist species that are more tolerant of human activity (e.g., mourning doves) are likely to be least affected by the projects, while specialist species that are more sensitive (e.g., grasshopper sparrows) may be affected more.

The potential effects of the construction of project facilities on upland game birds may include nest abandonment and reproductive failure caused by project-related disturbance and increased noise. Reduction of noise levels in areas near leks would minimize this potential impact. If leks are found, surface disturbance will be avoided within 0.25 mile (0.4 km) of leks. If disturbance activities within the 0.25-mile (0.4 km) lek buffer areas are avoided, no impacts are expected. To protect sharp-tailed grouse nesting habitats, construction activities will be limited within a one-mile (1.6-km) radius of an active lek between March 1 and June 30. Significant impacts to leks and subsequent reproductive success are not expected if these guidelines are implemented. Other potential effects involve increased public access and subsequent human disturbance that could result from new construction activities.

7.1.5.3.2.5 Raptors

Potential impacts to raptors within the MEA include: (1) nest desertions or reproductive failure as a result of project activities and increased public access; (2) temporary reductions in prey populations; and, (3) mortality associated with roads.

The primary potential impact to raptors from project activities is disturbance during nesting that might result in reproductive failure. To minimize this potential, construction would not be allowed during the critical nesting season (February 1 - July 31, depending on species) within 0.5 mile of an active nest of listed or sensitive raptor species, and 0.25 mile (depending on species or line of sight) of an active nest of other raptor species. The nature of the restrictions, exclusion dates, and the protection radii would vary, depending on activity status of nests, species involved, and natural topographic barriers, and line-of-sight distances should be developed in coordination within the NGPC or the USFWS.

Nests not used in 1 year, may potentially be used in subsequent years. Subsequent development within close proximity to these nests may preclude use of the nest in following years. Therefore, protection of nests that may potentially be used in the future may require limiting construction within 300 meters (depending on species or line of sight) to minimize impacts. If “take” of an inactive nest were unavoidable, development of artificial nesting structures would mitigate for the loss of the nest. In some instances, during the production phase when human activity is reduced, raptors may actually nest on artificial above-ground structures. Based on the foregoing, significant impacts to raptor nesting activities are not expected.

The development of wellfields and satellite facilities would disturb potential habitat for several species of small mammals that serve as prey for raptors. The small amount of short-term change in prey base populations created by construction is minimal in comparison to the overall status of the rodent and lagomorph populations. While prey populations on the project area would likely sustain some impact during the initial phase of the project, prey numbers would be expected to soon rebound to pre-disturbance levels following reclamation or active agricultural uses. Once reclaimed or in active agricultural uses, these areas would likely promote an increased density and biomass of small mammals that is comparable to those of undisturbed areas. For these reasons, implementation of the project is not expected to produce any appreciable long-term negative changes to the raptor prey base within the project areas.

The creation of new roads would increase public access to areas within the project area. As use of the project area increases, the potential for encounters between raptors and humans would increase and could result in increased disturbance to nests and foraging areas. Closure of roads located near active raptor nests to public vehicle use would offset this potential impact. Some raptor species feed on road-killed carrion on and along the roads, while others (owls) may attempt to capture small rodents and insects that are illuminated in headlights. These raptor behaviors put them in the path of oncoming vehicles where they are in danger of being struck and killed. The potential for such collisions can be reduced by requiring drivers to follow all posted speed limits.

7.1.5.3.2.7 Fish and Macroinvertebrates

At the MEA, suitable habitat for fish and macroinvertebrates exists within the Niobrara River and its tributaries. Fish and macroinvertebrates could be affected by reductions in water quality as a result of upstream activities. Construction activities could result in runoff carrying sediment into surface waters downstream of the projects. The potential for this to occur is low, given the low erosion potential of most the project areas and the mitigation measures that would be implemented for the limited areas of moderate to high erosion potential.

7.1.5.3.2.8 Threatened, Endangered, and Candidate Species

The USFWS and NGPC have identified the following threatened, endangered and candidate species with the potential to occur in Dawes County: northern long-eared bat (state/federal endangered), piping plover (federal threatened), monarch butterfly (federal candidate), western regal fritillary (federal proposed threatened), Suckley's cuckoo bumble bee (federal proposed endangered), swift fox (state endangered), blacknose shiner (state endangered), and northern redbelly and finescale dace (state threatened). The species with a reasonable possibility of occurring on or near the project sites are the swift fox and piping plover.

Northern Long-eared Bat

Northern long-eared bats are unlikely to occur in the project areas; therefore, impacts on this species would be unlikely. However, LC 9.13(A) of SUA-1534 requires that during the mating season for the northern long-eared bat (June 1 to July 31 annually), CBR must avoid tree clearing activities at the MEA.

Piping Plover

There is a limited availability of suitable piping plover breeding grounds within the project areas. In Nebraska, piping plovers breed along the Missouri, Platte, Elkhorn, Loup, and Niobrara rivers. Piping plovers only spend three to four months of the year on the breeding grounds. Therefore, any presence of piping plovers within the project area or surrounding area would be expected to be infrequent and transient. Based on our analysis of the effects of project implementation and the current and potential status of this species in northwestern Nebraska, the project will have no adverse effect on the piping plover.

Monarch Butterfly and Wester Regal Fritillary

Plant species specific to each butterfly are present in the project areas and therefore there is potential for the monarch butterfly and western regal fritillary. However, because there is suitable habitat adjacent to the project areas there will be no adverse effect on the monarch butterfly and western regal fritillary.

Suckley's Cuckoo Bumble Bee

The USFWS is in the process of developing consultation guidance, including a range map for the Suckley's cuckoo bumble bee. At this time, it is unlikely that there would be any adverse effect to the Suckley's cuckoo bumble bee.

<u>Swift Fox</u>

Because swift fox is known to occur within the region, and suitable mixed-grass prairie habitat occurs throughout the project areas, potential impacts to this species may result from project implementation. Construction activities within these mixed-grass prairie habitats could affect potential swift fox denning and foraging habitats. Destruction of swift fox dens could result in direct mortality of adults or pups. If swift fox is denning in the immediate vicinity of a planned project facility, construction activities may displace adults away from the den, at least during daytime periods of construction. Displacement could prevent the adults from securing adequate food for pups or prevent adults for adequately caring for their young. In addition, vehicular traffic associated with the construction and operation of project facilities could result in vehicle collisions resulting in direct mortality.

Because the potential for the mortality and/or displacement of swift fox exists, mitigation measures will be implemented to avoid and/or reduce such incidents. Prior to beginning construction activities in suitable swift fox habitat, CBR will have qualified biologists perform surveys for swift fox dens, and avoidance measures will be implemented to protect any dens that are located. Surveys will be conducted that are consistent with the NGPC standard protocol included in the CBR Mineral Exploration Permit Number NE0210824 as Attachment 1, issued by the NDEE on August 19, 2009, and modified to include the MEA.

Based upon the analysis of the effects of project implementation and the current and potential status of this species, it is concluded that the project and planned mitigation measures will result in no adverse population-level effects on the swift fox.

Fish

Three state-listed fish species (the blacknose shiner, northern redbelly dace, and finescale dace) may occur downstream of the project area and therefore may be affected. No direct effects to these species are anticipated because they do not occur within the project areas. However, indirect effects may include changes in water quality, particularly in the Niobrara River, associated with upstream activities. The potential for sediment delivery to the Niobrara River is low given the low erosion potential and the mitigation measures that would be implemented for the limited areas of moderate to high erosion potential.

7.1.6 Air Quality Impacts

7.1.6.1 Crow Butte Project

No additional air quality impacts during construction are expected as the Crow Butte Project because no additional construction is anticipated.

7.1.6.2 MEA

The relatively dry air in the region of the MEA, combined with seasonal high temperatures and wind extremes, create the potential for airborne dust from wellfield construction activities and traffic on unpaved roads. Under these conditions, it is expected that short-term air quality will be impacted in the immediate vicinity of the projects. However, based on historical experience, overall construction activities at the satellite facility are expected to cause minimal effects on local air quality.

Effects to air quality would be increased by suspended particulates from vehicular traffic on unpaved roads (in addition to existing fugitive dust caused by wind erosion) and diesel emissions from construction equipment. Application of water to unpaved roads would reduce the amount of fugitive dust to levels equal to or less than the existing condition. Diesel emissions from construction equipment are expected to be short-term only, ceasing once the operational phase begins. NRC estimated fugitive dust emissions during construction of uranium ISR operations are less than 2 percent of the NAAQS for $PM_{2.5}$ and less than 1 percent for PM_{10} (NRC 2009).

There will be an increase in the total suspended particulates (TSP) in the region as a result of construction of the satellite facility. This increase will be greatest during the site preparation phase of the satellite facility. Revegetation will be performed where possible to mitigate the problems associated with the resuspension of dust and dirt from disturbed areas. All areas disturbed during construction are revegetated with the exception of facility pad areas, roads, and parking/storage areas. Of these, the only significant source of TSP is dust emissions from unpaved roads.

7.1.7 Noise Impacts

7.1.7.1 Crow Butte Project

No additional noise impacts due to construction are anticipated because no additional construction activities are anticipated at the Crow Butte Project.

7.1.7.2 MEA

The MEA is surrounded by agricultural lands and rural residences. The existing ambient noise in the vicinity of the project area is dominated by intermittent noise from the BNSF rail line, intermittent, low levels of traffic noise, and agricultural equipment.

Increased vehicle travel and the operation of construction equipment during the construction phase would result in a slight increase in noise impacts to residents who live nearby. Potential noise impacts from construction equipment are expected to occur primarily from operation of drilling rigs during wellfield development. Although noise levels associated with a typical water well drilling rig may reach or exceed 100 A-weighted decibels (dBA) within 2 meters (6.6 feet) of the rig compressor, noise levels decrease to less than 90 dBA within 6 meters (20 feet) (NRC 2009) and 55 dBA at 1,067 meters (3,500 feet) from the source (BLM 2005). Impacts to residences and other sensitive receptors 300 meters (984 feet) or more from the facility would be small (NRC 2009). At the MEA, one occupied residence is located approximately 200 meters (656 feet) from the proposed wellfield in MU 4. Construction noise impacts at this residence would likely be moderate. All other residences near the MEA boundary are more than 300 meters from the proposed wellfield.

Construction activities would typically occur over an 8-hour workday, 5 days per week. Noise from construction would not be generated during nighttime hours. Increased noise levels would be intermittent and temporary. The resulting increase in vehicle noise from construction and construction traffic (including movement of heavy equipment, which would be much less dense and slower than typical highway traffic) would be barely perceptible over the existing ambient noise that is intermittently dominated by the BNSF railroad. Noise from construction and construction traffic would be temporary and would briefly add to existing noise levels.

7.1.8 Historic and Cultural Resources Impacts

7.1.8.1 Crow Butte Project

As discussed in Section 2.4, archaeological surveys were completed within the Crow Butte Project and the MEA. At the Crow Butte Project, field investigation in 1982 and 1987 identified 21 archeological resource locations. Six of these sites are considered to be potentially eligible for the NRHP and have been avoided and not directly impacted as a result of construction activities. Any further construction activities will avoid these identified resources and coordination will be maintained with the Nebraska State Historical Society.

Following the publication of the 2014 EA, the Board found that NRC staff did not meet its identification obligations under the NHPA. During the first half of 2021, the NRC staff held several meetings with representatives of the Oglala Sioux Tribe. These meetings culminated in the development of a methodology for conducting a tribal cultural survey to identify sites of historic, cultural, and religious significance to the Tribe within the Crow Butte license area that could be affected by the continued operation of the Crow Butte Project under the renewed license. The tribal cultural survey was conducted in November-December 2021. In 2022, NRC published a supplement to the EA for the license renewal of NRC License SUA-1534. The final FONSI and notice of issuance were published in the Federal Register on October 25, 2022 (87 FR 64524). In addition, the NRC sent a letter to officially inform the parties that the commission declined to review the decision of the ASLB in its January 5, 2023, Memorandum and Order, Granting Motion to Terminate Proceeding (LBP-23-01) and indicating final agency action.

7.1.8.2 MEA

At the MEA, field investigations in 2010 and 2011 identified 17 historic sites and six isolated finds. None of the historic sites were evaluated as either eligible or potentially eligible for the NHRP, although one historic farmstead was recommended for further archival work if the site would be disturbed by mining activities. The site was occupied and would be avoided by CBR.

In accordance with LC 9.8 of SUA-1534, CBR will complete cultural resource inventories prior to development of any areas not previously surveyed. In addition, CBR will stop work should any previously unknown cultural artifacts be discovered. The artifacts will be inventoried and evaluated in accordance with 36 CFR Part 800, and no disturbance of the area will occur until CBR has received authorization from the NRC to proceed.

7.1.9 Socioeconomic Impacts

The social and economic impacts to the City of Crawford and surrounding areas during the construction of the Crow Butte Project were slight given the relatively small scale of activities.

Given the similar size of the MEA facilities and scope of the project, the impact of MEA-related construction activities will be similarly slight. CBR estimates that four to seven temporary construction workers will be involved in constructing the MEA facility. The social and economic impacts of construction are discussed in more detail in Section 7.6.

7.1.10 Waste Management

7.1.10.1 Crow Butte Project

Liquid and solid wastes are discussed in detail in Chapter 4. There are no additional construction wastes anticipated at the Crow Butte Project.

7.1.10.2 MEA

At the MEA the only construction liquid wastes would be associated with well drilling and development. Well drilling fluid will be discharged to the drilling pit where it will evaporate. Well development water at the MEA will be captured and discharged into a cone bottom tank at the satellite plant for discharge into an onsite DDW or transported to the existing evaporation ponds at the CPF as described in Section 4.2.1.1. Solid wastes generated at the MEA during construction will be limited to hazardous waste (e.g., used oil, cement and commercial drilling mud products for well completions, and antifreeze) and construction debris. CBR has management procedures in place in the SHEQMS Volume VI, Environmental Manual, to control and manage hazardous wastes. Non-contaminated solid waste will be collected on the site in designated areas and disposed of in the nearest permitted sanitary landfill. Potential impacts from liquid and solid wastes as well as hazardous wastes during construction at the MEA would be minimal based on the small quantifies that will be generated and the regulatory requirement.

7.2 POTENTIAL IMPACTS DURING OPERATION, AQUIFER RESTORATION, AND DECOMMISSIONING

7.2.1 Land Use Impacts

Considering the relatively small size of the area impacted by operations, the exclusion of agricultural activities from this area over the course of the project operation will not significantly impact local or regional agricultural production. The limited impacts are considered temporary and reversible by returning the land to its former grazing use through post-mining surface reclamation. Mitigation measures for the land use impacts are discussed in Section 6.2.

7.2.1.1 Crow Butte Project

The current operations in the Crow Butte Project have shown that CBR can successfully restore the land surface following mining operations. Surface reclamation activities, including contouring and revegetation, have been performed routinely following initial MU construction. Additionally, CBR completed surface and subsurface reclamation of a significant portion of MU1 following approval of groundwater restoration. These areas have been successfully recontoured, and revegetation has been completed in accordance with NDEE requirements. Chapter 6 describes the methods that will be used for surface reclamation and decommissioning. By adhering to these methods, CBR will ensure that the land is returned to its premining use.

7.2.1.2 MEA

CBR anticipates that land use impacts during operation, aquifer restoration, and decommissioning at the MEA will be similar to those at the Crow Butte Project. As previously discussed, CBR has demonstrated that disturbed areas can be successfully returned to premining conditions.

7.2.2 Transportation

The following discusses the potential impacts to transportation from operations, aquifer restoration, and decommissioning. Transportation accidents are discussed in Section 7.5.5.

7.2.2.1 Crow Butte Project

Transportation impacts from operations, aquifer restoration, and decommissioning would be minimal because currently used major access roads are designed to allow for the safe access from current roads used by employees, contractors and delivery vehicles.

7.2.2.2 MEA

The 2018 MEA EA estimated the number of shipments based on information provided in the ISR GEIS. During operations, it is estimated that there will be one truck per working day for fuel and process chemicals and one shipment of resin will be transported to and from the Crow Butte Project daily. These shipments would not likely have an impact on local or regional transportation networks.

7.2.3 Geology and Soil Impacts

7.2.3.1 Crow Butte Project

No additional geologic impacts are expected to occur at the Crow Butte Project. Section 6.4 describes methods for conducting post-reclamation and decommissioning radiological surveys including surface soil cleanup. Based on the procedures in place, impacts to soils at the Crow Butte Project will be minimal during operation, aquifer restoration, and decommissioning.

7.2.3.2 MEA

Geologic impacts are expected to be minimal, if any. No significant matrix compression or ground subsidence is expected, as the net withdrawal of fluid from the basal sandstone of the Chadron Formation will be on the order of 1 percent or less, and the anticipated drawdown over the life of the projects is expected to be on the order of 10 percent of the available head, or less. Further, once mining and restoration operations are completed and restoration approved, groundwater levels will return to near original conditions under a natural gradient.

No faults are present within the project areas that would be subject to potential reactivation due to fluid injection.

Soils in the MEA are typically shallow to deep silt loams and loamy very fine sands. Consequently, wind and water erosion pose the most significant risks to soil health and productivity, especially where vegetation has been disturbed.

Operational impacts to soils are expected to be minor, and would only occur if BMPs and mitigation measures are not properly constructed, maintained, and monitored. Surface spills could occur at the MEA. If not remediated quickly, these materials have the potential to adversely impact soil resources. In order to minimize potential impacts from spills, a Spill Prevention, Control, and Countermeasure (SPCC) Plan will be implemented. The SPCC plan will include accidental discharge reporting procedures, spill response, and cleanup measures. In addition, Section 5.7.1.5 describes the spill contingency plans that will be implemented at the MEA.

Section 6.4 describes methods for conducting post-reclamation and decommissioning radiological surveys including surface soil cleanup. Based on the procedures in place, impacts to soils at the MEA will be minimal during operation, aquifer restoration, and decommissioning.

7.2.4 Water Resource Impacts

7.2.4.1 Surface Water Impacts

7.2.4.1.1 Crow Butte Project

The results of surface water sampling fall within the expected ranges, as shown in Tables 5.7-23 and 5.7-24. Uranium concentrations at the upstream and downstream locations on Squaw Creek show no noticeable differences. On English Creek, the upstream site has continually measured higher concentrations of uranium compared to the downstream site. CBR noted elevated concentrations in the English Creek drainage during preoperational monitoring, which indicates that these levels are anomalous natural background concentrations. Uranium concentrations in the impoundments have been the lowest in impoundment I-5, while impoundments I-3 and I-4 have measured uranium concentrations less than 0.2 mg/L. Radium-226 in Squaw Creek was less than 1 pCi/L at all sites, with the exception of the second quarter 2019 in which elevated radium-226 was measured at all sites. Both sites on English Creek and the impoundments measured radium-226 concentrations well below 2 pCi/L. Based on this, there are no expected impacts to surface water as a result of operation or aquifer restoration. Potential impacts to surface water during decommissioning would be similar to construction and would be minimal. As described in Section 7.1.4.1.1, CBR uses engineering measures to control runoff and the deposition of sediment in surface water features.

Surface water quality could potentially be impacted by accidents such as an evaporation pond leakage or failure or an uncontrolled release of process liquids due to a wellfield accident. Section 7.5.3 discusses the operation of the ponds and measures to prevent leaks. An additional measure to protect surface water is that wellfield areas are installed with dikes or berms to prevent spilled process solutions from entering surface water features. Process buildings are constructed with secondary containment, and a regular program of inspections and preventive maintenance is in place. In addition to the administrative and engineering controls routinely implemented by CBR, it is expected that surface water impacts from potential accidents at the Crow Butte Project and the MEA will be minimal since there are no nearby surface water features.

7.2.4.1.2 MEA

Protection of surface water from stormwater runoff during operations, aquifer restoration and decommissioning will be regulated by the NDEE.

Surface water quality could potentially be impacted by accidents such as failure or an uncontrolled release of process liquids due to a wellfield accident. These impacts will be minimal because of the measures CBR implements to prevent and control wellfield spills. Wellfield areas are installed with dikes or berms as an additional measure to protect surface water. The berms prevent surface spills from entering all surface water bodies and drainages that connect to surface water bodies and eliminate public dose and contaminant pathways to surface water.

The satellite building will have secondary containment (curbing around the structure) to contain any accidental spills or releases of contaminated fluids. This will eliminate the potential for such discharges to the adjoining groundwater surface and potential contamination of the surrounding soils and the Brule Formation. In addition, there is a regular program of inspections and preventive maintenance. Furthermore, it is expected that surface water impacts from potential accidents at the satellite facility and related facilities will be minimal.

7.2.4.2 <u>Groundwater Impacts</u>

7.2.4.2.1 Crow Butte Project

7.2.4.2.1.1 Groundwater Consumption

In accordance with LC 10.1.6 of SUA-1534, CBR is required to maintain an overall inward hydraulic gradient within the perimeter monitor well ring starting when lixiviant is first injected into the production zone and continuing until the initiation of the stabilization period. The inward hydraulic gradient is maintained by pulling a bleed. At the Crow Butte Project, the maximum injection rate is 9,000 gpm and the bleed is typically 0.5 to 1.0 percent. The bleed is the only consumptive use of groundwater at the Crow Butte Project during operation. During restoration there is consumptive use depending on the restoration method. Groundwater sweep results in the greatest consumptive use. As indicated in Table 1.7-1, Mine Unit 1 has been restored, Mine Units 2 through 6 are in stability monitoring, Mine Units 7 and 8 are currently undergoing restoration and Mine Units 9 through 11 on standby.

Section 2.7.2.1 provides potentiometric surfaces for the Brule sand and the Basal Chadron Sandstone. Most recent water levels were obtained by CBR in August 2024. A comparison of Figure 2.7-4d and Figure 2.7-4e shows that the water levels in the Brule Formation have not changed between 2009 and 2024. In the Basal Chadron Sandstone the water levels have decreased by 36 to 50 feet over the project area between 2009 and 2024 (see Figures 2.7-5d and 2.7-5e). Since distance decreases the drawdown effects of pumping, it is reasonable to assume that the drawdown in the potentiometric surface has decreased no more than 26 to 40 feet in the vicinity of Crawford. Although the piezometric surface was lowered in the Basal Chadron aquifer over the previous license period, the aquifer remained under a significant amount of pressure. Water levels in wells penetrating the Basal Chadron aquifer continue to rise very close to the land surface or actually flow under artesian pressure. The significance of this phenomenon is that it indicates that the Basal Chadron and Brule aquifers are not in good hydraulic communication. Therefore, drawdowns associated with pumping in the Basal Chadron aquifer will not be observed in the Brule aquifer.

The amount of consumptive water use during operations is expected to remain the same in the renewal period, so the drawdown will be similar. Because use of water from the Basal Chadron aquifer is limited in this area due to poor water quality, and because the aquifers will remain confined (i.e., saturated thickness will not decrease), the drawdowns associated with the pumping during ISR operations will not significantly impact the ground water quantity in the Brule or Basal Chadron aquifers.

7.2.4.2.1.2 Impacts on Groundwater Quality

Solution mining of a mineral deposit is accomplished by reversing the natural processes that deposited the uranium. The native formation waters in the ore zones in the Basal Chadron aquifer are not recommended for human consumption because of naturally high levels of dissolved radioactive materials (uranium and Ra-226). In addition to uranium, other metals are mobilized by the mining process. This process affects the mining zone, which is exempted from Clean Water Act protections by the NDEE and the EPA under the aquifer exemption provisions of the State and Federal UIC regulations.

Excursions represent a potential effect on the adjacent groundwater as a result of operations. 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, poor well integrity, and hydrofracturing of the ore zone or surrounding units.

Table 5.7-20 provides a summary of excursions reported for the Crow Butte Project. To date, there have been several confirmed horizontal excursions in the Chadron sandstone at the Crow Butte Project. These excursions were quickly detected and recovered through overproduction in the immediate vicinity of the excursion. In all but one case, 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 since the monitor wells are located well within the aquifer exemption area approved by the EPA and the NDEE.

As discussed in Section 5.7.8 of this LRA, an extensive water-sampling program has been and will continue to be conducted prior to, during and following mining operations at the Crow Butte facility to identify any potential impacts to water resources of the area. Private well monitoring for uranium and radium-226 have resulted in concentrations below the EPA MCLs with a few exceptions. Since the last LRA, there have been eight exceedances of the EPA MCL for uranium and four exceedances of the EPA MCL for radium-226. No trends of the exceedances were apparent, since no one well had exceedances more than twice, and exceedances were not on consecutive quarters or even within the same year.

7.2.4.2.1.3 Potential Groundwater Impacts from Accidents

Groundwater quality could potentially be impacted during operations due to an accident such as evaporation pond leakage or failure, or an uncontrolled release of process liquids due to a wellfield accident. If there should be an uncontrolled pond leak or wellfield accident, potential contamination of the shallow aquifer (Brule), as well as surrounding soil, could occur. This could occur as a result of a slow leak or a catastrophic failure, a shallow excursion, an overflow due to excess production or restoration flow, or due to the addition of excessive rainwater or runoff.

To mitigate the likelihood of pond failure, all ponds at the Crow Butte Project have been designed and built to NRC standards using impermeable synthetic liners. A leak detection system was also installed, and all ponds are inspected on a regular basis. In the event that a problem is detected, the contents of any given pond can be transferred to another pond while repairs are made. The pond design and operation are discussed in greater detail in Section 4.2.

Over the course of the current licensed operation, CBR has experienced several leaks associated with the primary pond liner on the commercial evaporation ponds. In addition, a leak occurred in the primary liner of the east cell of the R&D pond in March 2023. These small leaks are virtually unavoidable since the liners are exposed to the elements. In each case these leaks were quickly discovered during routine inspections, primarily due to a response in the underdrain system. Corrective actions included lowering the pond level and locating the leak to allow repairs. In none of these situations was the shallow groundwater affected since the outer pond liner functioned as designed and prevented release of the pond contents. All pond leaks, causes, and corrective actions are reported to the NRC and the NDEE.

With respect to potential overflow of a pond, current SOPs require that pond levels be closely monitored as part of the daily inspection. Process flow to the ponds is minimal in comparison to the pond capacity, thus it can easily be diverted to another pond if necessary. In addition, sufficient freeboard is maintained on all ponds to allow for a significant addition of rainwater with no threat of overflow. Finally, the dikes and berms around the ponds channel runoff away from the ponds.

Another potential cause of groundwater impacts from accidents could be from releases associated with a spill of injection or production solutions from a wellfield building or associated piping. As described in Section 1.2.2.4, there was one reportable spill that occurred on September 12, 2017. The spill was from an injection well that was leaking from a split in the wellhead casing below ground. The estimated volume of the spill was 27,287 gallons.

7.2.4.2.2 MEA

7.2.4.2.2.1 Groundwater Consumption

Groundwater impacts and consumption related to the satellite facility operation will be fully assessed in an Industrial Groundwater Permit application required by NDNR (application to be submitted following NDEE approval of the MEA Class III UIC permit). Based on drawdown data from years of operation at the Crow Butte Project, and on the formation characteristics from the MEA pumping test, the drawdown effect on the Chadron aquifer as a result of operations has been and is expected to remain minimal.

Groundwater consumption from the operation is expected to be on the order of 0.5 to 2.0 percent of the total mining flow (5,400 gpm). Consumptive volume (1,550 gpm) will increase during aquifer restoration, especially during the groundwater sweep phase. However, it is expected that, in peak years, the net consumption for the entire operation will be on the order of 50 to 100 gpm.

A simple hydrologic drawdown-distance analysis, using the Theis (1935) equation for confined aquifers, was conducted to estimate the drawdown at the MEA. The analysis used the water balance disposal estimate for the tenth year of operations. This year assumes the highest consumptive groundwater use. The analysis assumes that four MUs are in restoration with an estimated 250 gpm of consumptive water use, and that five MUs are in production with a bleed stream of 65 gpm. The total consumptive water use estimated for that year is 315 gpm. The 315 gpm consumptive water use represents the worst-case water use during the operation of the MEA. The available head over the formation is expected to be reduced by 10 percent.

The drawdown analysis of the MEA estimates that the drawdown during the worst-case year of operation is approximately 30 feet in the areas where active restoration is occurring. The estimated drawdown is about 6 to 7 percent of the total head available. The static water level at MEA is about 465 ft, and the expected water level during the tenth year of operations is estimated to be 435 ft. The drawdown in the basal sandstone of the Chadron Formation, at the monitor well ring, is approximately 15 ft, and the worst-case drawdown at the edge of the 2.25-mile review area will be about 2 ft. As such, this analysis of the MEA is in reasonable agreement with the actual operating data from the Crow Butte Project.

CBR reviewed private wells within a 2.25-mile radius of the MEA and found that none of the wells were completed in the basal sandstone of the Chadron Formation. All of the well completions are in the overlying Brule Formation and Arikaree Group because the wells are much shallower (60 to 300 feet) than the basal sandstone of the Chadron Formation (>1,000 ft), and the water quality of the overlying formations is superior to that of the basal sandstone of the Chadron Sandstone. Further, the pumping test demonstrated the integrity of the confining layer that separates the aquifer in the basal sandstone of the Chadron Formation from the overlying aquifers.

7.2.4.2.2.2 Impacts on Groundwater Quality

The primary groundwater supply in and near the MEA is the Brule Formation, typically encountered at depths from approximately 30 to 200 feet below land surface, with the exception of locations where the overlying alluvium is not present. In general, the static water level for the Brule Formation wells in the MEA ranges from 50 to 150 feet below land surface, depending on local topography. Excursions represent a potential effect on the adjacent groundwater as a result of operations. However, as described in Section 7.2.4.2.1.2, horizontal excursions are quickly recovered and only one vertical excursion has been detected at the Crow Butte Project, which was corrected.

The subsurface interval composed of the Lower Dakota, Morrison, and Sundance Formations has been identified as the DDW injection zone at the MEA. The subsurface geologic characteristics beneath the MEA will prevent disposal fluids injected into the injection zone from impacting the overlying freshwater aquifers (i.e., Brule and Chadron Formations). Between the lowermost Chadron Formation and the injection zone are more than 2,500 feet of sediments primarily consisting of low permeability shale. This separating aquitard protects against vertical migration of injected fluids to the overlying Brule and Chadron Formations. Shales above and below the injection zone will encase the disposal fluids within the receiving formations and no structural elements with the potential to disrupt the natural vertical containment have been identified.

The estimated concentrations of TDS within the injection zone are in excess of 10,000 mg/L. No harmful or reactive incompatibility between the formation brine and the waste constituents are expected. CBR has satisfactorily operated two Class I DDWs at the Crow Butte Project since 1994 and 2011, respectively, without any adverse impacts.

7.2.4.2.2.3 Potential Groundwater Impacts from Accidents

Groundwater quality could potentially be impacted during operations due to an accident such as an uncontrolled release of process liquids due to a wellfield accident. If there should be a wellfield accident, potential contamination of the shallow aquifer (Brule), as well as surrounding soil, could occur. Wellfield accidents could take the form of a slow leak or a catastrophic failure, a shallow excursion, an overflow due to excess production or restoration flow, or due to the addition of excessive rainwater or runoff.

The satellite building will have curbing around the structure, which will contain any accidental spills or releases of contaminated fluids. This will eliminate the potential for such discharges to the adjoining groundwater surface and potential contamination of the surrounding soils and the Brule Formation.

The DDWs will receive wastewater from the wastewater tanks located at the satellite processing facility via an underground PVC/HDPE pipeline. Flow rates from the tankage, tank levels, and flow rates will be controlled and monitored to ensure any potential leakage is rapidly detected. All flows and pressures will have limits and alarms programmed to alert the operator as limits are approached and to control feed pumps. The details of these systems will be addressed in the Class I permit application that will be submitted to the NDEE as part of the required permitting process. CBR has successfully operated Class I DDWs at the Crow Butte Project for nearly 30 years without any significant spills or releases.

Another potential cause of groundwater impacts from accidents could be releases caused by a spill of injection or production solutions from a wellfield building or associated piping. To control these types of releases, all piping will be either PVC, HDPE with butt-welded joints, or equivalent. All piping will be leak-tested prior to production flow and following repairs or maintenance.

7.2.5 Ecological Resources Impacts

7.2.5.1 Crow Butte Project

7.2.5.1.1 Vegetation

Operations and restoration would have minor impacts on vegetation within the Crow Butte Project. Spills and leaks would have the potential to effect plant growth; however, as described in Section 7.2.4.1, spills and leaks at the Crow Butte Project are infrequent and mitigation measures are in place to reduce the potential. During reclamation, disturbed lands will be reclaimed and returned to the premining use as described in Section 6.2. Overall impacts to vegetation from operation, restoration, and decommissioning will be minor.

7.2.5.1.2 Wetlands

As described in Section 2.7, no wetlands have been identified within the Crow Butte Project area.

7.2.5.1.3 Terrestrial Ecology

Adverse impacts associated with the current operation included ground disturbing activities resulting from the construction of access roads, processing facility, active wells, and other project related needs. These disturbances were less than 100 acres at any one time. These disturbances have not significantly affected ecological resources because, as discussed in Section 2.8, there is no critical habitat for any species within the Crow Butte Project. Additionally, the small amount of project-disturbed land compared to the amount of similar habitat surrounding the area reduces any potential impacts.

Impacts during reclamation will be similar to those during construction and should only have a minimal impact.

7.2.5.2 MEA

7.2.5.2.1 Vegetation

Impacts to vegetation during operation and restoration will be minor because activities will be limited. During decommissioning, impacts to vegetation will be similar to those described in Section 7.1.5.1 for construction.

In general, the duration of effects on cultivated agricultural land and mixed-grass prairie vegetation are significantly different. Cropland areas can be readily returned to production through fertilizer treatments and compaction relief. However, disturbed native prairie tracts require reclamation treatments and natural succession to return to predisturbance conditions of diversity (both species and structural). Reestablishment of mixed-grass prairie to predisturbance conditions would be influenced by climate (growing season, temperature, and precipitation patterns) and edaphic (physical, chemical, and biological) conditions in the soil.

During reclamation, disturbed lands will be reclaimed and returned to the premining use as described in Section 6.2. Previously planted agricultural fields would be recontoured to approximate precontours and ripped to depths of 12 to 18 inches to relieve compaction. If mixed-grass prairie tracts were disturbed by surface activities, these areas would be completely reclaimed. Reclamation of mixed-grass prairie would generally include: (1) completing cleanup of the disturbed areas (wellfields and access roads); (2) restoring the disturbed areas to the approximate ground contour that existed before construction; (3) replacing topsoil, if removed, over all disturbed areas; (4) ripping disturbed areas to a depth of 12 to 18 inches; and (5) seeding recontoured areas with a locally adapted, certified weed-free seed mixture.

7.2.5.2.2 Wetlands

During operation, restoration, and decommissioning impacts to wetlands will be minimal. CBR will implement mitigation measures to reduce the risk of sedimentation.

7.2.5.2.3 Terrestrial Ecology

Impacts to terrestrial ecology during operation and restoration will be minor because activities will be limited. Wildlife avoid the area due to noise and traffic. During decommissioning, impacts to terrestrial ecology will be similar to those described in Section 7.1.5.1 for construction. Due to the type of disturbance (relatively small areas disturbed and the sequential nature of the disturbance), impacts to small mammals and birds, big game, passerine and upland game birds, raptors, fish and macroinvertebrates, and threatened or endangered species related to the operations, restoration, and decommissioning phases would be less than those described for construction.

7.2.6 Socioeconomic Impacts

Since the inception of the operational phase, the overall effect of the Crow Butte Project on the local and regional economy has been beneficial. In addition, the current mine operation has not resulted in any significant impact to the community infrastructure (including schools, roads, water and sewage facilities, law enforcement, medical facilities, and any other public facility) in the City of Crawford or in Dawes County. Based on this, it is assumed that the MEA would have similar impacts. Economic and social effects of operation are discussed in detail in Section 7.6 and the costs and benefits are discussed in Chapter 9.

7.2.7 Air Quality Impacts

7.2.7.1 Crow Butte Project

The 2014 EA for the CBR renewal indicated that any new construction activities at the Crow Butte Project would cause minimal impacts on local air quality. Regional air monitoring presented in Section 2.5.4 shows that particulate matter, sulfur dioxide, nitrogen dioxide, and ozone have remained consistent throughout the period (2010-2023) and have remained in compliance with NAAQS.

7.2.7.2 MEA

Air emissions during operation, aquifer restoration, and decommissioning will be similar to construction for the MEA. Nonradiological emissions will include fugitive dust and combustion emissions during each phase and radiological emissions will be associated with the release of radon from the wellfields and during resin transfer. Section 7.2.1 of the MEA application (2015) included an estimate of particulate emissions during operations onsite and offsite on paved and unpaved roads. Similar to the Crow Butte Project, the estimated emissions at the MEA will be below levels that will require an NDEE air permit and are not anticipated to affect local ambient air quality. CBR will minimize impacts by applying water for dust control to unpaved roads within the MEA license area.

Drilling rigs and pump may also contribute to air emissions at the MEA. However, Section 4.5.1 of the 2018 MEA EA (NRC 2018) states that the amount of other pollutants generated by these sources and vehicles at the project site are expected to be minor and would not affect local ambient air quality. Overall, air emissions from the MEA would be minimal and will not affect local ambient air quality.

7.2.8 Noise Impacts

Noise sources during operation at the Crow Butte Project have increased over baseline noise sources due to increased vehicle travel related to increased numbers of employees traveling to and from Crawford for work at the CPF. In addition, there is some additional noise due to periodic truck deliveries and shipments associated with operations. Train usage has not increased as a result of operations. Processing equipment at the MEA would be minimal and is not expected to add to existing noise sources. Increases in noise levels due to operation are less than noise levels generated during construction. Therefore, noise levels during operation are expected to continue to be barely perceptible over the existing ambient noise that is dominated by vehicle noise from SH 2/71 and the BNSF railroad. Noise levels during decommissioning will be similar to construction but reduced due to the phased nature.

7.2.9 Historic and Cultural Resources Impacts

7.2.9.1 Crow Butte Project

Impacts to historic and cultural resources are expected to be minimal throughout operation, restoration and decommissioning at the Crow Butte Project. In accordance with LC 9.8 of SUA-1534, CBR will complete cultural resource inventories prior to development of any areas not previously surveyed. In addition, CBR will stop work should any previously unknown cultural artifacts be discovered. The artifacts will be inventoried and evaluated in accordance with 36 CFR Part 800, and no disturbance of the area will occur until CBR has received authorization from the NRC to proceed.

7.2.9.2 MEA

At the MEA, impacts to historic and cultural resources will be similar to the Crow Butte Project during operation, restoration, and decommissioning. CBR will adhere to LC 9.8 of SUA-1534, as described in Section 7.2.9.1.

7.2.10 Waste Management

7.2.10.1 Crow Butte Project

Liquid and solid wastes are discussed in detail in Chapter 4. As described in Section 6.3.3, materials, equipment, and structures that cannot be decontaminated to meet the appropriate release criteria will be disposed of at a disposal site licensed by the NRC or an Agreement State to receive 11e.(2) byproduct material.

7.2.10.2 MEA

At the MEA, wastes generated during operation, restoration, and decommissioning will be disposed as discussed in Chapters 4 and 6. Based on this, potential impacts from waste management are expected to be minimal.

7.3 RADIOLOGICAL EFFECTS

An assessment of the radiological effects must consider the types of emissions, the potential pathways present, and an evaluation of potential consequences. The primary airborne radiological emission from the projects is radon-222 gas (radon) and its decay products. Radon is present in the ore body and is formed from the decay of radium-226. Radon is dissolved in the lixiviant as it travels through the ore body to a production well, where the solution is brought to the surface.

The CPF is licensed for a maximum flow rate of 9,000 gpm, excluding restoration flow. Approximately 5,000 gpm of the process solution is passed through upflow ion exchange columns which vent the majority of the radon into the exhaust manifold. From these columns, the solution is transferred to an injection surge tank, where it is refortified with chemicals before being pumped to the wellfield. The tank is vented in a manner similar to the IX column and if any additional radon leaves the solution, it is vented at this location. The remaining 4,000 gpm of process solution is processed using pressurized fixed bed downflow IX columns. With pressurized columns the radon remains in solution and is returned to the formation and not released to the atmosphere. There may be minor releases of radon during the air blowdown prior to elution and during the filling of the columns after elution has been completed. The air blowdown and the gas released from the vent during column filling is vented into the exhaust manifold and discharged via the main exhaust stack along with the radon contained in the process solutions from the upflow columns. It is estimated that less than 10 percent of the radon from the pressurized columns is vented to the atmosphere. A vacuum dryer is in use at the CPF. 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 100 percent.

The MEA satellite facility will have a production flow capacity of approximately 5,400 gpm, excluding restoration, and will use fixed-bed downflow IX columns to separate uranium from the pregnant production fluid. The facility will also have a capacity to treat 1,550 gpm of restoration solution. The restoration process will use fixed-bed downflow IX columns to remove the uranium and RO to remove the dissolved solids. Waste disposal at the satellite facility will be via deep injection well. The satellite facility will not have precipitation equipment. The loaded IX resin will be transferred from the columns to a resin trailer for transport to the CPF for regeneration and stripping. The reclaimed resin will be transported back to the satellite facility and reused in IX columns.

The following describes the most recent MILDOS-AREA simulations and the results. Because conditions have not changed at the Crow Butte Project since the last renewal or the MEA since added to the license, this LRA does not include an updated MILDOS-AREA simulation.

On October 17, 2006, CBR submitted a license amendment request to increase the annual plant throughput from 5,000 gpm, exclusive of restoration flow, to 9,000 gpm, exclusive of restoration flow. The license amendment was approved in November 2007. As part of the amendment request, CBR provided an updated MILDOS-Area simulation. In the source term calculation CBR adjusted the radon release value to show that all of the contained radon in the 5,000 gpm flow processed by upflow IX will be released to the environment and that 10% of the contained radon found in the 4,000 gpm flow processed by pressurized downflow IX columns will be released to the environment. For the purposes of the evaluation, CBR estimated that 25% of the radon was released in the wellfield. Calculations, source terms, and other MILDOS-AREA parameters are included in Appendix A of the 2006 Amendment (CBR 2007).

The 2007 LRA provided the MILDOS-Area results for the combined Crow Butte Project (at the 9,000 gpm flow scenario described above) and North Trend Expansion Area (NTEA). The NTEA was a separate license amendment submitted to NRC in June 2007. In a letter dated April 4, 2018, CBR requested NRC to suspend review of the NTEA application (CBR 2018). The withdrawal was accepted by the Atomic Safety and Licensing Board panel in a February 29, 2024, Memorandum and Order. The NTEA, which would be located approximately 5 miles northwest of the Crow Butte Project, is similar to the MEA, in that it would be a satellite facility with an average production flow rate of 4,500 gpm. The process flow would flow through pressurized downflow IX columns. The MILDOS-Area simulation assumed 10 percent of the radon would be released during resin transfer and venting and 25 percent of the radon would be released in the wellfields. The source term assumptions and other MILDOS-AREA parameters are included in Appendix A of the 2007 LRA.

The MEA TR includes the MILDOS-AREA results for the satellite plant at flow rate of 6,000 gpm, which is higher than the license maximum of 5,400 gpm. In the absence of evaporation ponds, CBR estimated that 75 percent of the radon released will be vented from the satellite facility, and 25 percent of the radon will be released from the wellfields. A sensitivity analysis demonstrated that radiation doses using a 25 percent/75 percent distribution of radon released from the MU wellhouses and from the satellite facility did not appear to be significantly different from the doses calculated using a 10 percent/90 percent distribution, respectively (Savignac 2014). A detailed presentation of the source term and other MILDOS-AREA parameters is included in Appendix M of the MEA TR.

7.3.1 Exposure Pathways

There exists an inhalation pathway as a result of the emission of radon gas. As the radon daughters' ingrow, deposition on the ground surface increases. A pathway also exists due to external radiation exposure arising from two sources. One source is radon and its daughters in the air, which is considered the cloud contribution. The other source is from radon daughters deposited on the ground; this source being termed the ground contribution.

A third pathway exists, which is the ingestion pathway. This results from direct foliar deposition and radionuclides in the soil being assimilated by the vegetation. The vegetation may represent a direct ingestion pathway to man if consumed, and a secondary pathway if fed to animals that are in turn consumed by man.

All of the above pathways were evaluated using MILDOS-AREA. A human exposure pathway diagram addressing planned and unplanned radiological emissions is presented in Figure 7.3-1.

7.3.1.1 Exposures from Water Pathways

7.3.1.1.1 Crow Butte Project

The solutions in the zone to be mined are controlled and adequately monitored to ensure that migration does not occur. The overlying aquifers are also monitored.

Three commercial evaporation ponds located approximately 2,000 feet from the CPF have been constructed for commercial operation. There are also two R&D evaporation ponds located approximately 1,000 feet from the CPF. The R&D 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 ponds, therefore, are not considered a source of liquid radioactive effluents. The use of ponds to manage liquid waste was discussed in further detail in Chapter 4.

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.

The primary method of waste disposal at the Crow Butte Project is by deep disposal well injection. The two DDWs are completed at approximate depths of 3,500 to 4,000 feet, isolated from any underground source of drinking water by approximately 2,500 feet of shale (Pierre and Graneros Shales). The wells were constructed under a Class I Underground Injection Control (UIC) Permit issued by the NDEE and meet all requirements of the NDEE UIC program. The use of deep disposal wells to manage liquid waste is discussed in further detail in Chapter 4.

Since there are no routine liquid discharges of process water from the CPF, there are no definable water related pathways.

7.3.1.1.3 MEA

The solutions in the zone to be mined will be controlled and adequately monitored to ensure that migration does not occur. The overlying aquifers will also be monitored.

The satellite facility will not have surge/evaporation ponds or surge tanks to store waste solutions, thereby eliminating the potential of releases and exposures via water pathways. Wastewater tanks located in the satellite building will discharge to DDWs, which will be the primary method of waste disposal at the satellite facility. The deep wells will be completed at depths of approximately 4,000 to 5,000 ft, isolated from any underground source of drinking water by approximately 1,500 ft of Pierre Shale. The wells will be constructed under a permit from the NDEE and meet all requirements of the UIC program.

The satellite facility will be located on a curbed concrete pad to prevent any liquids from entering the environment. Solutions used to wash down equipment will drain to a sump and will be pumped to the DDWs. The pad will be of sufficient size to contain the contents of the largest tank if it ruptures.

Because no routine liquid discharges of process water are expected, there are no definable water-related pathways.

7.3.1.2 Exposures from Air Pathways

7.3.1.2.1 Crow Butte Project

2007 LRA

As described above the MILDOS-Area simulation in the 2007 LRA reflects the CBR at a flow rate of 9,000 gpm, excluding restoration flow, and includes the NTEA satellite facility.

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 CPF and the NTEA is less than 100 mrem/yr. The results of the MILDOS-Area simulation are presented in Table 7.3-1, which shows the estimated TEDE from operation of the CPF and the NTEA satellite plant. The source values and the locations of the sources are presented in Table 7.3-2. Receptor locations and appropriate identifiers are shown on Figure 7.3-2.

No TEDE limits were exceeded. An evaluation of the TEDE follows:

- The maximum TEDE was 31.7 mrem/yr at Receptor #15, which is located approximately 0.25-mile northeast of the CPF.
- Receptor #31 (NT-1) is the closest resident in the downwind direction for the NTEA satellite plant. The estimated TEDE at this location was 5.8 mrem/yr. The estimated TEDE at Receptor # 6, located on the east side of the town of Crawford, was 1.65 mrem/yr.
- The effect of the NTEA satellite operation on the nearby residents of the existing Crow Butte facility is less than 1 mrem/yr.

- Since radon-222 is the only radionuclide emitted, public dose limits in 40 CFR 190 and the 10 mrem/yr constraint rule in 10 CFR §20.1101 are not applicable to the CBR facility.

Based on the site specific data (Table 7.3-3) and method of estimation of the source term presented in Appendix A of the 2007 LRA, the modeled emission rate of radon from the Crow Butte Project and NTEA satellite facility was 7,178 Ci/yr and 1,482 Ci/yr, respectively.

The annual population dose commitment to the population in the region within 80 km of the Crow Butte Project was also predicted by the MILDOS-Area code. The results are listed in Table 7.3-4, where the dose to the bronchial epithelium is expressed in person-rem. For comparison, the dose to the population within 80 km of the facility due to natural background radiation is included in the table. These figures are based on the 1980 population and average radiation doses reported for the Western Great Plains.

The atmospheric release of radon also results in a dose to the population on the North American continent. This continental dose is calculated by comparison with a previous calculation based on a 1 kilocurie release near Casper, Wyoming, during the year 1978. The results of these calculations are included in Table 7.3-4 and also combined with dose to the region within 80 km of the facility to arrive at the total radiological effects of one year of operation at the Crow Butte Project.

For comparison of the values listed in Table 7.3-4, the dose to the continental population as a result of natural background radiation has been estimated. This estimate is based on a North American population of 346 million and a dose to each person of 500 mrem/yr to the bronchial epithelium. The maximum radiological effect of the combined operation of the NTEA satellite plant and the Crow Butte Project would be to increase the dose to the bronchial epithelium of the continental population by 0.0023 percent.

2006 Increase in Process Flow Amendment

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 CPF is less than 100 mrem/yr. The assessment considered only the increase in radon releases under stylized conditions to assure that all other factors being equal, increases in radon releases are linearly related to estimated TEDE. Thus, the analysis demonstrated by calculation that the TEDE to the individual most likely to receive the highest dose is much less than 100 mrem/yr. The dose to the most effected resident (Receptor 19) was extrapolated to be 25% of the allowable limit.

The results of the MILDOS-Area simulation are presented in Table 7.3-5, which shows the estimated TEDE from operation of the Crow Butte Project at 5,000 gpm and 9,000 gpm. Based on the site specific data and method of estimation of the source term, the emission rate of radon from the Crow Butte Project is 7,178 Ci/yr, which consists of a flow of 5,000 gpm in existing upflow ion exchange columns (5,042 Ci/yr.) along with the proposed 4,000 gpm of flow treated in the pressurized downflow ion exchange columns (1,311 Ci/yr.).

Summary of Radon Emissions from Operational Monitoring

Radon emissions from operations and restoration activities at the Crow Butte Project are presented in Section 5.7.7 of this LRA.

The monitoring program included seven locations (AM-1 through AM-6 and AM-8) up to 2015, when a new residence was constructed near the Crow Butte Project. Location AM-9 was added at this time and this location represents the highest exposed member of the public. Location AM-6 is considered the background location. The applicant reviewed the radon monitoring data obtained at the AM-1 through AM-6 and AM-8 locations from 1991 through 2023 and these data are found in Table 5.7-13 and Figures 5.7-11 through 5.7-17. Figure 5.7-18 depicts the trends for radon monitoring between 2015 and 2023 for location AM-9.

The results of the area ambient radon 222 concentrations and radionuclide concentrations for each monitoring site were within the historical ranges for all semi-annual reporting periods between the second half of 2008 through the second half of 2023. In the second half of 2008, the laboratory indicated that the track etch cups may have received some exposure during shipping or storage. These results were slightly higher than previous results but well below the effluent concentration limit in 10 CFR Part 20, Appendix B, Column 2.

7.3.1.2.2 MEA

MILDOS Output – Radiation Dose Rates

Table 7.3-6 presents the dose rates calculated for the major cities and towns within a 50-mile (80-km) radius of the MEA; ten residences; two unoccupied structures; and for the north, south, east, and west property boundaries. Locations of the nearby and regional receptors are shown on Figures 7.3-3 and 7.3-4, respectively. The dose rates were calculated using the MEA onsite meteorological data and using the 316 gpm maximum wastewater flow rate expected in years nine through twenty. Conclusions from those dose rates are as follows:

- All dose rates to the public at the property boundaries, the cities and towns within a 50-mile (80-km) radius from the MEA, and at the nearest residence were below the 100 mrem/yr limit specified in 10 CFR 20 (TEDE).
- The highest cumulative MEA boundary dose rate was 55 mrem/yr at the south property boundary.
- The highest cumulative dose rate at the nearest Residence #2 (unoccupied) was 27 mrem/yr.
- The highest cumulative dose rate from all existing and proposed ISR facilities at cities and towns within a 50-mile (80-km) radius from the MEA was 6.0 mrem/year at Crawford, and 3 mrem/yr at both the Towns of Hemingford and Marsland.
- The average dose rate from the nearby ISR facilities was 2 mrem/yr.
- The 40 CFR 190 dose rate was 0 mrem/yr which was below the 10 mrem/yr dose limit for emissions that exclude radon and its progeny.
- The total population effective dose rate was 411 person-rem/year.

For comparison naturally occurring background radiation, from cosmic and terrestrial sources, is approximately 365 mrem/yr.

MILDOS Output – Public and Occupational Radiation Dose Rates

Dose rates for the public inside the MEA boundary apply to delivery personnel, regulatory inspectors, visitors, or other personnel that may spend up to 10 hours per month on site. Occupational dose rates apply to personnel that may spend an estimated 2,000 hours per year working on site such as company employees or contractors.

Table 7.3-7 shows the MEA public and occupational dose rates. At maximum flow during years nine through twenty, the maximum dose rate to the public attributable to MEA was 0.16 mrem/yr, and the maximum occupational dose rate to employees and contractors was 32 mrem/yr with an average of 17 mrem/yr.

In addition, ranchers holding the leases for the MEA may graze cattle and cut hay within the MEA boundary, but only outside the perimeter monitor well ring. The scenario was run at the point 1.5 km southeast of the plant 1 and assumed the rancher spending 416 hours per year attending grazing cattle (8 hours per day, 1 day per week, 52 weeks per year) and up to 160 hours per year cutting hay (8 hours per day, 5 days/week, 4 weeks per year). The incremental dose to the rancher would be 8.5 mrem/year for grazing and 3.3 mrem/year for haying. This situation cannot occur and any dose to ranchers performing these activities will be significantly less.

7.3.1.3 Exposures to Flora and Fauna

The exposure to flora and fauna was evaluated in Environmental Reports submitted in September of 1987 for the Central Plant, and in 2007 for the North Trend Satellite Plant, and the doses were found to be negligible. The proposed increase in process flow to 9,000 gpm at the CPF, as well as the addition of the MEA and NTEA, was not expected to have any measurable impact on dose to flora and fauna.

7.4 NON-RADIOLOGICAL EFFECTS

ISR mining is by design a self-contained mining circuit. Wastes generated by the facilities are contained and eventually removed to disposal elsewhere. The potential non-radiological effects of the operation include the possibility of lixiviant excursion, evaporation pond leakage, and temporary disturbance of the land during site preparation, construction and operations. Non-radiological effects of site preparation and construction activities are discussed in Section 7.1 and impacts on operational and decommissioning activities are discussed in Section 7.2. The environmental monitoring programs given in Section 5.7 are designed to quickly identify any adverse conditions that may result during operations. No long-term irreversible effects are anticipated.

7.4.1 Airborne Emissions

As discussed in Sections 7.1 and 7.2, overall emissions associated with equipment and facility operations during construction, operations, aquifer restoration, and decommissioning would be expected to be minimal and should not affect the local ambient air quality.

Hydrochloric acid is the main gaseous non-radiological effluent at the Crow Butte Project. Hydrochloric acid that is kept on-site is stored in a tank twelve feet in diameter and ten feet tall. This tank is vented into a process tank to remove hydrogen chloride gas from the air passing from the vent. The only other possible gaseous effluent is carbon dioxide, which is also located on-site in a fifty-four ton tank. Very minor amounts of CO_2 could escape into the atmosphere when the tanks are charged.

To predict the concentration of hydrogen chloride in the region around the process facility, its rate of release must be estimated. The following assumptions were used in the estimate:

- Hydrogen chloride gas is emitted from the scrubber only during the process of filling the tank.
- The acid concentration is 32 percent with a temperature of 10° C (50° F) and a partial pressure of 11.8 mm Hg.
- One tank truck delivery is 1,497 kg (3,300 pounds) of acid and it requires one hour to fill the tank.
- The scrubber efficiency is 99 percent.
- Emissions occur from a scrubber vent 3.0 meters (9.8 feet) above the facility foundation. The vent has a diameter of 0.20 meters (8.0 inches) and a flow velocity of 0.2 meters/second (0.66 feet/second).

The estimate of hydrogen chloride gas released during tank filling process is 3.2 grams. Using this source term, atmospheric dispersion calculations, and the average meteorological condition, the highest concentration of hydrogen chloride is anticipated to be 2.5×10^{-2} µg/m^3 in the vicinity of the facility. The threshold limit for hydrogen chloride is 7,000 µg/m^3. This predicted concentration is very low and only occurs during the one hour required to fill the tank. It is estimated that this tank needs to be filled approximately 43 times per year. Even if the satellite process facility is built with a tank of similar capacity, the effect of this emission on the region surrounding the Crow Butte Project will be insignificant.

As described in Section 7.2.4, there will be an increase in particulate matter as a result of the Crow Butte Project and the MEA. Mitigation measures, such as the application of water to unpaved roads, would reduce emissions.

7.5 EFFECTS OF ACCIDENTS

Accidents involving human safety associated with the ISR uranium mining technology typically have far less severe consequences than accidents associated with underground and open pit mining methods. ISR mining provides a higher level of safety for personnel and neighboring communities when compared to conventional mining methods or other energy related industries. Accidents that may occur would generally be quite minor when compared to other industries, such as an explosion at an oil refinery or chemical plant. Radiological accidents that might occur would typically manifest themselves slowly and are therefore easily detected and mitigated. The remote location of the facility and the low level of radioactivity associated with the process both decrease the potential hazard of an accident to the general public.

7.5.1 Tank Failure

Process fluids are contained in vessels and piping circuits within the CPF or satellite plant or in bermed outside storage tanks. The CPF and satellite plant has been designed to control and confine liquid spills should they occur. The plant building structures and concrete curbs contain the liquid spills from the leakage or rupture of a process vessel and will direct any spilled solution to floor sumps. The floor sumps then pump any spilled solutions back into the plant process circuit or to the waste disposal system.

Instantaneous failure is thus highly unlikely. Tank failure would more likely occur as a small leak in the tank. In this case, the tank would be emptied to at least a level below the leaking area and repairs or replacement made as necessary. SOPs are in place to respond to any spill that may occur.

7.5.2 Pipe Failure

The rupture of a pipeline within the CPF or satellite plant is easily visible and can be repaired quickly. Spilled solution is contained and removed in the same fashion as for a tank failure.

The rupture of an injection or recovery line in a wellfield, or a trunkline between a wellfield and the CPF or satellite plant would result in either a release of barren or pregnant lixiviant solution that would contaminate the ground in the area of the break.

All piping from the CPF and satellite plant, to and within the wellfield is buried for frost protection. Pipelines are constructed of PVC, high-density polyethylene with butt-welded joints or equivalent. All pipelines are pressure tested at operating pressures prior to final burial and production flow. As no additional stress is placed on a pipeline following burial, catastrophic failures are unlikely. The section of trunkline that flows under Squaw Creek has been double contained for additional safety.

Each wellfield has a number of wellfield houses, where injection and recovery lines are continuously monitored. Individual lines can each have high and low flow alarm limits set. All set points and alarms are monitored in the control room via the computer system. In addition, each wellfield building has a “wet” alarm to detect the presence of any liquids that may be present.

Small occasional leaks at pipe joints and fittings in the wellfield house or at the wellheads may occur from time to time. Until remedied, these leaks may drip some solution into the underlying soil. After repair, the soil will be surveyed for contamination and removed as appropriate. Preventative maintenance programs are in place to preclude this type of spill to the extent possible. In the event of a catastrophic pipe failure, solutions released would still be minimal as the pressure in the lines is not that great. In addition, all drainages to Squaw Creek have been diked and bermed to protect this water source.

7.5.3 Pond Failure

An accident involving a leak in a solar evaporation pond is detectable either from the regular visual inspections or via the leak detection system. The inspection program consists of daily, weekly, monthly and quarterly inspections in conjunction with an annual technical evaluation of the pond system. Any time six inches or more of fluid is detected in the standpipes, it is analyzed for specific conductance. If the water quality is degraded beyond the action level, it is sampled again and analyzed for chloride, alkalinity, sodium, and sulfate.

In the event of a leak, the contents of any one pond can be transferred to the other ponds while repairs are made. Freeboard requirements may be waived during this period. Catastrophic failure of a berm is also unlikely given the design requirements of the pond and the freeboard that is maintained. The pond soil foundation is compacted and has low ambient moisture, thus leaking solutions would not tend to migrate. Contingency plans are in place to address situations that may occur.

7.5.4 Lixiviant Excursion

Mining fluids are normally maintained in the production aquifer within the immediate vicinity of the wellfield. The function of the encircling monitor well ring, which is installed prior to any production activity, is to detect any lixiviant that may migrate away from the production area due to fluid pressure imbalance. This system has been proven to function satisfactorily over many years of operating experience with in-situ mining.

Monitor wells are located no further than 300 feet from the wellfields and screened in the ore-bearing Chadron Aquifer. Additionally, monitor wells are placed in the first overlaying aquifer above each wellfield segment. Sampling on these wells occurs on a regular basis as described in Section 5.7.8 of this LRA. The total effect of close proximity of the monitor wells, low flow rate from the well patterns, and over-production of leach fluids (production bleed) makes the likelihood of an undetected excursion remote.

7.5.5 Transportation Accidents

Transportation of materials to and from Crow Butte Project and MEA can be classified as follows:

- Shipments of yellowcake (Crow Butte Project only)
- Shipments of process chemicals or fuel from suppliers to the site.
- Shipment of radioactive waste from the site to a licensed disposal facility.
- Shipments of uranium-laden resin from the satellite plant to the CPF.
- Shipments of barren eluted resin or eluate from the CPF back to the satellite plant.

Accidents involving these transportation occurrences are discussed below.

7.5.5.1 *Accidents Involving Yellowcake Shipments*

Accidents involving yellowcake shipment can take two forms. The first would involve a shipment of dried yellowcake product being shipped from the CPF after processing. The second would involve the shipment of uranium oxide or yellowcake slurry. The slurry could be enroute from Crow Butte to another facility for processing, or it could be a shipment being sent to Crow Butte for processing. Slurry would generally be shipped from Crow Butte only if the dryer were not operational. Regarding slurry shipments to Crow Butte, there are currently no contracts or plans that would anticipate such a situation.

The dried yellowcake that is produced at Crow Butte is generally packaged in fifty-five gallon 18 gauge drums holding an average of 364 kg (800 pounds), classified by the Department of Transportation as Type A packaging (49 CFR Parts 171-189 and 10 CFR Part 71). An average truck shipment contains approximately 55 drums, or 17.5 tons of yellowcake. At the 9,000 gpm production level, it is expected that approximately three to four shipments per month would be necessary. If it becomes necessary to transport slurry, it will be transported in either a trailer-mounted tank vessel or in lined drums.

All vehicles and shipments are surveyed prior to leaving the site. The driver is provided with copies of all documents in the shipping packet. The shipping packet contains current copies of the shipping papers containing an exclusive use statement, the bill of lading, the Form 741, the contamination survey results, copies of the emergency telephone numbers, the emergency procedures, a list of materials in the spill control kit, and the driver responsibility statement.

In the accident analysis of the Sand Rock Mill Project in NUREG-0925, a transportation accident involving yellowcake was assumed for which an environmental release fraction of 9×10^{-3} of fractional probability of occurrence was calculated. This represents the initial airborne material released at an accident site carried by a five meter/second (10 mph) wind for a twenty-four hour period. Assuming a population density of sixty-two people per square kilometer, a fifty-year dose commitment to the lungs in the general population was estimated at between 0.9 and 13 man-rem, depending upon the severity of the spill. This value was considered small when compared with the estimated fifty year integrated lung dose of 1,427 man-rem from natural background (NRC 1982). The relatively low activity of the product combined with the low population density in Northwest Nebraska and Wyoming would produce even lower dose commitments than the above estimates in the event of an accident.

7.5.5.2 *Accidents Involving Shipments of Process Chemicals*

Based on the Crow Butte Project current restoration schedule and material balance, it is estimated that approximately 12 bulk chemical deliveries per year will be made to the site. This averages about one truck per month for delivery of chemicals throughout the remaining life of the project. At the MEA, it is estimated that there will be approximately 150 bulk chemical shipments per year.

Types of deliveries include carbon dioxide, hydrochloric acid, sodium chloride, sodium sulfide, hydrogen peroxide, oxygen, and soda ash. Since no unusual or hazardous driving conditions are known to exist in the northwest part of Nebraska, the accident rate should be that of the overall chemical trucking industry.

NUREG-0706 concluded that the probability of a truck accident in any year is 11 percent for each uranium extraction facility or mill. This calculation used average accident probabilities (4.0×10^{-7}/km for rural interstate, 1.4×10^{-6}/km for rural two-lane road, and 1.4×10^{-6}/km for urban interstate) that NUREG/CR-6733 determined were conservative with respect to probability distributions used in a later NRC transportation risk assessment (CNWRA 2001). For the Crownpoint ISR Project in New Mexico, NRC determined that the probability of an accident involving such a truck was 0.009 in any year (NRC 1997).

Truck accident statistics include three categories of events:

- Collisions- between the transport vehicle and other objects, whether moving vehicles or fixed objects.
- Noncollisions- accidents involving only one vehicle, such as when it leaves the road and rolls over.
- Other events- include personal injuries suffered on the vehicle, persons falling from or being thrown against a standing vehicle, cases of stolen vehicles, and fires occurring in a standing vehicle.

The likelihood of a truck shipment of chemicals or product from the Crow Butte Project or the MEA being involved in an accident of any type is approximately 1 percent.

7.5.5.3 Accidents Involving Radioactive Wastes

Low level radioactive solid byproduct material or unusable contaminated equipment generated during operations are transported to a licensed disposal site as needed. Because of the low levels of radioactive concentration involved, these shipments are considered to have minimal potential impact in the event of an accident. Emergency response procedures are the same as for yellowcake shipments.

7.5.5.4 Accidents Involving Resin Transfers

One of the potential impacts of a satellite plant is the transfer of the uranium-loaded resin or eluate from the satellite to the main process facility.

Resin will be transported to and from the MEA satellite facility in a 4,000-gallon capacity tanker trailer. It is currently anticipated that one load of uranium-laden resin will be transported to the CPF for elution and one load of barren eluted resin will be returned to the satellite facility on a daily basis.

The transfer of resin between the MEA satellite facility and the CPF will occur on SH 2/71 and county and private roads. CBR has established a primary access route and an alternate access route. The primary access route will entail approximately 28.9 km (18 miles) of travel on SH 2/71 and approximately 19.3 km (12 miles) on county and private roads. The Alternate A access route is approximately 22.5 km (14 miles) long, with all of the roads being unpaved county and private roads.

Resin or eluate shipments will be treated similarly to yellowcake shipments in regard to DOT and NRC regulations. Shipments will be handled as LSA material for both uranium-laden and barren eluted resin. Pertinent procedures include:

- The resin, either loaded or eluted, will be shipped as "Exclusive Use Only". This will require the outside of each container or tank to be marked "Radioactive LSA" and placarded on four sides of the transport vehicle with "Radioactive" diamond signs.
- A bill of lading will be included for each shipment (including eluted resin). The bill of lading will indicate that a hazardous cargo is present. Other items identified shall be the shipping name, ID number of the shipped material, quantity of material, the estimated activity of the cargo, the transport index, and the package identification number.
- Before each shipment of loaded or barren eluted resin, the exterior surfaces of the tanker will be surveyed for alpha contamination. In addition, gamma exposure rates will be obtained from the surface of the tanker and inside the cab of the tractor. All of the survey results will appear on the bill of lading.
- Licensed and trained CBR drivers will transport the resin between the satellite facility and the CPF.
- Crow Butte's current emergency response plan for yellowcake and other transportation accidents to or from the Crow Butte site is contained in the SHEQMS Volume VIII, *Emergency Manual*. This plan will be expanded to include an emergency resin transfer accident procedure. Personnel at both the satellite facility and the CPF will receive training for responding to a resin transfer transportation accident.

Currently, CBR intends to treat the eluted resin the same as the uranium-loaded resin. It is possible that the eluted resin may be clean enough to be transported as non-radioactive material, as defined by DOT regulations. Operating experience will aid in the determination of the most practical and efficient way of dealing with the shipment of barren resin. Regardless, compliance with all applicable DOT and NRC regulations will be the primary determining factor.

The worst-case accident scenario involving resin transfer transportation would be an accident involving the transport truck and tanker trailer when carrying uranium-laden resin where the entire tanker contents were spilled. Because the uranium is ionically bonded to the resin, and the resin is in a wet condition during shipment, the radiological and environmental impacts of such a spill are minimal. The radiological or environmental impact of a similar accident with barren, eluted resin would be very minor. The primary environmental impact associated with either accident would be the salvage of soils impacted by the spill area and the subsequent damage to the topsoil and vegetation structure. Areas impacted by the removal of soil would be revegetated.

In the event of a transportation accident involving the resin transfer operation, CBR will institute its emergency response plan for transportation accidents. To minimize the impacts from such an accident, the following procedures will be followed:

- Each resin hauling truck will be equipped with a radio that can communicate with either the CPF or the satellite facility. In the event of an accident and spill, the driver can radio to both sites to obtain help.
- A check-in and check-out procedure will be instituted where the driver will call the receiving facility prior to departure from his location. If the resin shipment fails to appear within a set time, a crew would respond and search for this vehicle. This system will ensure a reasonably quick response time in the case that the driver is incapacitated in the accident.
- Each resin transport vehicle will be equipped with an emergency spill kit that the driver can use to begin containment of any spilled material.
- Both the satellite and CPF will be equipped with emergency response packages to quickly respond to a transportation accident.
- Personnel at the satellite and CPF, as well as the designated truck drivers, will have specialized training to handle an emergency response to a transportation accident.

7.5.6 Natural Disaster Risk

NUREG/CR-6733 evaluates the potential risks to an ISR facility from natural disasters. Specifically, the risk from an earthquake and a tornado strike were analyzed. NRC determined that the primary hazard from these natural events was from dispersal of yellowcake from a tornado strike and failure of chemical storage facilities and the possible reaction of process chemicals during either event. NUREG/CR-6733 recommended that licensees follow industry best practices during design and construction of chemical facilities. CBR is committed to following these standards.

7.5.6.1 Tornado Risk

NUREG/CR 6733 evaluates tornado risks associated with ISR facilities for the release of radioactive materials or hazardous chemical due to the effects of a tornado. It was determined that in the event of a tornado strike, chemical storage tanks could fail resulting in the release of chemicals. This guidance document concluded the risk of a tornado strike on an ISR facility was very low and that no design or operational changes were necessary to mitigate the potential risks. However, it was important to locate chemical storage tanks far enough from each other to prevent contact of reactive chemicals in the event of an accident.

The Crow Butte Project and the MEA are located in an area subject to tornadoes. The site is located in Dawes County, Nebraska in which there have been 40 tornadoes since 1950, with three tornado touch downs reported between 2013 and 2023 (University of Nebraska-Lincoln 2024). One tornado occurred in 2017 and 2 occurred in 2020. On June 12, 2017, a tornado briefly touched down about 15 miles west-northwest of Chadron, NE in Dawes County. The tornado did not exceed a Fujita or Enhanced Fujita scale (F- or EF-scale, respectively) magnitude of F0 or EF0 and no injuries, deaths, property or crop damage occurred. The two reported tornadoes reported on July 2, 2020, were from the same event. NWS damage survey confirmed the tornado as an EF-2 that developed 5.8 miles east of Marsland and traveled west-northwest for 3.4 miles.

Trees were uprooted, center pivot points were mangled, and three steel power poles were destroyed.

It has been concluded that tornado risk in Dawes County is relatively low compared to the surrounding region. Dawes County averages less than 1 tornado a year, while Nebraska averages 41.5 tornadoes a year, with the majority occurring in May and June (University of Nebraska-Lincoln 2024). The FEMA national risk index indicates that Dawes County has a very low risk for a tornado, when compared to the rest of the U.S. (FEMA 2024). During the final design phase, CBR will assess the location(s) and construction of chemical storage tanks and containment features in order to reduce the risk of potential leaks caused by tornado damage which may result in harmful chemical reactions.

CBR emergency procedures currently contained in the SHEQMS Volume VIII, *Emergency Manual*, provide instructions for response and mitigation of natural disasters and spills or radioactive materials. CBR's Emergency Manual contain emergency provisions such as notification to personnel of severe weather; evacuation procedures, security plans and threats associated with source material, medical emergencies, damage inspection/assessment and reporting, and cleanup and mitigation of spills of chemicals. CBR will have separate containment berms around storage tanks to reduce the risk of mixing of incompatible chemicals in the event of a spill. In addition, the site's SOPs, training and personnel protective equipment will be available to personnel for response and mitigation of hazardous chemical releases.

7.5.6.2 Seismic Risk

The projects, along with most of the State of Nebraska, is in seismic risk Zone 1. Most of the central U.S. is within seismic risk Zone 1, and only minor damage is expected from earthquakes that occur within this area. As discussed in Section 2.6, there have been 23 earthquakes within 125 km of Crawford since 1980, with the highest magnitude earthquake (4.0) occurring in January 1990. The FEMA national risk index indicates that Dawes County has a very low risk for an earthquake, when compared to the rest of the U.S. (FEMA 2024).

NUREG/CR-6733 concluded that risk from earthquakes at ISR facilities was no greater than for a tornado strike, and that no design or operational changes were required to mitigate the risk. However, the NRC advised that it was important to located chemical storage tanks far enough from each other to prevent contact of reactive chemicals in the event of an accident.

As stated above for potential tornado strikes, CBR emergency procedures currently contained in the SHEQMS Volume VIII, *Emergency Manual*, provide instructions for response and mitigation of natural disasters and spills or radioactive materials. CBR will have separate containment berms around storage tanks to reduce the risk of mixing of incompatible chemicals in the event of a spill. In addition, the site's SOPs, training and personnel protective equipment will be available to personnel for response and mitigation of hazardous chemical releases.

7.5.6.3 Fires

Historically, there have been no fires of any significance at the Crow Butte Project, and none would be expected to occur in the future. CBR's Emergency Manual maintains procedures for dealing with potential fires, whether associated with man-made events at the operations or associated with wildfires.

Wildfires have typically not been a problem and are not considered a major threat. The FEMA national risk index indicates that Dawes County has a relatively low risk for a wildfire, when compared to the rest of the U.S. (FEMA 2024). On August 31, 2012, CBR was ordered by the Dawes County Sheriff's Office to evacuate the current Crow Butte operations site due to threatening wildfire to the east of the project (CBR 2012). CBR advised the NRC of this order, and operations were temporarily shut down and site personnel evacuated. All project personnel were evacuated with the exception of a crew of five CBR personnel that remained on-site for security purposes. On September 1, 2012, the evacuation order was lifted, and operations were re-started on September 2, 2013. The wildfire never entered the licensed area and as a result there were no releases to the environment. During the evacuation, all source material on the site was kept under 24-hour surveillance. CBR's Emergency Manual procedures were followed during the evacuation and there were no incidents.

7.5.7 Other Accidents

Other potential accidents involving non-radiological materials are associated with the various chemical and fuel storage tanks maintained outside the CPF and satellite facilities. Each of the liquid chemical storage tanks is located on curbed concrete pads to contain any spills. The oxygen and carbon dioxide, which are stored as liquefied gases, do not require a curbed concrete pad for containment since these chemicals will convert to gaseous form and vent to the atmosphere if a leak occurred. These tanks are stored away from the processing building and yellowcake storage area.

Accidents involving personnel are also a possibility, although with a small work force, not considered to be likely. Personnel are trained in safety and emergency procedures in accordance with Mine Safety and Health Administration regulations. Initial and refresher training include occupational safety, first aid, radiation safety and fire procedures.

7.6 ECONOMIC AND SOCIAL EFFECTS OF CONSTRUCTION AND OPERATION

The preliminary evaluation of socioeconomic impacts of the Crow Butte Project was completed in 1987 as reported in the original commercial license application. The preliminary evaluation was divided into two phases: construction and operation. The evaluation concluded that the construction phase would cause a moderate, positive impact to the local economy, resulting from the purchases of goods and services directly related to construction activities. Impacts to community services such as roads, housing, schools, and energy costs would be minor or non-existent and temporary.

Since the inception of the operational phase, the overall effect of the current Cameco facility operations on the local and regional economy has been beneficial. Purchases of goods and services by the mine and mine employees contribute directly to the local economy. Local, state, and federal governments benefit from taxes paid by the mine and its employees. Indirect impacts, resulting from the circulation and recirculation of direct payments through the economy, are also beneficial. These economic effects further stimulate the economy, resulting in the creation of additional jobs.

The current mine operation has not resulted in any significant impact to the community infrastructure (including schools, roads, water and sewage facilities, law enforcement, medical facilities, and any other public facility) in the City of Crawford or in Dawes County. As discussed in further detail below, CBR currently employs a workforce of approximately 18 employees. The majority of these employees have been hired from the surrounding communities.

In summary, monetary benefits have and continue to accrue to the community from the presence of the existing Crow Butte Project. Against these monetary benefits are the monetary costs to the communities involved, such as those for new or expanded schools and other community services. Economic impacts are discussed in detail in Chapter 9 of this LRA.

7.7 REFERENCES

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Table 7.3-1 Estimated TEDE to Receptors Near the Crow Butte Project

Receptor #	Description	X (km)	Y (km)	Distance from Main Plant (km)	TEDE* (mrem/y)
1	R1	-1.21	-0.44	1.29	6.64
2	R2	-1.95	1.95	2.76	4.82
3	R3	-1.89	2.71	3.30	6.14
4	R4	-3.34	2.80	4.36	1.92
5	R5	-3.57	3.99	5.35	1.98
6	Crawford	-4.39	4.45	6.25	1.65
7	R7	-1.99	3.96	4.43	4.87
8	R8	-1.99	3.60	4.11	5.16
9	R9	-1.57	3.23	3.59	8.12
10	R10	-1.16	2.80	3.03	16.0
11	R11	-1.78	2.77	3.29	7.34
12	R12	-0.30	2.35	2.37	17.7
13	R13	0.03	1.49	1.49	28.1
14	R14	0.51	0.98	1.10	28.3
15	R15	0.52	0.34	0.62	31.7
16	R16	1.31	0.30	1.34	9.48
17	R17	1.31	-0.34	1.35	6.06
18	Ehlers	0.73	-0.06	0.73	15.5
19	Gibbons	0.73	0.73	1.03	24.9
20	Stetson	-0.46	1.22	1.30	19.9
21	Knode	-1.89	2.68	3.28	6.09
22	Brott	-1.37	1.34	1.92	16.2
23	SP1	0.73	0.15	0.75	18.1
24	SP2	0.67	0.58	0.89	26.2
25	SP3	0.67	0.91	1.13	24.8
26	McDowell	-2.16	4.36	4.87	4.24
27	Taggart	-1.89	4.45	4.83	4.87
28	Franey	-0.98	4.76	4.86	6.55
29	Bunch	1.01	4.27	4.39	7.54
30	Dyer	-2.44	0.55	2.50	3.27
31	NT-1	-3.97	11.33	12.01	5.84
32	NT-2	-4.12	8.93	9.83	3.41
33	NT-3	-4.75	7.87	9.19	3.09
34	NT-4	-5.82	6.69	8.87	2.14
35	NT-5	-4.61	6.76	8.18	2.42
36	NT-6	-7.20	11.65	13.7	1.63
37	NT-7	-8.25	9.86	12.86	1.04
38	NT-8	-0.44	2.76	2.79	15.9

* No differences in TEDE between age classes were observed.

Table 7.3-2 Source Coordinates for Crow Butte Project and NTEA Satellite

Source	East (km)	North (km)	Rn-222 (Curies)
1. Plant Vent	0.00	0.00	4603
2. Satellite Plant Vent	-5.30	9.60	342
3. MU-2-4 (restoration)	-0.30	0.16	350
4. MU-5	0.0	0.74	454
5. MU-6&8	1.92	-1.20	908
6. MU 7&9	0.00	-0.74	908
7. North Trend Wellfield	-5.30	9.60	1320

Table 7.3-3 Site Specific Information Crow Butte Project and NTEA

Parameter	Value
Average ore quality, U_3O_8, in ore body	0.27 percent
Ore radon activity, assuming equilibrium with U-238	761 pCi/g
Operating days per year (plant factor)	365 days
Dimensions of ore body	
Area per year to be mined	20 acres
Average thickness of body	5 ft
Average screened interval	15.1 ft
Average production flow rate (Satellite Facility)	4,500 gpm
Average production flow rate (Main Facility)	9,000 gpm
Formation porosity	29 percent
Process recovery	95 percent
Leaching efficiency	60 percent
Rock density	1.89 g/cm^3
Restoration flow rate (Satellite Facility)	500 gpm
Restoration flow rate (Main Facility)	1,000 gpm
Restoration Residence time	35 days
Production cell parameters	
Residence time	7 days
Type of cell pattern	variable
Average cell area	10,000 ft^2
Average cell flow rate	121 lpm
Source stack description (Main)	
Stack height	15.9 m
Stack diameter	0.30 m
Stack velocity	11 m/sec
Source stack description (Satellite)	
Stack height	10 m
Stack diameter	0.2
Stack velocity	10 m/sec

ft/ft^2 = feet/square feet
g/cm^3 = grams per cubic centimeter
gpm = gallons per minute
lpm = liters per minute
m = meter
m2/sec = meters squared per second
pCi/g = picoCuries per gram

Table 7.3-4 Dose to the Population Bronchial Epithelium and Increased Continental Dose from One Year's Operation at the Crow Butte Facility

Criteria	Dose (person-rem/yr)
Dose received by population within 80 km of the facility	171
Natural background by population within 80 km of the facility	24025
Dose received by population beyond 80 km of the facility	224
Total continental dose	394
Natural background for the continental population	$1.73 \times 10^{+8}$
Fraction increase in continental dose	2.27×10^{-6}

Table 7.3-5 2006 Amendment TEDE to Nearby Residences 5,000 gpm and 9,000 gpm

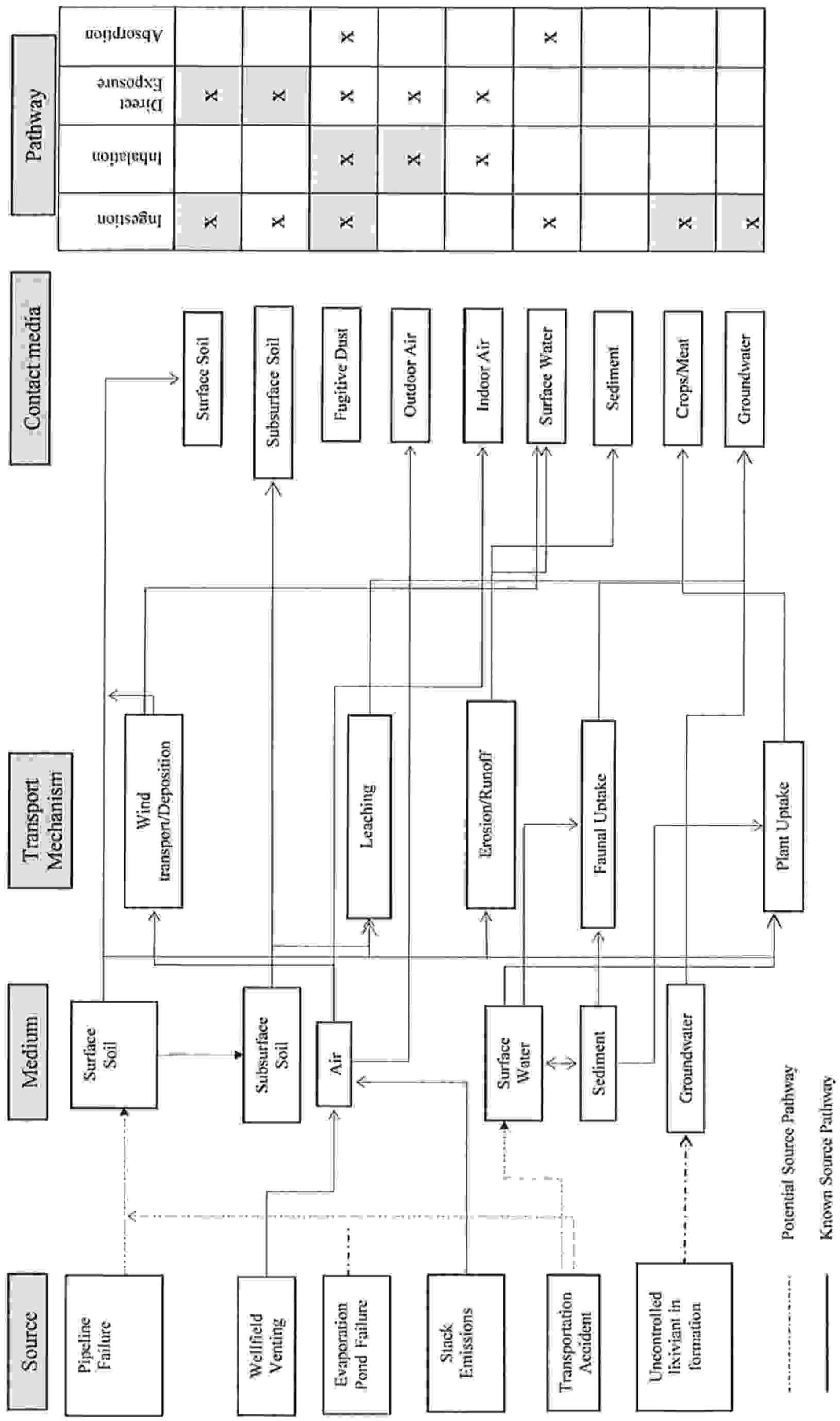
Receptor	TEDE (mrem/yr) 5,000 gpm	TEDE (mrem/yr) 9,000 gpm
#6 (Town of Crawford)	1.40	1.65
#18 (Ehlers)	10.7	15.5
#19 (Gibbons)	21.0	25.0
#20 (Stetson)	15.1	18.9
#21 (Knode)	4.41	6.10
#22	10.1	16.2
#26 (McDowell)	3.29	4.24
#27 (Taggert)	3.73	4.87
#28 (Franey)	5.05	6.55
#29 (Bunch)	5.98	7.54
#30 (Dyer)	2.34	3.27

Table 7.3-6. Radiation Dose Rates from MEA Only and Cumulative Dose Rates

Description	Distance from MEA Satellite Facility (km)	Radiation Dose Rates (mrem/yr)		
		MEA Only	Nearby Existing and Proposed ISR Operations	MEA plus Nearby Existing and Proposed ISR Operations
Alliance	54.4	0.5	0.7	1
Berea	39.1	0.7	0.9	2
Chadron	42.2	0.4	0.8	1
Clinton	79.9	0.2	0.3	1
Crawford	24.1	0.7	4.9	6
Harrison	55.4	0.3	0.7	1
Hay Springs	50.7	0.3	0.5	1
Hemingford	24.9	1.4	1.4	3
Marsland	7.2	1.3	2.1	3
Minatare	79.1	0.2	0.4	1
Mitchell	77.2	0.1	0.3	0
Oelrichs	75.5	0.2	0.6	1
Rushville	69.6	0.2	0.4	1
Scottsbluff	77.9	0.2	0.4	1
Van Tassell	70.7	0.2	0.5	1
Whitney	31.4	0.5	1.7	2
Residence 1	1.0	15.0	3.3	18
Residence 2	1.0	24.2	3.0	27
Residence 3	2.2	6.7	2.9	10
Residence 4	3.5	5.0	2.5	7
Residence 5	4.8	7.3	2.1	9
Residence 6	5.0	4.7	4.2	9
Residence 7	4.2	7.1	3.1	10
Residence 8	6.5	3.1	1.8	5
Residence 9	2.7	5.1	1.9	7
Residence 10	1.5	4.3	2.0	6
Unoccupied 1	2.1	28.6	3.8	32
Unoccupied 2	3.3	9.5	3.2	13
East Boundary	1.4	13.6	2.7	16
South Boundary	0.5	51.9	3.3	55
West Boundary	0.7	38.5	3.6	42
North Boundary #1	5.2	13.1	4.5	18
North Boundary #2	3.4	12.6	3.9	17

Table 7.3-7. Public and Occupational Doses for the MEA

Radon Sources Distribution	Public Dose/Deliveries	Occupational
Location of Dose	**mrem/yr from 10 hrs/month Onsite**	**mrem/yr from 2,000 hrs/yr Onsite**
North Boundary #1	0.08	15
East Boundary	0.02	3
South Boundary	0.12	25
West Boundary	0.09	17
MU-1	0.10	20
MU-2	0.16	32
MU-3	0.12	25
MU-4	0.13	27
MU-5	0.10	19
MU-A	0.13	26
MU-B	0.13	26
MU-C	0.02	4
MU-D	0.02	3
MU-E	0.01	2
MU-F	0.01	2
Satellite	0.02	3
Southeast (1.5 km)[1]	0.21	41
Average	**0.09**	**17**



Note: X depicts the pathway that outlines the route which radiological omissions may follow to reach the public.
Gray shading depicts predominant pathway.

PERMIT TO MINE NO.

NO.	REVISION	BY	DATE
4	---	---	---
3	---	---	---
2	---	---	---
1	---	---	---
0	---	---	---

CROW BUTTE RESOURCES, INC.

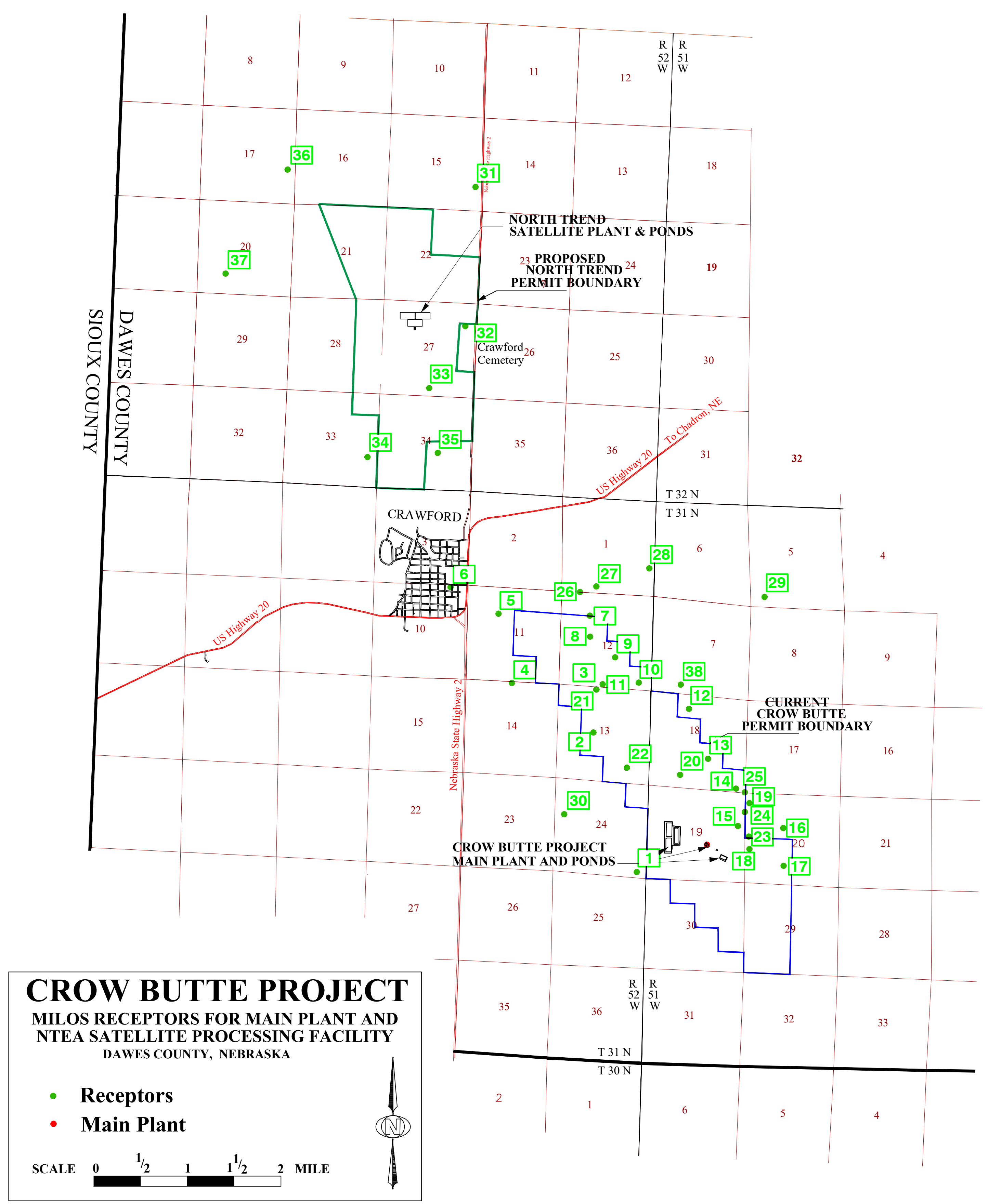
DAWES COUNTY, NEBRASKA

DRAWN BY: RAV
CHECKED BY: BAW
APPROVED BY: ---
DATE: 09/2024

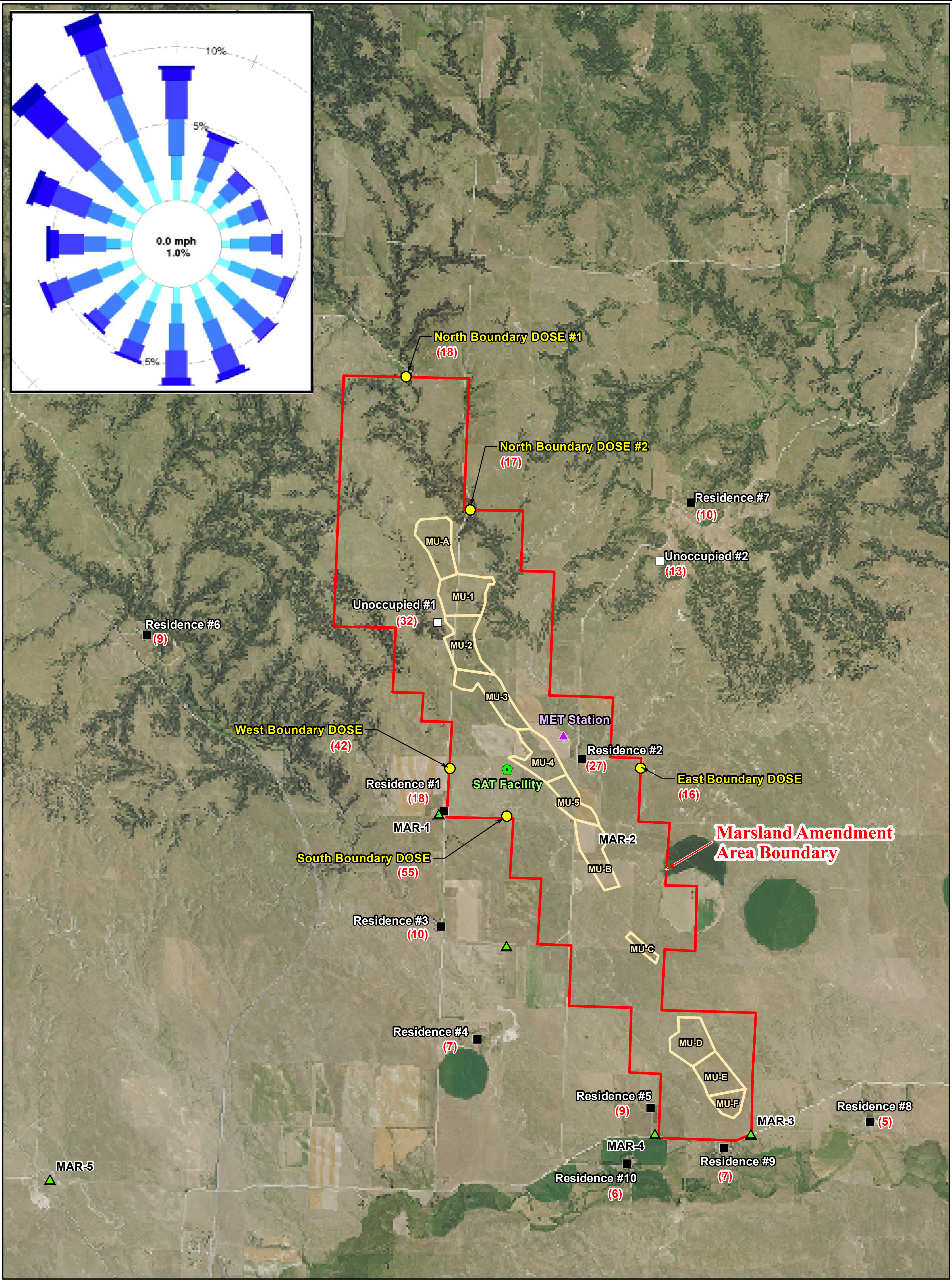
HUMAN EXPOSURE PATHWAYS FOR KNOWN AND POTENTIAL SOURCES OF RADIOLOGICAL OMISSIONS

FIGURE **7.3-1**

Figure 7.3-2


NORTH TREND
SATELLITE PLANT & PONDS
PROPOSED
NORTH TREND
PERMIT BOUNDARY
Crawford
Cemetery
SIOUX COUNTY
DAWES COUNTY
CRAWFORD
US Highway 20
To Chadron, NE
Nebraska State Highway 2
T 32 N
T 31 N
T 30 N
R 52 W
R 51 W
CURRENT
CROW BUTTE
PERMIT BOUNDARY
CROW BUTTE PROJECT
MAIN PLANT AND PONDS
CROW BUTTE PROJECT
MILOS RECEPTORS FOR MAIN PLANT AND
NTEA SATELLITE PROCESSING FACILITY
DAWES COUNTY, NEBRASKA
Receptors
Main Plant
SCALE 0 1/2 1 1 1/2 2 MILE
N

Path: K:\CBR_Projects\CO001636_Marsland\2_GIS\ArcMaps\0004_NRC_TR\Figure 7_3-3_MILDOS Receptors Residences and Designated MEA License Boundary Locations.mxd | Date: 9/16/2024 | User: rventling



LEGEND

- Air Sample Station
- Boundary Dose Point
- Residence (Occupiable)
- Unoccupied Structure (Unoccupiable)
- Proposed Satellite Plant Location
- MEA Met Station
- Project Boundary
- Mine Unit
- (10) MEA Mildos Estimated Radiation Dose Rate (in mrem/yr)

MEA = Marsland Expansion Area
mrem = millirems per year

Map Updated on: 9/16/2024

N

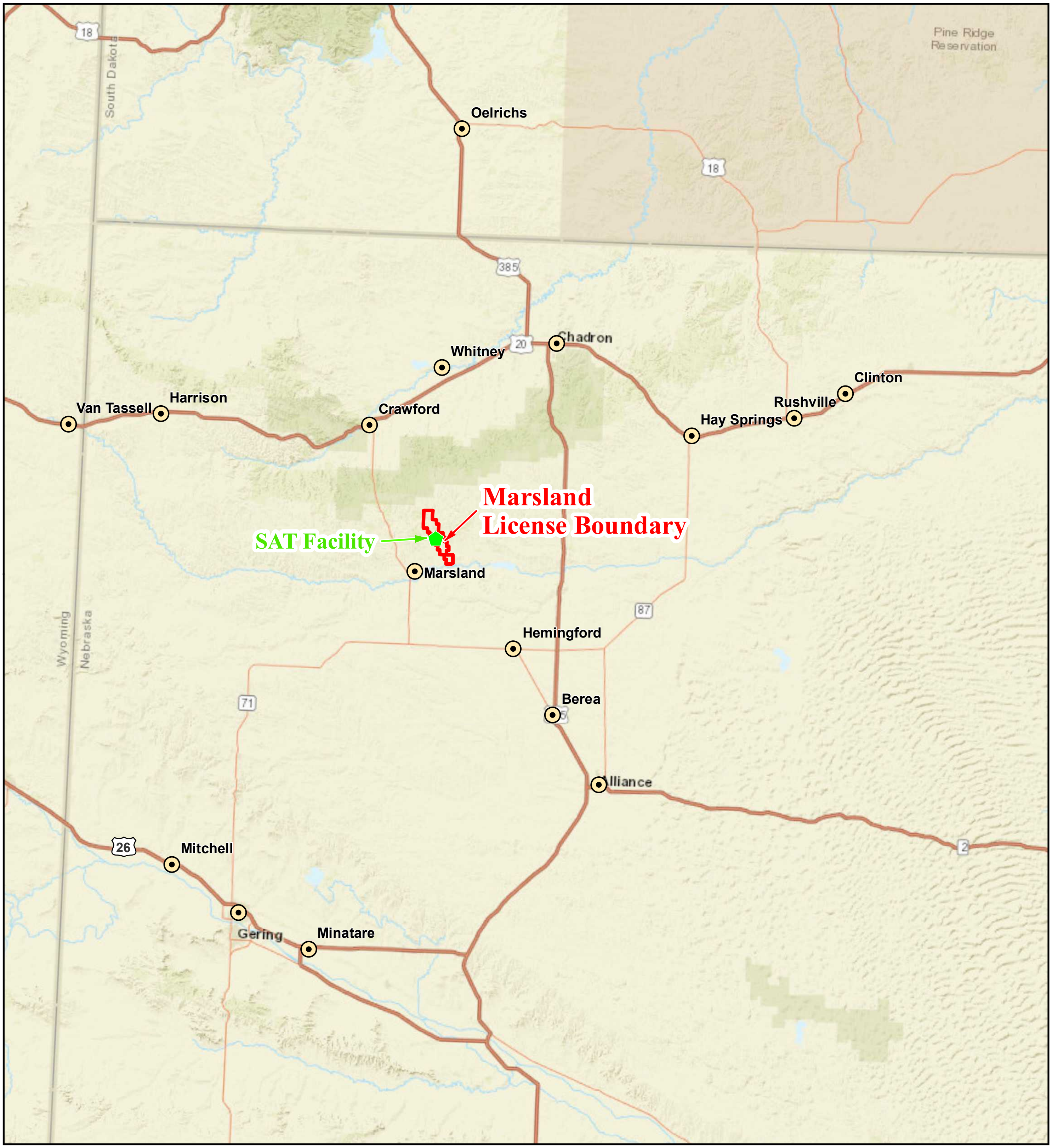
0 2,000 4,000
Feet

PROJECTION: NAD1983,
STATE PLANE NEBRASKA NORTH, FIPS 2600
SOURCES: USDA NAIP IMAGERY 2010

CROW BUTTE RESOURCES, INC.

FIGURE 7.3-3
MILDOS RECEPTORS
RESIDENCES AND DESIGNATED MEA
LICENSE BOUNDARY LOCATIONS

PROJECT: CO001636 MAPPED BY: JC CHECKED BY: MS



N

0 7.5 15

Miles

PROJECTION: NAD 1983, STATE PLANE NEBRASKA NORTH, FIPS 2600
SOURCES: WORLD STREET MAP SERVICED BY ESRI ARCGIS ONLINE

CROW BUTTE RESOURCES, INC.

FIGURE 7.3-4
MILDOS RECEPTORS
CITIES AND TOWNS IN REGION AROUND MEA

PROJECTION: CO001636 MAPPED BY: BB CHECKED BY: J. CEARLEY

Path: K:\Sheridan\Cameco Resources\2023078 Crow Butte LRA\06GIS\Figure 7_3-4_MILDOS Receptors - Cities and Towns in Region Around MEA.mxd | Last Saved By: rventling | Last Saved On: 9/16/2024

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8.0 ALTERNATIVES

8.1 SUMMARY OF CURRENT ACTIVITY

CBR currently operates the Crow Butte Project; a commercial ISR uranium mining operation located approximately 4.0 miles southeast of Crawford in Dawes County, Nebraska. Operation is allowed under NRC Source Materials License SUA-1534.

An R&D facility was operated on the property in 1986 and 1987. Construction of the commercial process facility began in 1988, with production beginning in April of 1991. The total current License Area occupies 2,875 acres, and the surface area to be affected by the current commercial project is approximately 1,265 acres. Facilities include the R&D facility, the commercial process facility and office building, solar evaporation ponds, parking, access roads, and wellfields.

In the Crow Butte Project, uranium is recovered by ISR from the Chadron Sandstone at a depth that varies from 400 feet to 800 feet. The overall 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 percent to greater than 0.5 percent U_3O_8, with an average grade estimated at 0.27 percent U_3O_8. Mine Units 9 through 11 are currently in standby. Groundwater restoration has been completed and received regulatory approval in Mine Unit 1. Mine Units 2 through 6 are currently in stability monitoring and groundwater restoration is currently underway in Mine Units 7 and 8.

The current extraction plant is operating with a licensed process flow rate of 9,000 gpm exclusive of restoration flow. Maximum allowable throughput from the plant under SUA-1534 is currently 2 million pounds of U_3O_8 per year.

By letter dated May 16, 2012, CBR submitted an application to the NRC to amend the existing source materials license SUA-1534 to authorize construction and operation of a satellite facility, named the Marsland Expansion Area (MEA). The NRC amended license SUA-1534 in May 2018 (Amendment 3) to include the MEA. No construction or operation has occurred at the MEA to date.

Uranium extracted from the MEA wellfields will be processed at a satellite facility located within the MEA. SUA-1534 LC 10.3.3 limits the maximum flow rate at the satellite facility to 5,400 gpm, excluding restoration flow. The uranium extracted from the MEA will be loaded onto IX resin in the MEA satellite facility, which will then be transported by tanker truck to the CPF for elution, precipitation, drying, and packaging. Barren resin will be returned to the MEA satellite facility by tanker truck.

8.2 NO ACTION ALTERNATIVE

The no-action alternative would allow CBR to continue mining operations in the current Crow Butte Project and the MEA until the NRC formally denied the renewal of the license application. As long as CBR submits a source material renewal application to the NRC at least thirty days before the expiration date of the existing license (November 5, 2024), the license would not expire until the NRC determined the final disposition of the renewal application and advised CBR of its decision. If the license renewal was not approved by the NRC, restoration and reclamation activities would then become the primary activities.

If renewal of the current source material license was not approved, all current activities as well as potential future activities at the Crow Butte Project not associated with groundwater restoration and decommissioning would be terminated. In addition, none of the uranium within the MEA would be recovered and the satellite facility would not be constructed. The results would be a decrease in employment opportunities coinciding with potential adverse effects to the Dawes County economy. At the completion of decommissioning activities at the Crow Butte Project, all employment opportunities at the mine would be terminated.

In addition to the loss of significant employment opportunities in Crawford and Dawes County, the premature closing of the Crow Butte Project and the MEA before commercially viable resources had been recovered would adversely affect the economic base of Dawes County. As discussed in Chapter 9, the Crow Butte Project currently provides a significant economic impact to the local Dawes County economy.

A decision to not renew SUA-1534 would leave a large resource unavailable for energy production supplies. In 2023, total domestic U.S. uranium production was 50,000 pounds U_3O_8, which was significantly down from the 4.9 million pounds U_3O_8 produced in 2014 (EIA 2024). During the same year, owners and operators of U.S. civilian nuclear power reactors purchased 51.6 million pounds of uranium concentrate. Domestic supply accounted for 5% of total purchases in 2023. In May 2024, the U.S. banned imports of uranium products from Russia beginning in August, although companies may apply for waivers through January 1, 2028. The Crow Butte Project and the MEA represent important sources of domestic uranium supplies that are essential in 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 license renewal 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 this license renewal would also have an adverse economic impact on the individuals who have surface leases with CBR and own the mineral rights within the Crow Butte Project and the MEA.

8.3 PROPOSED ACTION

With NRC approval of the Source Material License SUA-1534 renewal, CBR would continue to operate the Crow Butte Project and the MEA as discussed in Chapter 5 of this LRA. Amendments to the license may be sought as needed in order to recover the uranium resources, for which CBR holds valid claims, in the most effective manner.

8.4 CUMULATIVE EFFECTS

8.4.1 Cumulative Radiological Impacts

The NRC website provides the location of all fuel cycle facilities in the United States, including source material facilities (e.g., uranium mills). The website was reviewed to identify the location of fuel cycle facilities within an 80-km (50-mile) radius of the CBR ISL facility (NRC 2025).

There are no other licensed uranium recovery facilities within 50-miles of the CBR or MEA. Th nearest licensed uranium recovery facility is the Dewey-Burdock ISR Project, located near Edgemont, South Dakota, approximately 55 miles northwest of the Crow Butte Project. The fully licensed facility (SUA-1600) has not been constructed. CBR has no present or future plans to license the Three Crow Expansion Area (TCEA) or the North Trend Expansion Area (NTEA). There is one operating nuclear reactor located in the state of Nebraska beyond the 80-km radius: Cooper Boiling Water Reactor, located 23 miles south of Nebraska City. Potential impacts associated with the cumulative impacts associated with other existing radiological sources are considered to be *de minimus*. This is due primarily to the only nuclear fuel cycle facilities located within a 80-km radius of the Crow Butte Project and MEA not being constructed and there have been no cumulative impacts observed during the operating life of the CBR facility (23 years), and the CBR facility has operated for approximately 23 years with no observable significant adverse impacts associated with its operations (e.g., environmental).

8.4.2 Other Past, Present and Reasonably Foreseeable Projects

There are no past, present or reasonably foreseeable wind energy projects within 50-miles of the Crow Butte Project and MEA. The nearest solar energy project is the proposed Lookout Solar Park Project, located in Oglala Lakota and Custer counties on the Pine Ridge Indian Reservation approximately 60 miles north of the Crow Butte Project. The 140-megawatt project with span 840 acres and interconnect to high voltage transmission lines under the jurisdiction of the Western Area Power Administration (2025). The solar project is not likely to have a significant cumulative impact to the resource areas as it will occupy a relatively small footprint and is located outside of the 50-mile radius.

In Niobrara County, Wyoming there are two proposed hydrogen projects (Sidewinder and Pronghorn). Each project will utilize wind energy and water to create hydrogen and liquid fuels (Sidewinder Clean Hydrogen 2025 and Pronghorn Clean Energy 2025). Exact locations for the projects are not disclosed at this time. The hydrogen projects are not likely to have a significant cumulative impact to the resource areas because the projects will be located around 50 miles west of the Crow Butte Project and MEA.

Cumulative impacts associated with local and regional socioeconomic issues would also be important considerations associated with significant future uranium development in the area of the existing CBR uranium operations.

8.5 COMPARISON OF THE PREDICTED ENVIRONMENTAL IMPACTS

Table 8.5-1 summarizes the environmental impacts for the no-action alternative and proposed action Environmental impacts are discussed in greater detail in Chapter 7 of this LRA.

8.6 REFERENCES

Pronghorn Clean Energy, 2025, Frequency asked questions. Available on the Internet as of April 2025 at: https://www.pronghornh2.com/

Sidewinder Clean Hydrogen, 2025, Frequency asked questions. Available on the Internet as of April 2025 at: https://www.sidewinderh2.com/faq

U.S. Energy Information Administration (EIA), 2024, Domestic Uranium Production Report – Annual 2023. Available on the Internet as of August 2024 at: https://www.eia.gov/uranium/production/annual/.

U.S. Nuclear Regulatory Commission (NRC), 1982, Draft Environmental Statement Related to the Operation of the Teton Project, NUREG-0925.

U.S. Nuclear Regulatory Commission (NRC), 2025, Locations of Fuel Cycle Facilities. Available on the Internet as of March 2025 at: https://www.nrc.gov/info-finder/fc/index.html.

Western Area Power Administration, 2025, Lookout Solar Project. Available on the Internet as of April 2025 at: https://www.wapa.gov/about-wapa/regions/ugp/environment/lookoutsolar/

Table 8.5-1. Comparison of Predicted Environmental Impacts

Resource Area	No-Action Alternative		Proposed Action	
	Crow Butte Project	**MEA**	**Crow Butte Project**	**MEA**
Land Surface Impacts	None. Project area would be reclaimed and returned to premining use.	None – No construction activities would occur.	Minimal. No additional construction is anticipated. Land would be returned to premining use following restoration and decommissioning.	Minimal temporary impacts in wellfield areas; Significant surface and subsurface disturbance confined to a portion of the MEA satellite plant site.
Land Use Impacts	None. Project area would be reclaimed and returned to premining use.	None – No construction activities would occur.	Minimal. No additional construction is anticipated. Land would be returned to premining use following restoration and decommissioning.	Loss of crop and cattle production in impacted area for duration of project.
Transportation Impacts	Minimal. Current transportation impacts would continue through decommissioning.	None – No construction activities would occur.	Minimal. Current transportation impacts would continue through decommissioning.	Minimal impact on current traffic levels. Estimated additional heavy truck traffic of 500 trips per year; additional 6 to 8 vehicle trips per day light-duty trucks.
Geology and Soil Impacts	Minimal. Soils would be reclaimed as described in Chapter 6.	None – No construction activities would occur.	Minimal. Soils would be reclaimed as described in Chapter 6.	Minimal. Soils would be reclaimed as described in Chapter 6.
Surface Water Impacts	Minimal. Stormwater runoff would continue to be controlled by NDEE NPDES regulations through decommissioning.	None – No construction activities would occur.	Minimal. Stormwater runoff would continue to be controlled by NDEE NPDES regulations through decommissioning.	Minimal. Stormwater runoff is controlled through by NDEE NPDES regulations.

Table 8.5-1. Comparison of Predicted Environmental Impacts (Cont.)

Resource Area	No-Action Alternative		Proposed Action	
	Crow Butte Project	**MEA**	**Crow Butte Project**	**MEA**
Groundwater Impacts	Minimal. MU1 has been restored, MU2-MU6 are in stability monitoring, MU7-MU8 are undergoing restoration and MU9-MU11 are on standby. CBR would continue restoration in MU7-MU8 and commence restoration in MU9-MU11.	None – No construction activities would occur.	Minimal. MU1 has been restored, MU2-MU6 are in stability monitoring, MU7-MU8 are undergoing restoration and MU9-MU11 are on standby. Operation and restoration have resulted in 36-50 feet of drawdown of the Basal Chadron Sandstone within the project area. Drawdown will remain the same and will not significantly impact the groundwater quantity in the Brule or Basal Chadron aquifers. Water quality outside of the aquifer exemption boundary has not been affected. Water quality in the Basal Chadron aquifer will be restored as described in Chapter 6.	Consumption of Chadron groundwater for control of mining solutions and restoration (estimated at 50 gpm average). Water quality outside of the aquifer exemption boundary will not be impacted by operations and restoration described in Chapter 6 will ensure the water quality in the Basal Chadron aquifer is restored.
Ecological Impacts	Minimal. Current ecological impacts would continue through decommissioning.	None – No construction activities would occur.	Minimal. Current ecological impacts would continue through decommissioning.	Minimal. There would be no substantive impairment of ecological stability or diminishing of biological diversity.
Air Quality Impacts	Minimal. Current air quality impacts would continue through decommissioning.	None – No construction activities would occur.	Minimal. Current air quality impacts would continue through decommissioning.	Minimal. The MEA would add 23.7 tons per year total dust emissions due to vehicle traffic on gravel roads.
Noise Impacts	Minimal. Current noise impacts would continue through decommissioning.	None – No construction activities would occur.	Minimal. Current noise impacts would continue through decommissioning.	Minimal. There would be a barely perceptible increase over background noise levels in the area.

Table 8.5-1. Comparison of Predicted Environmental Impacts (Cont.)

Resource Area	No-Action Alternative		Proposed Action	
	Crow Butte Project	MEA	Crow Butte Project	MEA
Historic and Cultural Impacts	Minimal. In accordance with LC 9.8 of SUA-1534, CBR will complete cultural resource inventories prior to development of any areas not previously surveyed. In addition, CBR will stop work should any previously unknown cultural artifacts be discovered.	Minimal. In accordance with LC 9.8 of SUA-1534, CBR will complete cultural resource inventories prior to development of any areas not previously surveyed. In addition, CBR will stop work should any previously unknown cultural artifacts be discovered.	Minimal. In accordance with LC 9.8 of SUA-1534, CBR will complete cultural resource inventories prior to development of any areas not previously surveyed. In addition, CBR will stop work should any previously unknown cultural artifacts be discovered.	Minimal. In accordance with LC 9.8 of SUA-1534, CBR will complete cultural resource inventories prior to development of any areas not previously surveyed. In addition, CBR will stop work should any previously unknown cultural artifacts be discovered.
Visual/Scenic Impacts	Minimal. Current visual/scenic impacts would continue through decommissioning.	None – No construction activities would occur.	Minimal. Following reclamation and decommissioning there would no visual or scenic impacts because the land would be returned to premining use.	Minimal impact; noticeable minor industrial component in sensitive viewing areas.
Socioeconomic Impacts	Loss of positive economic benefit to the local area as remaining reserves are not recovered.	Loss of positive economic benefit to the local area as reserves are not recovered	As described in Chapter 9, the Crow Butte Project will continue to have a positive impact on the local communities.	Extension of the current annual direct economic impact of $3.5M plus the addition of between $5.6M and $6.5M annual direct economic impact to the local area.
Non-radiological Health Impacts	Minimal. Current non-radiological impacts would continue through decommissioning.	None – No construction activities would occur.	Minimal. As described in Section 7.4 there are few non-radiological impacts. Gas vapors would continue through operations and air particulates would continue through decommissioning.	Minimal. The only non-radiological emission would be related to air particulate from ground disturbing activities and travel on gravel roads.

Table 8.5-1. Comparison of Predicted Environmental Impacts (Cont.)

Resource Area	No-Action Alternative		Proposed Action	
	Crow Butte Project	**MEA**	**Crow Butte Project**	**MEA**
Radiological Health Impacts	Minimal. Current radiological impacts would continue through decommissioning.	None – No construction activities would occur.	Minimal. As described in Section 5.7 radiological emissions have remained ALARA and this would continue through decommissioning.	Minimal. MILDOS estimated that the maximum dose to the public would be 0.16 mrem/yr and the maximum occupational dose rate to employees and contracts would be 32 mrem/yr.
Waste Management Impacts	Minimal. Current waste management impacts would continue although there may be a small increase in waste during reclamation for materials, equipment, and structures that cannot be decontaminated to meet the appropriate release criteria. These materials would be transported to a disposal site licensed by the NRC or an Agreement State to receive 11e.(2) byproduct material.	None – No construction activities would occur.	Minimal. Current waste management impacts would continue although there may be a small increase in waste during reclamation for materials, equipment, and structures that cannot be decontaminated to meet the appropriate release criteria. These materials would be transported to a disposal site licensed by the NRC or an Agreement State to receive 11e.(2) byproduct material.	Minimal. Generation of additional liquid and solid waste for proper disposal.

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9.0 COST-BENEFIT ANALYSIS

9.1 GENERAL

The general need for production of uranium is assumed in the operation of nuclear power reactors. In reactor licensing evaluations, the benefits of the energy produced are weighed against environmental costs including a prorated share of the environmental costs of the uranium fuel cycle. The incremental impacts of typical mining and milling operation required for the fuel cycle are justified in terms of the benefits of energy generation to the society in general. However, the specific site-related benefits and costs of an individual fuel-cycle facility such as the Crow Butte Project and the MEA must be reasonable as compared to that typical operation.

9.2 ECONOMIC IMPACTS

Monetary benefits accrue to the community from the presence of the Crow Butte Project and the MEA, such as local expenditures of operating funds and the federal, state and local taxes paid by the project. Against these monetary benefits are the monetary costs to the communities involved, such as those for new or expanded schools and other community services. While it is not possible to arrive at an exact numerical balance between these benefits and costs for any one community, or for the project, because of the ability of the community and possibly the project to alter the benefits and costs, this section summarizes the economic impact of the project to date.

9.2.1 Tax Revenues

Table 9.2-1 summarizes the tax revenues from the Crow Butte Project. Future tax revenues depend on uranium prices, which cannot be forecast with accuracy; however, these taxes also somewhat depend on the number of pounds of uranium produced by CBR. Spot market values for U_3O_8 peaked at approximately $136 per pound in 2007 and fell below $20 per pound in 2016 (Seeking Alpha 2024). In January 2024, the spot price was $100 per pound and is currently between $80 and $90 per pound.

The present taxes are based on a relatively consistent production rate of 800,000 pounds per year. The additional production from the MEA facility should be approximately 553,000 pounds per year. The incremental contribution to taxes would be on the order of $700,000 per year in combined taxes.

Beneficiaries of CBR contributions to the General Fund, and therefore to Dawes County government subdivisions, include school districts, fire districts, county and municipal government agencies, and the White River Natural Resource District.

9.2.2 Temporary and Permanent Jobs

9.2.2.1 Current Staffing Levels

CBR currently employs approximately 18 employees. Short-term contractors and part-time employees may also be employed for specific projects and/or during the summer months. In 2023, the CBR total payroll was $2,280,000.

Total CBR payroll for the past 5 years was:

2019	$2,213,000
2020	$2,185,000
2021	$2,216,000
2022	$2,119,000
2023	$2,280,000

The average annual wage for all workers in Dawes County was $41,600 in 2023 (U.S. Bureau of Labor Statistics 2024). By way of comparison, the average wage for CBR employees was approximately $70,000. Entry-level workers for CBR earn a minimum of $23.00 per hour or $46,000 per year, not including overtime, bonuses, or benefits.

9.2.2.2 *Project Short-Term and Long-Term Staffing Levels*

The MEA will require 10 to 12 full-time employees, 4 to 7 full-time contractor employees, and 10 to 15 part-time employees and short-term contractors for construction activities. The full- and part-time employees will be needed for the satellite facility and wellfield operator and maintenance positions. Contractor employees (e.g., drilling rig operators) may also increase by four to seven employees depending on the desired production rate. It is anticipated that the majority of the proposed MEA full-time and part-time workforce and contractors would be available from the current labor force in Dawes County. The unemployment rate in Dawes County in June 2024 was 3.4 percent, which is slightly higher than the state unemployment rate of 3.1 percent (Nebraska Department of Labor 2024). CBR expects that any new positions will be filled from this pool of available labor. These additional positions should increase payroll by $700,000 to $840,000 per year.

CBR actively pursues a policy of hiring and training local residents to fill all possible positions. Due to the technical skills required for some positions, a small percentage of the current CBR staff (less than 5 percent) have been hired elsewhere and relocated to the area. Because of the small number of people who have needed to move into the area to support this project, the impact on the community in terms of expanded services has been minimal.

Because skills and services required for the MEA project would be available in the existing local labor force, it is not anticipated that the project would require the migration of additional workers into the nearby City of Crawford and City of Chadron, or Dawes County. In the event that project requirements for specialized skills could not be met with the current workforce or local labor force, a small number of workers could be hired from outside of Dawes County. However, any such labor needs would represent a negligible change in the population of Dawes County. It is not anticipated that there would be any change in the local population from implementation of the project.

Because no changes in employment or population are anticipated as a direct result of the MEA, no impacts to housing availability, including public housing, are expected. There would be no short- or long-term employees that would require temporary housing; therefore, the proposed project would not affect the lodging capacities of nearby communities.

There would be no noticeable increase in the local population from the construction, operation, and maintenance of the MEA; consequently, there would be no increase in the need for law enforcement and fire safety, medical facilities, public schools, grocery stores, or other community resources in Dawes County.

No increases in existing levels of domestic water usage in Dawes County are expected, nor are effects to existing domestic water facilities anticipated from an increase in population. In addition, the water requirements of the MEA construction and operations would not affect municipal water systems.

Electricity, water, propane and other fuel, sanitary water, and wastewater treatment required for construction and operations will be provided by the utilities that currently provide these services to existing CBR operations. The project may increase the total quantities of electricity, water, propane and other fuel consumed by CBR activities for a limited period of time during operations at MEA because the satellite facility would commence operations as operations in the Crow Butte Project are winding down. Because the scope of production at MEA would be similar to current operations in the Crow Butte Project, it is anticipated that fuel and utility requirements would also be similar. No substantial increases are likely for new operations at the satellite facility over existing operational uses.

It is not anticipated that construction or operational activities would increase costs to other customers supplied by the affected utilities or increase the requirement for utility services beyond the capacities of the providers. There would be no substantial uses of electricity for construction activities. Fuel would continue to be provided by local suppliers. There would be no interruption of fuel deliveries to other customers from increased propane, diesel, and gasoline usage at MEA construction sites.

The Solid Waste Agency of Northwest Nebraska currently has the capacity and would not be affected by the receipt of construction wastes or trash from the satellite facility. Other wastes are managed on site by CBR. Provision of waste services by local waste disposal providers would not be affected, as waste is managed on site by CBR.

9.2.3 Impacts on the Local Economy

It is anticipated that the monetary benefits and costs from the MEA would be similar to those associated with current CBR operations. In addition to providing a number of well-paid jobs in the local Nebraska communities of Crawford, Harrison, and Chadron, CBR actively supports the local economies through purchasing procedures that emphasize obtaining all possible supplies and services in the local area.

Total CBR payments made to Nebraska businesses for the past 5 years were:

2019	$1,033,000
2020	$1,006,000
2021	$1,066,000
2022	$991,000
2023	$980,000

The vast majority of these purchases were made in the City of Crawford and Dawes County. This level of business is expected to continue depending upon CBR project activities in any given year, although not in strict proportion to production. As production at the CPF mine site ceases due to depleted ore reserves, expansion areas will be brought on stream. These expansion areas will be sequenced (brought on line) in a manner that will continue CPF production consistent with current production rates. While there are some savings due to some fixed costs, additional expenses are expected to be higher (e.g., wellfield development). Therefore, it can be estimated that the overall effect on local purchases will be proportional to the number of pounds of uranium produced. Local purchases that will be made annually for the MEA are estimated to be in excess of $1,000,000. Most of these purchases will continue to be made in the City of Crawford and Dawes County. Production royalties and rental payments of $215,000 were paid to landowners in 2023. Additional royalty payments would be made to MEA landowners when production commences. Most of the landowners are residents of Dawes County; therefore, beneficial impacts to county revenues and local businesses will be accrued through the spending and circulation of these dollars in the local economy.

9.2.4 Economic Impact Summary

The Crow Butte Project and the MEA provides a significant economic impact to the local Dawes County economy. Approval of this LRA would continue to have a positive impact on the local economy as summarized in Table 9.2-2.

9.2.5 Estimated Value of the Marsland Expansion Area Resource

CBR continues to develop the reserve estimates for the MEA. Based on the current recoverable resource estimate of 5,667,926 pounds of U_3O_8 and the current market price of uranium ($80 per pound in September 2024), the total estimated value of the energy resources at MEA is approximately $453,434,080. This value will fluctuate as the market price and realized price vary.

9.2.6 Short-Term External Costs

9.2.6.1 Housing Impacts

The available housing resources should be adequate to support short-term needs during facility construction. In 2020, a total of 677 housing units were vacant in Dawes County out of a total housing base of 4,002 units (US Census Bureau 2024). Of the vacant units, 126 were available for rent. In addition to this availability of rental housing units, there are two small hotels in the City of Crawford that generally have vacancies and routinely provide units for itinerant workers such as railroad crews. Temporary housing resources have experienced little change in the past two decades.

Recent data for the City of Crawford indicate that in 2020 there were a total of 538 houses in Crawford, with 397 occupied and 141 vacant (U.S. Census Bureau 2024). There were 56 housing units available for purchase or rent. The average value for a home in Crawford is $116,441 (Zillow 2024).

9.2.6.2 Noise and Congestion

No short-term increases in noise or congestion are anticipated at the Crow Butte Project; however, the MEA may increase the noise and congestion in the immediate vicinity during initial construction of the facility. This will include heavy truck and equipment traffic and access to the jobsite by construction workers. These impacts will be most noticeable to residents in the immediate vicinity of the facility and will be temporary in nature. The increase in noise should be considered in light of the project location, which has two minor rural roads (Hollibaugh and River Roads) used primarily for access.

Along the western boundary of the Crow Butte Project the BNSF rail line is used for combining local “pusher” engines with south bound trains to assist them in climbing the Pine Ridge south of Crawford. As a result, there is a significant amount of noise generated by this activity including trains parked for extended periods. Dust from construction activities will be controlled using standard dust suppression techniques used in the construction industry.

9.2.6.3 Local Services

As previously noted, CBR actively recruits and trains local residents for positions at the mine. CBR expects that the majority of permanent positions would be filled with local hires. As a result of using the local workforce, the impact on local services should be minimal. In many cases these services (e.g., schools) are underutilized due to population trends in the area.

9.2.7 Long-Term External Costs

9.2.7.1 Housing and Services

Because of the small number of people who have needed to move into the area to support CBR activities in the past, the impact on the community in terms of expanded services has been minimal. CBR expects that the types of long-term positions that will be created by the MEA will be filled with individuals from the local workforce. Therefore, there will be no significant impact on services and resources such as housing, schools, hospitals, recreational facilities, or other public facilities. As stated earlier, CBR expects that the new positions at the satellite facility will be filled from the local pool of available labor.

9.2.7.2 Noise and Traffic Congestion

No long-term increases in noise or congestion are anticipated at the Crow Butte Project; however, the addition of the MEA may increase the noise and congestion in the immediate vicinity during initial construction of the facility. Most of this will consist of increased traffic from employees commuting to and from the work site and performing work in the wellfields. Some increase in heavy truck traffic will occur due to deliveries of process chemicals such as O_2 and the shipment of IX resin from the satellite facility to the CPF. Delivery and IX shipments should average two per day. These impacts will be most noticeable to residents in the immediate vicinity of the facility. As noted in Section 9.2.6.2, there is significant existing noise in the immediate area generated by the adjacent rail line and highway.

In the area around Crawford, the increased traffic will be unnoticeable due to the presence of U.S. Highway 20 and SH 2/71, which are both significant transport routes. The annual average

24-hour total and heavy vehicle count for U.S. Highway 20 at the eastern approach to Crawford for 2023 was 1,500 and 180, respectively (NDOT 2024). The limited additional traffic related to potential new satellite operations will not significantly affect these main routes.

The 2022 average daily traffic counts for a segment of SH 2/71 near intersection of SH 71 and SH 2 was 596 total vehicles, including 77 heavy commercial vehicles. 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. The limited additional traffic related to the MEA operation will not significantly affect these routes.

9.2.7.3 Aesthetic Impacts

No additional aesthetic impacts are anticipated at the Crow Butte Project; however, impacts to aesthetic resources resulting from the construction of new satellite facilities may occur. The primary visible surface structures for the MEA include wellhead covers, wellhouses, electrical distribution lines, one satellite processing building. The project will use existing and new roads to access each wellhouse, the DDW building, and the satellite processing building. Project development would alter the physical setting and visual quality of portions of the landscape, which would affect the overall landscape to some degree. The MEA facilities would introduce new elements into the landscape and would alter the existing form, line, color, and texture which characterize the existing landscape. The MEA project would primarily affect agricultural land.

In foreground-middleground views, the satellite processing building, wellhouses, and associated access road clearings would be the most obvious features of development. Clearings and access roads would be visible as light tan exposed soils in geometrically shaped areas with straight, linear edges that provide some textural and color contrasts with the surrounding cropland. The satellite facility processing building, wellhouses, and wellhead covers would be painted to harmonize with the surrounding soil and vegetation cover. These facilities would be visible from Squaw Mound Road and the residence within the license boundary, but would be subordinate in scale to the rural landscape.

The electric distribution line poles would be an estimated 20 feet tall, and would be located throughout the project area to connect wellhouses with existing lines. The distribution lines are similar in appearance to those typical of the rural landscape, but would occur at a higher density than on adjacent lands. The lines would be obvious to viewers at the viewing areas, but would not change the rural character of the existing landscape.

Wellhead covers would be difficult to discern in the landscape from any sensitive viewing area. The form and textural contrast would be very weak because the relatively low profile (3 feet high) and small size of these would blend with the surrounding textures of soil and vegetation. Generally, color contrasts are most likely to be visible in foreground-middleground distance zone.

9.2.7.4 Land Access Restrictions

Property owners of land located within the immediate wellfield and facility boundaries will lose access and free use of these areas during mining and reclamation. The areas impacted are all used for agricultural purposes and the owners will lose the ability to use the areas for production purposes. Offsetting these land use restrictions are the surface lease and mineral royalty payments to the landowners.

9.3 THE BENEFIT COST SUMMARY

The benefit-cost summary for a fuel-cycle facility such as the Crow Butte Project and the MEA involves comparing the societal benefit of a constant U_3O_8 supply (ultimately providing energy) against possible local environmental costs for which there is no directly-related compensation. For this project, there are basically three of these potentially uncompensated environmental costs:

- Groundwater impact
- Radiological impact
- Disturbance of the land

The groundwater impact is considered to be temporary in nature, as restoration activities will restore the groundwater to a pre-mining quality. The successful restoration of groundwater during the Research and Development (R&D) project and the commercial restoration of Mine Unit 1 have demonstrated that the restoration process can meet this criterion successfully.

The radiological impacts of the Crow Butte Project and the MEA are small, with all radioactive wastes being transported and disposed of off-site. Radiological impacts to air and water are also minimal. Extensive on-going environmental monitoring of air, water, and vegetation has shown no appreciable impact to the environment from the Crow Butte Project.

The disturbance of the land for an ISR facility is quite small, especially when compared with conventional surface mining techniques. All of the disturbed land will be reclaimed after the project is decommissioned and will become available for previous uses.

9.4 SUMMARY

In considering the energy value of the U_3O_8 produced to U.S energy needs, the economic benefit to the local communities, the minimal radiological impacts, minimal disturbance of land, and mitigable nature of all other impacts, it is believed that the overall benefit-cost balance for the Crow Butte Project is favorable, and that issuing an license renewal for SUA-1534 is the appropriate regulatory action.

9.5 REFERENCES

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U.S. Bureau of Labor Statistics, 2024, County Employment and Wages in Nebraska — Fourth Quarter 2023. Available on the Internet as of July 2024 at: https://www.bls.gov/regions/midwest/news-release/countyemploymentandwages_nebraska.htm.

U.S. Census Bureau, 2024. Explore Census Data. Available on the Internet as of July 2024 at: https://data.census.gov/.

Zillow, 2024, Crawford, NE Housing Market. Available on the Internet as of July 2024 at: https://www.zillow.com/home-values/31096/crawford-ne/.

Table 9.2-1. Tax Revenues for the Crow Butte Project

Type of Taxes	2019	2020	2021	2022	2023
Property Taxes	$82,000	$70,000	$65,000	$62,000	$63,000
Sales and Use Taxes	$16,000	$17,000	$23,000	$18,000	$14,000
Total	**$98,000**	**$87,000**	**$88,000**	**$80,000**	**$77,000**

Note:
Severance Tax not included because it has fallen below the threshhold for the past 5 years

Table 9.2-2. Current Economic Impact of Crow Butte Project

Activity	Current Crow Butte Operation	Estimated Economic Impact due to Marsland Expansion Area
Employment		
Full-Time Employees	18	+ 10 to 12
Full-Time Contractor Employees	0	+ 4 to 7
Part-Time Employees and Short-Term Contractors	0	+ 4 to 7**
CBR Payroll, 2023	$2,280,000	+ $700,000 to $840,000
Taxes		
Property Taxes	$63,000	—
Sales and Use Taxes	$14,000	—
Severance Taxes	$0	—
Total Taxes	$77,000	+ $0.95 million
Production Royalties		
Royalty/Rental Payments, 2023	$215,000	+ $325,000
Local Purchases		
Local Purchases, 2023	$980,000	+ $3,650,000 to $4,350,000
Total Direct Economic Impacts	**$3,552,000**	**+ $5,625,000 to $6,465,000**

**All construction workers

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10.0 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

10.1 ENVIRONMENTAL APPROVALS FOR THE CROW BUTTE PROJECT

As discussed previously, this is an LRA for Radioactive Source Materials License SUA-1534, originally submitted in September of 1987 and renewed in 1997 and 2007. All other required permits for the Crow Butte Project have been obtained and maintained since that time. A summary of the relevant permits and authorizations for the current License Area is given in Table 10.1-1.

10.2 ENVIRONMENTAL APPROVALS FOR THE MEA

The MEA will be subject licensing and permitting requirements similar to the Crow Butte Project. Table 10.1-2 contains a summary list of the type of license, permit or authorization, the granting authority, and the status.

Table 10.1-1. Environmental Approvals for the Crow Butte Project

Issuing Agency	Permit Description	Status
U.S. Nuclear Regulatory Commission Washington, DC 20555	Source Material License SUA – 1534 Issued December 29, 1989 1st Renewal: February 28, 1998 2nd Renewal: November 5, 2014	Timely Renewal
	Source Materials License SUA – 1534 Amendment to Increase Flow Issued: November 30, 2007	SUA-1534 Amendment 22: November 30, 2007
U.S. Environmental Protection Agency 1200 Pennsylvania Avenue, NW Washington, DC 20460	Aquifer Exemption – Crow Butte Project	Approved: March 23, 1984
Nebraska Department of Environment and Energy PO Box 98922 Lincoln, NE 68509	Underground Injection Control Class III Authorization NE0122611 Crow Butte Project	Approved: April 24, 1990 Modified: June 12, 2014
	Underground Injection Control Class I Authorization Deep Disposal Well #1 - NE0211670 Crow Butte Project	Approved: August 26, 2024 Expires: August 25,2034
	Underground Injection Control Class I Authorization Deep Disposal Well #2 - NE0210825 Crow Butte Project	Approved: November 14, 2011 Expires: November 22, 2030
	National Pollutant Discharge Elimination System Permit NE0130613	Approved: October 1, 2021 Expires: September 30, 2026
	Authorization for Class V Well Underground Injection NE0210917	Approved: May 14, 2010 Expires May 13, 2030
	Evaporation Pond Design	Approved: July 21, 1988
Nebraska Department of Natural Resources 301 Centennial Mall South Lincoln, NE 68509	Industrial Ground Water Permit (I-2A)	Approved: October 30, 2014
Nebraska Department of Health and Human Services Regulation and Licensure PO Box 95007 Lincoln, NE 68509	Class IV Public Water Supply Permit NE3121024	Approved: April 12, 2002

Table 10.1-2. Environmental Approvals for the MEA

Issuing Agency	Description	Status
U.S. Nuclear Regulatory Commission Washington, DC 20555	Amendment to Source Materials License SUA-1534 (10 CFR 40)	Approved May 2018
U.S. Environmental Protection Agency 1200 Pennsylvania Ave, NW Washington, DC 20460	Aquifer exemption application forwarded to EPA following NDEE action	Aquifer exemption application forwarded to EPA by NDEE following NDEE action
Nebraska Department of Environment and Energy PO Box 98922 Lincoln, NE 68509-8922	Underground Injection Control Class III Permit (NDEE Title 122)	Class III UIC Permit application submitted to NDEE in July 2012. In March 2018 CBR requested NDEE cease review.
	Aquifer Exemption (NDEE Title 122)	Aquifer exemption application submitted to NDEE in July 2012. In November 2015, CBR submitted most up to date AEP (pending approval).
	Underground Injection Control Class I (NDEE Title 122)	Class I UIC Permit application submitted to NDEE in April 2013. CBR submitted revision to NDEE in December 2015 (pending approval).
	Industrial Stormwater NPDES Permit (NDEE 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 (NDEE 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 NDEE requirements.
	Underground Injection Control Class V (NDEE 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; to be submitted following approval of Class III UIC permit.