Attachment 3

Clean Version of Page Changes

FIGURES

MeV	mega electronvolt
µg/m^3	micrograms per cubic meter
mg/L	milligrams per liter
MIT	mechanical integrity test
mph	miles per hour
mREM	miliroentgen equivalent, man
MSDS	material data safety sheet
msl	mean sea level
NAAQS	National Ambient Air Quality Standards
NASS	National Agricultural Statistics Service
NDED	Nebraska Department of Economic Development
NDEQ	Nebraska Department of Environmental Quality
NDNR	Nebraska Department of Natural Resources
NGPC	Nebraska Game and Parks Commission
NGS	National Geodetic Survey
NOAA	National Oceanic Atmospheric Association
NOI	Notice of Intent
NOU	Nebraska Ornithologists' Union's
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NTEA	North Trend Expansion Area
NUREG-1569	Standard Review Plan for In-situ Leach Uranium Extraction License Application
pCi/g	pico curies per gram
PPE	personal protective equipment
ppm	parts per million
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QAM	Quality Assurance Manual
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RMP	Risk Management Program
RO	reverse osmosis
ROI	radius of influence
RWP	Radiation Work Permit
SERP	Safety and Environmental Review Panel
SH	State Highway
SHEQMS	Safety Health Environment and Quality Management System
SHPO	State Historic Preservation Office
SOP	standard operating procedure
SPCC	Spill Prevention, Control, and Countermeasure
SSC	Structure, System, or Component
S.U.	Standard nits
SWPPP	Stormwater Pollution Prevention Plan
SRWP	standing radiation work permits
TDS	total dissolved solids

TEDE	Total Effective Dose Equivalent
TER	Technical Evaluation Report
TR	Technical Report
TSP	total suspended particulates
U_3O_8	triuranium octoxide
UCL	Upper Control Limits
UIC	Underground Injection Control
UMTRCA	Uranium Mill Tailings Radiation Control Act
USCB	United States Census Bureau
USDA	United States Department of Agriculture
USDW	Underground source of drinking water
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Survey
USFWS	United States Fish and Wildlife Service
USNRC	United States Nuclear Regulatory Commission
VRM	Visual Resource Management
WFC	Wyoming Fuel Company
WL	working levels
ww	Water well

2.4 REGIONAL HISTORIC, ARCHEOLOGICAL, ARCHITECTURAL, SCENIC AND NATURAL LANDMARKS

2.4.1 Historic, Archeological, and Cultural Resources

Identification and assessment of cultural resources within the Crow Butte License Area have involved two separate field investigations. The R&D stage of cultural resources investigation within the project was carried out during March and April 1982 by the University of Nebraska. Further investigations were completed for the remaining CSA lands during April and May 1987 by the Nebraska State Historical Society.

This section summarizes the results and recommendations of both studies. For detailed descriptions of each identified resource, please refer to the original 1987 license application.

Preliminary background and archival research were initiated in conjunction with intensive field surveys to obtain data required for preparation of both R&D and commercial applications. This work established a basis for addressing potential effects of the project on identified cultural resources. Preliminary literature and records research indicated that systematic investigations had not been previously conducted within the CSA and that no National Register of Historic Places (NRHP) eligible properties had been recorded within or immediately adjacent to the survey unit.

Limited previous studies in surrounding areas provided evidence that a wide range of paleontological, prehistoric and historic resources of potential significance to regional studies are present in the near vicinity and could likely be encountered within the CSA. Registered National Historic Landmarks representing military and Native American reservation period use of the CSA are located near the Crow Butte License Area.

Intensive (100 percent coverage) pedestrian inspection of the R&D area (in 1982) and the full CSA survey unit (in 1987) resulted in identification of 21 newly recorded resource locations (Table 2.4-1).

including eight sites representing Native American components, 12 Euro-American locations, and a buried bone deposit of undetermined cultural association. A figure depicting the location of these sites is provided, under a request for confidentiality in the Environmental Report.

Fifteen of these newly identified resources contained limited observed evidence of scientifically important cultural remains or were not determined to be of significant historic value based on the archival research. These sites do not warrant further National Register consideration.

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The remaining six sites are of potential archeological data recovery importance (25DW114, 25DW192, 25DW194, and 25DW198) or possible architectural interest (25DW112 and 25DW00-25). These six sites are potentially eligible for the National Register, but fully assessing the eligibility of these sites was not within the scope of this work.

Field observation in August of 1995 confirmed that the current commercial operation has not directly affected any of the six potentially significant sites. Additionally, there are no properties within the CSA listed in the National Register or registered as natural or historic landmarks. Project development staff has detailed location maps of these properties, and there is coordination with the Nebraska State Historical Society before any development occurs in the immediate vicinity of the six potentially eligible sites.

2.4.2 **Visual/Scenic Resources**

2.4.2.1 Introduction

The Crow Butte License Area is on private land that is not managed to protect scenic quality by any public agency. However, it is located in scenic landscape of the Pine Ridge area of northwestern Nebraska and is visible from sensitive viewing areas. The existing landscape and the visual effect of the facilities have been inventoried and assessed for the License Area using the United States Department of Interior (USDOI), Bureau of Land Management (BLM) Visual Resource Management (VRM) system.

2.4.2.2 Methods

The VRM system is the basic tool used by the BLM to inventory and manage visual resources on public lands and is used in this analysis. The VRM inventory process involves rating the visual appeal of a tract of land, measuring public concern for scenic quality, and determining whether the tract of land is visible from travel routes or observation points.

The scenic quality inventory was based on methods provided in BLM Manual 8410 – *Visual Resource Inventory* (BLM 1986). The key factors of landform, vegetation, water, color, influence of adjacent scenery, scarcity, and cultural modifications were evaluated according to the rating criteria and provided with a score for each key factor. The criteria for each key factor ranged from high to moderate to low quality based on the variety of line, form, color, texture, and scale of the factor within the landscape. A score was associated with each rating criteria, with a higher score applied to greater complexity and variety for each factor in the landscape. The results of the inventory and the associated score for each key factor are summarized in **Table 2.4-2**. According to NUREG-1569, 2.4.3(7), if the visual resource evaluation rating is 19 or lower, no further evaluation is required. The total score of the scenic quality inventory is 14; therefore, the visual effect of the Crow Butte Project on the local visual resources was not further analyzed.

Table 2.4-2: Scenic Quality Inventory and Evaluation for the Crow Butte License Area

Key Factor	Rating Criteria	Score
Landform	Flat to rolling terrain with no interesting landscape features	1
Vegetation	Some variety of vegetation; cropland, range, riparian	3
Water	Water is present, but not evident as viewed from residences and roads	0
Color	Some variety in colors and contrasts with vegetation and soil	3
Influence of adjacent scenery	Adjacent scenery is very similar to Crow Butte License Area and provides little contrast	1
Scarcity	Landscape is common for the region	1
Cultural modifications	Existing modifications consist of Crow Butte Project facilities.	5
Total Score		**14**

2.4.3 References

U.S.D.I. Bureau of Land Management (BLM). 1986. Visual Resource Inventory. BLM Manual Handbook 8410-1.

Table 2.9-9 Baseline Surface Water Quality Parameters	
Physical Indicators	
Specific Conductivity	Temperature
Alkalinity (as $CaCO_3$)	pH
Total Dissolved Solids	Total Suspended Solids
Conductivity	
Common Constituents	
Ammonia – N	Chloride
Silica	Magnesium
Sodium	Calcium
Nitrate – N	Carbonate
Nitrite – N	Bicarbonate
Potassium	Sulfate
Trace and Minor Elements	
Aluminum	Lead
Arsenic	Manganese
Barium	Mercury
Boron	Molybdenum
Cadmium	Nickel
Chromium	Selenium
Cobalt	Vanadium
Copper	Zinc
Fluoride	
Iron	
Radionuclides	
Radium-226	Uranium

Squaw Creek passes through the License Area as it flows towards the White River. Four sampling points located on Squaw Creek were utilized. Locations W-1, W-2 and W-3 on the White River were also part of the commercial preoperational monitoring program.

The stream and river samples were also analyzed for suspended sediment content. Sampling was initiated in 1982 and samples were taken from sites S-1, S-2, S-3 and W-2 (White River) for four quarters in 1982. Sampling continued at sites S-2 and S-3 from 1982 through 1987. Results of the suspended sediment sampling are found in **Table 2.9-10**. Average Squaw Creek suspended sediment ranges from 5.6 to 29.1 mg/L with site S-3 consistently higher in suspended sediments than sites S-1 and S-2.

Table 2.9-10: Suspended Sediment in Flowing Waters of Squaw Creek and White River

	Time Period	Range	Average	Std. Dev.
S-1	1982	5-36	13.5	15.1
S-2	1982 - 1987	<1-24	5.6	5.6
S-3	1982 - 1987	2.7-76	29.1	24.4
W-2	1982	7-190	73.8	80.0

Notes: Results given as Total Suspended Solids in mg/L.

The White River suspended sediment was an average of 74 mg/L for the year period.

Eight impoundments are located within the CSA; I-1 through I-8. Samples were collected and handled in the same manner as described above. Sampling sites were also used for obtaining sediment material for radiometric determinations discussed in **Section 2.7**.

Total suspended solids measurements have not been collected since 1982 and there are no plans to sample in the future.

2.9.5 Stream Flow

Squaw Creek flows through the Crow Butte License Area from east to northwest. The flow rate of this perennial stream was monitored at two locations according to the schedule given in **Table 2.9-1**. In addition, discharge rates of the Squaw Creek above the License Area and the White River were monitored.

Flow was determined using a water current meter. This instrument operated utilizing a propeller driven photo-optical device to measure water velocity. It is a broad range, low threshold instrument. Measurement range is 0-6.1 m/sec (0-20 ft/sec) with an accuracy of ± 1 percent.

Flow rates were determined as follows. First the height of the water at the deepest point and width of water were measured and drawn on the cross-section. Next, the numbers of flow measurements to be taken were determined. If the stream width was less than one meter, then one measurement was taken at a point 0.5 times the width. The depth of measurement was 0.6 times the depth, down from the surface. If the width was greater

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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.

3.1.2.4 Well Integrity Testing

Field-testing of all (i.e., injection, production, and monitor) wells is performed to demonstrate the mechanical integrity of the well casing. This mechanical integrity test (MIT) is performed using pressure-packer tests. Every well will be tested after well construction is completed before it can be placed in service, after any workover with a drill rig or servicing with equipment or procedures that could damage the well casing, at least once every five years, and whenever there is any question of casing integrity. To assure the accuracy of the integrity tests, periodic comparisons are made between the field pressure gauges and a calibrated test gauge. The MIT procedures have been approved by the NDEQ and are currently contained in the Safety Health Environment and Quality (SHEQ) Program Volume III, *Operating Manual.*

The following general 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 twenty minutes.
- If more than ten percent of the pressure is lost during this time period, the well has failed the integrity test. When possible, a well that fails the integrity testing will be repaired and the testing repeated. If the casing leakage cannot be repaired or corrected, the well is plugged and reclaimed as described in **Section 6.0**.

CBR submits all integrity testing records to the NDEQ 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 **Wellfield Design and Operation**

The Crow Butte Mine Unit map, which shows the layout of the mine units and water well withdrawal points, is depicted in **Figure 3.1-4**. The mine schedule is shown in **Figure 1.7-2. Table 3.1-1** shows the history of mining operations to date.

The cell dimensions vary depending on the formation and the characteristics of the ore body. The injection wells in a normal pattern are expected to be 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 monitor well ring, after pretreatment and prior to recirculation (if conducted) and 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." The minimum bleed rate will be 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 recirculation (if conducted) or stability monitoring described in Section 6.1.5 begins.

Monitor wells will be placed in the Chadron Formation and in the first significant water-bearing Brule sand above the Chadron Formation. All monitor wells will be completed by one of the three methods discussed above and developed prior to leach solution injection. The development process for monitor wells includes establishing baseline water quality before the initiation of mining operations.

Injection of solutions for mining will be at a rate of 9,000 gpm with a 0.5 percent to 1.0 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 leak tested and buried prior to production operations.

A water balance for the current CBR Facility is shown on **Figure 3.1-6.** The liquid waste generated at the plant site will be 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 would be 47,304,000 gallons per year. CBR adequately handles the liquid waste through the combination of deep disposal well injection and evaporation ponds.

Figure 3.1-5: Typical Wellfield Layout

An Industrial Groundwater Use Permit application was submitted to NDEQ by Ferret of Nebraska, Inc. (predecessor to CBR) in 1991. The application states that water levels in the City of Crawford (approximately three miles northwest of the mining area) could potentially be impacted by approximately 20 feet by consumptive withdrawal of water from the Basal Chadron Sandstone during mining and restoration operations (based on a 20-year operational period). No impact to other users of groundwater is expected because (1) there is no documented existing use of the Basal Chadron in the CBR License Area, and (2) the potentiometric head of the Basal Chadron Sandstone in the CBR License Area ranges from approximately 10 to more than 50 feet above ground surface.

Because the Basal Chadron Sandstone (production zone) is a deep confined aquifer, surface water impacts are expected to be minimal. A detailed analysis of potential surface water impacts is provided in **Section 7.4**.

Further, the geologic and hydrologic data presented in **Sections 2.6** and **2.7**, respectively, demonstrate that (1) the occurrence of uranium mineralization is limited to the Basal Chadron Sandstone, and (2) the Basal Chadron is isolated from underlying and overlying sands. Hence, the mining operations are expected to impact water quality only in the Basal Chadron Sandstone, and restoration operations will be conducted in the Basal Chadron following completion of mining. Groundwater is expected because (1) there is no documented existing use of the Basal Chadron in the License Area, and (2) the potentiometric head of the Basal Chadron Sandstone within the License Area ranges from approximately 10 to more than 50 feet below ground surface.

Based on a bleed of 0.5 percent to 1.5 percent which has been successfully applied in the current Licensed Area, the potential impact from consumptive use of groundwater is expected to be minimal. In this regard, the vast majority (e.g., on the order of 99 percent) of groundwater used in the mining process will be treated and re-injected (**Figure 3.1-6**). Potential impacts on groundwater quality due to consumptive use outside the License Area are expected to be negligible.

To generally quantify the potential impact of drawdown due to mining and restoration operations, the following assumptions were used:

- Mining/restoration life: 20 years
- Average net consumptive use: 112 gpm
- Location of pumping centroid: Center of Section 19
- Observation radius: 3.4 miles radially from centroid of pumping
- Formation transmissivity: 330 ft^2/d
- Formation thickness: 40 ft
- Formation hydraulic conductivity: 9.0 ft/d
- Formation storativity: 9.0×10^{-5}

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

- The aquifer is confined and has apparent infinite extent;
- The aquifer is homogeneous and isotropic, and of uniform effective thickness over the area influenced by pumping;
- The piezometric surface is horizontal prior to pumping;
- The well is pumped at a constant rate;
- No recharge to the aquifer occurs;
- The pumping well is fully penetrating; and,
- Well diameter is small, so well storage is negligible.

As discussed in **Section 5.8.8** of this application, an extensive water-sampling program will 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.

The groundwater monitoring program will continue to be 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 will include sampling of monitoring wells and private wells within and surrounding the License Area to establish pre-mining baseline water quality. Water quality sampling will be continued throughout the operational phase of mining for detection of excursions. Water quality sampling will also be 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 will continue to be to detect and correct conditions that could lead to an excursion of lixiviant or detect such an excursion, should one occur. The techniques employed to achieve this objective include monitoring of production and injection rates and volumes, wellhead pressure, water levels and water quality.

Monitoring of production (extraction) and injection rates and volumes enable an accurate assessment of water balance for the wellfields. A bleed system results in less leach solution being injected than the total volume of fluids (leach solution and native groundwater) being extracted. A bleed of 0.5 percent to 1.5 percent is maintained during production. Maintenance of the bleed will cause an inflow of groundwater into the production area and prevent loss of leach solution.

Injection pressures are monitored in the wellhouse at the manifold with an audible and visible alarm monitored 24 hours per day, 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 125psi integrity test pressure. Due to line losses, pressures at the wellheads remain below that which is monitored at wellhouse manifold.

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

Water level measurements will continue to be 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 would be 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 shut down 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 leach 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 5.8.8**.

3.1.4 Process Description

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

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

Oxidation: $UO_{2\,(solid)} + H_2O_{2\,(in\ solution)} \rightarrow UO_{3\,(at\ solid\ surface)} + H_2O$

$UO_{2\,(solid)} + \frac{1}{2}\,O_{2\,(in\ solution)} \rightarrow UO_{3\,(at\ solid\ surface)}$

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

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

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.

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:

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

The process flow sheet for the above steps is shown in **Figure 3.1-7**.

3.1.4.1 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:

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

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

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

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

3.2.2 Chemical Storage Facilities

Chemical storage facilities at the CBR Facility 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.

3.2.2.1 Process Related Chemicals

Process-related chemicals stored in bulk at the CBR Facility 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 material safety data sheets (MSDSs) for each of the process-related chemicals onsite, and these sheets are available upon request.

- **Carbon Dioxide** - Carbon dioxide is stored at the CBR Facility where it is added to the lixiviant. Carbon dioxide 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 (50% aqueous solution) is stored at the CBR Facility where it is added to the lixiviant. It serves as an oxidant used during the precipitation phase of uranium and can be used in place of oxygen. This phase of the process is described in Section 3.1.4.3. 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 is also typically stored at the plant, 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 CBR plant 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).

The design locations of the carbon dioxide and oxygen storage tanks are shown on **Figure 3.2-1**.

- **Sodium Hydroxide** – Sodium hydroxide is used at the CBR Facility for pH adjustment during the uranium precipitation phase. The sodium hydroxide raises the pH to a level conducive for precipitating pure crystals. This phase of the process is described in Section 3.1.4.3. 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 at the CBR Facility. The HCl acidifies the pregnant eluant in order to destroy the uranyl carbonate complex ion. 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 in 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 Central Plant (**Figure 3.2-1**) 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 Central Plant where HCl is added to the precipitation circuit. Since precipitation is not performed at CBR satellite

3.3 INSTRUMENTATION AND CONTROL

The basic control system at the Crow Butte site is built around an Allen-Bradley SCADA (Sequential Control and Data Acquisition) 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 control room 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 exceedences, flow disruptions and the presence of liquids in the well houses..

The Allen-Bradley 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 suppy systems with 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 Crow Butte 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 plant, the total injection flow leaving the plant, and the total waste flow leaving the plant. Instrumentation is provided on the plant 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, overpressuring 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 CBR facility. Specifications for this equipment are included in CBR's SHEQMS*Program Volume IV, Health Physics Manual,* and are discussed in further detail in Section 5. The location of monitoring points, monitoring procedures, and monitoring frequencies for in-plant radiation safety is also discussed in Section 5.

The types of health physics instrumentation that are used at the existing CBR facility include the following:

Air Sampling Equipment

- Eberline RAS-1 or Aircon 2 samplers (0-100 liters per minute (lpm) or equivalent

  Calibrated semiannually or after repair-on site with a primary standard instrument or a properly calibrated secondary standard instrument

- BDX II or SKC lapel samplers (0-5 lpm) or equivalent

  Calibrated daily before each use-on site with a primary standard instrument or a properly calibrated secondary standard instrument

External Radiation Equipment

- Ludlum Model 19 Gamma Meter (μR/hr) or equivalent
- Ludlum Model 3 Gamma Meter with Ludlum Model 44-38 G-M detector (mR/hr) or equivalent
- Ludlum Model 2221 Ratemeter/Scaler with a Ludlum Model 44-10 NaI detector (counts per minute [cpm]) or equivalent

  Calibrated annually or after repair-manufacturer or qualified accredited vendor

Surface Contamination Equipment

- Ludlum Model 2241 scaler or a Ludlum Model 12 Ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe or equivalent (Total Alpha)
- Ludlum Model 177 Ratemeter with a Ludlum Model 43-5 alpha scintillation probe or equivalent (Personnel Contamination)
- Ludlum Model 2000 Scaler or Model 2200 Scaler with an Eberline SAC-R5 or Ludlum Model 43-10 alpha scintillation sample counter or equivalent (Removable Alpha, Radon Daughters, Airborne Radioactivity)

Instruments are calibrated annually or at a frequency recommended by the manufacturer, whichever is more frequent. Repairs are by the manufacturer or by a qualified accredited vendor, and the instrument is calibrated following such repair. The calibration vendor provides the as-found calibration condition of each instrument. If greater than 10% of the instruments are out of calibration when received by the calibration vendor, consideration is given to increasing the calibration frequency.

The manufacturer or a qualified accredited vendor calibrates portable survey instruments, counter/scalers, mass flow meters and/or dry cell calibrators, and calibration sources. Calibration is performed as recommended in ANSI N323 and ANSI N323A. The ANSI

standard requires that radiation detection instruments are performance tested on an annual basis to verify that they continue to meet operational and design requirements. Instruments must be tested for range, sensitivity, linearity, detection limit, and response to overload. The specific calibration requirements for various types of instruments are discussed in CBR's SHEQMS Program *Volume IV, Health Physics Manual.*

Regulatory Guide 8.30 specifies requirements for routine maintenance and calibration of radiological survey instruments. Regulatory Guide 8.30 references the standards contained in ANSI N323-1978, *Radiation Protection Instrumentation Test and Calibration.* ANSI is in the process of a major revision of this Standard that will result in three separate Standards that apply to radiological instrumentation. The first revision, ANSI-N323A-1997, *Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments*, was incorporated in this Chapter. When conflicts arise between NRC Regulatory Guide 8.30 and the ANSI Standard, the Regulatory Guide recommendations are followed.

Calibration vendors provide a certificate of calibration for all instruments. These calibration certificates are maintained by the RSO on file for that instrument. Records of repair completed by the calibration vendor are also maintained in the instrument file.

Documentation of calibration of air samplers performed on site are be maintained. This documentation is maintained by the RSO in the sampler file.

Record of instrument checks, including the daily checks and initial checks, will be maintained in a format determined by the RSO. These records will be readily available and provided in a format that will allow the RSO to review the records for the types of potential problems (e.g., background drift in a continuous direction, battery check that does not respond, ratemeter that does not zero and alpha background rates greater than 0.5 cpm).

All records of instrument calibration and checks will be retained until NRC License termination. The RSO will be responsible for record retention.

Details as to calibration, functional tests, procedures and recordkeeping/retention are discussed in CBR's SHEQMS Program *Volume IV, Health Physics Manual.*

Contract Laboratory Quality Control

CBR's radiological quality assurance program is discussed in Section 2.9 of the SHEQMS Program *Volume IV, Health Physics Manual.* Quality control efforts are implemented to ensure that radiological data provided by contract laboratories are accurate and reliable. CBR conducts periodic audits of its QA/QC program as it relates to the health physics program; these audits are reviewed by facility and corporate management.

One purpose of the quality control program is to determine the precision and accuracy of the monitoring processes. Quality control sampling includes replicate samples to determine precision, spiked samples with a known concentration to determine accuracy, and blank samples to detect and measure contamination of analytical samples. NRC Regulatory Guide 4.15, *Quality Assurance for Radioloigcal Monitoring Programs (Normal Operations) – Effluent Streams and the Environment*, describes requirements for these types of quality control samples. Generally, NRC recommends that 5 to 10% of the analytical load at an environmental laboratory should be quality control samples. The contract laboratory quality assurance program is required to describe the program implemented to meet these requirements. Each qualified laboratory is required to have an acceptable QA/QC program in place. The Manager of Health Safety and Environmental Affairs or designee reviews the vendors QA/QC program and is responsible for approving the use of the vendor. Qualified laboratories are required to submit verification of an appropriate NRC License and certification(s) to meet NRC requirements.

3.3.1 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.*

National Fire Protection Association (NFPA). 1996. NFPA-50, *Standard for Bulk Oxygen Systems at Consumer Sites.*

Liquid process waste

The operation of the process plant results in two primary sources of liquid waste, an eluant bleed and a production bleed. These bleeds are routed to either the deep disposal well or an evaporation pond.

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, 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 Crow Butte, it is anticipated that during restoration, groundwater will be treated using ion exchange (IX) and reverse osmosis (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. Reverse osmosis will be used to reduce the total dissolved solids (TDS) 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.

4.2.1.2 Secondary Water Sources

Stormwater Runoff

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.

Stormwater management is controlled under permits issued by the NDEQ. CBR is subject to stormwater National Pollutant Discharge Elimination System (NPDES) permitting requirements for industrial facilities and construction activities. The NDEQ NPDES regulatory program contained in Title 119 (NDEQ 2005) requires that procedural and engineering controls be implemented such that runoff will not pose a potential source of pollution.

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. These systems are in common use throughout the United States and the effect of the system on the environment is known to be minimal when the systems are designed, maintained, and operated properly. CBR currently maintains a Class V UIC Permit issued by the NDEQ for operation of the septic system at the current License Area.

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 deep disposal well.

4.2.1.3 Liquid Waste Disposal

Two methods of disposal are used for the Crow Butte Central Plant:

- Deep disposal well injection; and
- Evaporation via evaporation ponds.

Deep Disposal Well Injection

CBR currently operates two non-hazardous Class I injection well in the current license area for disposal of wastewater under Permits #NE0206369 and #NE0210825 (Well #1 and Well #2 respectively . The wells are permitted under NDEQ regulations in Title 122 (NDEQ 2002) and operated under a Class I UIC Permit. The permits for both wells allow unlimited flow and a maximum operating pressure of 650psi. To preserve optimum performance, Well #1 has typically been operated at up to 40 psi with a 200 gpm flow.

CBR has operated Well #1 at the current license area for over ten years with excellent results and no serious compliance issues. Well #2 was incorporated into the license by action of the CBR Safety and Environmental Review Panel on November 18, 2011, CBR has found that permanent deep disposal is preferable to evaporation in evaporation ponds.

Evaporation Pond

Evaporation pond design, installation and operation criteria are those found in USNRC Regulatory Guide 3.11 (USNRC 1977). CBR maintains three commercial and two R&D evaporation ponds in the current License Area. 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 USNRC recommendations in Regulatory Guide 3.11.1 (USNRC 1980) and is approved in 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 USNRC.

- 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 percent 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., USNRC and NDEQ) 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 seven days during the leak period, and once every seven days for at least two weeks following repairs.

4.2.1.4 Potential Pollution Events Involving Liquid Waste

Although there are a number of potential sources of pollution present at the Crow Butte facility, existing regulatory requirements from the USNRC and NDEQ, and provisions of the CBR SHEQMS, have established a framework that significantly reduces the possibility of such an occurrence. Extensive training of all personnel is standard policy at the CBR facility. Frequent inspections of waste management facilities and systems are conducted. Detailed procedures are included in the CBR SHEQMS Program.

There are primarily six potential sources of pollution at the Crow Butte Project.

- Solar Evaporation Ponds
- Wellfield Buildings and Piping
- Process Building
- Piping
- Transportation Vehicles
- Spills

Solar Evaporation Ponds

The solar evaporation ponds could contribute to a pollution problem in several ways. First, a pond could fail, either in a catastrophic fashion or as a result of a slow leak. In addition, a pond could overflow due to excess production or restoration flow, as well as due to the addition of rainwater.

With respect to a pond failure, all ponds have been built to USNRC standards, and are equipped with leak detection systems. SOPs require a periodic inspection of all ponds, liners, and berms. In the event of a leak, the contents of the pond can be transferred to another pond while repairs are made.

With respect to pond overflow, operating procedures are such that no individual pond is allowed to fill to a point where overflow is considered a realistic possibility. The flow rate of liquids to the ponds is minimal, thus there is ample time to reroute the flow to another pond. Regarding the addition of rainwater, the freeboards of ponds considered "full" are sufficient to contain the addition of significant quantities of rainwater before an overflow would occur. The inclusion of the freeboard allowance also precludes over-washing of the walls during high winds.

Wellfield Buildings and Piping

Wellfield buildings are not considered to be a potential source of pollutants during normal operations, as there are no process chemicals or effluents stored within them. The only instance in which a wellfield building could contribute to pollution would be in the event of a release of injection or recovery solutions due to pipe failure. The possibility of such an occurrence is considered to be minimal, as the piping is leak checked before it is initially placed into service. Piping from the wellfields is generally buried, minimizing the possibility of an accident. In addition, the flows through the piping and manifold pressure gauges in the wellhouses are monitored twenty four hours per day, seven days per week by control room operators using visual and audible alarms. . Flow monitoring provides alarms in the event of a significant piping failure which allow flow to be stopped, preventing any significant migration of process fluids. Wellfield buildings also are equipped with wet alarms for early detection of leaks.

Process Building

The process building serves a central hub for most of the mining operations, thus has the greatest potential for spills or accidents resulting in the release of potential pollutants. Spills could result due to a release of process chemicals from bulk storage tanks, piping failure, or a process storage tank failure.

The design of the building is such that any release of liquid waste would be contained within the structure. A concrete curb is built around the entire process building. This pad has been designed to contain the contents of the largest tank within the building in the event of a rupture. In the event of a piping failure, the pump system can be immediately shut down, limiting any release. Liquid inside the building, either from a spill or from washdown water, is drained through a sump and sent to the evaporation ponds.

Piping

As previously discussed, all piping is leak checked prior to operation. Piping from the wellfields is generally buried, minimizing the possibility of an accident. Large leaks in the pipe would quickly become apparent to the plant operators due to a decrease in flow and pressure, thus any release could be mitigated rapidly.

Transportation vehicles

The release of pollutants to the environment could occur due to accidents involving transportation vehicles. This could involve either vehicles delivering bulk chemical products, transport of radioactive contaminated waste from the site to an approved disposal site, or from vehicles carrying yellowcake slurry or dried yellowcake.

All chemicals and products delivered to or transported from the site are carried in DOT approved packaging. In the event of an accident, procedures are currently in place in the SHEQMS Program Volume VIII, *Emergency Manual*, to insure a rapid response to the situation.

Spills can take two forms within an ISL facility; surface spills such as pond leaks, piping ruptures etc., and subsurface releases such as a well excursion, in which process chemicals migrate beyond the wellfield, or a pond liner leak resulting in a release of waste solutions.

Engineering and administrative controls are in place to prevent when possible both surface and subsurface releases to the environment, and to mitigate the effects should an accident occur.

Spills

Spills can take two forms within an in-situ facility. These are surface spills (such as pond leaks, piping ruptures etc.) and subsurface releases such as a well casing failure, or a pond liner leak resulting in a release of waste solutions.

Engineering and administrative controls are in place at the Central Plant to prevent both surface and subsurface releases to the environment, and to mitigate the effects should an accident occur. The most common form of surface release from in-situ mining operations occurs from breaks, leaks, or separations within the piping that transfers mining fluids from the process plant to the wellfield and back. With the current CBR monitoring system, these are generally small releases and are quickly discovered and mitigated.

In general, piping from the plant, to and within the wellfield is constructed of PVC, high-density polyethylene pipe (HDPE) with butt-welded joints or equivalent. All pipelines are pressure tested prior to final operation. It is unlikely that a break would occur in a buried section of line because no additional stress is placed on the pipes. n addition, underground pipelines are protected from a major cause of potential failure, which is vehicles driving over the lines causing breaks. Typically, the only exposed pipes are at the process plant, the wellheads and in the control house in the wellfield. Trunkline flows and manifold pressures are monitored each shift for process control.

4.2.2 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 site 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 11(e).2 byproduct materials.

4.2.2.1 Non-contaminated Solid Waste

Non-contaminated solid waste is waste which is not contaminated with 11(e).2 byproduct material or which can be decontaminated and re-classified as non-contaminated waste. This type of waste may include 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 **Section 5**.

CBR has recently estimated that the current licensed site produces approximately 1,055 cubic yards (yd^3) of non-contaminated solid waste per year. This estimate is based on the number of collection containers on site and the experience of the contract waste hauler. Non-contaminated solid waste is collected on the site in designated areas and disposed of in the nearest permitted sanitary landfill.

4.2.2.2 11(e).2 Byproduct Material

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

11(e).2 byproduct material generated at ISL facilities consists of filters, Personal Protective Equipment (PPE), spent resin, piping, etc. CBR has recently estimated that the current licensed site produces approximately 60 to 90 yd^3 of 11(e).2 byproduct material waste per year. This estimate is based on the historical number of shipments to the licensed disposal facilities. These materials are stored on site until such time that a full shipment can be sent to a licensed waste disposal site or licensed mill tailings facility. CBR currently maintains an agreement for waste disposal at a properly licensed facility as a License Condition requirement for SUA-1534. CBR is required to notify USNRC in writing within 7 days if the disposal agreement expires or is terminated, and to submit a new agreement for USNRC approval within 90 days of the 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 USNRC guidance (USNRC 1987). An area is maintained inside the restricted area boundary for storage of contaminated materials prior to their disposal.

4.2.2.3 Septic System Solid 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. Disposal of solid materials collected in septic systems must be performed by companies or individuals licensed by the State of Nebraska. NDEQ regulations for control of these systems are contained in Title 124 (USNRC 2005).

4.2.2.4 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 (NDEQ 2007). Based on waste determinations conducted by CBR as required in Title 128, CBR is a Conditionally Exempt Small Quantity Generator (CESQG). To date CBR only generates universal hazardous wastes such as used waste oil and batteries. CBR recently estimated that the current operation generates approximately 1,325 liters of waste oil per year. Waste oil is disposed of by a licensed waste oil recycler. CBR has management procedures in place in SHEQMS Program Volume VI, *Environmental Manual,* to control and manage these types of wastes.

5 OPERATIONS

CBR operates a commercial-scale in-situ leach uranium mine (the Crow Butte Project) near Crawford, Nebraska. CBR maintains a headquarters in Denver, Colorado where site-licensing actions originate. 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/ADMINISTRATIVE PROCEDURES

CBR will maintain a performance-based approach to the management of the environment and employee health and safety, including radiation safety. The 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 will allow CBR to operate efficiently and maintain an effective environment, health and safety program.

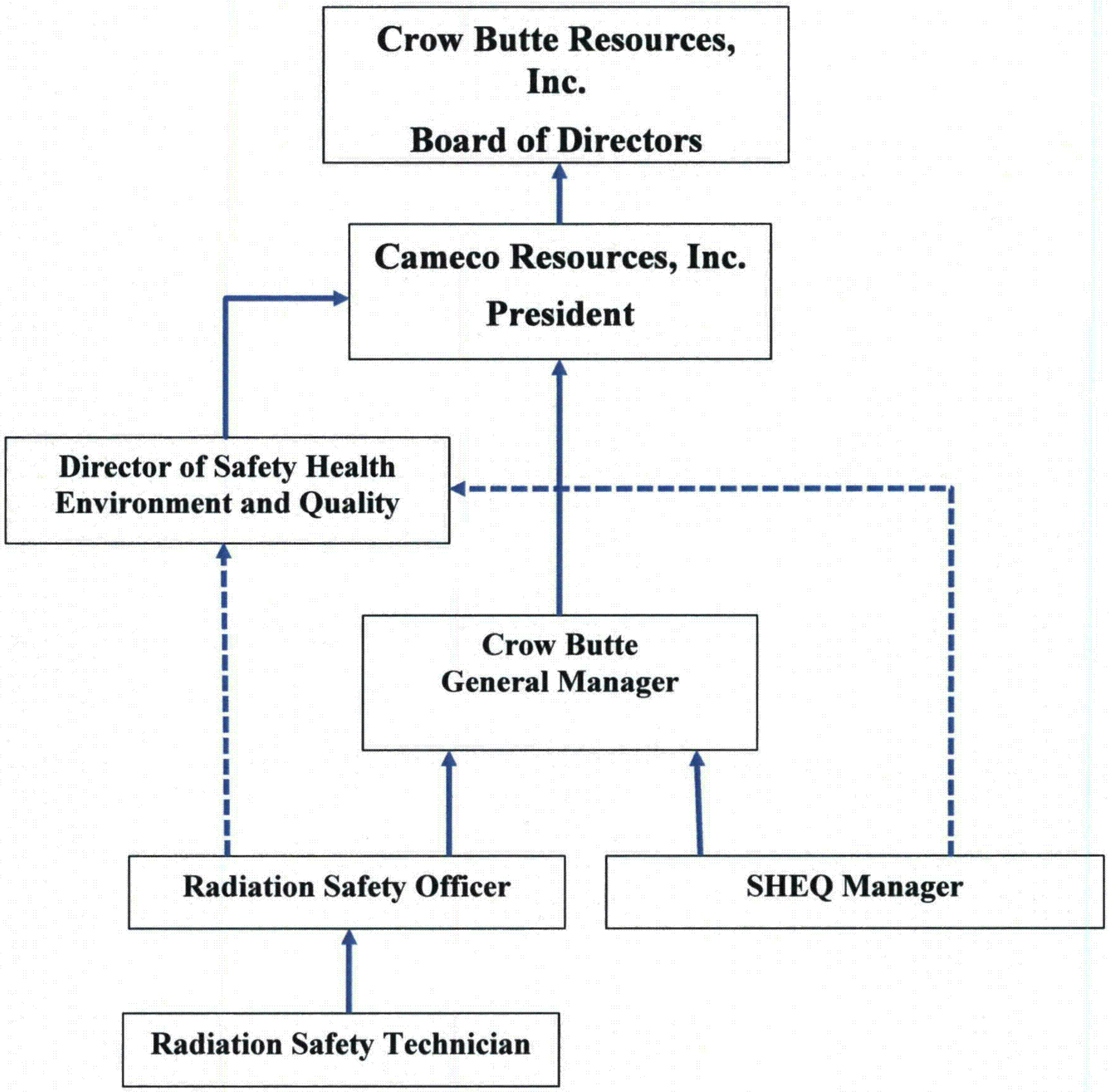
Figure 5.1-1 is a partial organization chart for CBR with respect to the operation of the CPF and associated operations and represents the management levels that play a key part in the SHEQMS that will also apply to the satellite facility. The personnel identified are responsible for the development, 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 Safety and Environmental Review Panel (SERP) described under Section 5.3.3.

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.

Figure 5.1-1: Crow Butte Resources Organizational Chart



5.1.2 President

The President of Crow Butte Resources, Inc. is responsible for interpreting and acting upon the Board of Directors policy and procedural decisions. The President directly supervises General Manager of Operations. The President is empowered by the Board of Directors to have the responsibility and authority for the radiation safety and environmental compliance programs at the Crow Butte facility. The President is responsible for ensuring that CBR operations staff comply with all applicable regulations and permit/license conditions through direct supervision of the General Manager of Operations. The President has overall responsibility for approving the facility design including radiological controls (e.g., ventilation systems), and the manner in which the RSO is integrated into this process.

5.1.3 General Manager

The General Manager of Nebraska operations is responsible for all uranium production activities. The General Manager is also responsible for implementing any industrial and radiation safety and environmental protection programs associated with operations. The General Manager is authorized to immediately implement any action to correct or prevent hazards. The General 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 General Manager cannot unilaterally override a decision for suspension, postponement or modification if that decision is made by the Safety Health Environment and Quality Manager (SHEQ Manager) or the RSO. The General Manager reports directly to the President .

5.1.4 Director of Safety Health Environment and Quality

The Director of Safety Health Environment and Quality reports directly to the President and is responsible for ensuring that personnel comply with industrial safety, radiation safety, environmental and quality programs as required by NRC regulations and established in the Cameco program. The Director of SHEQ has the responsibility and authority to terminate immediately any activity that is determined to be a threat to employees or public health, the environment, or potentially a violation of state or federal regulations as indicated in reports from the RSO. The Director of SHEQ may also serve as Corporate Radiation Safety Officer (CRSO) and if doing so, shall meet the RSO qualifications described in Section 5.1.6.

5.1.5 Safety Health Environment and Quality Manager

The Manager of SHEQ is responsible for health and safety, and environmental programs as stated in the SHEQMS and for ensuring that CBR complies with all applicable regulatory requirements. The manager is located at the offices of site operations. This manager is responsible for the drafting, approving and updating SHEQMS procedures on an annual basis. The SHEQ Manager reports directly to the General Manager to ensure that the environmental monitoring and protection programs are conducted in a manner consistent with regulatory requirements. This position assists in the development and review of environmental sampling and analysis procedures and is responsible for routine auditing of the programs. The SHEQ Manager 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. As such the Manager of SHEQ has a secondary reporting requirement to the Director of SHEQ. The Manager of SHEQ has no production-related

5.1.6 Radiation Safety Officer

Reporting directly to the General Manager of Operations and secondarily to the Director of SHEQ, The CBR 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 review and approve new equipment and changes in processes and procedures that may affect radiological safety and 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 recommends improvements to any and all radiological safety-related controls. The RSO has no production-related responsibilities. The RSO reports directly to the Manager of Health, Safety, and Environmental Affairs.

5.1.7 Health Physics Technician

The CBR Health Physics Technician (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.

5.1.8 Safety Supervisor

The CBR Safety Supervisor is responsible for the non-radiation-related health and safety programs. The Safety Supervisor is authorized to conduct inspections and to immediately order any change necessary to preclude or eliminate safety hazards and/or maintain regulatory compliance. The Safety Supervisor's 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 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 reports directly to the Manager of Health, Safety, and Environmental Affairs.

5.2 ALARA POLICY

The purpose of the ALARA (As Low As Reasonably Achievable) Policy is to keep exposures to all radioactive materials and other hazardous material as low as 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.

5.2.1 Management Responsibilities

Consistent with Regulatory Guide 8.31 *Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Reasonably Achievable* (Revision 1, May 2002), 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.

5.2.2 Radiation Safety Officer Responsibility

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 5.4.3** 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.

5.2.3 Supervisor Responsibility

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.

5.2.4 Worker Responsibility

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 as low as possible. Worker responsibilities include:

- Adherence to all rules, notices, and operating procedures as established by management and the RSO through the SHEQMS Program;

- 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.

5.3 MANAGEMENT CONTROL PROGRAM

5.3.1 Environmental, Health, and Safety 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 assuring 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 Environmental, Health, and Safety (EH&S) Policy and regulatory requirements.

The CBR SHEQMS Program:

- Assures 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.

5.3.1.1 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. 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. A copy of the written procedure will be kept in the area where it is used. 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.

5.3.1.2 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

pertinent radiation survey records, a discussion of any trends in the ALARA program, and a review of adequacy of the implementation of the USNRC license conditions. Recommendations are made for any corrective actions or improvements in the process or safety programs.

5.4.2 Evaporation Pond Inspections

The inspection program developed by CBR for use on the ponds in the current production area is contained in SHEQMS Program Volume VI, *Environmental Manual* and is based on the guidance in USNRC Regulatory Guide 3.11.1. The inspection program is summarized below.

5.4.2.1 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 a concentration of seepage.

5.4.2.2 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.

5.4.2.3 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.

5.4.2.4 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 will be conducted annually. A survey of the pond embankments will be 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 will be 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 will also be reviewed for signs of seepage in the embankments.

The inspection report will present the results of the technical evaluation and the analysis of inspection data collected since the last report. The report will be kept on file at the site for review by regulatory agencies. A copy is also submitted to the USNRC within 1 month of the annual inspection.

5.4.3 **Annual ALARA Audits**

CBR will conduct annual audits of the radiation safety and ALARA programs. The Manager of Health, Safety, and Environmental Affairs may conduct these audits. Alternatively, CBR may use 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 provide assurance that all radiation health protection procedures and license condition requirements are being conducted properly at the Crow Butte Project facility. Any outside personnel used 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 minimum qualifications for education and experience 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 USNRC Regulatory Guide 8.31. A written report of the results is submitted to corporate management. The RSO may accompany the auditor but may not contribute to the conclusions.

The annual ALARA audit report summarizes the following data:

- Employee exposure records;
- Bioassay results,
- Inspection log entries and summary reports of mine and process inspections,
- Documented training program activities,
- Applicable safety meeting reports,
- Radiological survey and sampling data,
- Reports on any overexposure of workers, and
- Operating procedures that were reviewed during this period.

The ALARA audit report specifically discusses the following:

- Trends in personnel exposures;
- Proper use, maintenance, and inspection of equipment used for exposure control; and
- Recommendations on ways to further reduce personnel exposures from uranium and its daughters.

The ALARA audit report is submitted to and reviewed by the CBR President and Mine Manager. Implementation of the recommendations to further reduce employee exposures, or improvements to the ALARA program, is discussed with the ALARA auditor.

An annual audit of the Quality Assurance/Quality Control (QA/QC) program is also conducted. An individual qualified in analytical and monitoring techniques who does not have direct responsibilities in the areas being audited performs the audit. The results of the QA/QC audit are documented with the ALARA Audit. The RSO has the primary responsibility for the implementation of the radiological QA/QC programs at the Crow Butte Project facilities.

5.4.4 **Records Management**

Detailed discussions of recordkeeping policies, responsibilities and procedures are maintained in CBR's SHEQMS Program Volume II, Management Procedures Manual. Key components of the recordkeeping retention policies are discussed below.

<u>Determination of Records to be Maintained</u>

Records that are maintained as part of the CBR's records retention policy are identified by utilizing the following sources of information:

- Records and maintenance periods established by regulations (e.g., 10 CFR 20 and 10 CFR 40);
- Records and maintenance periods established by license or permit requirements;
- Records established by industry and international standards (e.g., ISO-14001:2004); and
- Records established by Company policies.

Records that are deemed critical to records retention includes, but is not limited to:

- Decision on communication of significant environmental aspects*;
- Record of changes to documented procedures resulting from corrective action*;
- External communication records*;
- Environmental Management System (EMS) audit records*;
- EMS management review records*;
- Records of calibration and maintenance of monitoring equipment*;
- Training records*;
- Information on applicable laws or other requirements;
- Process monitoring information, where it has a bearing on environmental, health and safety aspects, impacts, or operational controls;
- Monitoring data;
- Change management records;
- Nonconformance and incident reports;
- Information on emergency response situations; and
- Product information, including lists and composition of products (i.e. MSDS's).

* required by the ISO 14001:2004 and OHSAS-18001:1999 standards

Records are classified as permanent and non-permanent for purposes of retention timelines:

- Permanent records are maintained for the life of the project, operation or facility. **All such records must be maintained until the NRC has terminated any license authorizing operations.** These records may be required to meet any of the following criteria:

    1. Records that are required to maintain and decommission a facility (e.g., operating history);
    2. Information which may be of value in determination of an accident, a malfunction, etc., (e.g., test results);
    3. Baseline data;
    4. Personnel medical records, including health physics data;
    5. Facility design documents;
    6. Monitoring data identified in State permits and NRC licenses.

- Non-permanent records are those that do not meet any of the above criteria but are required to provide evidence that an activity was performed according to the requirements. Examples of these types of records are certificates, inspection reports, operator qualifications, purchase orders, personnel qualifications, inspections and test plans, audits, etc.

CBR complies with the record retention requirements stated in 10 CFR 20 and 10 CFR 40. For example, this would include, but not limited to, requirements specified in 10 CFR 20.2102 (Records of radiation protection programs), 20.2103 (Records of surveys), 20.2104 (determination of prior occupational doses), 20.2105 (Any records of planned special exposures), 20.2106 (Records of individual monitoring results), 20.2107 (Records of dose to individual members of the public) and 20.2108 (Records of waste disposal). In addition records would be retained as specified in 10 CFR 40.61 (Records) for the receipt, transfer, and disposal of source or byproduct material as specified in this regulation. Record retention timelines typically vary from 3 years following the generation of the record or until termination of the license that authorizes the activity and associated record. For example, as per 10 CFR 20.2102, records of CBR's radiation protection program (including provisions of the program) shall be maintained until the NRC terminates the site's radioactive material license requiring the record, and records of audits and other reviews shall be maintained for 3 years after the record is made.

Where possible, site records are identified in the appropriate project implementing procedures. Retention time and personnel responsible for handling of the records are also identified. For instance, record retention times for radiological monitoring records required by the NRC License are identified in CBR's SHEQMS Program Volume IV, Health Physics Manual.

All records are required to be legible and traceable to the applicable activity, product or service. The form of records is maintained as per 10 CFR 20.2110.

<u>Record Storage</u>

Obsolete versions of some documents may be considered a record and will be retained in the SHEQMS Program records. An example would be history copies of previous revisions of implementing procedures and operating manuals.

Records are filed as to allow for prompt retrieval in accordance with the retention time criteria stipulated in CBR's Record Management Matrix.

Records are stored in an environment that minimizes damage or deterioration and/or loss. Backup copies of critical and permanent records are maintained in a separate location. Backup copies may be paper or electronic versions.

Records are retained for a minimum of three years unless otherwise specified in other documents or subject to longer record retention requirements specified in regulations such as 10 CFR 20 and 10 CFR 40.

Review of Recordkeeping Requirements

The format and contents of the records will be reviewed **at least annually** as part of the established review of the site programs and changes initiated will be reflected in the revisions to this procedure.

As additional EMS-related records (including new or revised regulatory requirements) are identified, they will be incorporated into this recordkeeping review procedure as part of continual improvement to this procedure.

5.6 TRAINING

All site employees and contractor personnel at the Crow Butte Project are administered a training program based on the SHEQMS Program covering radiation safety, radioactive material handling, and radiological emergency procedures. This training program is administered in keeping with standard radiological protection guidelines and the guidance provided in USNRC Regulatory Guide 8.29, *Instructions Concerning Risks From Occupational Radiation Exposure* (Revision 1, February 1996); Regulatory Guide 8.31, *Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Reasonably Achievable* (Revision 1, May 2002); and Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure* (Revision 3, June 1999). The content of the training program is under the direction of the RSO. The RSO or a qualified designee conducts all radiation safety training.

5.6.1 Training Program Content

5.6.1.1 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.

5.6.1.2 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 5.6.1.3**.

5.6.1.3 Crow Butte Resources Employees

The CBR SHEQMS Program Volume VII, *Training Manual*, incorporates the following topics recommended in USNRC Regulatory Guide 8.31, *Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Reasonably Achievable* (Revision 1, May 2002), USNRC Regulatory Guide 8.29, *Instruction Concerning Risks From Occupational Radiation Exposure (Revision 1, February 1996, and* USNRC Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure (Revision 3, June 1999)*:

Fundamentals of Health Protection

- The radiological and toxic hazards of exposure to uranium and its daughters.
- How uranium and its daughters enter the body (inhalation, ingestion, and skin penetration), and
- Why exposures to uranium and its daughters should be kept as low as reasonably achievable (ALARA).

Personal Hygiene at Uranium Mines

- Wearing protective clothing;
- Using respirators when appropriate;
- Eating, drinking, and smoking only in designated areas; and
- Using proper methods for decontamination.

Facility-provided Protection

- Cleanliness of working spaces,
- Safety designed features for process equipment,
- Ventilation systems and effluent controls,
- Standard Operating Procedures, and
- Security and access control to designated areas.

Health Protection Measurements

- Measurements of airborne radioactive material,
- Bioassay to detect uranium (urinalysis and in vivo counting),
- Surveys to detect contamination of personnel and equipment, and
- Personnel dosimetry.

Radiation Protection Regulations

- Regulatory authority of USNRC, MSHA, and state;
- Employee rights in 10 CFR Part 19; and
- Radiation protection requirements in 10 CFR Part 20.

Emergency Procedures

All new workers, including supervisors, are given specialized instruction on the health and safety aspects of the specific jobs they will perform. This instruction is performed in the form of individualized on-the-job training. Retraining is conducted annually and documented. Every 2 months, all workers attend a general safety meeting.

Consistent with USNRC Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure (Revision 3, June 1999),* all female workers and those supervisors who will work with them will be given specific instruction about prenatal exposure risks to the developing embryo and fetus.

5.6.2 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 worker understanding is achieved. Workers who fail the exam are retested, and test results remain on file.

5.6.3 On-The-Job Training

5.6.3.1 Health Physics Technician

On-the-job training is provided to HPTs in radiation exposure monitoring and exposure determination programs, instrument calibration, plant inspections, posting requirements, respirator programs, and health physics procedures contained in the SHEQMS Program Volume IV, *Health Physics Manual.*

5.6.4 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.

5.6.5 Training Records

Records of training are kept for 5 years for all employees trained as radiation workers (occupationally exposed employees).

5.7 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 USNRC 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 USNRC 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 material at the Crow Butte Project 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 ion exchange resin removed from the restricted area for transfer to other areas.

5.7.1 License Area and Plant Facility Security

5.7.1.1 Central Processing Facility Area

All Central Processing Facility 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 Central Processing facility. A 24-hour-per-day, 7-day-per-week staff is on duty in the Central Processing facility.

Central Plant operators perform an inspection 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

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.

5.8.1.3 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 facility 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; surface spills such as pond leaks, piping ruptures, transportation accidents, etc., and subsurface releases such as a well excursion, in which process chemicals migrate beyond the wellfield, or a pond liner leak resulting in a 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.

> **Surface Releases** - The most common form of surface release from in-situ mining operations occurs from breaks, leaks, or separations within the piping that transfers mining fluids between the process plant and the wellfield. These are generally small releases due to engineering controls that detect pressure changes in the piping systems and alert the plant operators through system alarms.
>
> In general, piping from the plant to and within the wellfield is constructed of PVC, high-density polyethylene pipe with butt-welded joints or 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 a major cause of potential failure - that of vehicles driving over the lines causing breaks. The only exposed pipes are at the process plant, the wellheads, at temporary transfer lines and in the control house in the wellfield. Trunkline flows and wellhead pressures are monitored each shift for process control. One section of underground piping that passes beneath Squaw Creek is double contained for additional protection. Spill response is specifically addressed in the Radiological Emergencies and Emergency Reporting chapters of SHEQMS Program Volume VIII, *Emergency Manual.*

CBR's spill control programs have been very effective at limiting surface releases from mining operations. CBR has never had a spill that was reportable under 10 CFR 20 reporting requirements. 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.

Transportation accidents - SHEQMS Program Volume VIII, *Emergency Manual* provides the CBR emergency action plan for responding to a transportation accident involving a radioactive materials shipment. The Emergency Manual provides instructions for proper packaging, documentation, driver emergency and accident response procedures, and cleanup and recovery actions. Spill response is also addressed in SHEQMS Program Volume VIII, *Emergency Manual.*

Sub-surface releases - 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 in-situ mining.

At the Crow Butte Project site, an undetected excursion is highly unlikely. All wellfields are surrounded by a ring of monitor wells located no further than 300 feet from the wellfield and screened in the ore-bearing Chadron aquifer. Additionally, monitor wells are placed in the first overlying aquifer above each wellfield segment. Sampling of these wells is done on a biweekly basis. Past experience at in-situ leach mining facilities has shown that this monitoring system is effective in detecting leachate 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 has plugged all exploration holes to prevent co-mingling of Brule and Chadron aquifers and to isolate the mineralized zone. Successful plugging was tested by conducting four hydrologic tests prior to mining. Results indicated that no leakage or communication exists between the mineralized zone and overlying aquifers. In addition, prior to placing

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 USNRC Regulatory Guide 8.30, *Health Physics Surveys in Uranium Recovery Facilities*, Section 1.4. Beta evaluations may be substituted for surveys using radiation survey instruments. Surveys or evaluations will be performed whenever a change in equipment or procedures has occurred that may significantly affect worker exposures.

5.8.2.2 Personnel Dosimetry

Program Description

All employees working in the process facility 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.

Historical Program Results

Figure 5.8.1 depicts the average and maximum external exposure levels for all employees at the Crow Butte Project from 1994 through 2006. 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 13-year period was 94 mREM, ranging from 33 to 165 mREM. The maximum external exposure for this time period ranged from 114 to 495 mREM.

For the years of 2000 through 2006, measurements indicated average external exposure levels of ranged from 81 to 129 mREM, with maximum exposures ranging from 238 to 448. The average and maximum exposure levels for 2006 (88 and 252 mREM, respectively) were lower than 2005 values (118 and 425, respectively) by approximately 24 percent and 41 percent, respectively.

As can be seen in **Figure 5.8-1**, there were noticeable elevations in the maximum exposure levels for the years 2001, 2002 and 2005. The most likely cause of these 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).

Figure 5.8-2 depicts the total Person-Rem due to external exposure for each year from 1994 through 2006. The results of the trend analysis indicate a significant decrease in the *combined external exposure* to gamma radiation from 2001/2002 to 2006 at the Crow Butte Project. As discussed above, once the yellowcake dryer was able to maintain production, the combined external exposure decreased from 5.28 Person-Rem in 2002, to 3.14 Person-Rem in 2003. The combined external exposure was further reduced from 3.44 Person-Rem in 2005 to 2.63 Person-Rem in 2006.

More detailed information as to the external exposure measurements are described in the CBR Semiannual Radiological Effluent and Environmental Monitoring Report and annual ALARA Review reports (1997 – 2006).

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 facilities 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 SHEQMS Program Volume IV, *Health Physics Manual*.

5.8.3 In-Plant Airborne Radiation Monitoring Program

5.8.3.1 Airborne Uranium Particulate Monitoring

Program Description

Airborne particulate levels at solution mines which ship slurry yellowcake product are normally very low since the product is wet. Yellowcake drying operations began 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.

Area Sampling

There are four required airborne uranium survey locations in the plant plus the dryer room. The monitoring frequency for the dryer room location is weekly, while the frequency for the other four locations is monthly. 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.

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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 plant. 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 Eberline RAS-1 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 CBR facility is 5 E-11, which is 10% of the current DAC of 5 E-10 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 Derived Air Concentration (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 Ra-226. The DAC for Ra-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 facility. 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 5.8.4 of the application 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).

Historical Program Results

- Airborne Uranium Monitoring – Main Plant

Airborne Uranium monitoring has been performed at the Central Plant at the locations shown in **Figure 5.8-5** since 1994. **Table 5.8-1** provides the results of gross alpha monitoring for airborne uranium from the period of 1994 through 2006. 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 Derived Air Concentration (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 2006 was 2.96 x E-12 µCi/ml (0.6 percent of DAC), with a range of 1.28 E-12 to 4.02 E-12 µCi/ml. The maximum average airborne activity values ranged from 3.70 E-12 to 2.33 E-11 µCi/ml (0.7 percent and 4.7 percent of the DAC, respectively). In 2005 and 2006, the average airborne activity was 3.80 E-12 µCi/ml (0.8 percent DAC) and 3.86 E-12 µCi/ml (0.8 percent DAC), respectively, with a maximum value of 5.03 E-12 µCi/ml (1.0 percent DAC) and 4.87 E-12 µCi/ml (1.0 percent DAC), respectively.

- Airborne Uranium Exposures

Exposure to airborne uranium is based upon the results obtained from air sampling discussed in Area Sampling above. Routine exposure is based upon the monthly average plant airborne uranium concentrations. For personnel assigned full-time to the plant, a conservative occupancy time of 100 percent is used to determine exposure. For all other personnel, actual time in the plant is used 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.

Table 5.8-1: In-plant Airborne Uranium Monitoring Results

Airborne Uranium Monitoring Period (Calendar Year)	Annual Average Airborne Activity µCi/Ml Gross α (% Dac)[1]	Maximum Monthly Average Airborne Activity µCi/Ml Gross α (%Dac)[1]
1994 (includes dryer room sample results)	3.22 E-12 (0.6% DAC)	6.07 E-12 (1.2% DAC)
1995	3.80E-12 (0.8%)	9.36E-12 (1.9%)
1996	1.28E-12 (0.3%)	4.71Ee-12 (0.9%)
1997	2.77 E-12 (0.5% DAC)	5.43 E-12 (1.1% DAC)
1998	3.06 E-12 (0.6% DAC)	5.36 E-12 (1.1% DAC)
1999	2.87 E-12 (0.6% DAC)	4.44 E-12 (0.9% DAC)
2000	2.63 E-12 (0.5% DAC)	5.84 E-12 1.1% DAC)
2001	3.30 E-12 (0.7% DAC)	7.05 E-12 (1.4% DAC)
2002	2.25 E-12 0.5% DAC)	3.70 E-12 (0.7% DAC)
2003	4.02 E-12 (0.8% DAC)	2.33 E-12 (4.7% DAC)
2004	1.65 E-12 (0.3% DAC)	5.99 E-12 1.0% DAC)

Table 5.8-1: In-plant Airborne Uranium Monitoring Results

Airborne Uranium Monitoring Period (Calendar Year)	Annual Average Airborne Activity µCi/Ml Gross α (% Dac)[1]	Maximum Monthly Average Airborne Activity µCi/Ml Gross α (%Dac)[1]
2005	3.80 E-12 (0.8% DAC)	5.03 E-12 (1.0% DAC)
2006	3.86e-12 (0.8%)	4.87e-12 (1.0%)

Notes:
[1] Samples compared to the DAC where DAC=5 E-10 µCi/ml (10 CFR §§ 20.1001-2401 App B)

Uranium intakes for the time period 1994 through 2006 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.

The maximum individual uranium intake for 2005 and 2006 was 1.94×10^{-2} µCi and 2.14×10^{-2} µCi, respectively, corresponding to a dose of 97 mREM (2 percent of the regulatory limit) and 107 mREM (2 percent of the regulatory limit), respectively. The average for all monitored employees in 2005 and 2006 was 5.87×10^{-3} µCi and 6.94×10^{-3} µCi, respectively, corresponding to a dose of 29 mREM (0.6 percent of the regulatory limit) and 35 mREM (0.7 percent of the regulatory limit), respectively. The combined uranium intake at the Crow Butte Uranium Project for 2005 was 0.170 µCi for the 29 employees that were monitored. This corresponds to a combined dose due to uranium intake of 0.85 Person-Rem. Uranium intake for 2006 was 0.208 µCi for 30 monitored employees, which corresponds to a combined dose due to uranium intake of 1.04 Person-Rem.

Figure 5.8-3 depicts the average and maximum exposure in Rem for each year from 1994 through 2006. The results of the exposure analysis indicate a noticeable increase in the both the average and maximum exposure to airborne uranium at the Crow Butte Project in 2005 and 2006. The average exposure increased by 9 mREM from 2004 (20 mREM) to 2005 (29 mREM) and 6 mREM from 2005 to 2006 (35 mREM). The maximum exposure more than doubled from 46 mREM in 2004 to 97 mREM in 2005, followed by an additional higher value of 107 mREM in 2006.

The maximum airborne uranium exposure in 2006 was due 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.

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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 5.8-4 plots the combined exposure due to airborne uranium exposure for each year from 1994 through 2006. The combined exposure increased from 0.470 Rem in 2004 to 0.851 Rem in 2005, followed by an additional increase to 1.041 Rem in 2006. This is an increase of approximately 45 percent from 2004 to 2006.

Average airborne uranium exposures for facility staff and maximum doses for individuals were found to be acceptably low, although trend review indicated an increase from 2004 through the years 2005 and 2006. These increases, even though well below permissible limits, were deemed to warrant some potential for minor ALARA reduction. ALARA opportunities to address these increases were identified in the site's calendar year 2005 and 2006 annual ALARA audits. One of the ALARA Opportunities identified during the 2006 audit was that during the remainder of 2007, new methods to reduce worker doses related to U_3O_8 airborne concentrations should be considered, and existing methods should be examined to determine whether improvements are feasible within ALARA constraints. Site personnel continue to examine the reasons for the 2005 and 2006 dose increases, with the objective to identify opportunities to reduce the impact of the primary contributors to airborne uranium exposure during 2005 and 2006.

<u>Proposed In-Plant Airborne Uranium Monitoring Program</u>

CBR proposes to continue with the same airborne uranium-monitoring program at the Crow Butte Project that has been performed to date with the following changes.

Airborne sampling will be performed on a monthly basis in accordance with the instructions currently contained in SHEQMS Program Volume IV, *Health Physics Manual.* These procedures implement the guidance contained in USNRC Regulatory Guide 8.25, *Air Sampling in the Workplace*. Sampler calibration will be performed in accordance with the instructions currently contained in SHEQMS Program Volume IV, *Health Physics Manual.*

5.8.3.2 In-Plant Radon Daughter Surveys

<u>Program Description</u>

There are 12 monitoring locations for radon daughter concentrations in the Central Plant, 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.

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 with the following changes.

Based on operating experience, CBR proposes to continue radon daughter sampling at the locations shown in **Figure 5.8-5**. CBR believes that these locations provide accurate monitoring of plant radiological conditions.

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*.

5.8.3.3 Total Effective Dose Equivalent

The TEDE for each monitored employee at the Crow Butte Project from 1994 through 2006 was well below the annual regulatory limit of 5 Rem. **Figure 5.8-8** depicts the combined and average TEDE for the project in Person-Rem and mREM, respectively, for each year from 1994 through 2006. The combined dose from 1994 through 1996 averaged 11.6 Person-Rem, with a range of 7.9 to 17.9 Person-Rem.

The maximum individual TEDE for 2005 and 2006 was 675 mREM (15 percent of regulatory limit) and 713 mREM (14.3 percent of regulatory limit), respectively, with an average TEDE for all monitored employees of 103 mREM (2 percent of regulatory limit) and 0.323 mREM (6.5 percent of regulatory limit), respectively. The combined TEDE at the CBR Project for 2005 and 2006 was 7.943 Person-Rem (29 employees) and 9.7 Person-Rem (30 employees) who are monitored for occupational exposure.

The average TEDE values showed only a slight increase for the years 2002, 2003, and 2204 (370, 378, and 388 mREM, respectively). The average TEDE was reduced significantly from 388 mREM in 2004 to 274 mREM in 2005, but the average TEDE increased to 323 Person–Rem in 2006 (15 percent increase). However, the 2006 value was lower than measurements for the years 1995 through 2004.

Figure 5.8-9 shows the total dose contributions of external exposure, radon daughter exposure, and airborne uranium exposure to the total effective dose from 1994 through 2006. The primary contributors to dose during 2006 were radon daughter exposures and external radiation exposures. External exposures have remained relatively constant during the past several years, and in fact were reduced significantly in 2006. Airborne uranium and radon daughter exposures, on the other hand, increased. ALARA actions being taken to address these increases are discussed in **Sections 5.8.3.1 and 5.8.3.2**.

5.8.3.4 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 USNRC Regulatory Guide 8.15, *Acceptable Programs for Respiratory Protection.* The respirator program is administered by the RSO as the Respiratory Protection Program Administrator (RPPA).

5.8.4 **Exposure Calculations**

Employee internal exposure to airborne radioactive materials has been determined at the Crow Butte Project facility 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.

5.8.4.1 Natural Uranium Exposure

Exposure calculations for airborne natural uranium are carried out using the intake method from USNRC Regulatory Guide 8.30, *Health Physics Surveys in Uranium Recovery Facilities*, Revision 1, Section 3. 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 X_i (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 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 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 lunch room, 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 5.8.3.1**.

Historical Program Results

Table 5.8-3 summarizes internal exposure results at Crow Butte Project from airborne uranium. The data show that internal exposure at Crow Butte Uranium Project has been maintained ALARA. The maximum individual internal exposure to airborne uranium

during the period between 1994 and 2006 was significantly lower than the allowable regulatory limit of 1 μCi. For example, the average exposure level of 6.94 E^{-03} μCi in 2006 was 0.7 percent of the 1 μCi allowable, and the maximum exposure level of 2.14 E^{-02} μCi was 2.1 percent of the allowable level.

Table 5.8-3: Annual Airborne Uranium Exposure Results

Airborne Uranium Exposure Monitoring Period (Calendar Year)	Average Airborne Uranium Exposure (μCi)[1]	Maximum Airborne[1] Uranium Exposure (μCi)[1]
1994	3.66×10^{-3}	9.03×10^{-3}
1995	4.04×10^{-3}	1.07×10^{-2}
1996	2.59×10^{-3}	4.70×10^{-3}
1997	5.49×10^{-3}	8.37×10^{-3}
1998	5.81×10^{-3}	8.26×10^{-3}
1999	5.14×10^{-3}	7.89×10^{-3}
2000	4.38×10^{-3}	8.23×10^{-3}
2001	4.55×10^{-3}	$1{,}06 \times 10^{-2}$
2002	3.24×10^{-3}	7.82×10^{-3}
2003	5.24×10^{-3}	1.28×10^{-2}
2004	4.05×10^{-3}	9.17×10^{-3}
2005	5.87×10^{-3}	1.94×10^{-2}
2006	6.94×10^{-3}	2.14×10^{-2}

Note:[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.

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 (ML11102020132). The results show that the average ALI for the Crow Butte Operations yellowcake is 0.98μCi and the average DAC is 4.8E-10μCi/ml. For consistency with the convention used to round values in the regulation, an ALI and DAC of 1μCi and 5E-10μCi/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 NRC Regulatory Guide 8.30 to estimate internal doses. As an example, the Committed Effective Dose Equivalent (CEDE) can be calculated using Equation 2 in NRC Regulatory Guide 8.30 where:

H_{iE} = CEDE from radionuclide (rem)

Radon Daughter Concentration Determination

Radon-222 daughter concentrations are determined from surveys performed as described in **Section 5.8.3.2**.

The working-level months for radon daughter exposure are calculated on the appropriate forms. The working-level months are totaled and entered onto each employee's Occupational Exposure Record.

Historical Program Results

Table 5.8-4 summarizes the results of radon daughter exposure calculations at Crow Butte Uranium Project between 1994 and 2006. The data show that internal exposure due to radon daughters at Crow Butte Uranium 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 2005 and 2006 (0.101 and 0.161 working-level months, respectively). These levels are approximately 3 percent and 4 percent, respectively, of the allowable regulatory limit of 4 working-level months. The maximum internal exposure to radon daughters was also at its lowest over this 13-year period at 0.213 in 2005 and 0.283 in 2006, (approximately 5 percent and 7 percent of the regulatory limit, respectively)

Table 5.8-4: Annual Radon Daughter Exposure Results

Radon Daughter Exposure Monitoring Period (Calendar Year)	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	.0527
1997	0.467	0.643
1998	0.25	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

Note:
1 The annual limit was 4 working-level months.

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 NRC Regulatory Guide 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:

$$H_{iE} = 5*1/4 = 1.25 \text{ rem}$$

5.8.4.3 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

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 percent. All samples were rerun, and after the second run, the agreement range was 24 percent. The cause of the exceedance was an ELI analytical error made by the contract laboratory.

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 USNRC Regulatory Guide 8.22, *Bioassay in Uranium Mills*, Revision 1. 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 percent 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 percent of the spiked value, with exceedances being rare. In 2006, there was only one exceedance and none have been observed through the first three quarters of 2007. Past exceedances have been due to either occasional laboratory error or the facility's spike results were incorrect. 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 laboratory analysis. Actions taken in regard to investigating spiked sample value exceedances are recorded and maintained on file at the facility.
- The analytical laboratory spikes 10 percent to 30 percent 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 percent.

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 USNRC Regulatory Guide 8.22, *Bioassay in Uranium Mills*, Revision 1 and with the instructions currently contained in SHEQMS Program Volume IV, *Health Physics Manual*.

5.8.6 Contamination Control Program

CBR's contamination control program at Crow Butte Project consists of the following elements.

5.8.6.1 Surveys for Surface Contamination

CBR performs surveys for surface contamination in operating and clean areas of the Crow Butte Project facilities in accordance with the guidelines contained in USNRC Regulatory Guide 8.30, *Health Physics Surveys in Uranium Recovery Facilities*, Revision 1. Surveys for alpha contamination in clean areas, such as lunchrooms change rooms and offices, are conducted weekly. An action level of 25 percent of the limits from USNRC Regulatory Guide 8.30 is used for clean areas.

5.8.6.2 Surveys for Contamination of Skin and Personal Clothing

All personnel leaving the restricted area are required to perform and document alpha contamination monitoring. In addition, personnel who could come in contact with potentially contaminated solutions outside a restricted area, such as in the wellfields, are required to monitor themselves prior to leaving the area. All personnel receive training in the performance of surveys for skin and personal contamination. Personnel are also allowed to conduct contamination monitoring of small, hand-carried items as long as all surfaces can be reached with the instrument probe and the item is used in another process area. All other items are surveyed as described in the next section.

As recommended in USNRC Regulatory Guide 8.30, *Health Physics Surveys in Uranium Recovery Facilities* Revision 1, CBR conducts quarterly unannounced spot checks of personnel to verify the effectiveness of the surveys for personnel contamination. Employees assigned to the mine site are spot-checked, concentrating on plant operators and maintenance personnel. The purpose of the surveys is to ensure that employees are adequately surveying and decontaminating themselves prior to exiting the restricted areas.

5.8.6.3 Surveys of Equipment Prior to Release to an Unrestricted Area

Consistent with Regulatory Guide 8.31, the RSO, radiation safety staff, or qualified employees will survey all items from the restricted areas with the exception of the small, hand-carried items described above. Lead Operators and plant/wellfield operators with a minimum of six months experience, will be trained by the RSO or radiation staff in the use of applicable radiation survey instruments and procedures, including hands-on use of the instrumentation. The operators will have also received job specific training as operators as well as the radiation safety training described in Section 5.6.1.3.

The release limits for beta gamma contamination are 0.2 mrad average and 1.0 mrad maximum at 1 cm as required by *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses For*

Byproduct, Source, or Special Nuclear Materials, USNRC, May 1987 ("Annex B"). Surveys are performed with the following equipment:

1. Total surface activity will be measured with an appropriate alpha survey meter. A Ludlum Model 2241 Scaler or a Ludlum Model 177 Ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe, or equivalent, will be used for the surveys.

2. Portable GM survey meter with a beta/gamma probe with an end window thickness of not more than 7 mg/cm^2, a Ludlum Model 3 survey meter with a Ludlum 44-38 probe or equivalent;
3. Swipes for removable contamination surveys as required;
4. Survey equipment is calibrated annually or at the manufacturer's recommended frequency, whichever is more frequent. Surface contamination instruments are checked daily when in use. Alpha survey meters for personnel surveys are response checked before each use with other checks performed weekly;
5. The contamination control program will continue in accordance with the instructions currently contained in SHEQMS Program Volume IV, *Health Physics Manual.*

5.8.6.4 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.

5.8.6.5 Contamination Control Program

CBR proposes to continue with the same contamination control program that is currently in use. The program has proven to be effective at controlling contamination of personnel and clean areas. The program is carried out in accordance with the instructions currently contained in SHEQMS Program Volume IV, *Health Physics Manual*

5.8.7 **Airborne Effluent and Environmental Monitoring Programs**

5.8.7.1 Program Description and Historical Monitoring Results

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 5.8-5** provides the sampling locations, types, frequency, methods, and parameters for the Crow Butte Project facilities.

5.8.7.2 Radon

The radon gas effluent released to the environment is monitored at seven locations (AM-1 through AM-6 and AM-8). Location AM-6 is considered the background location. Monitoring is performed using Track-Etch radon cups provided by Landauer Corporation. The cups are exchanged on a semiannual 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 exposes duplicate radon Track Etch cups for each monitoring period. 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). **Table 5.8-6** contains the results of radon monitoring for the Crow Butte Uranium Project facility between 1991 and 2007. **Figure 5.8-10** through **Figure 5.8-16** depict the trends for radon monitoring between 1991 and 2007 for each location. The total estimated radon release trend between 1991 and 2007 is shown in **Figure 5.8-17.**

As recommended in Regulatory Guide 8.37, a trend analysis of the radon monitoring results since commercial operations began in 1991 was performed. In 2003, three monitoring stations (AM-1, AM-2, and AM-8) exhibited significant spikes from historical radon concentrations in the second half. These sample locations are along the eastern and northern boundaries of the License Area and Section 19. In the 2003 ALARA Audit Review, CBR noted that the cause of the elevated radon-222 concentrations was not known. Radon release levels from the Crow Butte Project for the period are consistent with those since increased process flows were approved in 1998, so it did not appear that project releases were the source. Concentrations at the three locations ranged from 34 percent to 37 percent of the effluent concentration limit from 10 CFR Part 20, Appendix B Column 2, which is above normal concentrations at the environmental monitoring stations (generally less than 10 percent) but well below levels that are protective of the public.

in 1998 before mining operations began in this area showed similar elevated uranium concentrations.

The sample locations are in a wetland 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 5.8-35** is a trend graph for English Creek sediment sample points since 1998 that shows the elevated uranium concentrations noted in past sediment samples.

5.8.7.9 Proposed Airborne Effluent and Environmental Monitoring Program

CBR proposes to continue the Airborne Effluent and Environmental Monitoring Program described in this section.

5.8.8 Groundwater/Surface Water Monitoring Program

5.8.8.1 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 5.8-5**.

5.8.8.2 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 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.

Tables 5.8-12 through **5.8-15** summarizes all private wells and surface waters within 1 kilometer of the wellfield area boundary are sampled 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 5.8-12** for private wells and **Table 5.8-14** for surface waters. The results for radium are shown in **Tables 5.8-13** for private wells and **5.8-15** for surface waters. The maximum allowable uranium and radium concentration as specified by Nebraska Department of Environmental Quality (NDEQ) Title 118 – Ground Water Quality Standards and Use Classification, are 5 piC/L and 0.030 mg/L respectively. All sampling results reported have been well below the maximum allowable concentrations for uranium and radium.

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 appears 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. Quarterly monitor well results for uranium are shown in **Table 5.8-14** and for radium in **Table 5.8-15**. 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). One sample for the baseline parameters shown in Table 2.9-2. Analytical results are presented in Section 6.1.3.

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, upper control limits (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 were 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, wellhead 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 will be documented.

Excursion Verification and Corrective Action

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 percent, 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 USNRC Project Manager is notified by telephone within 48 hours and notified in writing within 30 days.

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 weekly. An excursion is considered concluded when the concentrations of excursion indicators do not exceed the criteria defining an excursion for three consecutive 1-week samples.

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.

5.8.10 **Monitoring Program Summary**

Section 5.8 of this renewal application has reviewed the radiological monitoring data produced at Crow Butte Project for the years 1990 through 2007. 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 5.8-16** provides a tabular summary of both programs as well as the regulatory guidance provided in USNRC Regulatory Guide 8.30, *Health Physics Surveys In Uranium Recovery Facilities*, Revision 1.

Table 5.8-16: 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.

1994. Mine Unit 1 was successfully restored to the approved primary or secondary restoration standards for all parameters.

The commercial groundwater restoration program consists of two stages, the restoration stage and the stabilization stage. The restoration stage consists of four activities:

- Groundwater transfer
- Groundwater sweep
- Groundwater treatment
- 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 for six months 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 and during restoration until the start recirculation (if conducted) or 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 application. 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 Mine Unit 1 at the current CBR operations. For the remainder of the mine units (Mine Units 2 through 11), 11 pore volumes will be used

The pore volumes (in gallons) affected by the extraction process within the commercial area ore body water bearing zone are as follows:

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*	3,610,000	18.0	0.29	7.481	140,955,000
MU11*	2,100,000	22.0	0.29	7.481	100,217,000
*Estimated					

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 ion exchange columns and filtration during this step if suspended solids are sufficient in concentration to present a problem with blocking the injection well screens.

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 waste water 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 the Stabilization Stage 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 Groundwater Stabilization

Upon completion of restoration, a groundwater stabilization monitoring program will begin.in which the restoration wells and monitor wells will be sampled and analyzed for the restoration parameters listed in **Table 6.1-1**.

Although CBR's CSA 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 quarter-year 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 5.8.8.2, will continue until NRC determines that groundwater stabilization has been demonstrated.

6.1.6 Groundwater Restoration 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 USNRC. This information will also be included in the final report on restoration.

Upon completion of restoration activities and before stabilization, all designated restoration wells in the mine unit will be sampled for the constituents listed in **Table 6.1-1**. If restoration activities have returned the wellfield average of restoration parameters to concentrations at or below those approved by the USNRC and the NDEQ, CBR will proceed with the stabilization phase of restoration.

During stabilization, all designated restoration wells will be sampled monthly for the constituents listed in **Table 6.1-1**. At the end of a six-month stabilization period, CBR will compile all water quality data obtained during restoration and stabilization and submit a final report to the regulatory agencies. 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**.

7.4 WATER RESOURCES IMPACTS

7.4.1 Surface Water Impacts of Construction and Decommissioning

When stormwater drains off a construction site, it typically carries sediment and other pollutants that can harm lakes, streams and wetlands. USEPA 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 National Pollutant Discharge Elimination System (NPDES) regulations.

Construction activities at the Crow Butte Project to date have had a minimal impact on the local hydrological system. CBR conducts construction activities under NDEQ permitting regulations for control of construction stormwater discharges contained in Title 119. CBR is required by NDEQ General Construction Stormwater NPDES Permit NER 100000 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 NDEQ under the general permit.

The results of stream sediment sampling for most semiannual periods between 1998 and 2007 fall within the expected ranges, as shown in **Table 5.8-11** and **Figures 5.8-32** through **5.8-37**. In the second half of 2005, the concentrations of natural uranium in several English Creek samples were well above regional background levels. CBR has noted these elevated concentrations in the English Creek drainage during preoperational monitoring, which indicates that these levels are anomalous natural background concentrations.

7.4.2 Surface Water Impacts of Operations

7.4.2.1 Surface Water Impacts from Sedimentation

Protection of surface water from stormwater runoff during on-going wellfield construction related to operations is regulated by the NDEQ as discussed in **Section 7.4.1**.

7.4.2.2 Potential Surface Water Impacts from Accidents

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 7.4.3.3 discusses the operation of the ponds and measures to prevent and control wellfield spills. 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 facilities will be minimal since there are no nearby surface water features.

7.4.3 Groundwater Impacts of Operations

Potential impacts to water resources from mining and restoration activities include the following.

7.4.3.1 Groundwater Consumption

As discussed in **Section 2.7**, a regional pump test has been conducted to assess the hydraulic characteristics of the Basal Chadron Sandstone, and overlying confining units. Pump tests are also performed for each mine unit 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 Chadron Sandstone.

A full and detailed analysis of the potential impacts of the mining operations at Crow Butte on surrounding water users have been provided in an Industrial Groundwater Use Permit application required by NDEQ. The permit application was submitted to NDEQ by Ferret of Nebraska, Inc. (predecessor to CBR) in 1991. The application states that water levels in the City of Crawford (approximately three miles northwest of the mining area) could potentially be impacted by approximately 20 feet by consumptive withdrawal of water from the Basal Chadron Sandstone during mining and restoration operations (based on a 20-year operational period).

A similar order of magnitude impact (drawdown) likely exists for the Crow Butte operations. No impact to other users of groundwater has been observed, nor is expected during future operations because: (1) there is no documented existing use of the Basal Chadron in the License Area; and, (2) the potentiometric head of the Basal Chadron Sandstone in the License Area ranges from approximately 40 to 200 feet below ground surface.

Because the Basal Chadron Sandstone (production zone) is a deep confined aquifer, no surface water impacts are expected. Further, the geologic and hydrologic data presented in **Sections 2.6** and **2.7**, respectively, demonstrate that (1) the occurrence of uranium mineralization is limited to the Basal Chadron Sandstone; and, (2) the Basal Chadron is isolated from underlying and overlying sands. Hence, the mining operations are expected to impact water quality only in the Basal Chadron Sandstone, and restoration operations will be conducted in the Basal Chadron following completion of mining.

Based on a bleed of 0.5 percent to 1.5 percent, which has been successfully applied in the current licensed area, the potential impact from consumptive use of groundwater is expected to be minimal. In this regard, the vast majority (e.g., on the order of 99 percent) of groundwater used in the mining process will be treated and re-injected. Potential