
Safety Evaluation Report (Revised)
License Renewal of the Crow Butte
Resources ISR Facility Dawes
County, Nebraska Materials License
No. SUA-1534

Docket No. 40-8943
Crow Butte Resources, Inc.

U.S. Nuclear Regulatory Commission

**Office of Federal and State Materials and Environmental
Management Programs**

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INTRODUCTION

By letter dated November 27, 2007, Crow Butte Resources, Inc. (CBR) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) for renewal of source material license SUA-1534 for the Crow Butte facility located in Dawes County, Nebraska. The Crow Butte facility is a uranium in situ recovery (ISR) facility subject to safety requirements found in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 40, "Domestic Licensing of Source Material" and 10 CFR Part 20, "Standards for Protection Against Radiation."

CBR's license renewal application (LRA) for the Crow Butte facility consisted of a combined technical and environmental report (CBR, 2007a). During staff's review process, the applicant revised the LRA (CBR, 2009a, 2009b, 2010) in response to requests for additional information (RAIs) made by the staff. In addition, one page that was missing from the original LRA was added as an NRC document (NRC, 2008). The LRA formed the basis for staff's review. This safety evaluation report (SER) documents the staff's review of the safety aspects to the renewal application under 10 CFR Part 40.

The Atomic Energy Act of 1954, as amended by the Uranium Mill Tailings Radiation Control Act of 1978, authorizes the NRC to issue licenses for the possession and use of source material and byproduct material. The NRC must license facilities, including ISR operations, in accordance with NRC regulatory requirements to protect public health and safety from radiological hazards. In accordance with 10 CFR 40.32, "General Requirements for Issuance of Specific Licenses," the NRC staff is required to make the following safety findings when issuing an ISR license:

- The application is for a purpose authorized by the Atomic Energy Act.
- The applicant is qualified by reason of training and experience to use the source material for the purpose requested in such a manner as to protect health and minimize danger to life or property.
- The applicant's proposed equipment, facilities, and procedures are adequate to protect health and minimize danger to life or property.
- The issuance of the license will not be inimical to the common defense and security or to the health and safety of the public.

This safety evaluation report (SER) documents the safety portion of the staff's review of the LRA, as amended, and includes an analysis to determine CBR's compliance with these and other applicable 10 CFR Part 40 requirements, and applicable requirements set forth in 10 CFR Part 40, Appendix A, "Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for Their Source Material Content." This SER also evaluates CBR's compliance with applicable requirements in 10 CFR Part 20, "Standards for Protection against Radiation."

An Environmental Assessment (EA) is being prepared in parallel with this SER to address environmental impacts of the proposed action in accordance with 10 CFR Part 51, the NRC's implementation regulations for the National Environmental Policy Act (NEPA).

The staff's safety review of the Crow Butte facility was performed using NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications," and is a comprehensive assessment of CBR's ISR facility. The regulations at 10 CFR Parts 20 and 40, and those in Appendix A to 10 CFR Part 40 contain the technical requirements for licensing an ISR facility. This SER is organized following the organization of NUREG-1569, except that sections addressing environmental aspects are not included in the SER as they are addressed in the EA.

This renewal request is the second renewal request for this license. The Crow Butte facility has had the commercial license to operate and has operated since 1989. The initial license was issued in 1989 for a 6-year time period, and a 1995 renewal application was approved in 1998 for a 10-year time period. The expiration date for the current license was February 28, 2008. Because CBR submitted a renewal application within the regulatory mandated timeframe, the existing license continues in effect until a decision is made by the NRC on the renewal application in accordance with 10 CFR 40.42(a). As such, the renewal period begins at the time of staff's approval of the application, not the expiration date of the existing license.

The CBR license renewal application did not request any specific modification from the current license. However, during the previous 10 years of operations, the license has been modified through the appropriate amendment process. In addition, the previously approved license application has been modified through the applicant's Safety and Environmental Review Panel (SERP) process.

Several regulatory actions occurred after the applicant submitted the LRA to NRC in 2007 but prior to the staff's completion of its review of the LRA. Those actions include:

- Routine on-site inspections of the operation of the Crow Butte ISR facility by staff.
- The submission by the applicant of results from the on-going operational monitoring programs at the Crow Butte facility.
- Amendments to the existing license (see SER Section 1.3, Table 1-1)
- SERP approvals to the previously approved license application

In addition, several licensing actions related to the Crow Butte facility are pending staff review. Those actions include:

- License amendment request to include a satellite facility at the North Trend Expansion Area.
- License amendment request to include a satellite facility at the Three Crow Expansion Area.

Consequently, in addition to the responses to RAIs, this safety evaluation incorporates the staff's review of actions completed during the interim period. However, this safety evaluation report (SER) does not include reviews of the previously mentioned pending license amendment requests.

The staff's review of CBR's license renewal application for the Crow Butte facility identified a number of facility specific issues that require additional or modified license conditions to ensure that the operation of the facility will be adequately protective of public health and safety. Table 1 includes the license condition language as well as the section of this SER where the regulatory need for the license condition was identified. The staff concludes that the findings described in succeeding sections of this SER, including the necessary license conditions, support the renewal of this license. By e-mails dated January 2, 2013 (CBR, 2013) and July 29, 2014 (CBR, 2014), the applicant accepted all license conditions described in this SER.

Table 1: License Conditions

SER Section	License Condition
3.1.4	Flow rates on each injection and recovery well, and manifold pressures on the entire system, shall be monitored and recorded daily. During well field operations, injection pressures shall not exceed 100 pounds per square inch at the injection well heads.
3.1.4	The licensee shall maintain an overall inward hydraulic gradient within the perimeter monitor well ring starting when lixiviant is first injected into the production zone and continuing until the initiation of the stabilization period.
3.1.4	License Condition 10.1 will be modified to the following: The licensee shall use a lixiviant composed of native groundwater, with added sodium carbonate/bicarbonate, carbon dioxide, oxygen and/or hydrogen peroxide, as described in the approved license application.
3.2.4	If hydrogen sulfide is used, the storage and handling procedures to prevent impacts to radiological and worker safety shall be provided to the NRC for review and approval.
4.1.4	The license shall provide flow rates for discharges to unrestricted areas and air exchange rate for the facility, and describe what method(s) will be used to control releases to unrestricted areas.
4.2.4	The final paragraph in License Condition 11.4 will be included in a new License Condition 11.9 to read as follows: The licensee shall perform and document inspections in accordance with the February 5, 1996, revision to its Evaporation Pond Onsite Inspection Program. Any time 6 inches or more of fluid is detected in a commercial pond standpipe, it shall be analyzed for specific conductance. If the water quality is degraded beyond the action level, the water shall be further sampled and analyzed for chloride, alkalinity, sodium, and sulfate. Any time 6 inches or more of fluid is detected in an R&D pond standpipe, it shall be analyzed for specific conductance, chloride, alkalinity, sodium, and sulfate. Upon verification of a liner leak, the licensee shall notify NRC in accordance with LC 11.6, lower the fluid level sufficiently to eliminate the leak by transferring the pond's contents to an alternate cell or approved destination, and undertake repairs, as needed. Water quality in the affected standpipe shall be analyzed for the five parameters listed above

Table 1: License Conditions

	<p>once every 7 days during the leak period and once every 7 days for at least 14 days following repairs. The licensee shall submit a corrective action plan within 30 days to NRC for review. The corrective action plan will document steps to adequately address the leak and procedures used to verify that the leak has been adequately addressed and permanently fixed. The corrective action plan should also evaluate how much and for how long the diminished waste disposal capacity will impact operations.</p>
<p>5.3.4</p>	<p>The licensee shall follow the guidance set forth in NRC Regulatory Guides 8.22, “Bioassay at Uranium Mills” (as revised), and 8.30, “Health Physics Surveys in Uranium Recovery Facilities” (as revised), or NRC-approved equivalent.</p> <p>The licensee shall follow the guidance set forth in Regulatory Guide 8.31, “Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable” (as revised), or NRC approved equivalent, with the following exception:</p> <p style="padding-left: 40px;">The licensee may identify one or more qualified designees to perform daily inspections in the occasional absence of the radiation safety officer (RSO) and health physics technicians (HPTs). A qualified designee will meet the minimum qualifications and perform only those duties as outlined for a qualified Designated Operator as specified in the licensee’s submittals dated March 4, 2014 (ML14064A143) and May 15, 2014 (ML14135A414).</p> <p style="padding-left: 40px;">A qualified designee may perform daily inspections on weekends, holidays, and times when both the RSO and HPTs must both be absent (e.g., illness or offsite training). With the exceptions of those instances when a Federal holiday falls on a Friday or Monday, the Thanksgiving holiday, or a site closure due to weather or other safety or security related event, qualified designees will not conduct the daily inspections for more than a total of two days per week. When a Federal holiday falls on a Friday or Monday, qualified designees may perform the daily inspections for a total of three consecutive days. For the Thanksgiving holiday only, qualified designees may perform the daily inspections for a total of four consecutive days. When weather or other safety or security related event causes a site closure, a qualified designee, if available, will continue performing the daily inspections until the RSO or HPT can access the site after such an event. The licensee will also have the RSO or HPT available by telephone while a qualified designee is performing the daily inspections.</p> <p style="padding-left: 40px;">Reports generated by a qualified designee will be reviewed by the RSO or an HPT as soon as practicable, but not later than the close of business of the next work day following an absence (including site closure due to weather or other safety or security related event) , weekend, or holiday. The RSO or HPT review shall be annotated with</p>

Table 1: License Conditions

	date and time on the report or other document that can be inspected upon request.
5.6.4	Security measures for the mine units and header houses that address the requirements of 10 CFR Part 20, Subpart I, shall be described in writing to the NRC staff.
5.7.4.4	The licensee shall conduct isotopic analyses for alpha- and beta-emitting radionuclides on airborne samples at each in-plant air particulate sampling location at a frequency of once every six months for the first two years and annually thereafter to ensure compliance with 10 CFR 20.1204(g). For any changes to operations, the licensee shall conduct an evaluation to determine if more frequent isotopic analyses are required for compliance with 10 CFR 20.1204(g).
5.7.4.4	Uranium compounds that have no assigned inhalation classification, or for which no site-specific data is available, such as uranium carbonates, shall be assigned to inhalation class W for radiation protection purposes.
5.7.7.4	<p>The licensee shall develop a survey program for beta/gamma contamination for personnel exiting from restricted areas, and beta/gamma contamination in unrestricted and restricted areas that will meet the requirements of 10 CFR Part 20, Subpart F and submit to NRC for review and written verification.</p> <p>The licensee shall provide for NRC review and written verification the surface contamination detection capability (minimum detection concentration (MDC)) for radiation survey instruments, including scan MDC for portable instruments, used for contamination surveys to release equipment and materials for unrestricted use and for personnel contamination surveys. The detection capability in the scanning mode for the alpha and beta radiation expected shall be provided in terms of dpm per 100 cm².</p>
5.7.7.4	<p>Release of surficially contaminated equipment, materials, or packages for unrestricted use shall be in accordance with the NRC guidance document "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," (the Guidelines) dated April 1993 (ADAMS Accession No. ML003745526), or in accordance with a suitable alternative program which shall be approved by NRC prior to any such release.</p> <p>The Guidelines or approved alternative program shall also apply to the removal of equipment, materials, or packages from restricted areas that have the potential for accessible surface contamination levels above background regardless of the intent to release these items for unrestricted use,. The licensee shall document their surveys of equipment, materials, or packages prior to removing them from a restricted area.</p> <p>Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established in the Guidelines for alpha- and beta-gamma-emitting nuclides shall apply independently.</p>

Table 1: License Conditions

	<p>Personnel performing these contamination surveys for items released for unrestricted use or from restricted areas shall meet the qualifications for health physics technicians or radiation safety officer as defined in Regulatory Guide 8.31, except as provided in an alternative program submitted under one of the last two paragraphs of this license condition. Personal effects (e.g., notebooks and flash lights) which are hand carried need not be surveyed by personnel meeting the above qualifications, but these items should be subjected to the same survey requirements as the individual possessing the items.</p> <p>For release to unrestricted areas, the licensee may provide an alternative program for releasing equipment, materials, or packages that have the potential for accessible surface contamination levels above background (i.e., “controlled release”) to the NRC headquarters staff for review and written verification. The alternative program for controlled release shall demonstrate how the licensee will maintain radiological controls over the equipment, materials, or packages that have the potential for accessible surface contamination levels above background until they have been released for unrestricted use as specified in the first paragraph above, and shall describe the methods that will be used to limit the spread of contamination to unrestricted areas. An alternative program proposed under this paragraph shall not be implemented without written verification from NRC headquarters staff.</p> <p>For releases with a final destination to one of the licensee’s restricted areas, whether through an unrestricted area or not, the licensee may, as part of an alternative program, identify one or more qualified designees to perform the surveys associated with releasing equipment, materials, or packages that have the potential for accessible surface contamination levels above background. The qualified designees shall have completed education, training, and experience, in addition to general radiation worker training as specified by the licensee. The licensee must submit the education, training, and experience requirements for qualified designees to the NRC headquarters staff for review and written verification, and must receive written verification of those requirements prior to allowing qualified designees to perform these surveys.</p>
<p>5.7.8.4</p>	<p>The licensee shall provide the following information for the airborne effluent and environmental monitoring program for which it shall develop written procedures for NRC written verification to:</p> <ul style="list-style-type: none"> A. Discuss how, in accordance with 10 CFR 40.65, the quantity of the principal radionuclides from all point and diffuse sources will be accounted for, and verified by, surveys and/or monitoring. B. Evaluate the member(s) of the public likely to receive the highest exposures from licensed operations consistent with 10 CFR 20.1302. C. Discuss and identify how radon (radon-222) progeny will be factored

Table 1: License Conditions

	<p>into analyzing potential public dose from operations consistent with 10 CFR Part 20, Appendix B, Table 2.</p> <p>D. Discuss how, in accordance with 10 CFR 20.1501, the occupational dose (gaseous and particulate) received throughout the entire License Area from licensed operations will be accounted for, and verified by, surveys and/or monitoring.</p>
5.7.8.4	<p>The licensee shall provide for NRC written verification an operational soil sampling program consistent with Regulatory Guide 4.14 or justification for an alternate program.</p>
5.7.9.4	<p>If an overlying aquifer monitoring well in Mine Unit 6 or Mine Unit 8 is placed on excursion status per LC 11.5, the licensee shall test it weekly for natural uranium in addition to the required indicators of Alkalinity, Conductivity, and Chloride. The natural uranium data from wells on excursion status in the overlying aquifer in Mine Units 6 or 8 shall be maintained in the on-site records. If a well in these specific mine units remains on excursion for more than 60 days, the licensee shall provide the natural Uranium data with the UCL indicator data in the required sixty day excursion report in accordance with LC 11.5.</p>
5.7.10.4	<p>The licensee shall submit a Quality Assurance Program (QAP) to the NRC for review and approval. The QAP will address the topics recommended in Regulatory Guide 4.15 (as revised).</p>
6.1.4	<p><u>Ground Water Restoration.</u> The licensee shall conduct ground water restoration activities in accordance with the approved license application. Permanent cessation of lixiviant injection in a well field would signify the licensee’s intent to shift from the principal activity of uranium production to the initiation of ground water restoration. Prior to initiation of ground water restoration activities, the licensee shall determine the restoration schedule. If the licensee determines that these activities are expected to exceed 24 months, then the licensee shall submit an alternate schedule request that meets the requirements of 10 CFR 40.42.</p> <p><u>Restoration Standards.</u> Hazardous constituents in the ground water shall be restored to the numerical ground water protection standards as required by 10 CFR 40, Appendix A, Criterion 5(B)(5). In submitting any license amendment application requesting review of proposed alternate concentration limits (ACLs) pursuant to Criterion 5(B)(6), the licensee must also show that it has first made practicable efforts to restore the specified hazardous constituents to the background or maximum contaminant levels (whichever is greater).</p> <p><u>Restoration Stability Monitoring.</u> The licensee shall conduct sampling of all constituents of concern on a quarter year basis during restoration stability monitoring. The sampling shall include the specified ore zone aquifer wells. The applicant shall continue the stability monitoring until the data show the most recent four consecutive quarters indicate no statistically significant increasing trend for all constituents of concern which would lead to an exceedance above the respective Criterion 5B(5) standard.</p>

Table 1: License Conditions

	<p>Changes to ground water restoration or post-restoration monitoring plans shall be submitted to the NRC for review and approval at least 60 days prior to ground water restoration in a well field.</p> <p>The restoration schedule for mine units two through five shall be as described in the request dated July 24, 2009, (ADAMS Accession No. ML092220668) and as approved in NRC staff's letter dated February 18, 2010(ADAMS Accession No. ML092510030).</p>
<p>6.1.4</p>	<p><u>Establishment of Background Water Quality.</u> Prior to injection of lixiviant for each mine unit, the licensee shall establish background ground water quality data for the ore zone and overlying aquifers. The background water quality will be used to define the background ground water protection standards required to be met in 10 CFR 40, Appendix A, Criterion 5B(5), for the ore zone aquifer and surrounding aquifers. Water quality sampling shall provide representative background ground water quality data and restoration criteria as described in Sections 5.8.8 and 6.1.3 of the approved license application.</p> <p>The data shall consist, at a minimum, of the following sampling and analyses:</p> <ul style="list-style-type: none"> A. Four samples shall be collected from production and injection wells at a minimum density of one production or injection well per four acres. These samples shall be collected at least 14 days apart. B. Four samples shall be collected from each designated monitoring well at a minimum density of: 1) one upper aquifer monitoring well per five acres of mine unit area, and 2) all perimeter monitoring wells. These samples shall be collected at least 14 days apart. The results of these analyses shall constitute the baseline for each designated well. C. The samples shall be analyzed for ammonia, arsenic, barium, cadmium, calcium, chloride, copper, fluoride, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, nitrate, pH, potassium, radium-226, selenium, sodium, sulfate, total carbonate, total dissolved solids, uranium, vanadium, and zinc. D. Prior to operation of a mine unit, representative background concentrations shall be established on a parameter-by-parameter basis using either the mine unit or well-specific mean value. E. The licensee shall submit all mine unit hydrologic test packages to the NRC for review.
<p>6.4.4</p>	<p>The licensee shall submit for NRC written verification additional information on its Wellfield Decommissioning Plan for Crow Butte Uranium Project, dated June</p>

Table 1: License Conditions

	2004 regarding the ability to detect radionuclides other than radium. Specifically, the licensee shall provide a technical basis for applying the gamma action level derived from radium to radionuclides other than radium and provide background levels that will be utilized for radionuclides other than radium (e.g., uranium).
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NRC finds that the license renewal application for the Crow Butte facility materials license complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's regulations. Based on its review, as documented in this SER, the staff concludes that the application meets the applicable requirements in 10 CFR Parts 20 and 40. More specifically, in accordance with 10 CFR 40.32(b-c), the staff finds that CBR is qualified by reason of training and experience to use source material for the purpose it requested; and that CBR's proposed equipment and procedures for use at its Crow Butte facility are adequate to protect public health and minimize danger to life or property. Therefore, in accordance with 10 CFR 40.32(d), staff finds that the renewal of the license to CBR will not be inimical to the common defense and security or to the health and safety of the public.

References

10 CFR Part 40, Appendix A, "Criteria Relating to the Operation of Uranium Mills and to the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily from their Source Material Content."

10 CFR Part 20, "Standards for Protection Against Radiation."

Atomic Energy Act of 1954, as amended, 42 U.S.C. § 2011 et seq.

CBR, 2007. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

CBR, 2009a. Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2009b. Response to letter received April 18, 2009 (Dated April 15, 2009) - Request for Additional Information (Environmental), License Renewal Amendment Request, Crow Butte Resources, Inc., Crawford, Nebraska, License SUA-1534 (TAC J00555), Crow Butte Resources, Inc., July 13, 2009, ADAMS Accession No. ML091980473.

CBR, 2010. Replacement pages in response to letter dated June 30, 2010, Open Issues, License Amendment, Crow Butte Resources, Inc., Crawford, Nebraska, License SUA-1534 (TAC J00555), Crow Butte Resources, Inc., September 28, 2010, ADAMS Accession No. ML102740030.

CBR, 2013. E-mail from J. Schmuck (CBR) to R. Burrows (NRC), RE: Comment on fourth draft of Crow Butte License Renewal language, Crow Butte, January 2, 2013, ADAMS Accession No. ML13002A135.

CBR, 2014. E-mail from J. Schmuck (CBR) to R. Burrows (NRC), RE: Request concurrence: revised draft license conditions for Designated Operator, Crow Butte, July 29, 2014, ADAMS Accession No. ML14211A029.

NRC, 2003. "Standard Review Plan for *In-Situ* Leach Uranium Extraction License Applications - Final Report," NUREG-1569. Washington, DC: June 2003.

NRC, 2008. NRC Staff submittal to the Atomic Safety and Licensing Board in the Matter of Crow Butte Resources, Inc., ASLBP No. 08-867-02-OLA-BD01, August 28, 2008. ADAMS Accession No. ML082410902.

1. PROPOSED ACTIVITIES

1.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant's description of the proposed activities at the Crow Butte facility in the LRA is in compliance with the applicable requirements in 10 CFR 40.31.

1.2 Regulatory Acceptance Criteria

The application was reviewed for compliance with the applicable requirements of 10 CFR 40.31 using the acceptance criteria presented in Section 1.3 of NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications,"(NRC, 2003) (NUREG-1569).

1.3 Staff Review and Analysis

Unless otherwise stated, information presented in this section was obtained from LRA Section 1.0 (CBR, 2007a). CBR is proposing to renew its source and byproduct materials license SUA-1534 for an additional 10-year period. The proposal is for the continued operations of the ISR facility at the Crow Butte facility located in Dawes County, Nebraska. The facility consists of 11 mine units, a central processing plant (CPP), a former research and development (R&D) site, commercial evaporation ponds, R&D evaporation ponds, and a deep injection disposal well, all of which are located within the licensed area.

The CPP is located approximately four miles southeast of the city of Crawford, Nebraska. The applicant is permitted by the current iteration of the license to recover uranium through the ISR process as source material (herein described as yellowcake) and dispose of byproduct material through environmentally isolated evaporation ponds and injection in a Class I deep waste disposal well permitted by the Nebraska Department of Environmental Quality (NDEQ) (permit no. NE0206369). Pursuant to the current license, the maximum permitted production flow rate is 34,000 liters per minute (Lpm) [9,000 gallons per minute (gpm)] as a result of a plant upgrade (discussed below) and maximum annual yellowcake production is 909,100 kilograms (kg) [2,000,000 pounds (lbs)].

The applicant does not propose substantive changes to the current license for the renewal period. The applicant stated (CBR, 2007a) that at that rate of annual production—that being approximately 363,640 kg (800,000 lbs) of yellowcake—it anticipated that production would continue until 2012, at which time reserves in the subsurface will begin to be depleted, and at 2014, commercial operations would no longer be economically viable. As of the first half of 2012, the applicant continued to expand production (CBR, 2012e). Completion of ground water restoration for all mine units is scheduled for 2023.

The applicant has also submitted under separate cover letters license amendment requests to expand their ISR operations into nearby areas. The amendment requests include the North Trend Expansion Area and the Three Crow Expansion Area (CBR, 2007b, 2010a). If approved, the expansion areas will be developed and operated by CBR as satellite facilities to the existing

Crow Butte facility. A satellite facility is one in which the above ground processing capabilities are limited, (*i.e.*, the facility does not include a dryer to produce the final yellowcake product). CBR plans to transport uranium bearing resins from each proposed expansion area satellite to the existing CPP to complete the processing to yellowcake. As these amendment requests seek the authorization of activities beyond the scope of those sought by the LRA — that being the renewal of the Crow Butte facility—the staff's review of the amendment requests for the expansion areas were not included as part of the safety review for the existing license renewal application.

Aspects of the CBR's licensed activities that remain unchanged from the previous license renewal include the location of the facility, land ownership, ore-body locations, the proposed recovery process, and waste management and disposal plans. These particular aspects of the CBR's activities were approved during the previous license renewal, and the staff did not identify any information that invalidated the staff's previous approvals (NRC, 1998a, 1998b).

Certain operational aspects of the Crow Butte Project have changed since the previous license renewal. The CPP design throughput was increased from 5,000 gpm to 9,000 gpm (NRC, 2007).

CBR updated its corporate structure information in the application (CBR, 2008). As stated in Section 1.2 of the approved application, CBR does business as Cameco Resources in the State of Nebraska. NRC staff confirmed the trade name of Cameco Resources through a search on the State of Nebraska website (Nebraska, 2011). CBR is owned by Cameco US Holdings, Inc. which the staff confirmed is registered in the State of Nevada (Nevada, 2011). Cameco US Holdings, Inc. is held by Cameco Corporation, a Canadian corporation.

Production and restoration schedules are different from the last license renewal, as well. According to the 1995 license renewal application, Mine Unit 1 was in restoration, Mine Units 2 – 4, were in production, and Mine Unit 5 was being developed (CBR, 1995). Currently, Mine Unit 1 has been restored, Mine Units 2 – 5 are in restoration, Mine Units 6 – 10 are in production, and Mine Unit 11 is in development. Regarding restoration, CBR provided a restoration schedule in the 2007 license renewal application; however, the staff approved an amendment to the schedule in February 2010 (NRC, 2010a). CBR requested this amended schedule in July 2009 to comply with 10 CFR 40.42(i), which requires the completion of decommissioning of outdoor areas within 24 months of starting these activities (CBR, 2009). However, alternate decommissioning schedules may be requested if decommissioning requires more time. CBR requested alternate schedules for Mine Units 2 through 5, for which decommissioning is expected to be completed from 2012 to 2016. This request was approved on August 20, 2009 (NRC, 2009)

Regarding the applicant's financial assurance, according to License Condition 9.5 of Materials License SUA-1534, CBR provides updates to its surety estimate annually to the staff. The latest approved surety update is dated April 20, 2010 and is included as Amendment No. 25 to the previously mentioned license (NRC, 2010b). CBR's current surety is \$28,902,051, and has been approved by the staff. CBR maintains a letter of credit for the full surety amount, which is revised annually and submitted to the staff, as well as the NDEQ.

The staff reviewed the inspection reports prepared since the last license renewal. A review of the inspection reports (SER Table 1-1) indicates that the applicant incurred several Security Level IV violations during the renewal period. These included a failure to prepare radiation

safety procedures for the yellowcake dryer, failure to collect some required samples (pond wells and ponds), failure to perform required integrity tests on certain wells, failure to provide certain employee training, failure to perform certain release surveys, and incomplete health physics records. In most cases, the licensee identified the violation. None of the violations were severe enough to warrant the imposition of civil penalties.

Table 1-1: List of Inspection Reports

Inspection Date	ADAMS Accession No.	Inspection Results
Sept. 21 – 23, 1999	ML993300032	Level IV violation – dryer radiation safety
March 20 – 22, 2000	ML003705485	No violations
April 2 – 5, 2001	ML011280480	No violations
May 21 – 23, 2002	ML021680257	No violations
August 25 - 27, 2003	ML032650623	No violations
Sept. 14 - 16, 2004	ML042920385	No violations
Sept. 20 – 22, 2005	ML052930434	No violations
August 15 – 17, 2006	ML062540084	No violations
Sept. 17 – 19, 2007	ML072890610	Level IV violations – missed pond well sampling, failure to survey released package. Licensee identified violations.
July 15 – 17, 2008	ML082410870	Level IV violation – missed integrity tests. Licensee identified violation.
July 14 – 16, 2009	ML092670138	Level IV violations – missed pond samples, failure to request alternate decommissioning schedule, failure to survey a vehicle being released, failure to provide hazardous materials training to several employees. Licensee identified two violations
June 8 – 10, 2010	ML102320543	Level IV violations – incomplete occupational dose records, incomplete health physics training for one employee, missed integrity tests on two wells. Licensee identified one violation.
June 20 – 24, 2011	ML11216A179	No violations

Table 1-2, below, presents a list of amendments issued to the applicant during the renewal period. Other than standard surety updates, corrections, and monitoring plan changes, significant amendments included Amendment 7 (approving changes in disposal well operations), Amendment 15 (approving the restoration of Mine Unit 1), Amendment 16 (approving changes to the excursion monitoring parameters), and Amendment 22 (approving the central plant upgrade).

Table 1-2: List of License Amendments

Date	Amendment No.	Amendment Purpose	Accession No.
5/8/1998	1	Surety modifications and monitoring well sampling frequency	9805190338
2/3/1999	2	Surety update	9909020215
3/30/1999	3	Groundwater environmental sampling revision	9904070140
4/22/1999	4	Restricted area boundary and adding a perimeter well condition	9905110222
9/23/1999	5	Surety Update	ML091470403
4/5/2000	6	Administrative corrections	ML081300466
7/5/2001	7	Modification to Class I well	ML102360546
1/21/2001	8	UCL Calculation Method	ML010590206
2/1/2001	9	Surety Update	ML010330107
4/4/2001	10	Address change	ML011080554
6/26/2001	11	Restoration goals, baseline constituents	ML011830343
7/24/2002	12	Surety update	ML022060156
9/3/2002	13	Administrative change – remove duplication	ML022480203
11/7/2002	14	Surety update	ML023170592
2/12/2003	15	Approval of Mine Unit 1 Restoration	ML030440055
10/20/2003	16	Excursion monitoring parameters and surety update	ML032940073
4/19/2004	17	Approves groundwater restoration plan	ML041130127
11/16/2004	18	Surety update	ML043240605
6/8/2005	19	Address change	ML051660217
1/4/2006	20	Surety update	ML060030429
1/29/2007	21	Surety update	ML063600067
11/30/2007	22	Plant upgrade	ML073120066
5/12/2008	23	Surety update	ML080950175
10/21/2009	24	Surety update	ML092220252
4/20/2010	25	Surety update	ML100830012

1.4 **Evaluation Findings**

Staff reviewed the proposed activities at the Crow Butte Project in accordance with review procedures in Section 1.2 and acceptance criteria outlined in Section 1.3 of NUREG-1569 (NRC, 2003), considering changes to the facility since the last license renewal, per Appendix A of NUREG-1569 (NRC, 2003). The staff determined that the following aspects of the Crow Butte Project have not changed since the last license renewal: (1) the location of the facility, (2) land ownership, (3) ore-body locations, (4) the proposed recovery process, and (5) waste management and disposal plans. In its review, the staff has found nothing to invalidate previous

conclusions regarding these activities. Aspects of Crow Butte Project that have changed are as follows: (1) the corporate entities involved, (2) operating plans and design throughput, (3) schedules for construction, startup, and duration of operations, and (4) financial assurance. For those aspects of the operations that have changed, the staff reviewed both information provided by the applicant and licensing actions approved by the staff since the last license renewal and since the 2007 license renewal application was submitted. Furthermore, the staff reviewed inspection reports prepared during the renewal period (SER Table 1-1). Inspection reports indicate that the facility has operated safely and that only minor cited and non-cited Security Level IV violations have occurred. Most of these violations were self-identified by the licensee.

Based upon the staff's review of the information presented above, the information provided in the application, as supplemented by information from NRC staff licensing actions, meets the applicable acceptance criteria of Section 1.3 of the standard review plan and the requirements of 10 CFR 40.31.

1.5 References

CBR, 1995, Crow Butte Project - Application for Renewal of USNRC Radioactive Source Material License, Crow Butte Resources, Inc., December 31, 1995 (ADAMS Accession No. ML082140217).

CBR, 2007a, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007 (ADAMS Accession No. ML073480264).

CBR, 2007b, Application for Amendment of USNRC Source Materials License SUA-1534, North Trend Expansion Area, Crawford, Nebraska, May 30, 2007 (ADAMS Accession No. ML071730274).

CBR, 2008. Revision to Section 1.2 of Crow Butte License Renewal Application. December 16, 2008 (ADAMS Accession No. ML090020026).

CBR, 2009. Request for Alternate Decommissioning Schedule (Groundwater Restoration), July 24, 2009 (ADAMS Accession No. ML092220668).

CBR, 2010a, Application for Amendment of USNRC Source Materials License SUA-1534, Three Crow Expansion Area, Crawford, Nebraska, August 2010 (ADAMS Accession No. ML102230009).

CBR, 2012e, Crow Butte Uranium Project: Radiological Effluent and Environmental Monitoring Report: First and Second Quarters, 2012, USNRC Source Materials License SUA-1534, August 30, 2012 (ADAMS Accession No. ML12257A470).

NDEQ, 2010. Letter to NRC Staff Regarding Proposed Class I Injection Permit, Nebraska Department of Environmental Quality, July 28, 2010 (ADAMS Accession No. ML102220485).

Nebraska, 2011.

https://www.nebraska.gov/sos/corp/corpsearch.cgi?search_type=keyword_search&status=A&corpname=Cameco+Resources&keyword_type=all&acct-num=&search=1, accessed December 8, 2011.

Nevada, 2011.

<http://nvsos.gov/sosentitysearch/CorpDetails.aspx?lx8nvq=vu5gZ6SZ92iRUdqXh2ol8w%253d%253d&nt7=0>, accessed December 8, 2011.

NRC, 1998a. Safety Evaluation Report (SER) for Renewal of Source Material License SUA-1534, Crow Butte Project, February 1998, ADAMS Accession No. ML081080325.

NRC, 1998b. Environmental Assessment for Renewal of Source Material License No. SUS-1534, Crow Butte Resources, Incorporated, Crow Butte Uranium Project, Dawes County, Nebraska, February 1998, ADAMS Accession No. ML071520242.

NRC, 2003. "Standard Review Plan for *In-Situ* Leach Uranium Extraction License Applications - Final Report," NUREG-1569. Washington, DC: June 2003.

NRC, 2007. License Amendment No. 22, Central Processing Plant Upgrade, November 30, 2007 (ADAMS Accession No. ML072700128).

NRC, 2009. Letter to Crow Butte Approving Alternate Decommissioning Schedule for Mine Units 2 through 5, August 20, 2009 (ADAMS Accession No. ML092300140).

NRC, 2010a. Letter to CBR Approving Alternate Decommissioning Schedule, February 18, 2010 (ADAMS Accession No. ML092510030).

NRC, 2010b. License Amendment No. 25, Revised Surety Estimate for Crow Butte Resources, Inc., April 20, 2010 (ADAMS Accession No. ML100830012).

2. SITE CHARACTERIZATION

2.1 Site Location and Layout

2.1.1 Regulatory Requirements

The staff determines if the applicant has adequately identified the site location in accordance with the requirements of 10 CFR 40.31(g)(2).

2.1.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR 40 using the acceptance criteria presented in NUREG-1569 Section 2.1.3 (NRC 2003).

2.1.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application.

The Crow Butte facility is located in Dawes County, Nebraska, with the central processing plant located approximately 6.4 kilometers (km) (4 miles [mi]) southeast of the City of Crawford, Nebraska (CBR, 2007). The areal extent of the license area is shown in Figure 2.1-1. The license area is located within the following land survey sections: Sections 11, 12, 13 and 24 of Township 31 North, Range 52 West; and Sections 18, 19, 20, 29 and 30 of Township 31 North, Range 51 West. The existing license area covers approximately 1,165 hectares (2,875 acres) and the anticipated total surface area affected by the activities proposed throughout the life of the license is estimated at 512 hectares (1,265 acres). The northern boundary of the license area lies within approximately 2 km (1 mi) of the City of Crawford. (CBR, 2007)

Three restricted areas have been delineated within the license area (CBR, 2007). Restricted areas include the commercial evaporation ponds, the Central Processing Plant and the former research and Development (R&D) site (pilot plant building and ponds). Access to the restricted areas is controlled by perimeter fencing with the appropriate display of warning signs. (CBR, 2007) Although a perimeter fence exists around individual mine units, access to the mine units is not controlled as such areas are not considered restricted access areas.

The staff reviewed site location and layout information provided by the applicant, and visited the site on several occasions during the course of this review to confirm information presented in the application. The staff observed that the license area is the same as that identified in the original license application (FEN, 1987), and site land ownership has not changed since the 1995 license renewal application (CBR, 1995). A review of the application also indicated that the applicant provided appropriate scaled maps of the region including counties, site

configuration, major drainages, nearby population centers, and transportation links (application Figure 2.1-3, CBR, 2007). The applicant has provided recent data on the population and nearby land-use in the narrative and maps (application Figure 2.2-1, CBR, 2009).

Some aspects of plant have changed since the last renewal. On November 30, 2007, the staff issued License Amendment No. 22, which approved an upgrade to the central processing plant. This upgrade allowed the applicant to increase its plant flow rate from 4,500 gpm to 9,000 gpm (NRC, 2007). The applicant addressed the plant upgrade in application Section 3.2.1 (CBR, 2007). Staff observes that the applicant constructed a new chemical storage area for sodium sulfide, which it uses to increase the reducing capacity of the production zone during restoration. The applicant's SERP report 08-05 discusses releasing this area adjacent to the existing reverse osmosis (RO) building for use as the location for the sodium sulfide storage area (CBR, 2009).

In accordance with Appendix A of the SRP, the staff reviewed any changes to the site location and layout at the Crow Butte Facility. The application, supplemented by SERP 08-05, has sufficiently described the site layout and location, and, therefore, meets the requirements of 10 CFR 40.31(g)(2).

2.1.4 Evaluation Findings

The staff has reviewed the site location and layout of the Crow Butte Facility in accordance with the review procedures in Appendix A and per the acceptance criteria in standard review plan Section 2.1.3. The NRC staff finds that the applicant has described the site location and layout with appropriately scaled and labeled maps showing the site layout, principal facilities and structures, boundaries, and topography. Based upon the review conducted by staff as indicated above, the NRC staff concludes that the information provided in the application, as supplemented by SERP Report 08-05 (CBR, 2009), meets the applicable acceptance criteria of standard review plan Section 2.1.3 (NRC, 2003) and the requirements of 10 CFR 40.31(g)(2).

2.1.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2009. Annual Report of Changes, Tests, or Experiments, January 26, 2009 (ADAMS Accession No. ML090400210).

CBR, 2007. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

CBR, 1995. Application for Renewal of USNRC Radioactive Source Material License No. SUA-1534, Crow Butte Resources Inc., December 31, 1995, ADAMS Accession No. ML082060561 (Package).

Ferret Exploration Company of Nebraska, Inc. (FEN), 1987. Application for Source Material License, Ferret Exploration Company of Nebraska, Inc., October 7, 1987, ADAMS Accession No. ML080940335 (Package).

NRC, 2003. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report.” June.

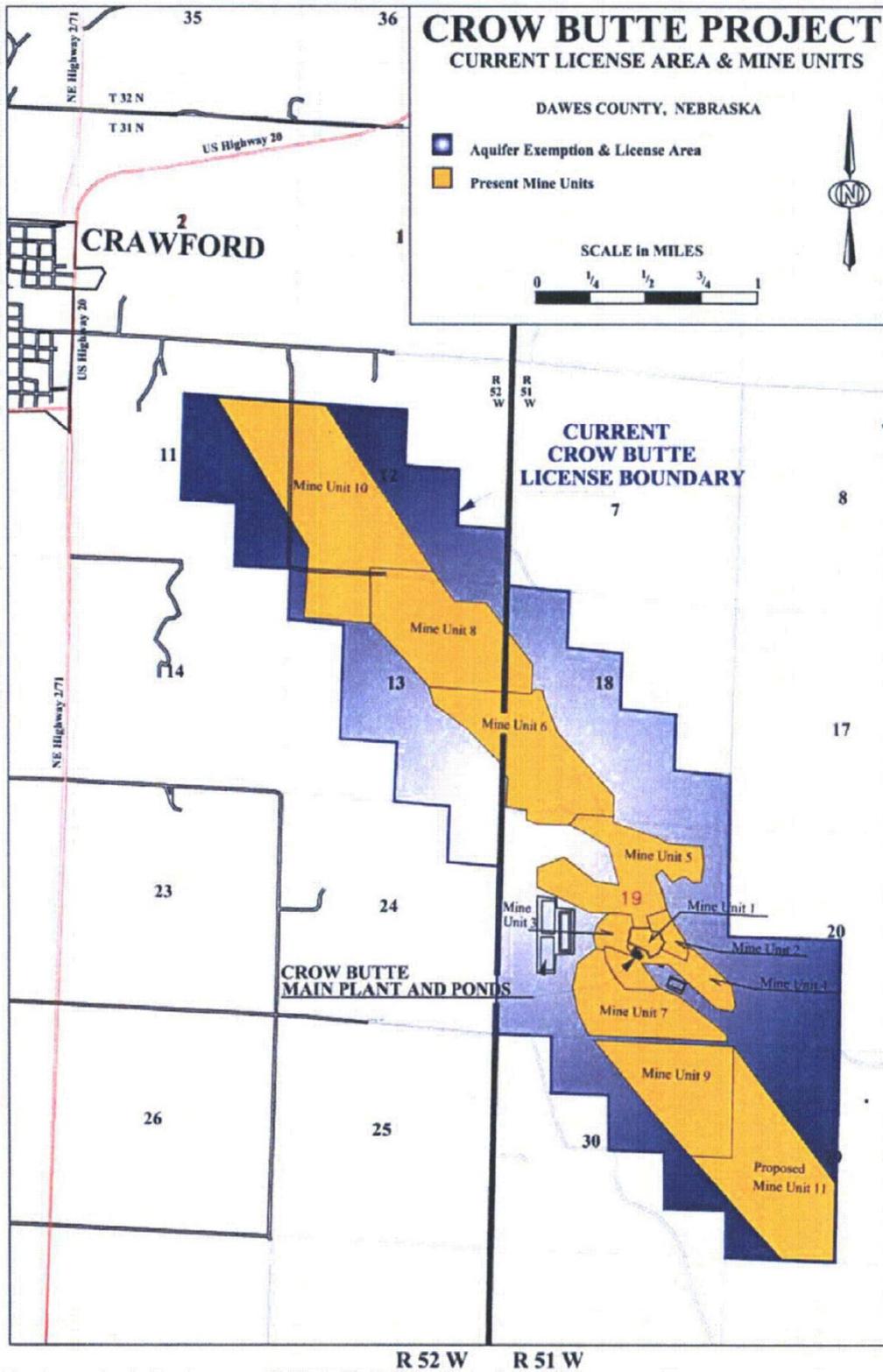


FIGURE 2.1-1 SITE LOCATION MAP (FROM FIGURE 1.7-2 OF CBR 2007)

2.2 Meteorology

This section discusses the meteorological conditions of the region surrounding and including the Crow Butte facility. Meteorological data is used for the selection of environmental monitoring locations, the assessment of the impact of operations on the environment, and the performance of radiological dose assessments.

2.2.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the meteorology program, which is part of the site monitoring programs required by Criterion 7 of Appendix A to 10 CFR Part 40, is sufficiently complete to allow for estimating doses to workers and members of the public.

2.2.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed to ensure that the facility will continue to operate so as to protect health and safety and the environment using the acceptance criteria presented in Section 2.5.3 of NUREG-1569 (NRC, 2003).

2.2.3 Staff Review and Analysis

The following sections present the staff's review and analysis of various aspects of the meteorological conditions at the Crow Butte Facility. Aspects reviewed in the following sections include: general site conditions, wind, and air quality. The information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated.

2.2.3.1 General Site Conditions

The applicant stated that climate in the area is considered to be semiarid and is characterized by cold winters and warm summers (Section 2.5 of CBR, 2009). The applicant previously reported that the data obtained at the on-site meteorological station during the period May 1982 to April 1984 for precipitation, evaporation and temperature were in good agreement with the results from the National Weather Service Stations located at Scottsbluff, Nebraska and Rapid City, South Dakota (Section 2.5.6 of FEN, 1987). As a result of a request for additional information from NRC staff, the applicant also demonstrated that data for precipitation and temperature for Chadron, Nebraska is comparable to these parameters for Crawford, Nebraska (Applicant response to staff comment #1 for Section 2.5 Meteorology and Section 2.5 from CBR, 2009). The applicant also demonstrated that humidity data from Rapid City, South Dakota and Scottsbluff, Nebraska are better indicators for humidity in Crawford, Nebraska (Applicant response to staff comment #2 for Section 2.5 Meteorology and Section 2.5 from CBR, 2009). In addition, the applicant stated that Rapid City, South Dakota and Scottsbluff, Nebraska have weather stations that provide complete hourly meteorological data to the public, unlike Crawford, Nebraska and nearby Fort Robinson (Section 2.5 of CBR, 2009).

To demonstrate the comparability of temperatures for Crawford and Chadron, Nebraska, the applicant compared the temperatures for spring and summer of 1999 for these two locations (Figure 2.5-1 of CBR, 2009). The applicant stated that 1999 was the most recent year with actual temperature data for Crawford, Nebraska (Section 2.5 of CBR, 2009). The applicant also provided temperature data for Chadron, Nebraska for the years 1948 to 2003 (Tables 2.5-1 and 2.5-2 of CBR, 2009) and 2006 to 2007 (Table 2.5-3 of CBR, 2009). The applicant stated that temperature data for the years 2004, 2005, and 2008 were not used due to insufficient data (Section 2.5 of CBR, 2009).

The applicant provided a comparison of rainfall for Crawford and Chadron, Nebraska for spring and summer 1999 (Figure 2.5-2 and Table 2.5-6 of CBR, 2009). The applicant also provided precipitation data for Chadron, Nebraska for the years 1948 – 2003 (Table 2.5-4 of CBR, 2009) and Scottsbluff, Nebraska and Rapid City, South Dakota (Table 2.5-5 of CBR, 2009).

The monthly percent relative humidity was collected from Scottsbluff, Nebraska and Rapid City, South Dakota from 1982 to 1990 (Section 2.5 of CBR, 2009). The highest and lowest percent relative humidity measured was 81.1 percent and 35.1 percent, respectively, both in July at Scottsbluff, NE. The average humidities for 2006 in Chadron, NE, Scottsbluff, NE, and Rapid City, SD were 61.6%, 57.5%, and 56.8%, respectively. The relation of the humidity for the three stations during 2006 is shown on TR Figure 2.5-3. (Section 2.5 of CBR, 2009)

The staff has reviewed the updated information on temperature, precipitation, and percent relative humidity provided by the applicant and has determined that the applicant has provided sufficient data to characterize the site vicinity and that there are no unreviewed safety-related concerns. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not reexamining the results of the applicant's original precipitation, evaporation and temperature data.

2.2.3.2 Wind

A wind rose depicting the percentage of wind directions and wind speeds at the Crow Butte site during the period May 1982 to April 1984 is shown on TR Figure 2.5-6 (Section 2.5 of CBR, 2007). The average wind speed for all stability classes is 15.6 km/h (9.7 mph) (Figure 2.5-6 of CBR, 2007). NRC staff observes that the three most frequent wind directions are from the South, Southwest, and South Southwest and represent approximately 38% of the wind rose.

The applicant previously submitted this wind data for NRC staff review (Section 2.5 of CBR, 1995). Staff observes that there is no requirement for a licensee to maintain a meteorological station during operations and that the applicant dismantled their meteorological station after collecting data for their original licensing action. The applicant stated that they considered the two year Crow Butte site wind record to continue to be representative of the long-term wind conditions at the site (Section 2.5 of CBR, 2009). To demonstrate the validity of this statement, the applicant compared short-term wind data from 1984 to 1990 for Scottsbluff, Nebraska and Rapid City, South Dakota to longer-term wind data (1961 to 2003) for these same locations. The applicant stated that these comparisons showed that while wind patterns can change significantly for different locations, wind patterns at a specific site do not change significantly from year to year. (Section 2.5 of CBR, 2009) Staff agrees with the applicant's assessment as the information used for comparison is from an authoritative source and has found no technical reason for invalidating previous wind data.

Moreover, staff previously analyzed the original wind data and concluded that operation of the Crow Butte Project is protective of health and safety (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not reexamining the results of the applicant's original wind data.

2.2.3.3 Air Quality

The applicant presented updated data on the existing air quality in nearby areas that they determined to be geographically similar to the License Area (CBR, 2009). Non-radiological air concentrations for particulate matter with diameters less than 0.001 cm (0.00039 inches) were presented for a rural area in the Black Hills and suburban area in Rapid City, SD (CBR, 2009). The reported concentrations were obtained from the United States Environmental Protection Agency (EPA) air quality monitoring database and were below the National Ambient Air Quality Standards (NAAQS) for maximum 24 hour average concentrations and annual average concentrations (CBR, 2009). Staff finds this information acceptable as it comes from an authoritative reference source. In addition, staff finds the results acceptable for characterizing the air quality at the applicant's site as it is consistent with previous staff conclusions on ISR activity, in general, for both operations and restoration in the Nebraska-South Dakota-Wyoming Uranium Milling Region (NRC, 2009).

The applicant also stated that all counties within 80 km (50 mi) of the project are in attainment of NAAQS. Staff independently verified this statement by sampling EPA's database (EPA, 2011) for several air pollutants and therefore finds the information the applicant provided on air quality acceptable.

2.2.4 Evaluation Findings

Staff reviewed updates to the meteorological conditions in the vicinity of the Crow Butte facility in accordance with Appendix A of NUREG-1569 (NRC, 2003). The applicant provided updated information on temperature, precipitation, percent relative humidity and wind in sufficient detail for staff to evaluate meteorological conditions in the site vicinity. The applicant also provided sufficient information on existing air quality in nearby areas for staff to evaluate.

As noted above, staff previously concluded that operation of the Crow Butte Project is protective of health and safety (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff has not identified any unreviewed safety-related concerns and therefore is not reexamining the results of the applicant's meteorological or air quality data.

2.2.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40 Appendix A, "Criteria Relating to the Operation of Uranium Mills and to the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily from their Source Material Content."

CBR, 2009, Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2007, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

CBR, 1995. Application for Renewal of USNRC Radioactive Source Material License No. SUA-1534, Crow Butte Resources Inc., December 31, 1995, ADAMS Accession No. ML082060561 (Package).

EPA, 2011. Nonattainment Areas Map - Criteria Air Pollutants, AirData website located at: <http://www.epa.gov/air/data/reports.html>, accessed on May 4, 2011.

Ferret Exploration Company of Nebraska, Inc. (FEN), 1987. Application for Source Material License, Ferret Exploration Company of Nebraska, Inc., October 7, 1987, ADAMS Accession No. ML080940335 (Package).

NRC, 2009. NUREG-1910, Vol.1, "Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities, Chapters 1 through 4, Final Report," May, 2009.

NRC, 2003. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

NRC, 1998. Safety Evaluation Report for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., Crow Butte Uranium Project, Dawes County, Nebraska, February 1998, ADAMS Accession No. ML081080325.

2.3 Geology and Seismology

2.3.1 Regulatory Requirements

The purpose of this section is for the staff to determine if the applicant provided sufficient characterization of geology and seismology at the CBR facility for staff to be able to assess the applicant's ability to control production fluids containing source and byproduct materials, as required by 10 CFR 40.41(c).

2.3.2 Regulatory Acceptance Criteria

The applicant's characterization of geology and seismology at the CBR facility was reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 2.6.3 of NUREG 1569 (NRC, 2003).

2.3.3 Staff Review and Analysis

The following sections present the staff's review and analysis of various aspects of the geology and seismology at the CBR facility. The aspects reviewed in the following sections include:

regional geology, site geology, soils, and seismology. The information reviewed in this section is from information, data, and maps submitted by the applicant in its license renewal application (LRA) (CBR, 2007) and as updated. NRC staff also visited the site on several occasions during the course of this review.

2.3.3.1 Regional Geology

The applicant presented the regional bedrock geologic map and generalized stratigraphic column, respectively, of northwestern Nebraska in Figure 2.6-1 and Table 2.6-1 of the LRA (CBR, 2007). Geological units found in northwestern Nebraska include the Brule and Chadron formations, collectively referred to as the White River Group, and the Pierre Shale. The applicant reported that on a regional scale, the Dakota, Morrison, and Sundance Formations underlie the Pierre Shale and the Arikaree and Ogallala groups overlie the White River Group. The applicant described the Chadron Arc (anticline feature), Black Hill Uplift, the White River Fault, Bordeaux Fault, Pine Ridge Fault, Toadstool Park Fault, and Cochran Arch as part of the regional-scale structural features. (CBR, 2007)

NRC staff reviewed the geologic information provided by the applicant (CBR, 2007) and compared this information with independent sources to confirm the applicant's description of the regional geology. NRC staff confirmed that the applicant's description of the regional geology is consistent with the local and regional stratigraphy and geologic descriptions presented by Collings and Knode (1984), Miller and Appel (1997), and Hoganson, et al. (1998). The staff previously evaluated the regional geologic information in the prior license renewal review (NRC, 1998) and found it acceptable. Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not reexamining the results of the applicant's regional geologic data.

2.3.3.2 Site Geology

NRC staff observes recent studies of the regional geology have resulted in the proposal of a new nomenclature for some of the geologic layers within the license area (LaGarry, 2010). In its discussions of site geology, the applicant used the nomenclature found in the prior license applications (CBR, 1995). After reviewing information from the USGS, the staff determined that the USGS identifies a basal portion of the Chadron Formation, as well as a Chamberlain Pass Formation of Eocene age (38 to 55 million years ago) (USGS, 2011a). In Nebraska, the USGS does not identify a Chamberlain Pass Formation, but does identify a basal channel deposit at the base of the Chadron Formation (USGS, 2011b). Furthermore, the Nebraska Department of Environment uses the traditional stratigraphic terms, an example of which may be found in the applicant's application for a Class III underground injection control permit for its North Trend Expansion Area (CBR, 2010). Stratigraphic nomenclature aside, nothing in the naming conventions for the geologic units in Nebraska or at the Crow Butte facility changes the interpretation of the physical or hydraulic features of the rock units. Therefore, the staff will continue to use the current naming conventions presented in the LRA (CBR, 2007).

The applicant provided detailed information regarding the geology at the license area. Figure 2.6-2 of the LRA presents a stratigraphic column of the geologic units present within the license and abutting area (CBR, 2007). Thicknesses of the various geologic units are as follows:

Arikaree Group (all members)	60 to 120 m (200 to 400 ft).	High Plains Aquifer
Upper Brule (all members)	60 to 120 m (200 to 400 ft),	Upper Aquifer
Chadron and Lower Brule	60 to 90 m (200 to 300 ft),	Upper Confining Unit
Basal Chadron Sandstone	3 to 25 m (10 to 80 ft),	Ore Zone Aquifer
Pierre Shale	455 m (1,500 ft),	Lower Confining Unit

The local stratigraphic column the applicant provided (CBR, 2007; Section 2.6.2) indicates that the Basal Chadron sandstone is locally separated from the overlying Arikaree Group by a thick confining layer that consists of 35–75 m (120–250 ft)-thick middle and upper Chadron units and 150–200m (500–650 ft)-thick Brule Formation. The applicant reported this confining layer is regionally continuous. As shown in Figure 2.6-1 of the LRA, the Arikaree Group only occurs on the Pine Ridge Escarpment, which is along the southern portion of the site in Mine Unit 11 (CBR, 2007). The Pierre Shale which underlies the Basal Chadron sandstone is over 455 m (1500 feet) thick in the license area. It has a very low hydraulic conductivity and is regionally continuous. The Sundance and Morrison Formations are the sandstone layers below the Pierre Shale. (CBR, 2007)

The staff previously approved the site stratigraphy information in the prior license renewal review (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not reexamining the results of the applicant's site stratigraphy data.

The applicant provided several geological cross sections from the original license application (FEN, 1987) and three updated cross sections for the license area in the LRA (CBR,2009). The updates were provided in NW-SE cross sections A-A' and D-D' in Figure 2.6-4 and 2.6-10 and the northernmost E-W longitudinal geological cross section in Figure 2.6-5. An additional update was made to the NW-SE cross section in Figure 2.6-11. The updated cross sections in Figures 2.6-4 and 2.6-10 extended into the proposed North Trend Expansion Area. (CBR, 2009)

The applicant previously identified the structural feature north of the Crow Butte facility as a fault with a displacement in the Basal Chadron Formation of as much as 120 m (400 ft) in the area near the White River. This feature was originally interpreted as the White River Fault. In the LRA (CBR, 2007), the applicant stated that recent close spaced drilling indicates that this feature may be interpreted as a fold or bending of the White River Group above a blind fault structure at stratigraphically lower elevations rather than a fault that cuts through and vertically displaces the White River Formation as initially interpreted by Collings and Knode (1984). The newly revised cross sections therefore do not reflect the presence of the White River Fault feature (CBR, 2007).

NRC staff agrees with the applicant that the new interpretation without the fault shown on the cross sections is feasible. However, to further assess whether or not the structural feature is a fault or a monocline fold, NRC staff performed a probabilistic statistics analysis of 2 sets of 5 numerical ground water flow models. This analysis is discussed in SER Section 2.4.3.2.

The applicant provided isopach maps (contour maps depicting lines of a specific thickness for the designated unit) for the Basal Chadron sandstone and upper confining unit (upper Chadron and Lower Brule formation) (CBR, 2007). It also provided a structural contour map for the base

of the Chadron Formation in the vicinity of the license area. Based on the isopach and structural contour maps, the NRC staff observes the Basal Chadron Sandstone, within the license area, is approximately 25 m (80 ft) thick, and the upper confining unit is between 90 and 150 m (300 to 500 ft) thick. No gaps in the upper confining layer were identified in Figure 2.6-14 of the LRA (CBR, 2007).

The staff previously approved the site geologic information during the prior license renewal review (NRC, 1998). However, the applicant proposed a new interpretation of the White River structural feature, by declaring it a monocline fold instead of a fault. The staff concurs with the applicant's new interpretation, as further discussed in SER Section 2.4.3.3. Staff has found nothing else to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

2.3.3.3 Seismology

In the LRA, the applicant provided an updated seismicity map of Nebraska based on information from the U.S. Geological Survey National Earthquake Information Center, a list of earthquakes between the Chadron and Cambridge Arches and their intensities, and a seismic hazard map and a seismicity map showing epicenter locations in Nebraska (CBR, 2007). The applicant originally reported that Crow Butte is located in Seismic Risk Zone 1 corresponding to a low seismic zone. The updated seismic zone map from USGS in Figure 2.6-15 LRA (CBR, 2007) indicates the facility remains in a Seismic Risk Zone 1. NRC staff observes that within this risk zone the facility may experience a ground acceleration of 0.075 g based on the U.S. Seismic Zone Map presented in International Conference on Building Officials (1997). NRC staff therefore concludes that the Crow Butte license area is located in a low seismic risk area given that the ISR facility and the nearby regions are located in the Seismic Risk Zones 0 or 1. The staff finds the applicant's current assessment of the seismology to be acceptable as its analysis is supported by recently published information and is consistent with the acceptance criteria in standard review plan Section 2.6.3. The NRC staff approved the applicant's conclusions regarding seismology during the previous license renewal review (NRC, 1998). Staff has found nothing in the updated seismicity to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not reexamining its previous findings of the applicant's seismological data.

2.3.3.4 Soils

The applicant originally provided (FEN, 1987) a soil map for the permit area at an adequate scale and the description, areal coverage, and slope of soil types within the license area based on information from the U.S. Department of Agriculture, Natural Services Conservation Service, and Soil Survey of Dawes County, Nebraska. The NRC staff determined that the soils information was acceptable during the previous license renewal (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not reexamining its previous findings of the applicant's soils data.

2.3.4 Evaluation Findings

As noted above, staff previously approved the regional geologic, site geologic, seismologic, and soils data in the prior license renewal review (NRC, 1998). The applicant also updated its interpretation of the White River structural feature which is now considered a monocline fold. This staff agrees with this new interpretation, which is based on more detailed drilling performed during the last renewal period. Staff has found no other information to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not reexamining its previous findings of the applicant's geologic, seismologic, and soils data except for the updated information for the White River structural feature as discussed above.

2.3.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2010, Application for a Class III Underground Injection Control Permit, North Trend Expansion Area, January 31, 2010 (ADAMS Accession No. ML100432245).

CBR, 2009, Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2007, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

CBR, 1995. Application for Renewal of USNRC Radioactive Source Material License No. SUA-1534, Crow Butte Resources Inc., December 31, 1995, ADAMS Accession No. ML082060561 (Package).

Collings, S.F. and R.H. Knode, 1984, "Geology and Discovery of the Crow Butte Uranium Deposit, Dawes County, Nebraska. Proceeding of the Practical Hydromet' 83, 7th Annual Symposium on Uranium and Precious Metals. Littleton, Colorado: American Institute of Mining, Metallurgical, and Petroleum Engineering.

Ferret Exploration Company of Nebraska, Inc. (FEN), 1987. Application for Source Material License, Ferret Exploration Company of Nebraska, Inc., October 7, 1987, ADAMS Accession No. ML080940335 (Package).

Hoganson J.W., E.C. Murphy, and N.F. Forsman, 1998, "Lithostratigraphy, Paleontology, and Biochronology of the Chadron, Brule, and Arikaree Formations in North Dakota." *Depositional Environments. Lithostratigraphy, and Biostratigraphy of the White River and Arikaree Groups* Special Paper 325. D.O. Terry, H.E. LaGarry, and R.M. Hunt, Jr., eds. Boulder, Colorado: Geological Society of America. pp. 185–196.

LaGarry, H. E., 2010, "Proposed Lithostratigraphic Revision, Redescription, and Redefinition of the White River Group (Eocene-Oligocene) South Dakota," presented at the Geological Society of America, Rocky Mountain - 62nd Annual Meeting (21-23 April 2010), Rapid City, South Dakota

International Conference on Building Officials, 1997, *1997 Uniform Building Code*. Washington, DC: International Code Council.

Miller, J.A. and C.L. Appel, 1997, "Groundwater Atlas of the United States, Kansas, Missouri, and Nebraska." U.S. Geological Survey Report HA 730-D. Denver, Colorado: U.S. Geological Survey.

NRC, 2003. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

NRC, 1998, Environmental Assessment for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., Crow Butte Uranium Project, Dawes County, Nebraska. February 1998. ADAMS Accession No. ML071520242.

USGS, 2011a, Description of the White River Group in South Dakota, <http://tin.er.usgs.gov/geology/state/sgmc-unit.php?unit=SDTw%3B0>, accessed on December 13, 2011.

USGS, 2011b, Description of the White River Group in Nebraska, <http://tin.er.usgs.gov/geology/state/sgmc-unit.php?unit=NETw%3B0>, accessed on December 13, 2011.

2.4 Hydrology

2.4.1 Regulatory Requirements

The purpose of this section is to determine if the applicant has adequately demonstrated that the characterization of surface and ground water hydrology at the CBR facility is sufficient to support an analysis of the applicant's ability to maintain control over production fluids containing source and byproduct materials, as required by 10 CFR 40.41(c).

2.4.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 2.7.3 of NUREG 1569 (NRC, 2003).

2.4.3 Staff Review and Analysis

The following sections present the staff's review and analysis of various aspects of the surface water and ground water hydrology at the facility.

2.4.3.1 Surface Water Hydrology

The applicant originally reported (FEN, 1987) that the license area encompasses two watersheds, the Squaw Creek and English Creek watersheds. The Squaw Creek and English Creek are small perennial tributaries to the White River, which is the major regional water course. Flow in the streams within the license area is from south to north. The applicant reported that some hydraulic interaction exists between Squaw Creek and the shallow Brule sand during precipitation events. It described this interaction as recharge of the Brule sand when the stream levels were elevated

In addition to the streams, the applicant originally reported (FEN, 1987) eight (8) impoundments are located in the drainages within or near the license area. The impoundments generally are constructed with a low earthen perimeter berm. The impoundments are used for livestock watering and to a lesser extent crop irrigation. The applicant provides that no new impoundments have been constructed since the last license renewal

The applicant reported the mean annual discharge rate for the White River at Crawford is $0.57 \pm 0.08 \text{ m}^3/\text{s}$ ($20.3 \pm 2.8 \text{ ft}^3/\text{s}$) based on data the U.S. Geological Survey collected at the gauging station near Crawford from 1931 to 2004. The applicant provided additional streamflow data which the Nebraska Department of Natural Resources and the U.S. Geological Survey obtained at the same gauging station from 1992 through 2007. The mean annual discharge rate from 1992 to 2007 is $0.56 \text{ m}^3/\text{s}$ ($19.9 \text{ ft}^3/\text{s}$), which is consistent with the mean annual discharge rate from 1931 to 2004. Therefore, NRC staff concludes that the applicant provided enough data to assess the general trends for monthly and annual mean discharge rates of the White River at Crawford and there were no significant changes

Latest floodplain information from the Federal Emergency Management Agency (FEMA) indicates that Squaw Creek and English Creek, which traverse the facility, are special flood hazard areas (SFHAs) (FEMA, 2011). According FEMA Flood Insurance Rate Maps (FIRMs), Squaw Creek and English Creek are Zone A SFHAs, which means that the channels and areas adjacent to the channels are subject to the 1% flood (100-year flood) in any given year. However, no specific flood elevations have been calculated for Zone A SFHAs. (FEMA, 2011)

The staff observes that the applicant addressed the impacts of surface wellfield spills to surface water in Section 7.4.2.2 of the LRA (CBR, 2007a). In this LRA section, the applicant states that wellfield berms will be used to contain any wellfield berms. Furthermore, during the June 2011 inspection (NRC, 2011), the staff observed that the applicant utilized special wellhead construction techniques in wellfields adjacent to streams to protect wellheads from flood damage.

The staff finds the applicant's has acceptably addressed the current surface water features and the issue of potential flooding in the license area. This determination is based on a comparison of information previously accepted and by the new information provided by the applicant and developed by the staff. NRC staff previously accepted information regarding surface water hydrology during the previous license renewal (NRC, 1998) Staff has found that the applicant sufficiently updated the surface water hydrology and flooding information and found nothing in the updated information to invalidate previous findings. Therefore, the original findings stand and previous staff conclusions remain valid.

2.4.3.2 Hydrogeology

2.4.3.2.1 Regional Hydrogeology

LRA Section 2.7 presents the regional groundwater hydrology near the Crow Butte facility (CBR, 2007a). Based on a review of this information, the applicant's most recent interpretation of the regional hydrogeology is consistent with that of previous interpretations offered in the prior license renewal application (CBR, 1995). The NRC staff previously evaluated and found acceptable the regional hydrogeology interpretation during the prior license renewal (NRC, 1998) and does not find anything in the current license renewal application to invalidate previous findings. Therefore, the original findings stand and previous approvals remain valid.

2.4.3.2.2 Site Hydrogeology

At the license area, the applicant reported in the LRA that the target ore zone aquifer is in the Basal Chadron Sandstone. The applicant demonstrated the Basal Chadron was continuous across all cross sections and reported the aquifer was artesian in some locations. The applicant also reported that the ore zone aquifer is confined above by the siltstones of the overlying Chadron Formation and two lower members of the Brule Formation. It is underlain by a thick confining layer known as the Pierre Shale. The applicant reported the Pierre Shale has a very low hydraulic conductivity and is over 455 m (1500 feet) thick in the license area. The applicant stated in the LRA that the overlying aquifer to the ore zone across the license area is in the upper member of the Brule Formation known as the Brown Siltstone Beds. The Brule aquifer is an unconfined aquifer which also acts as the surficial aquifer in the license area. The applicant reported that site characterization has shown saturated zones in the Brule are generally located in discontinuous sands of small areal extent. (CBR, 2007a)

Since the 1998 license renewal, the applicant has installed many new injection, production, and monitoring wells resulting in a large amount of new information. Such new information was compiled in a cross section in the LRA (CBR, 2009). None of this new information has contradicted previous interpretations of the site hydrogeology regarding the continuity of aquifers and confining layers

The aquifers underlying the Pierre Shale lower confining layer were originally identified by the applicant as the Sundance and Morrison Formations (bottom to top) (CBR, 2007a). The NDEQ reported that groundwater quality in these aquifers below the Pierre Shale is not suitable for local domestic water use due to high levels of total dissolved solids (NDEQ, 2010). Because of the poor water quality, the Sundance and Morrison formations have been receiving effluent from the Class 1 disposal well for the Crow Butte facility (CBR, 2007a). NRC staff previously concluded that the underlying aquifers were acceptably described during the prior license renewal (NRC, 1998).

The applicant provided a limited number of groundwater-level measurements for the overlying Brule Formation from 1982 to 1993 and more recent groundwater-level measurements in 2008 and 2009 (CBR, 2009; Figures 2.7-3b–2.7.3d). The applicant noted no seasonal variation in water level in the Brule aquifer in the recent water level measurements. In the northern portion of the license area, the applicant reported nearly 4.5 m (15 ft) higher water levels in 2008-2009 than in 1982–1983. Water levels in the southern and central portions of the license area in the

Brule did not show a significant change over the same time period. Based on the recent data, the applicant reported that the local groundwater flow in the Brule Formation is to the northwest in the Crow Butte project area. The average hydraulic gradient increased from 0.012 (in 1982–1983) to 0.025 to 0.043 (in 2008). NRC staff concludes this variation in water level and gradient is likely an artifact of the increased number of well measurements available to determine water level in 2008 as compared to 1982-1983. The applicant stated that the flow in the Brule converges on the White River north of the license area and the White River is likely to be a significant discharge point for the Brule Formation. Based on recent ground water elevation contour maps for the Brule Formation in the license renewal application, NRC staff agrees with the applicant's conclusions

The applicant also provided a limited number of groundwater level measurements for the Basal Chadron Formation from 1982 to 1993 and more recent groundwater-level measurements in 2008 and 2009 in the Basal Chadron sandstone (CBR, 2009; Figures 2.7-4b–2.7.4d). The applicant noted that groundwater flow direction in the Basal Chadron sandstone varies locally, with southeast directed flow south of Mine Unit 10 and predominantly north- and northeast-directed flow south of Mine Unit 8. Based on most recent data, the applicant reported that groundwater flows to the north and northwest in the Crow Butte project area and the mean hydraulic gradients in the Basal Chadron sandstone increased from 0.00016 in 1982–1983 to 0.04–0.064 in 2008. NRC staff observes that the variability of the in groundwater flow direction in the Basal Chadron aquifer is necessarily a function of the ISR operation. The applicant reported that groundwater levels in the Basal Chadron sandstone have decreased by 12–18 m (40–60 ft) throughout the licensed area since 1982–1983 from operations. NRC staff concludes that the reported drawdown of 12 to 18-m (40 to 60-ft) across the license area due to groundwater pumpage over the last 26 years is reasonable given the reported bleed of 2 percent (Table 2A of CBR, 2009).

The applicant previously conducted three aquifer pumping tests in 1982, 1987, and 1996 in the permit area to determine the hydraulic characteristics (storativity, transmissivity, and hydraulic conductivity) of the ore-bearing Basal Chadron sandstone aquifer and assess the integrity of the confining layers in the middle and northern regions of the license area. In 2002, the applicant conducted another pumping test to determine the aquifer characteristics of the southern portion of the license area. The applicant provided the location map and the radius of influence of each aquifer pumping test in Figure 2.7-8 in the LRA (CBR, 2007a).

The applicant used drawdown and recovery data from the four pumping tests to estimate hydrogeological properties of the ore-bearing aquifer and confining layers using one or more combinations of the Theis' Recovery Method, Jacob's Modified Nonequilibrium Method, Cooper and Jacob's Distance-drawdown Method, Hantush's Method, and the Neuman and Witherspoon Method (Driscoll, 1986). NRC staff concurs that these are commonly used methods to determine hydrogeological properties of aquifers and confining units (Driscoll, 1986). From these analyses, the applicant estimated the average transmissivity, hydraulic conductivity, and the storativity of the Basal Chadron Sandstone ore-bearing aquifer to be 44.5 m²/d (479 ft²/d), 4.3 × 10⁻³ cm/s (12.13 ft/d), and 8.8 × 10⁻⁵ (CBR, 2007a). These estimates were based on a reported average thickness of the ore-bearing aquifer as 12 m (40 ft) at the test sites, which was consistent with the thickness reported by Collings and Knode (1984). The reported average hydraulic conductivity for the Basal Chadron sandstone (equivalent to 4.3 × 10⁻³ cm/s (13.8 × 10⁻³ ft/s)) falls in the range of typical hydraulic conductivity for silty-sand to clean sand (Freeze and Cherry, 1979, p. 29). Based on the data, the applicant estimated the radius of influence in these aquifer pumping tests varied from 1,220–1,740 m (4,000–5,700 ft).

The applicant reported that there was no response in the overlying Brule aquifer in the prior or most recent pumping tests (CBR, 2007a). The applicant uses this fact, along with differences in geochemistry, to posit the absence of a hydraulic connection between the Basal Chadron and the Brule Aquifers. In addition, the applicant originally reported the average vertical hydraulic conductivity of the overlying confining layers from lab core tests ranged from 2.8×10^{-12} to 3.49×10^{-13} m/s (0.85 to 1.06 ft/s) and the average vertical hydraulic conductivity of the underlying confining layer to range from 3.4×10^{-13} to 6.3×10^{-13} m/s (1.04 to 1.92 ft/s). Based on this information, NRC staff concludes that the low vertical hydraulic conductivities of the thick underlying Pierre Shale confining layer and the thick overlying confining layer between the Basal Chadron sandstone and the Brule sandstone (CBR, 2009; Section 2.3) have and will continue to effectively confine the ore-bearing aquifer from above and below in the permit area. NRC staff previously concluded that the confining layers above and below of the Basal Chadron aquifer have been acceptably described (NRC, 1998). Staff has found nothing in the updated description to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

The NRC staff reviewed previously provided hydrogeologic information (CBR, 1995) and information provided in the current LRA (CBR, 2007a). Such information reviewed included, data on site confining layers, geochemistry of the Brule and Basal Chadron, water levels in the Brule and Basal Chadron, and pumping test information. Regarding confining layers, geochemistry, and water levels, the staff determined that the NRC previously evaluated this information during the previous license renewal (NRC, 1998) and found it acceptable. Considering prior NRC approvals and information in the current LRA, the staff has found nothing to invalidate previous findings; therefore, the previous determinations, as presented above, remain valid.

Regarding the pumping tests, NRC staff previously concluded that the hydrogeological properties of the Basal Chadron aquifer based on pumping tests conducted in 1982, 1987, and 1996, have been acceptably described (NRC, 1998). NRC staff reviewed information regarding a fourth pumping test performed in 2002 (CBR, 2007a). According to the applicant, results of this pumping test indicated that the hydraulic conductivity and the transmissivity are higher toward the Pine Ridge (CBR, 2007a). However, the applicant stated that the confining layers were intact, which corresponds to the previous pumping tests, discussed above, and newer cross sections (CBR, 2009). The staff concludes that the applicant has adequately characterized the hydraulic properties of the Basal Chadron and confining layers, and has found nothing in the updated hydrogeologic descriptions to invalidate previous findings. Therefore, the original findings stand and previous staff conclusions remain valid.

2.4.3.3 Evaluation of White River Structural Feature by Groundwater Modeling

As touched upon in the description of the applicant's geological characterization of the license area in SER Section 2.3.3.2 (CBR, 2007a), the applicant identified a structural feature north of the license area and in the southern portion of the proposed North Trend Expansion Area (NTEA) that is known as the White River Fault. In the LRA (CBR, 2007a), the applicant expressed uncertainty as to whether this feature is expressed as a fault through the formations of interest, or as a fold. The applicant proposed that recent close-spaced drilling data indicate that the feature could be interpreted as a fold in the Basal Chadron and Brule Formations (CBR, 2009). The applicant provided updated cross sections and a discussion that supported this

interpretation in the LRA. NRC staff observes the definition of this feature is important to determine the groundwater flow in and around the license area and NTEA. The staff observes that if the fault is not present in the Basal Chadron and Brule Formations, then the probability that a pathway exists through which water would be transmitted between the Basal Chadron and Brule aquifers would be very low.

To examine this issue, NRC staff performed an independent modeling exercise to assess conclusions drawn by the applicant that the White River Fault may not be expressed as a fault within the Basal Chadron and Brule formations. Specifically, as part of its review of the NTEA application (CBR, 2007b), NRC staff performed a modeling and uncertainty analysis to investigate the probability that the White River structural feature conducts water between the Basal Chadron and Brule aquifers. The staff used the maximum likelihood (ML) portion of the Maximum Likelihood Bayesian Model Averaging (MLBMA) model uncertainty procedure to assess this probability. This procedure is described in NUREG/CR-6940 (Meyer et al, 2007). The purpose of the ML procedure is to eliminate unreasonable groundwater flow scenarios and, correspondingly, to identify those that are the reasonable or likely. The ML method involved creating multiple groundwater models, calibrating the models, and using Bayesian statistics to estimate the relative probability of each scenario.

2.4.3.3.1 Groundwater Model Development

To undertake the ML analysis, NRC staff first developed two different base groundwater models (simulations) for the NTEA using MODFLOW 2000, as incorporated into a commercially front-end user interface known as the Groundwater Modeling System (GMS) developed by the U.S. Army Corps of Engineers. MODFLOW is a finite difference, groundwater flow modeling program developed by the U.S. Geological Survey and is widely used. The two base models differed by the manner in which the White River structural feature were simulated. Differences between these two models are as follows:

Simulation 1

- 6-layer model- geologic layers interpolated based on boring data
- model boundaries at basic site boundaries or physical feature boundaries
- discrete zone of different hydraulic conductivity to address pumping well efficiency
- fault simulated by converting one boundary in the ore zone layer to a drain to model a conductive fault and a barrier to model a no-flow fault
- All other hydraulic, geologic, and model parameters held constant
- None of the input data were weighted

Simulation 2

- 6-layer model, geologic layers linear, thickness based on borehole data
- artificial model boundaries beyond site boundaries
- fault simulated by a thin zone of differing hydraulic conductivity, high hydraulic conductivities to model a conductive fault and low hydraulic conductivities to model a no-flow fault
- all other hydraulic, geologic, and model parameters held constant
- none of the input data were weighted

Data input included well boring log data, hydraulic properties of the geologic units down to the Pierre Shale, well water level data, and boundary conditions. Because these models were developed for the NTEA, field data used for model development were obtained from the North Trend license amendment application (CBR, 2007b). After model development, the staff calibrated each model using PEST, a parameter estimation and automated calibration software package which is included in the GMS software. Each model was calibrated to a pumping test previously performed by the applicant.

NRC staff subsequently developed eight groundwater flow model scenarios (four based on each simulation) with variations to the base model to study the effect of a potential fault on the Basal Chadron aquifer flow system. Two models for each simulation assumed the fault acted as a transmissive flow boundary and two models for each simulation assumed it was a no flow or restricted flow boundary. These scenarios were developed by altering the conditions of the southern boundary of the proposed NTEA for Simulation 1 and altering the hydraulic conductivity of the linear zone for Simulation 2. After development, each scenario was calibrated, and the weighted sum of the squared residuals (WSSRs) are presented in Table 2.4-1

Table 2.4-1: Model Scenario WSSRs

Model	Drain/Barrier	Conductance or Conductivity	WSSR
Simulation 1			
Baseline	NA	0.56 m ² /d/m (6 ft ² /d/ft)	27.47
2	Barrier – Low Cond.	1E-5**	27.04
3	Barrier – very low cond.	1E-9	27.13
4	Drain- medium conductance	0.01 m ² /d/m (0.12 ft ² /d/ft)	2.15E+5
5	Drain -high conductance	9.3 m ² /d/m (100 ft ² /d/ft)	8.84E+5
Simulation 2			
Baseline	NA	1.5 m/d (5 ft/d)	620.2
2	Barrier – Low Cond.	3E-4 m/d (1.0E-3 ft/d)	783.1
3	Barrier – very low cond.	3E-6 m/d (1.0E-5 ft/d)	666.3
4	Conductive – medium k	3 m/d (10 ft/d)	916.2
5	Conductive – high k	305 m/d (1000 ft/d)	8.0e+4

*MODFLOW uses the term “hydraulic characteristic” for barriers which is units of 1/time.

2.4.3.3.2 Maximum Likelihood Analysis

Once the calibrations were completed, the NRC staff performed an ML analysis using all the aforementioned models, the two base models plus the eight scenario models. Procedures for this analysis are documented in NUREG/CR-6940 (Meyer et al, 2007). The objective of this analysis is to calculate the probability of each scenario relative to the other scenarios where posterior probability is computed using Bayes' Theorem. Bayes' Theorem is used to calculate conditional probabilities. One form of the formula is, as follows:

$$p(M_k | D) = \frac{p(D | M_k)p(M_k)}{\sum_{l=1}^K p(D | M_l)p(M_l)}$$

where:

$p(D|M_k)$ = likelihood of Model M_k
 $p(M_k)$ = prior probability of Model M_k
 $p(M_k|D)$ = posterior probability of all models

Prior probability is a value assigned by the modeler or other technical staff that reflects the opinions regarding the probability of certain scenarios being the most likely or reasonable. In this case NRC staff assigned the same prior probability to all the scenarios as to not interject any bias into this exercise. The likelihood term, in this case, is actually the Kashyap Information Criterion (KIC), as calculated by the following formula:

$$KIC = N \ln \hat{\sigma}_{ML}^2 - N_k \ln 2\pi + \ln |I|$$

where:

$\ln |I|$ = natural log of the determinant of the Fisher Information Matrix

$$\ln |I| = -N_k \ln \left(\frac{N - N_k}{N_k} \right) - \sum_{i=1}^{N_k} \ln \lambda_i$$

$$\hat{\sigma}_{ML}^2 = \frac{WSSR}{N - N_k}$$

WSSR = weighted sum of the square residuals

N = number of calibration data

N_k = number of calibration parameters

λ_t = eigenvalues calculated during calibration using PEST

Results of the ML analyses are presented in Tables 2.4-2 and 2.4-3

Table 2.4-2: Maximum Likelihood Analysis Results – Simulation 1

Data	BASELINE	BARRIER-LOWK	BARRIER-VLOWK	DRAIN-MEDK	DRAIN-HIGHK
N	35	34	34	32	32
Nk	3	3	3	3	3
WSSR	27.47	27.04	27.13	215000	8840000
Sigma Square	0.78	0.8	0.8	6718.75	276250
ln	-87.27	-6.89	-1.4	-53.95	-41.4
KIC	-101.48	-19.99	-14.5	222.54	354.02
p(Mk) (Prior Probability)	0.2	0.2	0.2	0.2	0.2
p(Mk D) (Posterior Probability)	1.0	0	0	0	0

Table 2.4-3: Maximum Likelihood Analysis Results – Simulation 2

Data	BASELINE	WALL-LOWK	WALL-VLOWK	FAULT-MEDK	FAULT-HIGHK
N	37	37	37	37	37
Nk	3	3	3	3	3
WSSR	620.2	783.1	666.30	916.20	80000.00
Sigma Square	16.76	21.17	18.01	24.76	2162.16
ln	-163.83	-163.9	-168.5	-96.97	-48.55
KIC	-65.04	-56.47	-67.05	16.26	230.05
p(Mk) (Prior Probability)	0.2	0.2	0.2	0.2	0.2
p(Mk D) (Posterior Probability)	0.267	0.004	0.729	0	0

A review of Tables 2.4-2 and 2.4-3 indicate that, in both modeling simulations, the high conductivity fault assumptions are the least likely to occur as demonstrated by 0% posterior probabilities. While the two model simulations differ in which scenario is the most likely, it is clear that a transmissive fault capable of conveying extraction fluids from the Chadron Aquifer upward to the Brule Aquifer is not a reasonable scenario at this facility.

Based on this analysis, the NRC staff concludes that the presence of a fault that penetrates the Pierre Shale through the Chadron and Brule Formations does not appear probable, and if one exists, it does not convey water from the Basal Chadron Formation to the Brule Formation. This finding is in agreement with the applicant's recent interpretation that the White River structural feature may be expressed as a fold in the formations of interest near the license areas. As such, it is the NRC staff's conclusion that no hydraulic connection likely exists to transfer process water between the Basal Chadron ore zone and Brule aquifers.

2.4.4 Evaluation Findings

As noted above, staff found the applicant's discussions of hydrogeology regarding the Crow Butte facility acceptable during the last license renewal (NRC, 1998). However, the applicant provided new information regarding the composition of the White River structural feature, which the staff incorporated into a modeling investigation. Based on the modeling effort and hydrogeologic characterization data presented above, the staff determined that the White River structural feature is not a fault but a fold, and as such, does not hydraulically connect the Basal Chadron with the Brule aquifer. This combined with pumping test data provided by the applicant (CBR, 2007a) reinforces previous conclusions that the Basal Chadron aquifer is hydraulically isolated from the Brule formation, above

2.4.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

10 CFR Part 51. Code of Federal Regulations, Title 10, Energy, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions".

CBR, 2009, Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2007a, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

CBR, 2007b, Application for Amendment of USNRC Source Materials License SUA-1534, North Trend Expansion Area, Crawford, Nebraska, May 30, 2007. ADAMS Accession No. ML071730274.

CBR, 1995. Application for Renewal of USNRC Radioactive Source Material License No. SUA-1534, Crow Butte Resources Inc., December 31, 1995, ADAMS Accession No. ML082060561 (Package).

Collings, S.F. and R.H. Knode, 1984, "Geology and Discovery of the Crow Butte Uranium Deposit, Dawes County, Nebraska. Proceeding of the Practical Hydromet' 83, 7th Annual Symposium on Uranium and Precious Metals. Littleton, Colorado: American Institute of Mining, Metallurgical, and Petroleum Engineering.

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Ferret Exploration Company of Nebraska, Inc. (FEN), 1987. Application for Source Material License, Ferret Exploration Company of Nebraska, Inc., October 7, 1987, ADAMS Accession No. ML080940335 (Package).

Freeze, A.R., and J.A. Cherry, 1979, Groundwater, Prentice-Hall Publisher, New Jersey, 604 pp.

Meyer, P.D., Ye, M., Rockhold, M.L., Neuman, S.P. and K.J. Cantrell, 2007, Combined Estimation of Hydrogeologic Conceptual Model, Parameter, and Scenario Uncertainty with Application to Uranium transport at the Hanford Site 300 Area, NUREG/CR-6940, prepared by Pacific Northwest National Laboratory, Richland, WA, Desert Research Institute, Las Vegas, NV, and the University of Arizona, Tucson, AZ for the U.S. Nuclear Regulatory Commission, June 2007.

NDEQ, 2010. Class 1 Non-Hazardous Injection Well, Proposed Permit, July 28, 2010 (ADAMS Accession No. ML102220485).

NRC, 2011, NRC Inspection Report 040-08943/11-001, Crow Butte Resources, Inc., Crow Butte Uranium Project, Dawes County, Nebraska. February 1998. ADAMS Accession No. ML11216A179.

NRC, 1998, Environmental Assessment for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., Crow Butte Uranium Project, Dawes County, Nebraska. February 1998. ADAMS Accession No. ML071520242.

NRC, 2003. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report.” June.

2.5 Background Surface Water and Ground Water Quality

2.5.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the characterization of surface and ground water quality at the Crow Butte facility has been performed to meet the requirements of 10 CFR Part 40, Appendix A, Criterion 7.

2.5.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 2.7.3 of NUREG 1569 (NRC, 2003).

2.5.3 Staff Review and Analysis

The following sections present the staff’s review and analysis of preoperational data for surface water and ground water quality the Crow Butte facility supplied by the applicant. Unless otherwise stated, the information reviewed in this section is from information, data, and maps

submitted by the applicant in its LRA (CBR, 2007, 2009). NRC staff visited the site on several occasions during the course of this review to confirm information presented in the LRA.

2.5.3.1 Surface Water

Prior to commercial operations, the applicant conducted regional background surface water quality analysis on samples collected from all surface water bodies within the licensed area. The data were reported in the original commercial license application (FEN, 1987). The initial program included the analysis of physical indicator parameters, common cation and anion constituents, trace and minor metals and radionuclides uranium and radium-226. The applicant has conducted monitoring of surface water during the life of the license, though the analytical parameters are limited to the radionuclides and to surface water bodies that could be affected by the operations at that time (see SER Section 5.7.9). The applicant provided no updates on background surface water quality within the license area from the original application (FEN, 1987). Based on this data, staff previously concluded that operation of the Crow Butte Project is protective of health and safety (NRC, 1989). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not reexamining the results of the applicant's background surface water data.

2.5.3.2 Ground Water

Prior to commercial operations, the applicant conducted regional background ground water quality analysis on samples collected from 18 private wells and 11 wells drilled by a previous owner of the property. The data were reported in the original commercial license application (FEN, 1987). The initial program included the analysis of physical indicator parameters, common cation and anion constituents, trace and minor metals, radionuclides uranium and radium-226, and water elevation and included data from the Brule and Basal Chadron Sandstone aquifers. The applicant has conducted monitoring of ground water during the life of the license, though the analytical parameters are limited to the radionuclides and locations are modified over the life of the facility, based on distance from an operating wellfield (see SER Section 5.7.9). The applicant provided no updates on background ground water quality in the license area from the original application (FEN, 1987). Based on this data, staff previously concluded that operation of the Crow Butte Project is protective of health and safety (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not reexamining the results of the applicant's background groundwater data.

2.5.4 Evaluation Finding

As noted above, staff previously approved preoperational background quality of surface and groundwater sources (NRC, 1989). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff findings remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff has not identified any unreviewed safety-related concerns and therefore is not reexamining the applicant's surface and ground water background water quality information.

2.5.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40 Appendix A, "Criteria Relating to the Operation of Uranium Mills and to the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily from their Source Material Content."

CBR, 2009, Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2007, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

Ferret Exploration Company of Nebraska, Inc. (FEN), 1987. Application for Source Material License, Ferret Exploration Company of Nebraska, Inc., October 7, 1987, ADAMS Accession No. ML080940335 (Package).

NRC, 2003. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

NRC, 1998, Environmental Assessment for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., Crow Butte Uranium Project, Dawes County, Nebraska. February 1998. ADAMS Accession No. ML071520242.

NRC, 1989. Safety Evaluation Report (SER) for Ferret Exploration Company of Nebraska, Crow Butte Project, December 12, 1989, ADAMS Accession No. ML080730272

2.6 Background Radiological Characteristics

Background radiological characteristics are used to evaluate the potential radiological impact of operations on human health and the environment. Such impacts could result from spills, routine discharges from operations, and other potential releases to the environment. In addition, the data collected are used to identify a radiological baseline for decommissioning, restoration, and reclamation.

2.6.1 Regulatory Requirements

The staff determines if the applicant has sufficiently supplied data regarding background radiological characteristics for the license area so as to be in compliance with Criterion 7 of Appendix A to 10 CFR Part 40.

2.6.2 Regulatory Acceptance Criteria

Changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 7 using the acceptance criteria presented in Section 2.9.3 of NUREG-1569 (NRC, 2003).

2.6.3 Staff Review and Analysis

The applicant conducted a preoperational monitoring program between the fourth quarter of 1981 and continuing through the second quarter of 1986. This data was originally reported by the applicant (FEN at that time) in its initial licensing application (Section 2.10 of FEN, 1987). Areas addressed in that licensing application included: air particulate and radon sampling, radon flux monitoring, vegetation, food, and fish sampling, direct radiation measurements, soil sampling, sediment sampling, ground water sampling, and surface water sampling. Based on this data, staff previously concluded that operation of the Crow Butte Project is protective of health and safety (NRC, 1989). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not reexamining the results of the applicant's background radiological data.

Criterion 7 of 10 CFR Part 40, Appendix A, also states that throughout the construction and operating phases of the mill, an operational monitoring program must be conducted to measure or evaluate compliance with applicable standards and regulations; to evaluate performance of control systems and procedures; to evaluate environmental impacts of operation; and to detect potential long-term effects. The applicant is conducting an operational monitoring program consistent with 10 CFR Part 40, Appendix A, Criterion 7. The applicant provided operational environmental monitoring information and data in Section 5 of the Technical Report (CBR, 2009) and this information and data is reviewed by NRC staff in Section 5 of the SER.

2.6.4 Evaluation Findings

As noted above, staff previously concluded that operation of the Crow Butte Project is protective of health and safety (NRC, 1989). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff has not identified any unreviewed safety-related concerns and therefore is not reexamining the results of the applicant's background radiological data.

2.6.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40 Appendix A, "Criteria Relating to the Operation of Uranium Mills and to the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily from their Source Material Content."

CBR, 2009, Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

Ferret Exploration Company of Nebraska, Inc. (FEN), 1987. Application for Source Material License, Ferret Exploration Company of Nebraska, Inc., October 7, 1987, ADAMS Accession No. ML080940335 (Package).

NRC, 2003. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

NRC, 1989. Safety Evaluation Report (SER) for Ferret Exploration Company of Nebraska, Crow Butte Project, December 12, 1989, ADAMS Accession No. ML080730272.

3. DESCRIPTION OF THE FACILITY

3.1 In Situ Recovery Process and Equipment

3.1.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant has demonstrated that the equipment and processes used in the well fields during operation at the Crow Butte facility will meet the requirements of 10 CFR 40.32(c) and 40.41(c).

3.1.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 3.1.3 of NUREG-1569 (NRC, 2003a).

3.1.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by the applicant in the LRA (CBR, 2007a) and as updated. As part of its review of the information supplied by the applicant, the NRC staff also examined past inspection reports of the Crow Butte facility (NRC, 1999-2003b, 2004-2007a, 2008-2010a). In addition, the staff visited the Crow Butte facility site on several occasions during the course of its review to confirm the veracity of information presented in the application.

The following subsections present the staff's review and analysis of various aspects of the ISR processes and equipment proposed for the Crow Butte facility. Review areas addressed in this section include: the uranium extraction and restoration operations, well field infrastructure, and the proposed schedule for operations.

3.1.3.1 Mine Unit and Mineralized Zone Description

NRC staff observes at the start of the previous renewal period (*i.e.*, 1998), the applicant had production in three mine units (Mine Units 2, 3 and 4), development in one mine unit (Mine Unit 5) and restoration operations at one mine unit (Mine Unit 1). In Table 3.1-1 of the LRA, the applicant reported it has production operations in Mine Units 6 through 10 and restoration operations in Mine Units 2 through 5 (CBR, 2007a). Mine Unit 11 is currently under development for future production (CBR, 2007a). Mine Unit 1 has been restored and such was approved by NRC staff in 2003 (NRC, 2003c). In accordance with the requirements of the Nebraska Department of Environmental Quality (NDEQ) Class III Underground Injection Control (UIC) permit, the applicant can operate a maximum of five mine units, restore a maximum of five mine units, and develop a maximum of three mine units, at any given time (NDEQ, 2009). Therefore, in order for the applicant to begin production operations in Mine Unit 11, the applicant must place one of currently producing mine units into restoration. NRC regulations do not require any such restrictions. NRC staff has previously approved the number of mine units in the prior license renewal (NRC, 1998) and has found nothing to invalidate

previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003a), staff is not reexamining this issue.

NRC staff determined the areal extent of individual mine units varies from 3.7 to 44.8 hectares (9.2 to 110.72 acres) using data presented in the LRA in Section 6.1.4.2 (CBR, 2007a). The total area for all mine units within the license area is 189.4 hectares (468 acres). NRC observed notes the mineralized zone at all mine units is within the Basal Chadron Sandstone. Based on financial assurance calculations for the 2011 surety update (CBR, 2010c), the completion thickness for production wells in the mineralized zone at the CBR mine units varies from 3.8 to 5.9 m (12.5 to 19.6 feet), with the average completion thickness of 4.9 m (16 feet). The depth to the mineralized zone varies between 122 to 274m (400 and 900 feet). The depth to the mineralized zone increases in the southeastern direction. NRC does not regulate the areal extent of individual mine units; however, the size of this area has implications for other aspects under review by staff (e.g., pore volume estimates and schedules). NRC staff finds the physical description of the mine units and mineralized zone to be acceptable

NRC staff observes the CBR facility uses a conventional seven-spot pattern as the typical mine unit production pattern. The LRA in Section 3.1.3 states that other patterns (e.g., 5-spot or alternating single line drives) may be used based on a specific mine unit configuration (CBR, 2007a). The applicant reported that the spacing between injection wells for a typical pattern is between 19.8 and 45.7m (65 and 150 feet) in LRA Section 3.1.3 (CBR, 2007a). Based on data supplied for the 2011 surety update (CBR, 2010c), the applicant reported 4857 wells within the license area (1690 production wells, 2789 injection wells, 201 monitoring wells in the overlying aquifer and 177 monitoring wells in the perimeter monitoring rings). The NRC staff notes the density of monitoring wells in the overlying aquifer is between one well per 0.77 hectares (1.9 acres) and one well per 1.82 hectares (4.5 acres) for all mine units. This density is consistent with the guidance of one well per 2 hectares (5 acres) in the current license (NRC, 2010b). The applicant does not have monitoring wells in the underlying aquifer because NRC staff previously determined the thickness and very low permeability of the underlying confining unit is sufficient to prevent any transport of fluids to an underlying aquifer. Each mine unit has between two and nine wellfield header houses. A wellfield header house controls the fluid flow to and from wells in the mine unit production patterns. The staff has previously approved the wellfield patterns and number and location of monitoring wells during the prior license renewal review (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003a), staff is not reexamining this issue.

3.1.3.2 Well Design, Construction and Integrity Testing

The applicant presented three methods that could be used in the construction of an injection or extraction well in the LRA Section 3.1.2.2 (CBR, 2007a). NRC staff observes all three methods use 11.43 cm (4.5-inch) diameter, Standard Dimension Ratio 17 (SDR-17) Polyvinyl chloride (PVC) casing surrounded with cement or bentonite grout and a screen installed for communication with the aquifer at the desired interval. The methods for well construction differ in the procedures for cementing and screen installations. Staff has previously approved the well installation and completion methods during the prior license renewal review (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and

previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003a), staff is not reexamining this issue.

NRC staff observes the application states in Section 3.1.2.4 (CBR, 2007a) that mechanical integrity tests (MITs) will be conducted on a well after installation, after it is serviced, whenever a well is suspected of having damage or at intervals of once every five years. The application also states that if a well fails an MIT, the applicant will repair or abandon the well to prevent the potential release of production fluids. The applicant is required by license condition 12.2 (NRC, 2010b) to notify NRC of all MIT failures and maintain documentation of corrective actions that were implemented. This documentation must be made available for staff to review during on-site inspections. The staff observes that the NDEQ also requires MITs to be performed on wells that are used for ISRs through their UIC program and has reporting requirements for MIT failures. Staff has previously approved the MIT testing and reporting during the prior license renewal review (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003a), staff is not reexamining this issue.

NRC staff evaluated the applicant’s MIT failures since the last license renewal. During this period, the applicant reported a total of 10 MIT failures for wells that were in service (SER Table 3.1-1, below). For all reported MIT failures, the applicant consulted with NDEQ staff to establish the potential for a release of production fluids and need for corrective actions, and reported the release and corrective actions to NRC.

Table 3.1-1: Summary of Historic MIT Failures

Well	Mine Unit	Date Detected	Depth M (feet)	Monitoring wells (MW) Installed	Release Detected in MW	Document Accession Number
P-2469		7/6/2010	18.3 (60)	No	No	ML101960372
P-4231	9	5/10/2010	73.1 (240)	No	No	ML102010407
P-821	5	11/19/2009	N/A	N/A	No	ML093380649
P-4231	9	5/10/2010	128 (420)	No	No	ML101540144
I2430-31	7	10/27/2005	11.6- 14.6 (38 – 48)	3	No	ML060230309
I723-14		7/4/2005	5.5-8.5 (18 – 28)	3	No	ML052430386
I622-10	4	2/19/2004	54.8 (180)	1	No	ML040960396
I567	4	9/20/1999	12.2 (40)	3	No	ML003685594;
I196-5	2	3/29/1996	12.2 (40)	15	Yes	ML090580383
I752-14	5	11/8/1996	30.5 (100)	2	No	ML090910569

Source: ADAMS as of February 7, 2011

On three occasions, NRC staff observes the applicant self-reported the failure to perform MITs within the requisite timeframe. In May 2008, the applicant reported that 42 wells in Mine Units 8 and 9 had missed their 5-year MITs by up to one year due to corruption of the applicant’s

electronic database that was used to schedule the tests. The applicant subsequently subjected all the missed wells to an MIT and all wells passed. The applicant performed a root cause analysis on why the MITs were not performed and proposed appropriate corrective actions to ensure similar failures are not repeated in the future. NRC issued a non-cited violation during the subsequent inspection for those failures, but also acknowledged that the applicant self-identified the failure, took appropriate corrective actions to ensure that: (1) the failures did not contribute to impacts to the environment, and (2) the failures will not be repeated (NRC, 2008).

On August 19, 2009, NRC staff observes the applicant self-reported that the 5-year MIT for well I-619 exceeded the 5-year limit by 16 days. This well is located in Mine Unit 1 and had not been in service since the last MIT test (CBR, 2009c). The applicant performed a root cause analysis on why the MIT was not performed and proposed appropriate corrective actions to ensure similar failures are not repeated in the future. No enforcement action was taken by NRC as the applicant self-reported the violation.

On October 19, 2009, NRC staff observes the applicant self-reported the failure to perform MITs on two wells (I-366 and I-367) prior to placing the wells back into service following workovers as required by license condition. Those wells were subsequently subjected to an MIT (within approximately 6 months) and both wells passed. The applicant performed a root cause analysis on why the MITs were not performed and proposed appropriate corrective actions to ensure similar failures are not repeated in the future. NRC issued a non-cited violation during the subsequent inspection for those failures, but also acknowledged that the applicant self-identified the failure, took appropriate corrective actions to ensure that: (1) the failures did not contribute to impacts to the environment, and (2) the failures will not be repeated (NRC, 2010a).

Staff observes that as a result of the inspections, two non-cited violations were made against the applicant for failures to perform MIT tests as required by license condition 10.2 (NRC, 2008, 2010a). Staff has evaluated the applicant's proposed corrective actions and found them to be acceptable. In addition, future inspections beginning in 2012 will be performed to determine that full compliance has been achieved and will be maintained.

3.1.3.3 Excursion Monitoring Wells

NRC staff observes the applicant has monitoring wells in the overlying aquifer and in perimeter rings surrounding all mine units. The density of wells in the overlying aquifer meets the guidance provided in the SRP (NRC, 2003a). The license application in Section 3.1.3 specifies that the distance to a perimeter well from the mine unit is a maximum of 91.4 m (300 feet) and the spacing between monitoring wells on the ring is a maximum of 121.9 m (400 feet) (CBR, 2007a). Based on staff's review of the available maps of monitoring well locations and the applicant's supporting documentation for the SERP reviews of the wellfield packages (CBR 2008c, 2004c, 2003c, 2000c), the existing location of the excursion monitoring wells is consistent with commitments provided in past approved license applications.

NRC staff observes in LRA Figure 3.1.4 (CBR, 2007a) that several mine units abut one another. During sequential development of mine units, monitoring wells that were established for one mine unit may be withdrawn as a monitoring well from the original mine unit and used for another function for the mine unit being brought into production. NRC staff finds this reclassification is not significant from a safety standpoint as the monitoring well is now considered to be part of the mine unit which has been brought into operation. It will therefore be

subject to restoration after extraction operations are completed in the mine unit. Staff has previously approved the number and location of the monitoring wells in the perimeter well ring and overlying aquifer during the prior license renewal review (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not reexamining this issue.

NRC staff observes that during production operations, the license requires all monitoring wells to be sampled for excursion indicators biweekly (NRC, 2010b). For a review of the historical data of excursion monitoring, see Section 5.7.9 of this SER.

3.1.3.4 Spills and Leaks

As stated in the LRA in Section 3.3 (CBR, 2007a) and verified by NRC staff during inspections, the applicant maintains continuous, real-time monitoring and control of the total production and injection flow rates; and pressure on the injection trunk lines. Wellfield header houses are equipped with wet alarms to detect the presence of liquids in the header house sump. Deep injection wells are equipped with sensors to monitor their status. The applicant has installed instrumentation in the plant to continuously monitor the total flow into the plant and the total waste flow leaving the plant on a real-time basis. The plant injection manifolds are equipped with sensors to alert the operator in the case of leak or rupture in the injection system. The applicant placed instrumentation to measure tank levels in chemical storage and process tanks. Automatic monitoring systems are in place for the dryer system and drum logging. Staff has previously evaluated the instrumentation and procedures for monitoring and control of pressure and flow of fluids at the facility during the prior license renewal review (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003a), staff is not reexamining this issue.

The NRC staff observes that during the previous license renewal period the applicant has not had a spill that exceeded the threshold criteria for a reportable spill under the regulations of 10 CFR Part 20. However, the applicant has had numerous leaks and spills that were required to be reported to the state regulators due to their volume and/or contaminant concentration. Under license condition 12.2, the applicant is also required to report these spills to NRC (NRC, 2010b). NRC staff observes that if warranted, the applicant has investigated the impacts immediately following the leak/spill and taken corrective actions to clean up these releases as required by NDEQ. The applicant is also required by license condition 12.2 to maintain a list of the spills/leaks on site and will be required to demonstrate compliance with the soil and ground water standards for unrestricted release during NRC review of decommissioning. Staff has previously evaluated the spill reporting and record keeping requirements at the facility during the prior license renewal review (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003a), staff is not reexamining this issue.

3.1.3.5 In Situ Process

3.1.3.5.1 Injection Pressures

NRC staff observes as part of the ISR process, injection wells subject the ore zone to elevated pressures during operations. The purpose of the higher pressures is to permit the desired concentration of dissolved oxygen to be achieved and to ensure that the desired injection rates are maintained. To ensure operations are conducted safely and minimize the potential for leaks from wells and other well failures, the state of Nebraska has set a maximum injection pressure of 100 psig for the CBR Class III injection wells under NDEQ UIC permit NE0122611 (CBR, 2008d). Staff observes that the applicant notified NDEQ of an exceedance of the 100 psi pressure limitation at a well head manifold in Wellhouse 36 (CBR, 2011a). The pressure increased to 130 psi for about 10 minutes due a failure of the injection pressure reducing valve (PRV). Staff also observes that the application does not satisfactorily describe the relationship between the wellfield infrastructure (e.g., pumps and valves) and the pressure at the well head. Based on this information, staff is imposing a license condition requiring CBR to not exceed 100 psi at the injection well heads, and to conduct daily monitoring of manifold pressures and flow rates in each injection and recovery well during wellfield operations. This license condition is presented in SER Section 3.1.4. In addition to the potential for well leaks, NRC staff observes that exceeding the fracture pressure of the formation could cause fluids to move from the production zone.

The applicant reported the fracture gradient of the formation to be 0.63 psi/ft of well depth in the prior license renewal application in Section 3.1.3 (CBR, 1995). The Staff has determined that the maximum injection pressure of 100 psig required by NDEQ and the above-referenced license condition would ensure the downhole pressure remains less than fracture pressure calculated for this reported fracture gradient. Staff has previously concluded that the applicant will maintain injection pressures in a safe operating range during the prior license renewal review (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003a), staff is not reexamining this issue.

NRC staff observes the applicant has committed to record and maintain daily well head pressures in Section 3.1.3 of the LRA (CBR, 2007a). The applicant reports the monthly average and maximum wellhead pressures for each wellfield header house in the semi-annual effluent reports to NRC. Based on a review of these reports, the applicant has not exceeded the maximum allowable injection pressure except for one brief period (CBR, 2000 a,b, 2001a,b, 2002a,b, 2003a,b, 2004a,b, 2005a,b, 2006 a,b, 2007b,c, 2008a, b, 2009 a,b, 2010 a,b, 2011b). On June 4, 2008, the maximum injection pressure of 100 psig was exceeded by 5 psig at six wellfield header houses for a short period of time (a maximum of 4 hours). This event was abnormal and was attributed to a power outage from a thunder storm which caused a malfunction of the pressure reducing valves at those wellfield houses. The applicant's corrective actions included modifications to the alarm and control systems and installation of injection filters in the system prevent plugging to eliminate the potential for future exceedance of maximum injection pressure limits (CBR, 2008d). NRC staff finds these improvements in monitoring should prevent a similar failure in the future and are therefore acceptable.

3.1.3.5.2 Production Rates

In 2007, NRC amended the applicant's license to increase the maximum production (throughput) rate from 18,927 to 34,068 liters per minute (lpm) (5,000 to 9,000 gallons per minute (gpm)) under License Amendment 22 (NRC, 2007b). NRC staff observes that recent production rates as reported by the applicant were less than 18,927 lpm (5,000 gpm) prior to the fourth quarter of 2008, and less than 26,497 lpm (7,000 gpm) since that time through the fourth quarter of 2010.

By license condition, the applicant has an annual production limit for yellowcake of 907,185 kg (2 million pounds) per year (NRC, 2010b). The same limit is requested in the license renewal. NRC does not require submittal of data to verify compliance with this limit; however, the production rate is reviewed by staff during on-site inspections. The license application indicates that the historic production has been approximately 362,874 kg (800,000 pounds) per year and that production rate is expected to continue for the renewal period. This production rate is consistent with those values reported to the NRC staff by the applicant during the annual on-site inspections and with information presented in corporate literature (Cameco, 2011).

3.1.3.5.3 Bleed

In the license application in Section 3.1.3, the applicant discusses the production bleed (CBR, 2007a). The production bleed is defined as the difference between the amount the fluid produced and the amount of fluid injected in the wellfield. It should always have a positive value, such that more fluid is produced than injected. By producing more fluid than is injected, an inward gradient into the wellfield is created. This inward gradient draws fluids into the wellfield which enables the operator to maintain hydraulic control and prevent excursions outside of the wellfield. NRC staff concludes it is essential for the applicant to sustain an inward gradient during the entire operational life of a wellfield until restoration is completed to maintain control of fluids to ensure the safety of the operation.

The applicant has committed to maintaining a production bleed of 0.5 to 1.5 percent of total flow in LRA Section 3.1.3 (CBR, 2007a). NRC staff observes that during restoration the bleed may be increased during the phase of groundwater sweep and groundwater treatment as discussed in SER Chapter 6. In the semi-annual effluent monitoring reports, the applicant reported an average total monthly bleed of 0.5 to 2.8 percent during the previous license renewal period. NRC staff notes that this bleed is higher than the proposed range. However, based on staff's review of the LRA and License Amendment 22 (NRC, 2007b), the NRC finds the applicant has sufficient waste disposal capacity as discussed in SER Section 3.1.3.4.4. Therefore, the reported increase in average monthly bleed did not and will not pose any safety issues if it continues in the license renewal period.

While the applicant has committed to maintain the bleed during operations, the NRC staff finds there is insufficient clarity to ensure bleed is maintained at all times until the wellfields are restored. Therefore, staff is imposing the following license condition:

The licensee shall maintain an inward hydraulic gradient in each individual well field starting when lixiviant is first injected into the production zone and continuing until the groundwater restoration stability monitoring has begun.

3.1.3.5.4 Plant Material Balance and Flow Rates

In 2008, the applicant upgraded the facility's processing equipment in accordance with the request to increase the production rate from 18,927 to 34,068 lpm (5,000 to 9,000 gpm) which was approved in License Amendment 22 (NRC, 2007b). The upgrade primarily consisted of adding ion exchange (IX) columns to the processing circuit. Justification for the upgrade was, in part, to provide more efficient extraction capabilities which would aid in the aquifer restoration. The applicant stated that the facility's wastewater generation would not substantially increase despite the increased production rate because a lower bleed would be required with efficiencies of the upgrade. The applicant stated that the existing disposal system adequately handled the volume of waste water generated at the facility. The applicant also stated the upgrade consolidated and enhanced the restoration treatment equipment at the former R&D facility (NRC, 2007b).

Although the applicant addressed the water use in the LRA in Section 3.1.3 (CBR, 2007a), NRC staff finds the application did not provide a comprehensive evaluation of the overall facility water mass balance, or include the updated production rates or schedules (e.g., Table 7.12-1 of the application). Furthermore, for the CBR facility, NRC staff finds the maximum capacity of the waste water disposal system has not been clearly defined. The waste water disposal system consists of land irrigation (land application), evaporation ponds and a deep disposal well. The land application is currently not used by the applicant. The applicant has five evaporation ponds being used for waste disposal, three ponds associated with the commercial ISR plant and two ponds associated with the R&D site. The applicant is authorized to have an additional two evaporation ponds under the commercial license; however, those ponds have never been constructed. Finally, the permit for the deep well injection of waste was modified by NDEQ to remove the flow rate limitation if the surface well head injection pressure was maintained at the permit limit of 4481 kpscal (650 psi). In the License Amendment 7 request, the applicant estimated a potential rate for the deep disposal well between 757 to 1514 lpm (200 to 400 gpm) and estimated a life expectancy for the well to the year 2018.

To assess the waste disposal capacity, NRC staff evaluated the historical disposal rates to the evaporation ponds and deep disposal well, and, restoration rates as reported by the applicant in the semi-annual effluent monitoring reports (CBR, 2000 a,b, 2001a,b, 2002a,b, 2003a,b, 2004a,b, 2005a,b, 2006 a,b, 2007b,c, 2008a, b, 2009 a,b, 2010 a,b, 2011b). The historical disposal rates are summarized in SER Table 3.1-2. The semi-annual average historic flow rates to the evaporation ponds varied from 34 to 94.6 lpm (9 to 25 gpm). In general, the rates have been relatively constant during the past 10 years. The rates for the first half of the year are typically less than those for the second half of the year. NRC staff observes similar disposal rates would be expected to continue during the renewal period.

Table 3.1-2: Summary of Historic Disposal Rates

Semi-Annual Period		Byproduct Material Disposal Volume (megaliters (million gal))			Byproduct Material Disposal Rate(lpm (gpm))		
		Ponds	Deep Disposal Well	Total	Ponds	Deep Disposal Well	Total
2002	1st	17.1 (4.53)	41.8 (11.05)	58.9 (15.58)	64 (17)	159 (42)	227 (60)
	2nd	24.1 (6.36)	51.3 (13.55)	75.4 (19.91)	91 (24)	193 (51)	284 (75)
2003	1st	13.6 (3.59)	66.6 (17.59)	80.2 (21.19)	53 (14)	257 (68)	307 (81)
	2nd	9.87 (2.61)	72 (19.02)	81.8 (21.63)	38 (10)	272 (72)	310 (82)
2004	1st	18.9 (4.99)	78.1 (20.64)	97.0 (25.64)	72 (19)	299 (79)	371 (98)
	2nd	18.2 (4.82)	73.2 (19.33)	91.4 (24.16)	68 (18)	276 (73)	344 (91)
2005	1st	24.1 (6.38)	74.2 (19.6)	98.1 (25.91)	91 (24)	284 (75)	375 (99)
	2nd	10.8 (2.85)	73.8 (19.51)	84.7 (22.37)	42 (11)	280 (74)	318 (84)
2006	1st	10.1 (2.67)	81.7 (21.59)	93.3 (24.66)	38 (10)	318 (384)	360 (95)
	2nd	15.1 (3.98)	109.3 (28.9)	124.5 (32.9)	57 (15)	413 (109)	469 (124)
2007	1st	19.9 (5.26)	112 (29.6)	(132.1) 34.9	76 (20)	431 (114)	507 (134)
	2nd	14.3 (3.79)	76.1 (20.1)	90.5 (23.9)	53 (14)	288 (76)	341 (90)
2008	1st	24.7 (6.54)	84.7 (22.4)	109.4 (28.9)	95 (25)	325 (86)	416 (110)
	2nd	19.0 (5.03)	106.3 (28.1)	125.3 (33.1)	72 (19)	401 (106)	473 (125)
2009	1st	22.9 (6.07)	101.8 (26.9)	124.9 (33.0)	87 (23)	389 (103)	481 (127)
	2nd	17.9 (4.73)	132 (34.9)	150.3 (39.7)	68 (18)	499 (132)	568 (150)
2010	1st	8.85 (2.34)	159.3 (42.1)	168.1 (44.4)	34 (9)	610 (161)	643 (170)

NRC staff observes SER Table 3.1.2 shows the semi-annual mean flow rates to the deep disposal well varied between 158.9 and 609.4 lpm (42 and 161 gpm). The arithmetic mean for the previous 10 years is 337 lpm (89 gpm). The rates exhibit an increasing trend since 2008 which may be attributed to the increased restoration activities rather than to operational bleed. The flow rates are expected to continue to increase in the near future. Based on the estimated maximum disposal rate of 757 to 1514 lpm (200 to 400 gpm) for the deep disposal well, the NRC staff expects the applicant to have sufficient disposal capacity for operations. In addition, the NDEQ has informed NRC staff that they are proposing to issue a permit to CBR for a second Class I non-hazardous waste injection well to aide in the disposal of restoration fluids

(NDEQ, 2010). Although NRC staff finds the current disposal capacity to be sufficient with one well, NRC notes the addition of this disposal well provide the capacity to allow CBR to increase disposal rates as necessary to match any future increases in production and restoration operations. Any future increases in production will have to be approved by NRC in a license amendment.

3.1.3.5.5 Lixiviant Makeup

NRC staff observes that license condition 10.1 states that the lixiviant injected into the production aquifer consists of native groundwater with the addition of sodium carbonate/bicarbonate, and oxygen or hydrogen peroxide (NRC, 2010b). The license does not specifically state that the lixiviant will contain carbon dioxide but does include the phrase “as described in the approved license application” (NRC, 2010b). To eliminate any future ambiguities, staff is proposing to modify the license to specifically include carbon dioxide additions to the lixiviant. This modified license condition is presented in Section 3.1.3.5.7. Staff has previously concluded that the lixiviant composition was acceptable during the prior license renewal review (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003a), staff is not reexamining this issue.

3.1.3.5.6 Drawdown

NRC staff observes the applicant provided three recent potentiometric surface contour maps for the Basal Chadron production aquifer in the LRA in Section 2.7.2.1 for Spring 2008, Fall 2008 and Winter 2009 (CBR, 2007a). These maps display contours of the recent water levels in the Basal Chadron aquifer which may be used to determine the drawdown from consumptive water use over the life of the operations. Based on a comparison of these recent water levels to the limited 1982-1983 Basal Chadron water level data depicting static (pre-operational) potentiometric surface, drawdown within the mine units over this time period is estimated by staff to be approximately 14.3 m (47 feet). This drawdown agrees with the value of 40-60 feet which was estimated by the applicant for the Basal Chadron Aquifer across the permit area during operations. The applicant reported the original Basal Chadron water levels provided a water column height of approximately 91.4 to 121.9m (300 to 500 feet) of water above the ore zone. This original water column height translated into water levels 3.0-15.2m (10-50 feet) above ground surface in the license area. NRC staff finds this consumptive use of 14.3 m (47 feet) of drawdown represents about 10% of the available water level. Staff has previously concluded that the drawdown prediction was acceptable during the prior license renewal review (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003a), staff is not reexamining this issue.

3.1.3.5.7 Evaluation Findings

The staff reviewed the ISR processes and equipment for use at the Crow Butte facility in accordance with Section 3.1.3 of the standard review plan (NRC, 2003a). The applicant described the mineralized zone(s) and demonstrated control on the migration of process fluids that meet the following criteria:

- Downhole injection pressures are less than formation fracture pressures.
- Overall production rates are higher than injection rates to create a bleed sufficient to maintain hydraulic control.
- Wellfield operations are conducted in accordance with license application commitments and license conditions.
- Plant flow rates and production levels in accordance with license application commitments and license conditions.
- Drawdown levels from historical consumptive water use are acceptable
- Disposal operations and capacity are sufficient

NRC has concluded that to ensure injection well head pressures are maintained below the design pressure of the injection lines or the maximum pressure to be applied to the injection wells, the injection well head pressures shall not exceed 100 psi. Therefore NRC will impose a license condition which states:

Flow rates on each injection and recovery well, and manifold pressures on the entire system, shall be monitored and recorded daily. During well field operations, injection pressures shall not exceed 100 pounds per square inch at the injection well heads.

NRC has also concluded that to ensure the safety of the operation, the applicant must sustain an inward gradient during the entire operational life of a wellfield until restoration is completed to maintain control of wellfield fluids. Therefore NRC will impose a license condition which states:

The licensee shall maintain an overall inward hydraulic gradient within the perimeter monitor well ring starting when lixiviant is first injected into the production zone and continuing until the initiation of the stabilization period.

To eliminate any future ambiguities related to the lixiviant composition, staff is proposing to modify the license to specifically include carbon dioxide additions to the lixiviant. Therefore, staff is modifying the current license with the following license condition that will be listed as a standard license condition in SER Appendix A:

The licensee shall use a lixiviant composed of native groundwater, with added sodium carbonate/bicarbonate, carbon dioxide, oxygen and/or hydrogen peroxide, as described in the approved license application.

Based upon the review conducted by the staff as indicated above and the information provided in the application, the applicant's description of its in situ recovery process and equipment meets the applicable acceptance criteria of Section 3.1.3 of the standard review plan and the requirements of 10 CFR 40.32(c), and 10 CFR 40.41(c).

3.1.4 References

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Nebraska Department of Environmental Quality, 2009. Modification to UIC Permit Number NE0122611, Department of Environmental Quality Authorization for Underground Injection and Mineral Production Wells. Document Number 20091329462.

NRC, 2010a. NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, August 20, 2010, ADAMS Accession No. ML102320543.

NRC, 2010b, License Amendment No. 25- Revised Surety Estimate for Crow Butte Resources, Inc, April 20, 2010, ADAMS Accession No. ML100830012.

NRC, 2009. NRC Inspection Report 040-8943/09-001, Arlington, TX, September 28, 2009, Accession No. ML092670138.

NRC, 2008. NRC Inspection Report 040-8943/08-001, Arlington, TX, August 28, 2008, Accession No. ML082410870.

NRC, 2007a. NRC Inspection Report 040-8943/07-001, Arlington, TX, October 16, 2007, Accession No. ML072890610.

NRC, 2007b, License SUA-1534, Amendment 22, dated November 30, 2007, ADAMS Accession No. ML072700204 (Package).

NRC, 2006. NRC Inspection Report 040-8943/06-001, Arlington, TX, September 8, 2006, Accession No. ML062540084.

NRC, 2005. NRC Inspection Report 040-8943/05-001, Arlington, TX, October 20, 2005, Accession No. ML052930434.

NRC, 2004. NRC Inspection Report 040-8943/04-001, Arlington, TX, October 15, 2004, Accession No. ML042920385.

NRC, 2003a. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

NRC, 2003b. NRC Inspection Report 040-8943/03-001, Arlington, TX, September 22, 2003, Accession No. ML032650623.

NRC 2003c , License Amendment 15, Crow Butte Resources In Situ Leach facility, License No. SUA-1534, Wellfield #1 Restoration Acceptance. Letter and Attachments from Dan Gillen to Michael L. Griffin dated February 12, 2003. Accession No. ML030440055.

NRC, 2002. NRC Inspection Report 040-08943/02-01, Arlington, TX, June 17, 2002, ADAMS Accession No. ML021680257

NRC, 2001. NRC Inspection Report 040-08943/01-01, Arlington, TX, May 4, 2001, ADAMS Accession No. ML011280480.

NRC, 2000. NRC Inspection Report 040-08943/00-01, Arlington, TX, April 19, 2000, ADAMS Accession No. ML003705485.

NRC, 1999. NRC Inspection Report 040-8943/99-02, Arlington, TX, November 16, 1999, ADAMS Accession No. ML993300032 (Package).

NRC, 1998. Safety Evaluation Report (SER) for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc. , Crow Butte Uranium Project, Dawes County, NE, February 2, 1998, ADAMS Accession No. ML081080325.

NRC, 1989. Safety Evaluation Report (SER) for Ferret Exploration Company of Nebraska, Crow Butte Project, December 12, 1989, ADAMS Accession No. ML080730272.

3.2 Central Processing Plant and Other Facilities—Equipment Used and Materials Processed

3.2.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant has sufficiently demonstrated that the equipment and processes to be used during operations in the CPP and other facilities at the Crow Butte facility will meet the requirements of 10 CFR 40.32(c) and 40.41(c).

3.2.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 3.2.3 of NUREG-1569 (NRC, 2003a).

3.2.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application.

The current processing capabilities were approved by NRC staff through license amendment 22 (central processing plant (CPP) upgrade) (NRC, 2007b). Prior to the time, the processing capabilities consisted production fluid flows of up to 18,927 lpm (5,000 gpm) and restoration flows up to 2,271 lpm (600 gpm). The applicant presented updated information regarding the ISR processing system and equipment, including the 6 down flow IX columns added during the plant upgrade. The above ground facilities include a central processing plant and the former research and development (R&D) plant. During the upgrade, the restoration circuit was consolidated at the former R&D site (CBR, 2006). The current processing capabilities include production fluid flow rates of up to 34,068 lpm (9,000 gpm), and restoration flow rates of up to 3,785 lpm (1,000 gpm). Staff has found nothing to invalidate previous findings concerning the above-referenced upgrade to the CPP and R&D plant (CBR 2007b); therefore, the original findings stand and previous staff conclusions remain valid.

During 2010, the applicant began operation of a pond water treatment circuit. This circuit was added to treat the water in the applicant's commercial evaporation ponds with the ultimate goal of emptying the ponds. The applicant approved this addition through its SERP process (see SERP Evaluation Report 10-05 (CBR, 2011)).

Staff reviewed NRC inspection reports dating from 1999 to 2010. During each of these inspections (NRC, 1999-2003b, 2004-2007a, 2008-2010), NRC inspectors reviewed various aspects of the applicant's in situ recovery processing facilities. These reviews included a visual inspection of plant equipment and a comparison of plant operating parameters (e.g., flow, pressure) with licensed limits. In addition, during the 2010 inspection (NRC, 2010), SERP Report SERP 10-05 (CBR, 2011), discussed above, was reviewed by the inspectors and the associated equipment was visually inspected. As a result of these inspections, the NRC inspectors determined that the applicant was conducting its in situ recovery operations consistent with its license requirements. Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

Radon, oxygen, and carbon dioxide gases are removed from process tanks by venting. Section 5.8 of the license renewal application identifies the plant locations of fume or gas generation. The corresponding evaluation is in Section 5.7 of this safety evaluation report.

The applicant provided an expanded description of chemicals used during processing that identified storage locations, hazards, and human exposure symptoms. The following chemicals are stored in bulk at the Crow Butte ISR facility: carbon dioxide, hydrogen peroxide, oxygen, sodium hydroxide, hydrochloric acid, sodium carbonate, sodium bicarbonate, sodium chloride, and sodium sulfide.

According to the applicant, none of the hazardous chemicals at the Crow Butte ISR facility are regulated by the U.S. Environmental Protection Agency Risk Management Program. Nonetheless, the applicant adequately applies administrative and process controls as well as

design and operational measures. Bulk quantities of hazardous materials that could potentially affect radiological safety are stored outside in areas separated from the storage of licensed material. Oxygen is stored at the plant and in well fields for introduction into the injection stream. The oxygen storage facility is adequately separated from the main plant and other chemical storage areas. The storage of sodium sulfide, a hazardous chemical reductant used for groundwater restoration, is also separated from processing areas. As discussed in Section 3.2.2.1 of the application (CBR, 2007), the applicant applies precautionary measures during the handling and transfer of sodium sulfide.

The applicant also proposed the use of hydrogen sulfide as a chemical reductant. Although hydrogen sulfide has not been used by the applicant, in the event the applicant decides to use hydrogen sulfide, the applicant indicated that proper safety precautions will be taken to minimize potential impacts to radiological and chemical safety. To ensure potential safety impacts are minimized in the event hydrogen sulfide is used, staff will impose a license condition to require the storage and handling procedures to prevent impacts to radiological and worker safety be provided to the NRC for review and approval. This license condition is presented in SER Section 3.2.4.

Based on a risk assessment for chemical storage, the applicant identified hydrochloric acid as the most important hazard with respect to chemical and radiological safety. The applicant applies unloading procedures to ensure that safety controls are in place during the transfer of hydrochloric acid. Process controls are applied to the precipitation circuit within the main plant where hydrochloric acid is added.

The applicant identified petroleum and propane as chemicals that are not used directly in the uranium recovery process. Bulk quantities of petroleum and propane are stored outside away from process areas.

To the extent that hazardous chemicals may potentially affect radiological safety at the Crow Butte facility, NRC concludes that the controls, equipment, and procedures the applicant proposes for use to control hazardous chemicals is consistent with the acceptance criteria presented in Section 3.2.3 of the standard review plan (NRC, 2003a) and is therefore acceptable.

3.2.4 Evaluation Findings

To ensure the potential impacts to radiological and chemical safety are minimized in the event hydrogen sulfide is used at the Crow Butte ISR facility, the NRC will impose a license condition which states:

If hydrogen sulfide is used, the storage and handling procedures to prevent impacts to radiological and worker safety shall be provided to the NRC for review and approval.

The staff concludes that the applicant adequately described the equipment, facilities, and procedures that will be used during operations in the CPP and other facilities at the Crow Butte facility to protect health and minimize danger to life or property. Based upon the review conducted by the staff, as indicated above, the information provided in the application meets the acceptance criteria of Section 3.2.3 of the standard review plan (NRC, 2003a) as well as the requirements of 10 CFR 40.32(c) and 10 CFR 40.41(c).

3.2.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2011. Letter Re: Annual Report of Changes, Tests or Experiments at Cameco Resources Crow Butte Operation, February 1, 2011, ADAMS Accession No. ML110400434.

CBR, 2007. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

CBR, 2006. Request for License Amendment for Plant Upgrade, October 17, 2006, ADAMS Accession No. ML063390348.

NRC, 2010. NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, August 20, 2010, ADAMS Accession No. ML102320543.

NRC, 2009. NRC Inspection Report 040-8943/09-001, Arlington, TX, September 28, 2009, Accession No. ML092670138.

NRC, 2008. NRC Inspection Report 040-8943/08-001, Arlington, TX, August 28, 2008, Accession No. ML082410870.

NRC, 2007a. NRC Inspection Report 040-8943/07-001, Arlington, TX, October 16, 2007, Accession No. ML072890610.

NRC, 2007b. License SUA-1534, Amendment 22, dated November 30, 2007, ADAMS Accession No. ML072700204 (Package).

NRC, 2006. NRC Inspection Report 040-8943/06-001, Arlington, TX, September 8, 2006, Accession No. ML062540084.

NRC, 2005. NRC Inspection Report 040-8943/05-001, Arlington, TX, October 20, 2005, Accession No. ML052930434.

NRC, 2004. NRC Inspection Report 040-8943/04-001, Arlington, TX, October 15, 2004, Accession No. ML042920385.

NRC, 2003a. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

NRC, 2003b. NRC Inspection Report 040-8943/03-001, Arlington, TX, September 22, 2003, Accession No. ML032650623.

NRC, 2002. NRC Inspection Report 040-08943/02-01, Arlington, TX, June 17, 2002, ADAMS Accession No. ML021680257

NRC, 2001. NRC Inspection Report 040-08943/01-01, Arlington, TX, May 4, 2001, ADAMS Accession No. ML011280480.

NRC, 2000. NRC Inspection Report 040-08943/00-01, Arlington, TX, April 19, 2000, ADAMS Accession No. ML003705485.

NRC, 1999. NRC Inspection Report 040-8943/99-02, Arlington, TX, November 16, 1999, ADAMS Accession No. ML993300032 (Package).

NRC, 1998. Safety Evaluation Report (SER) for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc. , Crow Butte Uranium Project, Dawes County, NE, February 2, 1998, ADAMS Accession No. ML081080325.

3.3 Instrumentation and Control

3.3.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant has adequately demonstrated that the instrumentation and control proposed for the Crow Butte facility meet the requirements of 10 CFR 40.32(c) and 40.41(c).

3.3.2 Regulatory Acceptance Criteria

If not specifically stated otherwise, the application was reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 3.3.3 of the standard review plan (NRC, 2003a).

3.3.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application.

CBR maintains continuous, real-time monitoring and control of the total production and injection flow rates; and pressure on the injection trunk lines. Wellfield houses are equipped with wet alarms to detect the presence of liquids in wellfield house sump. Deep injection wells are equipped with sensors for monitoring their status.

The applicant installed instrumentation in the CPP to continuously monitor the total flow into the plant and the total waste flow leaving the plant on a real-time basis. The plant injection manifolds are equipped with sensors to alert the operator in the case of leak or rupture in the injection system. The applicant placed instrumentation to measure tank levels in chemical storage and process tanks. Automatic monitoring systems are in place for the dryer system and drum logging. The applicant equipped all critical equipments with an uninterrupted power source system in the event of power failure.

Staff reviewed NRC inspection reports dating from 1999 to 2010. During each of these inspections (NRC, 1999-2003b, 2004-2010), NRC inspectors reviewed various aspects of the applicant's in situ recovery processing facilities. These reviews included a visual inspection of equipment associated with the CPP, wellfield (header) houses and the yellowcake dryer along with their associated instrumentation and controls and a comparison of plant operating parameters (e.g., flow, pressure) with licensed limits. As a result of these inspections, the NRC inspectors determined that the applicant was conducting its in situ recovery operations consistent with its license requirements. Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

3.3.4 Evaluation Findings

The NRC staff has completed its review of the instrumentation and control techniques proposed for use at the Crow Butte ISL facility. This review included an evaluation using the review procedures in SRP Section 3.3.2 and the acceptance criteria in SRP Section 3.3.3. The instrumentation and control systems have been acceptably described for components, including the wellfields, wellfield houses, trunk lines, plant, and deep disposal wells. As discussed in SER Section 3.3.3, the instrumentation will allow for continuous monitoring and control of systems, including flow rates for total inflow to the plant and total waste flow exiting the plant. Appropriate alarms are part of the instrumentation systems. All critical equipments are equipped with an uninterrupted power source system in the event of power failure.

Based on the information provided in the application and the staff's detailed review of the instrumentation and control for the Crow Butte ISL facility, the staff concludes that the proposed instrumentation is acceptable and is in compliance with 10 CFR 40.32(c) and 10 CFR 40.41(c).

3.3.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2007. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

NRC, 2010. NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, August 20, 2010, ADAMS Accession No. ML102320543.

NRC, 2009. NRC Inspection Report 040-8943/09-001, Arlington, TX, September 28, 2009, Accession No. ML092670138.

NRC, 2008. NRC Inspection Report 040-8943/08-001, Arlington, TX, August 28, 2008, Accession No. ML082410870.

NRC, 2007. NRC Inspection Report 040-8943/07-001, Arlington, TX, October 16, 2007, Accession No. ML072890610.

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NRC, 2005. NRC Inspection Report 040-8943/05-001, Arlington, TX, October 20, 2005, Accession No. ML052930434.

NRC, 2004. NRC Inspection Report 040-8943/04-001, Arlington, TX, October 15, 2004, Accession No. ML042920385.

NRC, 2003a. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report.” June.

NRC, 2003b. NRC Inspection Report 040-8943/03-001, Arlington, TX, September 22, 2003, Accession No. ML032650623.

NRC, 2002. NRC Inspection Report 040-08943/02-01, Arlington, TX, June 17, 2002, ADAMS Accession No. ML021680257

NRC, 2001. NRC Inspection Report 040-08943/01-01, Arlington, TX, May 4, 2001, ADAMS Accession No. ML011280480.

NRC, 2000. NRC Inspection Report 040-08943/00-01, Arlington, TX, April 19, 2000, ADAMS Accession No. ML003705485.

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NRC, 1998. Safety Evaluation Report (SER) for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc. , Crow Butte Uranium Project, Dawes County, NE, February 2, 1998, ADAMS Accession No. ML081080325.

4. EFFLUENT CONTROL SYSTEMS

4.1 Gaseous and Airborne Particulates

This section discusses the basic design and operation of the gaseous and airborne particulates effluent control systems for the Crow Butte facility as proposed by the applicant in the LRA, as updated. The purpose of the effluent control systems is to prevent and minimize the spread of gaseous and airborne particulate contamination to the atmosphere by the use of emission controls and to ensure compliance for radiation doses limits to the public.

4.1.1 Regulatory Requirements

For gaseous and airborne particulates generated at the Crow Butte facility, the staff determines if the applicant has demonstrated that operations at the Crow Butte facility will comply with Criterion 8 of Appendix A to 10 CFR Part 40 which requires milling operations to be conducted so that all airborne effluent releases are reduced to levels as low as reasonably achievable (ALARA). The licensee must also demonstrate that releases of gaseous and airborne particulates are in compliance with other relevant sections of 10 CFR Parts 20 and 40.

4.1.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in Section 4.1.3 of the standard review plan (NRC, 2003).

4.1.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. The staff also visited the site on several occasions during the course of this review to confirm information presented in the application. The following sections present the staff's review and analysis of various aspects of the gaseous and airborne particulates that will be generated at the Crow Butte facility as well as the applicant's proposed control measures for those particulates.

4.1.3.1 Airborne Uranium

In Section 4 of the Technical Report (Crow Butte, 2009), the applicant stated that the Crow Butte facility will employ a vacuum dryer in the yellowcake drying facility at the Central Processing Plant. During dryer operations, yellowcake is dried in a heating chamber that is maintained at negative pressure. The applicant stated that airflow in a vacuum dryer is minimal and is from the outside of the drying chamber into the chamber. Any particulate that may be released goes to a bag filter with moisture-laden air going to a closed loop condenser where the water condenses and entrains any remaining particulate, with the vacuum source being a liquid ring vacuum pump acting as a final filter against any particulate escape. The applicant stated that the limited, intermittent, and variable exhaust flow from the vacuum pump is returned to the drying and packaging room. The drying room is shown in Figure 5.8-5 of the Technical Report

(Crow Butte, 2009) The staff has determined that the exhaust from the vacuum dryer and during packaging operations is not directly discharged to an unrestricted area (i.e., directly to the outside environment).

The applicant stated that during packaging, the packing drum is sealed by a gasket to the dryer discharge. The applicant further stated that as the dryer is operating under vacuum, any leaks around this gasket result in air being drawn into the drum during packaging of yellowcake, thus no contaminants are released. Air that may enter the discharge to the drum is also routed to the condenser system. As indicated in the previous paragraph, intermittent and variable exhaust flow from the vacuum pump is returned to the drying and packaging room.

The applicant is currently required by license condition to assure that negative pressure is maintained for the dryer and is required to shut the system down if it is not operating within specifications set forth in their standard operating procedures. This license condition will not change with this renewal. The staff notes that on two occasions during the last renewal period (NRC, 2001, 2002), mechanical failure resulted in a loss or partial loss of dryer vacuum. The applicant took appropriate action to shutdown the vacuum dryer and conducted proper air sampling surveys, including posting the dryer room as an airborne radioactivity area.

NRC staff previously evaluated the applicant's drying and packaging equipment and control systems and found them acceptable (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

The applicant stated that vacuum dryers do not discharge any uranium when operating. NRC staff notes that the applicant has not verified this statement with appropriate monitoring. A license condition to address this issue is discussed in SER Section 5.7.8.3.2

The applicant has established an action limit of 25 percent of the values given in Table 1 of Appendix B to 10 CFR 20 for uranium. This action limit is discussed in SER Section 5.7.4.3.3 and is found to be an acceptable ALARA goal.

4.1.3.2 Radon

The applicant indicated in Section 4.1.1 of the Technical Report (Crow Butte, 2009) that Rn-222 is contained in the pregnant lixiviant that comes from the wellfield into the plant, and the majority of the Rn-222 is released in the injection surge tanks and in the ion exchange columns. The applicant stated that the vessels are covered and vented to the atmosphere. The vents from the individual vessels go into a manifold that is exhausted to atmosphere outside the plant building via an induced draft fan. The applicant also stated that redundant exhaust fans direct collected gases to discharge piping that exhaust fumes to the outside atmosphere. Discharge stacks are located away from building ventilation intakes to prevent introducing exhausted radon into the facility as recommended by Regulatory Guide 8.31 (NRC, 2002). The applicant states that small amounts of Rn-222 may be released via solution spills, filter changes, Reverse Osmosis (RO) operations, and maintenance activities, but these are minimal releases on an infrequent basis.

NRC staff previously evaluated the applicant's radon controls and found them acceptable (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

Notwithstanding these previous findings, the applicant has not adequately addressed the discharge flow rate to the environment or provided any information on the flow rate for the redundant exhaust fans and air exchange rate for the facility. The applicant did not discuss any proposed methods for controlling such releases, including, specifically, how the applicant would detect, prevent or mitigate releases to the public to prevent or limit radiation exposures. Therefore, a license condition will be included in the license, as discussed in Section 4.1.4 of this SER.

4.1.4 Evaluation Finding

The staff reviewed the proposed effluent control systems for gaseous and airborne particulates for the Crow Butte facility in accordance with Section 4.1.3 of the standard review plan (NRC, 2003).

The applicant acceptably described the sources of both uranium and radon at the Crow Butte facility and emission controls for the yellowcake dryer. However, the applicant has not proposed an acceptable method for monitoring and controlling air effluent of particulate and radon to unrestricted areas. Therefore, the staff is imposing the following license condition to ensure that an acceptable method is developed to ensure that proper effluent monitoring is in place:

The license shall provide flow rates for discharges to unrestricted areas and air exchange rate for the facility, and describe what method(s) will be used to control releases to unrestricted areas.

Based upon the review conducted by the staff as indicated in above, the information provided in the application, as supplemented by the information submitted in accordance with the noted license condition, meets the applicable acceptance criteria of Section 4.1.3 of the standard review plan (NRC, 2003) and the requirements of 10 CFR Part 20 and 40.

4.1.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2009, Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2007. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

NRC, 2003. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report.” June.

NRC, 2002. NRC Inspection Report 040-08943/02-01, Arlington, TX, June 17, 2002, ADAMS Accession No. ML021680257.

NRC, 2002. “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable,” Regulatory Guide 8.31, Revision 1. Washington, DC: May 2002.

NRC, 2001. NRC Inspection Report 040-08943/01-01, Arlington, TX, May 4, 2001, ADAMS Accession No. ML011280480.

NRC, 1998. Environmental Assessment for Renewal of Source Material License No. SUS-1534, Crow Butte Resources, Incorporated, Crow Butte Uranium Project, Dawes County, Nebraska, February 1998, ADAMS Accession No. ML071520242.

4.2 Liquid and Solid

4.2.1 Regulatory Requirements

For liquid effluents generated at the Crow Butte facility, the staff determines if the applicant has demonstrated compliance with 10 CFR 20.1301, 20.2002, and 20.2007. For solid effluents generated at the Crow Butte facility, the staff determines if the applicant demonstrated compliance with 10 CFR Part 40, Appendix A, Criterion 2.

4.2.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 4.2.3 of NUREG 1569 (NRC, 2003).

4.2.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007a) and as updated. The staff also visited the site on several occasions during the course of this review to confirm information presented in the application. The following sections present the staff’s review and analysis of various aspects of the liquid and solid waste that will be generated at the Crow Butte facility, including the control and disposal of such wastes.

4.2.3.1 Liquid Waste

In Section 4.2.1 of the application (CBR, 2007a), the applicant discussed the different liquid waste streams at the Crow Butte facility which are categorized as byproduct or non-byproduct.

The applicant further categorized liquid waste based on the source of the waste. Liquid wastes generated during the uranium recovery process are considered liquid byproduct material. The Crow Butte facility does not release byproduct liquid effluents to the environment. All byproduct liquid waste is managed on-site and discharged to the evaporation ponds or to deep well disposal. For non-byproduct material, the applicant uses an on-site septic field (sanitary waste only) or off-site disposal.

4.2.3.1.1 Disposal Options

NRC staff observes the applicant has several disposal options for liquid wastes based on the type of waste, its source and chemical constituents. For liquid byproduct material, the disposal options include direct injection of the material into an on-site deep disposal well or solar evaporation into the atmosphere from the on-site evaporation ponds. The facility currently has one deep disposal well. NRC staff observes that discharges to the deep disposal well are permitted through the state of Nebraska (Nebraska Department of Environmental Quality (NDEQ)). The applicant has applied for a second deep well permit with NDEQ (NDEQ, 2010, 2011). Based on the applicant's reports, testing has been conducted on this second deep well in 2012 in preparation of its use in the near future (CBR, 2012f). The applicant also has three commercial and two R&D evaporation ponds, which comply with the design, installation, and operation criteria specified in the NRC Regulatory Guide 3.11 (NRC, 2008a). The applicant has two other disposal options, which have not been used. In accordance with the license amendment dated November 16, 1993 (NRC, 1998), one option is for the disposal of liquid byproduct material is through on-site land irrigation (land application); however, the facilities have never been constructed. The second option is the discharge to surface water. This option requires an National Pollutant Discharge Elimination System (NPDES) permit by the State of Nebraska, which would require treatment to specific water quality standards before any water is permitted to be discharged. NRC staff previously concluded that the above-referenced liquid waste disposal options proposed by the applicant were acceptable (NRC, 1998). Staff has found nothing to invalidate these previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

4.2.3.1.2 Liquid Byproduct Material Wastes

In Section 4.2.1 of the application (CBR, 2009b), the applicant identified the following sources of liquid byproduct waste: ISR process eluant and production/restoration bleed, and laboratory wastes. ISR process waste water is fluid generated from the eluant or production/restoration bleed. The bleed fluids are routed to either the deep disposal well or the solar evaporation pond at the discretion of the applicant (CBR, 2009b). The applicant's laboratory waste is disposed of in the solar evaporation pond or the deep disposal well. The applicant indicated that the laboratory waste disposed of on-site in the evaporation ponds or deep disposal well will not contain hazardous waste. The total monthly volume of laboratory waste disposed of on-site is estimated by the applicant at 11,356 liters per month (3,000 gallons per month) (CBR, 2009b).

NRC staff reviewed the applicant's semi-annual monitoring reports submitted to the NRC (CBR 2011a; 2010a,b; 2009a,c; 2008a,b; 2007b,c; 2006a,b; 2005a,b; 2004a,b; 2003a,b; 2002a,b; 2001a,b; 2000a,b) which described the amounts and activity of liquid byproduct materials which had been disposed of at CBR. NRC concludes the disposal of these materials has been conducted in a manner which was protective of the public health and safety. NRC staff

previously concluded that the byproduct material characterization, capacity, and methods of disposal were acceptable (NRC, 1998). Staff has found nothing to invalidate these previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

4.2.3.1.3 Other Liquid Wastes

The NRC staff observes the sources of non-byproduct liquid waste identified by the applicant consist of water generated during well completion and development, storm water runoff, and domestic liquid waste (CBR, 2009b).

Well development water is groundwater recovered from a well generally after its initial installation but before the aquifer had been exposed to the ISL process. Staff also observes that for some wells, particularly those screened in the mineralized zone, the development water may contain naturally occurring radionuclides. The applicant stated that well development water will be collected and discharged to the evaporation ponds. The development water may be subsequently treated with filtration and/or reverse osmosis for its use as plant make-up water, disposed in the deep disposal well or evaporated into the atmosphere from the pond (CBR, 2009b).

The storm water runoff is managed and controlled under permits issued by the NDEQ. Storm water is not specifically collected nor diverted for disposal. Domestic liquid waste water is sanitary waste generated from restrooms and the lunchroom and is disposed of in on-site septic system(s) under a permit issued by the NDEQ. The systems must meet requirements of the State of Nebraska and the discharge is limited to non-hazardous materials. The approaches to liquid nonbyproduct material management described above are considered acceptable by the NRC staff, as the applicant has identified plans for surface discharge, septic system, or disposal of these materials that are consistent with acceptance criterion: (1) in NUREG 1569, Section 4.2.3 (NRC, 2003). Additionally, the applicant has identified State permits that are required for disposal of liquid non-byproduct material. By identifying the State permits required, the staff finds that the applicant has addressed acceptance criterion (7) in NUREG 1569, Section 4.2.3. NRC staff previously concluded that the non-byproduct material waste disposal was acceptable (NRC, 1998). Staff has found nothing to invalidate these previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

4.2.3.1.4 Monitoring of the Disposal Options

Deep Disposal Well

NRC staff observes monitoring of the deep disposal well is required by the Nebraska UIC permit program to ensure the health and safety of worker and the public. The monitoring consists of daily measurements of flow rates and pressures, and performing mechanical integrity testing (MIT) every five years for the life of the well. In application section 5.4.4, the applicant committed to continue to retain deep disposal well operational monitoring data required by the Nebraska UIC program and make the data available to NRC staff during on-site inspections. NRC staff previously concluded that the licensee's operation and monitoring of deep well disposal was acceptable (NRC, 1998). Staff has found nothing to invalidate these previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

On-site Ponds

NRC staff observes the five on-site ponds are man-made impoundments constructed with an elevated earthen perimeter berm and synthetic liner (CBR 2007a). The three commercial ponds are constructed with dual liners with a leak detection (underdrain) system in between liners (refer to Section 4.2.1.3 of CBR 2009b). The two R&D ponds are constructed with a single liner with a leak detection system installed immediately below that liner (CBR 2007a). By license condition (NRC, 1991), the applicant must maintain a freeboard of 0.9m (3 feet) for the R&D ponds and 1.5m (5 feet) for the commercial ponds. The total allowable storage capacity for the ponds has been reported to be 138,643 cubic meters (122.4 acre-feet) for the existing system (CBR, 2010c). The estimated evaporative capacity for the existing ponds is 36.7 megaliters (9.7 million gallons) per year (NRC, 1998). Based on the semi-annual effluent monitoring reports, the maximum discharge rate to the evaporation ponds during the past 10 years is 22.7 megaliters (6 million gallons) per year (CBR, 2010c).

NRC staff observes that conditions at the evaporation ponds are monitored daily, weekly, monthly, quarterly, and annually by the applicant. The monitoring activities include visual inspections, technical evaluation of the various components (e.g., berm, liner, settlement) and monitoring for leaks (CBR, 2007a). The applicant's program was developed following the recommendations in Regulatory Guide 3.11.1 (NRC, 1980) (refer to Section 4.2.1.3 of CBR 2009b). However, Regulatory Guide 3.11.1 was subsequently withdrawn (73 FR 66686) and the content from the 1980 version of Regulatory Guide 3.11.1 has been updated and incorporated into Regulatory Guide 3.11 (NRC, 2008a).

Should a leak be detected in a pond's leak detection system, the applicant has committed to implement corrective actions (NRC, 1998), which include notifying NRC of the leak detection and lowering the water levels in the pond until the leak is repaired. In addition, dams associated with the applicant's ponds are inspected on a regular basis by the Federal Energy Regulatory Commission for the NRC (NRC, 2011b).

NRC observes that the applicant self reported that it failed to perform the quarterly sampling of the groundwater monitoring wells at the five ponds during the first quarter of 2009 as required by license condition (NRC, 2009). The failure was attributed to errors in administrative paperwork. The applicant modified their procedures to minimize such failures in the future. During the subsequent inspection by NRC, the applicant was issued a non-cited violation for this failure (NRC, 2009).

From 2000 to 2011, NRC observes that the applicant has reported 12 leaks in the three commercial evaporation pond leak detection systems (Table 4.2-1). Historically, the corrective actions were completed within one month of a detection, although corrective actions are still ongoing for two current leaks. The corrective actions include lowering the water levels below the leak level, injecting and extracting fluid to wash out water between the primary and secondary liners and weekly monitoring of groundwater quality of the shallow aquifer immediately downgradient of the ponds. To date, the applicant has not detected evidence of pond leaks in the downgradient shallow aquifer monitoring wells.

Based on the recent detection frequency of leaks for the on-site commercial ponds, NRC staff reviewed the applicant's pond inspection procedures. NRC staff observes that the applicant currently checks for the presence of liquids in the leak detection system on a weekly basis. This approach is not consistent with the guidance in Regulatory Guide 3.11 (NRC, 2008a), which

recommends daily checks for the presence of liquids in the leak detection system. In correspondence dated August 16, 2012 (CBR, 2012a), and August 30, 2012 (CBR, 2012b) the applicant identified the corrective actions typically taken to repair the primary liner system after a leak is detected. In correspondence dated October 4, 2012 (CBR, 2012c), the applicant identified infrastructure improvements underway to reduce the amount of time required to complete the corrective actions.

NRC staff reviewed the August and October 2012 correspondence as well as engineering features of the commercial ponds to determine if a weekly inspection of the leak detection system is acceptable. NRC staff determined that the applicant is taking action to reduce the amount of time necessary to repair and re-establish the primary liner system. Additionally, NRC staff observes that the commercial ponds at the facility do have a secondary synthetic liner system and that leakage through the secondary liner system has not been detected at the downgradient shallow monitoring wells. NRC staff observes that the secondary synthetic liner system provides additional protection beyond what is required by the regulations in 10 CFR Part 40, Appendix A, Criterion 5E. Based on these factors, the NRC staff determined that weekly checks for the presence of liquids in the leak detection system is acceptable.

Table 4.2-1: Summary of Reported Leaks for the On-Site Ponds Leak Detection System

Pond	Date Detected	Date Terminated	Monitoring Well Detection	Corrective Actions Complete	Document Accession Number
1	6/1/2011	6/22/2011	No		ML11187A319
3	3/9/2011	Note ¹	No		ML11109A095
3	6/11/2010	Note ¹	No		ML102310252
4	2/24/2010	Note ¹	No		ML101260026
4	12/31/2009	2/31/2010	No	Fixed Primary Liner	ML100470068
4	6/18/2009	7/14/2009	No	Fixed Primary Liner	ML091740085
1	6/4/2009	7/1/2009	No	Fixed Primary Liner	ML091960467
4	5/5/2006	6/1/2006	No	Fixed Primary Liner	ML061780355
1	5/14/2004	7/27/2004	No	Fixed Primary Liner	ML042400318
1	5/6/2003	5/31/2003	No	Fixed Primary Liner	ML031710020
1	8/20/2002	9/12/2002	No	Fixed Primary Liner	ML022770139
1	4/26/2001		No	Determined No Leak	ML012770257
1	6/9/2000	7/15/2000	No	Fixed Primary Liner	ML003781828
4	5/19/2000	8/28/2000	No	Fixed Primary Liner	ML003781911
3	8/24/2000	10/18/2000	No	Fixed Primary Liner	ML003763779

Source: ADAMS as of December 14, 2011

¹Note : Subsequent to the discovery of the potential leak, visual inspections did not identified a breach or tear in the upper liner. A contractor continues to monitor the underdrain level and inspect the upper liner for tears.

Based on the recent annual pond inspection report, NRC staff observes that fluid has been continuously detected between the primary and secondary liners and that leakage in one or more pond primary liners below the reported maximum operation level (CBR, 2010c). NRC staff observes the primary feature of a double liner system is defense in depth (i.e., if a primary liner develops a leak, the leak detection system will alert the applicant to the defect prior to the integrity of the secondary liner being compromised leading to a release to the environment). Reports of poor water quality of the fluids between the liners and the elevated fluid levels indicate that repairs to the pond may not be adequate even though the corrective actions have been undertaken by the applicant.

Based on these observations, NRC staff finds recent corrective actions taken by the applicant have not been effective in eliminating leaks. In addition, the applicant's approach to cleaning up leaks by washing the fluids between liners by injecting fluid and extracting from monitoring wells (CBR, 2010c) has not been discussed in either the original license application, supporting pond design report (WWC, 1988) or subsequent license renewal applications; thus, this procedure has not been evaluated by NRC. Finally, NRC finds that the practice of the continued operation of a pond at levels below existing leaks should be evaluated for the reduction in the pond's storage capability and thus its ability to accept fluids from another pond should a leak develop in the other pond. Consequently, staff is revising an existing license condition to ensure that corrective actions taken by the applicant are reviewed and approved to ensure leaks will be corrected and pond capacity is acceptable for ongoing operations. This license condition is presented in SER section 4.2.4.

4.2.3.2 Solid Waste

Solid waste can be generated from maintenance or non-routine activities, routine operations, and general housekeeping. The types of waste can include, but not be limited to, spent resin, resin fines, sludge in the ponds, empty reagent containers, miscellaneous piping and fittings, and domestic trash. The applicant classifies the solid waste into four types: (1) non-contaminated solid waste, (2) Byproduct Material, (3) Septic System Solid Waste, and (4) Hazardous Waste (CBR, 2009b).

- 1) Non-contaminated waste is waste which is not contaminated with byproduct material or is waste that can be decontaminated to remove any radiological materials to levels that are protective of human health and the environment. This type of waste may include, but not be limited to, piping, valves, instrumentation, equipment and any other item which is not contaminated or may be successfully decontaminated. The applicant estimates approximately 807 cubic meters (1,055 cubic yards) is generated each year and this waste is disposed of at the nearest permitted sanitary landfill.
- 2) Byproduct material is tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. Byproduct material can include, but not be limited to, filters, personal protective clothing, spent resin, sludge from the ponds, piping, etc. The applicant estimates

approximately 45.9 – 68.8 cubic meters (60-90 cubic yards) of 11(e).2 byproduct material waste is generated each year.

- 3) Domestic solid waste is that generated during normal operations of the restrooms and/or lunchrooms. The domestic solid waste is collected in the septic tanks of the septic system approved by the State of Nebraska. The domestic solid waste is extracted from the tank and hauled off-site for further processing by licensed haulers.
- 4) Hazardous Waste is solid waste that meets the definition of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). The applicant states that the site only generates universal hazardous wastes, such as used waste oil and batteries. The facility is classified as a Conditionally Exempt Small Quantity Generator under the RCRA hazardous waste program. To maintain this classification, the amount of hazardous waste generated or handled at this facility must be less than 100 kg (220 pounds) for any one month.

NRC staff previously concluded that the classification of solid waste sources by the applicant was acceptable (NRC, 1998). Staff has found nothing to invalidate these previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

4.2.3.2.1 Solid Waste Disposal Options

NRC staff observes for non-contaminated solid waste and domestic solid waste, the material must be disposed of off-site at a facility permitted by the State of Nebraska to accept those materials (e.g., solid waste landfill). For hazardous waste, the material must be disposed of off-site at a facility permitted to accept hazardous waste (e.g., a treatment, storage and disposal (TSD) facility permitted by the approved RCRA program). Byproduct material must be disposed of at a NRC licensed facility.

4.2.3.2.2 Monitoring of any On-site Storage of Solid Wastes

NRC staff observes solid byproduct material is collected and stored in appropriate containers which are eventually shipped to a licensed disposal facility (CBR, 2009b). During storage, the containers are located within a restricted access area (CBR, 2009b). Access to the solid byproduct storage facility is controlled through the use of security fencing, locked gates, and proper posting as a restricted area (CBR, 2009b). The applicant maintains an agreement for disposal of byproduct material with a licensed byproduct disposal facility (CBR, 2009b). The current agreement is with the operator of the White Mesa Mill, near Blanding, Utah. NRC staff has reviewed the applicant's byproduct disposal agreement and found it acceptable (NRC, 2010a). For this agreement, the maximum annual volume for disposal is 3823 cubic meters (5,000 cubic yards) of byproduct material; this maximum volume is common to many agreements. Based on staff's review of past inspection reports since the last license renewal, the applicant has maintained an acceptable agreement during this time (NRC, 2006, 2008b, 2009, 2010b, 2011a). In addition, these inspection records show that the applicant has met all solid waste management requirements and has been issued no violations in this regard. NRC staff, therefore, concludes that the applicant's solid waste management has been and will continue to be conducted in a manner which is protective of public health and safety in the future.

4.2.3.3 Spill Contingency Plans

In Section 5.8.1.3 of the LRA (CBR, 2009b), the applicant commits to maintaining a spill contingency plan for unplanned spills or releases to the environment. The RSO has the responsibilities to update the plan and to ensure enforcement of the plan. During the operation of the Crow Butte facility, the applicant has never had a spill that exceeded the reportable limit requirements of 10 CFR Part 20. The applicant maintains a list of spills reportable to Nebraska DEQ and made available to staff during on-site inspections. The applicant will be required to perform final survey of an area subjected to a spill during its operation during decommissioning. NRC staff previously concluded that spill contingency plans were acceptable (NRC, 1989). Staff has found nothing to invalidate these previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

4.2.4 Evaluation Findings

The staff reviewed the type, disposal and monitoring of liquid and solid effluents at the Crow Butte facility in accordance with Section 4.2.3 of NUREG 1569 (NRC, 2003). The applicant described the solid and liquid effluents that are generated at the facility. An acceptable disposal method was identified for liquid byproduct material including a deep disposal well approved through a Nebraska UIC permit as well as disposal through evaporation ponds. The disposal systems have adequate capacity to handle the anticipated byproduct fluids volumes. Acceptable methods of disposal were also provided for byproduct solid wastes. The monitoring of disposal of liquid and solid waste was also found to be acceptable with the exception of the sufficiency of corrective actions for evaporation pond liner leaks. Therefore, the staff is revising a current license condition to the following:

The applicant shall perform and document inspections in accordance with the February 5, 1996, revision to its Evaporation Pond Onsite Inspection Program.

Any time 6 inches or more of fluid is detected in a commercial pond standpipe, it shall be analyzed for specific conductance. If the water quality is degraded beyond the action level, the water shall be further sampled and analyzed for chloride, alkalinity, sodium, and sulfate. Any time 6 inches or more of fluid is detected in an R&D pond standpipe, it shall be analyzed for specific conductance, chloride, alkalinity, sodium, and sulfate.

Upon verification of a liner leak, the licensee shall notify NRC in accordance with LC 11.6, lower the fluid level sufficiently to eliminate the leak by transferring the pond's contents to an alternate cell or approved destination, and undertake repairs, as needed. Water quality in the affected standpipe shall be analyzed for the five parameters listed above once every 7 days during the leak period and once every 7 days for at least 14 days following repairs. The licensee shall submit a corrective action plan within 30 days to NRC for review. The corrective action plan will document steps to adequately address the leak and procedures used to verify that the leak has been adequately addressed and permanently fixed. The corrective action plan should also evaluate how much and for how long the diminished waste disposal capacity will impact operations.

The applicant has shown that effluent control systems, procedures, and required training will limit radiation exposures under both normal and accident conditions by providing information on the health and safety impacts of system failures and identifying preventive measures and mitigation for such occurrences.

Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented by information submitted in accordance with the noted license conditions, meets the applicable acceptance criteria of Section 4.2.3 of NUREG 1569 (NRC, 2003) and the requirements of 10 CFR Parts 20 and 40.

4.2.5 References

10 CFR Part 20. *Code of Federal Regulations*, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

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CBR, 2007a, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

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CBR, 2007c. Crow Butte Resources, Inc. Ltr dated 02/22/2007 Regarding Semiannual Radiological Effluent and Environmental Monitoring Report, February 22, 2007 ADAMS Accession No. ML070650290.

CBR, 2006a. Crow Butte Uranium Project - Semiannual Radiological Effluent and Environmental Monitoring Report, August 29, 2006, ADAMS Accession No. ML070570136.

CBR, 2006b. Letter from Licensee to NRC, Region IV, Enclosing Semiannual Radiological Effluent and Environmental Monitoring Report for Crow Butte Uranium Project - Docket 40-8943, February 21, 2006, ADAMS Accession No. ML060660122.

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5. OPERATIONS

5.1 Corporate Organization and Administrative Procedures

5.1.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that its corporate organization and administrative procedures for the Crow Butte facility are consistent with the requirements of 10 CFR 40.32(b) which requires that the applicant is qualified through training and experience to use source materials.

5.1.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 5.1.3 of NUREG 1569 (NRC, 2003).

5.1.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007, 2009). NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application.

The applicant's organizational structure is presented in the applicant's Safety and Environmental Review Panel (SERP) evaluation report 10-10 (CBR, 2011). The applicant's organizational structure flows vertically downward from the President. The President has the overall responsibility and authority for the radiation safety and environmental compliance programs (CBR, 2007). The Vice President of Operations is responsible for ensuring that operations are compliant with applicable regulations, license conditions, and reporting requirements.(CBR, 2011)

NRC staff reviewed the organizational structure and finds the definition of responsibilities and authority for radiation safety, industrial safety, and environmental protection programs are acceptable. The radiation safety officer responsibilities described in the application are consistent with the responsibilities outlined in, "Regulatory Guide 8.31 (NRC, 2002a). The radiation safety officer reports to the Manager of Safety, Health, Environment and Quality, which is also a position with no production-related responsibilities. The Manager of Safety, Health, Environment and Quality reports to the General Manager. The General Manager has production- and safety-related responsibilities and reports to the Vice President of Operations. Responsibility and authority for suspending, postponing, and modifying activities that may threaten worker or public health or regulatory compliance reside with the General Manager and Vice President of Operations. The General Manager cannot unilaterally override health- or compliance-related decisions made by the Manager of Safety, Health, Environment and Quality.

NRC staff has determined that the applicant's management structure and responsibilities are consistent with recommendations in Regulatory Guide 8.31 (NRC, 2002a) and are therefore acceptable.

The applicant's SERP composition is described by license condition. This license condition will not change with this license renewal. NRC staff previously evaluated this information and found it acceptable (NRC, 2002b). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.1.4 Evaluation Findings

The staff reviewed the corporate organization of the Crow Butte facility in accordance with Section 5.1.3 of NUREG 1569 (NRC, 2003). The applicant defined management responsibilities and authority at each level. Proposed integration among groups that support operation and maintenance of the facility is adequate. Staff has also previously determined that the applicant's SERP composition is acceptable. Based upon the review conducted by the staff as indicated above, the staff concludes that the proposed corporate organization and administrative procedures provided in the application meets the acceptance criteria of Section 5.1.3 of NUREG 1569 (NRC, 2003) and the requirements of 10 CFR 40.32(b). Based upon the review conducted by the staff as indicated above, the information provided in the application meets the acceptance criteria of Section 5.1.3 of NUREG 1569 (NRC, 2003) and as supplemented by SERP evaluation report 10-10 (CBR, 2011)

In addition, NRC staff previously evaluated information reported by the applicant (Ferret Exploration Company of Nebraska, Inc. (FEN) at that time) in its initial licensing documents (FEN 1987). Based on this data, staff concluded that operation of the Crow Butte Project is protective of health and safety (NRC, 1989) and therefore meets the requirement of 10 CFR 40.32(b). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.1.5 References

10 CFR Parts 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

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NRC, 2003. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report.” June.

NRC, 2002a. “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable,” Regulatory Guide 8.31, Revision 1. Washington, DC: May 2002.

NRC, 2002b. License Amendment 12, Crow Butte Resources In Situ leach Facility, License No. SUA-1534, July 24, 2002, ADAMS Accession No. ML022060156.

NRC, 1989. Safety Evaluation Report (SER) for Ferret Exploration Company of Nebraska, Crow Butte Project, December 12, 1989, ADAMS Accession No. ML080730272.

5.2 Management Control Program

5.2.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the management control program for the Crow Butte facility is consistent with the requirements of 10 CFR Part 20, Subpart L, Subpart M and with 10 CFR 40.61. The staff also determines whether or not the applicant has demonstrated compliance with the health and safety requirement of 10 CFR 40.32(c).

5.2.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in Section 5.2.3 of NUREG 1569 (NRC, 2003).

5.2.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application.

The applicant’s management control program for environmental, health, and safety management consists of written standards, management and operating procedures, and manuals. Written procedures are made available to all employees in accessible areas close to locations of operations. The radiation safety officer reviews and approves all procedures related to radiation safety and conducts an annual review of the operating procedures. Radiation work permits are required for all non-routine work tasks with a significant potential for radiological exposure and without a specific operating procedure. Based on information submitted by the applicant, inspection reports and the results of staff’s onsite review of operations, the staff has determined that the applicant’s management control program is consistent with Regulatory Guide 8.31 (NRC, 2002a) and is therefore acceptable.

The applicant is required by license condition to perform a cultural resource inventory before engaging in any construction activity not previously assessed by NRC. This license condition will not change with this license renewal. NRC staff previously evaluated this information and found it acceptable (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

The applicant's SERP composition is addressed in SER Section 5.1. The applicant discussed the SERP procedures and documentation requirements in Section 5.3.3 of the LRA. The SERP procedures and documentation requirement is consistent with its current license condition (the "Change, Test and Experiment License Condition") addressing the SERP. This license condition will not change with this license renewal. Staff continues to evaluate the applicant's annual reports submitted pursuant to this license condition as well as assess the SERP records through onsite inspections and finds the SERP procedures and documentation consistent with its license condition and therefore acceptable. In addition, NRC staff previously evaluated this information and found it acceptable (NRC, 2002b). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

The applicant has developed instructions for maintenance, control, and retention of records that are consistent with Subpart L of 10 CFR Part 20 and 10 CFR 40.61, "Records." The Radiation Safety Officer (RSO) will be responsible for ensuring that the required records are maintained and controlled. Records of surveys, calibrations, personnel monitoring, bioassays, transfers or disposal of source or byproduct material, transportation accidents, and information pertinent to decommissioning and reclamation (e.g., spills, excursions, contamination events, site and aquifer characterization, and background levels) are and will be maintained on site and made available for NRC inspection until license termination. Some spills, excursions, and other contamination events at ISR facilities may not be captured by the Part 20 and Part 40 reporting requirements, but such events nonetheless need to be tracked to adequately ensure that the health and safety requirements of 10 CFR 40.32(c) will be met as stated in License Condition 11.6, Amendment no. 25, ML100830012 (NRC, 2010). Based on the history of inspections since the last license renewal, NRC staff has determined that the applicant is documenting and maintaining records of the events noted above consistent with its license conditions. Therefore, the staff finds that the applicant's implementation of its instructions is acceptable.

5.2.4 Evaluation Findings

The staff reviewed the management control program of the Crow Butte facility in accordance with Section 5.2.3 of NUREG 1569 (NRC, 2003). The applicant has developed operating procedures for all activities involving radioactive materials. Processes associated with the SERP have been identified. The applicant has also described maintenance, control, and retention of records at the facility. Based upon the review conducted by the staff as indicated above, staff concludes that the applicant's management control program meets the applicable acceptance criteria of Section 5.2.3 of NUREG 1569 (NRC, 2003) and the requirements of 10 CFR Part 20, Subpart L, Subpart M, 10 CFR 40.32(c) and 10 CFR 40.61. In addition, Staff finds that the applicant's record keeping and retention programs comply with 10 CFR 20.2103(b)(4), and 10 CFR 40, Appendix A, Criterion 8 and 8A.

5.2.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2007, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

NRC, 2010. License Amendment No. 25 – Revised Surety Estimate for Crow Butte Resources, Inc., April 20, 2010, ADAMS Accession No. ML100830012

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

NRC, 2002a. "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable," Regulatory Guide 8.31, Revision 1. Washington, DC: May 2002.

NRC, 2002b. License Amendment 12, Crow Butte Resources In Situ leach Facility, License No. SUA-1534, July 24, 2002, ADAMS Accession No. ML022060156.

NRC, 1998. Environmental Assessment for Renewal of Source Material License No. SUS-1534, Crow Butte Resources, Incorporated, Crow Butte Uranium Project, Dawes County, Nebraska, February 1998, ADAMS Accession No. ML071520242.

5.3 Management Audit and Inspection Program

5.3.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that it meets the requirements of 10 CFR 40.32 (b) and (c) for the Crow Butte facility as they relate to the acceptability of management audits to ensure protection of health and minimize danger to life and property.

5.3.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 5.3.3 of NUREG 1569 (NRC, 2003).

5.3.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the

site on several occasions during the course of this review to confirm information presented in the application.

As a result of Amendment 12 (NRC, 2002a) to its license, the applicant is required by license condition to follow the guidance in Regulatory Guide 8.31 (NRC, 2002b). This regulatory guide provides recommendations for inspections of worker health protection practices and radiation protection and As Low As is Reasonably Achievable (ALARA) program audits. Staff has reviewed the applicant's implementation of these aspects of its management audit and inspection program through onsite inspections and a review of inspection reports since Amendment 12 was approved and has determined that the applicant's implementation of its audit and inspection program has been consistent with the license condition and therefore acceptable. Through a standard license condition, the applicant will be required to submit the results of the annual audit of the radiation safety and ALARA programs and a land use survey. This standard license condition is presented in Appendix A of the SER.

The applicant's inspection program for its evaporation ponds and checks and action levels associated with yellowcake drying and packaging operations are specified by license conditions addressing the evaporation ponds and yellowcake dryers. These license conditions will be retained with this license renewal. Staff previously concluded that operation of the Crow Butte Project with these license conditions is protective of health and safety (NRC, 1998a, 1998b). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

Regulatory Guide 8.31 (NRC, 2002b) suggests that a daily inspection be conducted by the radiation safety officer (RSO) or designated health physics technician (HPT) and that a weekly inspection be conducted by the RSO and the facility foreman. The applicant stated that during the radiation safety inspections the RSO, Health Physics Technician (HPT) or a qualified designated operator will conduct the daily walkthrough inspection of the plant (refer to Section 5.4 of CBR, 2009).

The applicant provided additional details (CBR, 2014a, 2014b) on the qualification requirements and responsibilities of a qualified designated operator (hereafter referred to as a qualified designee) who would be performing the daily inspections recommended in Regulatory Guide 8.31 (refer to Section 2.3.1 of NRC, 2002b). The qualification requirements proposed by the applicant include minimum education, training, and experience requirements before the designee is considered qualified to perform the daily inspections (CBR, 2014a, 2014b). The proposed requirements also include a minimum grade of 80 percent on initial and refresher (annual) tests covering the topics identified by the applicant in Section 5.6.6.2 of the application as well as initial and refresher (semiannual) daily inspections performed under the supervision of the RSO or HPT (CBR, 2014a, 2014b).

The NRC staff evaluated the applicant's proposed program for qualified designees (CBR, 2014a, 2014b) performing the daily inspections recommended in Regulatory Guide 8.31 (refer to Section 2.3.1 of NRC, 2002b). Although Regulatory Guide 8.31 recommends that the daily inspections be performed by the RSO or HPT (refer to Section 2.3.1 of NRC, 2002b), the NRC staff has determined that the applicant's proposed program for qualified designees (CBR, 2014a, 2014b) is consistent with the recommendation in section 2.3.1 of Regulatory Guide 8.31 (NRC, 2002b).

This determination of consistency by the NRC staff is based on the following findings:

- The performance of these daily inspections is only one aspect of the responsibilities of the applicant's radiation protection staff.
- The skills required for the daily inspections represent a small subset of the qualifications for an RSO or HPT as recommended in Section 2.4 of Regulatory Guide 8.3.1 and can be acquired relatively easily.
- The majority of the daily inspections will still be performed by the RSO or HPT.
- There will be an RSO or HPT available by phone during times when a qualified designee is performing the daily inspection.
- Any reports generated by a qualified designee will be reviewed by the RSO or HPT in a timely fashion.

Therefore, the NRC staff has determined that the applicant's proposed program for qualified designees performing the daily inspections (CBR, 2014a, 2014b) recommended in Section 2.3.1 of Regulatory Guide 8.31 (refer to Section 2.3.1 of NRC, 2002b) is acceptable, and will include the applicant's commitments (CBR, 2014a, 2014b) discussed above as a license condition. The license condition can be found in Section 5.3.4 of this SER.

5.3.4 Evaluation Findings

The staff reviewed the management audit and inspection program of the Crow Butte facility in accordance with NUREG-1569 (NRC, 2003) and through onsite inspections and reviews of inspection reports. The applicant described the various aspects of daily and weekly inspections that will be performed by its staff. The applicant described the personnel that will perform these inspections, including identifying requirements for personnel that will perform daily inspections in the absence of the radiation safety staff. The following license condition reflects the NRC staff's approval of this program, which is an alternative to the program recommended in Regulatory Guide 8.31 (refer to Section 2.3.1 of NRC, 2002b):

The licensee shall follow the guidance set forth in NRC Regulatory Guides 8.22, "Bioassay at Uranium Mills" (as revised), and 8.30, "Health Physics Surveys in Uranium Recovery Facilities" (as revised), or NRC-approved equivalent.

The licensee shall follow the guidance set forth in Regulatory Guide 8.31, "Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable" (as revised), or NRC approved equivalent, with the following exception:

The licensee may identify one or more qualified designees to perform daily inspections in the occasional absence of the radiation safety officer (RSO) and health physics technicians (HPTs). A qualified designee will meet the minimum qualifications and perform only those duties as outlined for a qualified Designated Operator as specified in the licensee's submittals dated March 4, 2014 (ML14064A143) and May 15, 2014 (ML14135A414).

A qualified designee may perform daily inspections on weekends, holidays, and times when both the RSO and HPTs must both be absent (e.g., illness or offsite training). With the exceptions of those instances when a Federal holiday falls on a Friday or Monday, the Thanksgiving holiday, or a site closure due to weather or other safety or security

related event, qualified designees will not conduct the daily inspections for more than a total of two days per week. When a Federal holiday falls on a Friday or Monday, qualified designees may perform the daily inspections for a total of three consecutive days. For the Thanksgiving holiday only, qualified designees may perform the daily inspections for a total of four consecutive days. When weather or other safety or security related event causes a site closure, a qualified designee, if available, will continue performing the daily inspections until the RSO or HPT can access the site after such an event. The licensee will also have the RSO or HPT available by telephone while a qualified designee is performing the daily inspections.

Reports generated by a qualified designee will be reviewed by the RSO or an HPT as soon as practicable, but not later than the close of business of the next work day following an absence (including site closure due to weather or other safety or security related event) , weekend, or holiday. The RSO or HPT review shall be annotated with date and time on the report or other document that can be inspected upon request.

Based upon the review conducted by the staff as indicated above, as supplemented with the noted license condition, staff concludes that the applicant's management audit and inspection program meets the applicable acceptance criteria of Section 5.3.3 of NUREG 1569 (NRC, 2003), the requirements of 10 CFR 40.32(b) and (c) as they relate to the acceptability of management audits to ensure protection of health and minimize danger to life and property, the requirements of 10 CFR Part 40, Appendix A, Criteria 8 and 8A as they relate to yellowcake drying and packaging operations, and inspection of waste retention systems, and 10 CFR 20.1101(a) and (c).

5.3.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2007, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

CBR, 2009, Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2014a. Email from J. Schmuck (CBR) to R. Burrows (NRC) re: Revisions to Crow Butte License Renewal Application – Designated Operator, Crow Butte, March 4, 2014, ADAMS Accession No. ML14064A143.

CBR, 2014b. Email from J. Schmuck (CBR) to R. Burrows (NRC) re: Additional Revision to Designated Operator Changes Submitted to NRC in email dated 3/4/2014, Crow Butte, May 15, 2014, ADAMS Accession No. ML14135A414

NRC, 2003. NUREG–1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

NRC, 2002a. License Amendment 12, Crow Butte Resources In Situ leach Facility, License No. SUA-1534, July 24, 2002, ADAMS Accession No. ML022060156.

NRC, 2002b. "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable," Regulatory Guide 8.31, Revision 1. Washington, DC: May 2002.

NRC, 1998a. Safety Evaluation Report for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., Crow Butte Uranium Project, Dawes County, Nebraska, February 1998, ADAMS Accession No. ML081080325.

NRC, 1998b. Environmental Assessment for Renewal of Source Material License No. SUS-1534, Crow Butte Resources, Incorporated, Crow Butte Uranium Project, Dawes County, Nebraska, February 1998, ADAMS Accession No. ML071520242.

5.4 Qualifications for Personnel Conducting the Radiation Safety Program

5.4.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the personnel conducting the radiation safety program meet the requirements of 10 CFR Part 20.1101 and 10 CFR 40.32(b).

5.4.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in Section 5.4.3 of the NUREG 1569 (NRC, 2003). Regulatory Guide 8.31 (NRC, 2002a) provides recommendations for technical qualifications of radiation safety staff. The applicant is required by license condition to follow the recommendations in Regulatory Guide 8.31 (NRC, 2002b).

5.4.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application.

This section describes the qualification of key personnel conducting the radiation safety program. With regard to the qualifications of these key personnel, the applicant must demonstrate that its radiation safety program complies with 10 CFR 20.1101, which defines the radiation protection program requirements, and 10 CFR 40.32(b), which provides requirements for applicant qualifications. Regulatory Guide 8.31(NRC, 2002a) provides recommendations for the technical qualifications of radiation safety staff, including the radiation safety officer (RSO) and health physics technician (HPT). The applicant is required by license condition to follow the guidance in Regulatory Guide 8.31 (NRC, 2002a). This license condition will be retained with this license renewal. NRC staff previously evaluated and approved of CBR's adoption of the

recommendations of Regulatory Guide 8.31 for qualifications (NRC, 2002b). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.4.3.1 Radiation Safety Officer

Staff reviewed NRC inspection reports dating from 1999 to 2010. During several inspections (NRC, 1999, 2001, 2002c, 2004, 2005), NRC inspectors reviewed the responsibilities and qualifications for the RSO. As a result of these inspections, the NRC inspectors determined that all qualifications and required refresher training were complete and current as specified in the license and as prescribed in Regulatory Guide 8.31 (NRC, 2002a). The NRC staff has determined that the current RSO has been in this position since the last license renewal and therefore concludes that the RSO meets the minimum qualifications as defined in Regulatory Guide 8.31 (NRC, 2002a). Based on the history of inspections since the last license renewal, NRC staff has determined that the applicant is maintaining RSO qualifications consistent with its license condition and is therefore acceptable. Staff has found nothing to invalidate previous inspection findings; therefore, those findings stand and previous staff conclusions remain valid.

5.4.3.2 Health Physics Technician (HPT)

Staff reviewed NRC inspection reports dating from 1999 to 2010. During several inspections (NRC, 1999, 2001, 2002c, 2004, 2005), NRC inspectors reviewed the responsibilities and qualifications for the HPTs. With the exception of the notice of violation in 2010, (NRC, 2010a) the NRC inspectors determined that all qualifications and required refresher training were complete and current as specified in the license and as prescribed in Regulatory Guide 8.31 (NRC, 2002a). Staff has found nothing to invalidate previous inspection findings; therefore, those findings stand and previous staff conclusions remain valid.

As a result of the 2010 inspection, a violation was cited (NRC, 2010a) against the applicant for failing to have a minimum of one full-time HPT that met the education, training, and experience, as recommended by Regulatory Guide 8.31 (NRC, 2002a). Staff has evaluated the applicant's proposed corrective actions and found them to be acceptable (NRC, 2010b, 2011). In addition, after issuance of this renewal license, future inspections will be performed to determine that full compliance has been achieved and will be maintained.

5.4.4 Evaluation Findings

Based on the information provided in the LRA and the staff's detailed review of the qualifications of facility personnel conducting the radiation safety protection program at the Crow Butte ISR facility (as well as the applicant's corrective actions in response to the cited violation, as noted above), NRC staff concludes that the qualifications of facility personnel conducting the radiation safety protection program are acceptable and are in compliance with 10 CFR 20.1101, which defines radiation protection program requirements, and 10 CFR 40.32(b), which provides requirements for applicant qualifications.

5.4.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2007, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

NRC, 2011. NRC staff letter to Crow Butte Resources, Inc., Second Response to NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, March 18, 2011, ADAMS Accession No. ML110770561

NRC, 2010a. NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, August 20, 2010, ADAMS Accession No. ML102320543.

NRC, 2010b. NRC staff letter to Crow Butte Resources, Inc., Response to NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, December 15, 2010, ADAMS Accession No. ML103490123.

NRC, 2005. NRC Inspection Report 040-8943/05-001, Arlington, TX, October 20, 2005, Accession No. ML052930434.

NRC, 2004. NRC Inspection Report 040-8943/04-001, Arlington, TX, October 15, 2004, Accession No. ML042920385.

NRC, 2003. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

NRC, 2002a. "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as is Reasonably Achievable," Regulatory Guide 8.31, Revision 1, Washington, DC: May 2002.

NRC, 2002b. . License Amendment 12, Crow Butte Resources In Situ leach Facility, License No. SUA-1534, July 24, 2002, ADAMS Accession No. ML022060156.

NRC, 2002c. NRC Inspection Report 040-08943/02-01, Arlington, TX, June 17, 2002, ADAMS Accession No. ML021680257

NRC, 2001. NRC Inspection Report 040-08943/01-01, Arlington, TX, May 4, 2001, ADAMS Accession No. ML011280480.

NRC, 1999. NRC Inspection Report 040-8943/99-02, Arlington, TX, November 16, 1999, ADAMS Accession No. ML993300032 Package).

5.5 Radiation Safety Training

5.5.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that its radiation safety training program for the Crow Butte facility meets the requirements of 10 CFR 20.1101 and 40.32(b).

5.5.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 20 and Part 40 using the acceptance criteria presented in Section 5.5.3 of NUREG-1569 (NRC, 2003).

5.5.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application.

This section describes the radiation safety training program for all personnel employed and visiting the applicant's facility. The staff observed that the applicant did not identify any changes to previously approved Radiation Safety Training Program (CBR, 1997).

The applicant stated (CBR, 2009) that it will administer the training program consistent with Regulatory Guides 8.29 (NRC, 1996), 8.31 (NRC, 2002), and 8.13 (NRC, 1999). The applicant also stated (CBR, 2009) that all site employees and contractor personnel are administered a training program that includes radiation safety, radioactive material handling, and radiological emergency procedures.

Staff reviewed NRC inspection reports dating from 1999 to 2010. During several inspections (NRC, 2006, 2007, 2008, 2009, 2010), NRC inspectors reviewed employee radiation safety training. As a result of these inspections, the NRC inspectors determined that the applicant met regulatory and license requirements as described in Section 5.5.2 of SER. Based on the history of inspections since the last license renewal, NRC staff has determined that the applicant is maintaining radiation safety training consistent with applicable regulations and license conditions and is therefore acceptable. Staff has found nothing to invalidate previous inspection findings; therefore, those findings stand and previous staff conclusions remain valid.

5.5.4 Evaluation Findings

The staff reviewed the radiation safety training aspects of the proposed Crow Butte facility in accordance with Section 5.5.3 of NUREG 1569 (NRC, 2003). The applicant proposed a radiation safety training program for the Crow Butte facility that is consistent with the guidance contained in Regulatory Guide 8.31 (NRC, 2002), Regulatory Guide 8.13 (NRC, 1999), and Regulatory Guide 8.29 (NRC, 1996). The staff observed that the applicant did not identify any changes to previously approved Radiation Safety Training Program (CBR, 1997). Therefore, the staff finds that the content of the training material, testing, on-the-job training, and the extent

and frequency of retraining are acceptable. Radiation safety instructions for employees are acceptable to the staff.

Based on the information provided in the license renewal application and the staff's detailed reviews of the radiation safety training program at the Crow Butte ISR facility as noted above, NRC staff concludes that the radiation safety training program is acceptable and is in compliance with 10 CFR 20.1101, which defines radiation protection program requirements, and 10 CFR 40.32(b), as it relates to applicant qualifications through training.

5.5.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2009, Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2007, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

CBR, 1997. Crow Butte Uranium Project, Dawes County Nebraska, Revised Section 5 Operations of the Renewal Application, Source Materials License SU-1534, October 1995, ADAMS Accession No. ML080800212.

NRC, 2010. NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, August 20, 2010, ADAMS Accession No. ML102320543.

NRC, 2009. NRC Inspection Report 040-08943/09-001 and Notice of Violation, Arlington, TX, September 24, 2009, ADAMS Accession No. ML092670138.

NRC, 2008. NRC Inspection Report 040-08943/08-001, Arlington, TX, August 28, 2008, ADAMS Accession No. ML082410870.

NRC, 2007. NRC Inspection Report 040-08943/07-001, Arlington, TX, October 16, 2007, ADAMS Accession No. ML072890610.

NRC, 2006. NRC Inspection Report 040-08943/06-001, Arlington, TX, September 8, 2006, ADAMS Accession No. ML062540084.

NRC, 2003. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

NRC, 2002. "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as is Reasonably Achievable," Regulatory Guide 8.31, Revision 1, Washington, DC: May 2002.

NRC, 1999. "Instruction Concerning Prenatal Radiation Exposure," Regulatory Guide 8.13, Revision 3. Washington, DC: June 1999.

NRC, 1996. "Instruction Concerning Risks from Occupational Radiation Exposure," Regulatory Guide 8.29, Revision 1. Washington, DC: February 1996.

5.6 Security

5.6.1 Regulatory Requirements

The application was reviewed for compliance with all applicable requirements of 10 CFR Part 20 using the acceptance criteria as outlined in NUREG-1569, Section 5.6.3.

5.6.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 20, using the acceptance criteria presented in Section 5.6.3 of the NUREG 1569 (NRC, 2003a).

5.6.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application.

5.6.3.1 License Area and Plant Facility Security

The applicant stated that all central processing facility areas where source or byproduct material is handled are fenced. The main access road is equipped with a locking gate. The applicant employs strategically placed surveillance cameras to monitor the access road and areas around the central processing facility. The applicant employs staff 24 hours per day, 7 days a week at the central processing facility.

Operators perform inspections to ensure that proper storage and security of licensed material at the beginning of each shift (CBR,2009). The operator inspection determines whether all licensed material is properly stored in a restricted area or, if in controlled or unrestricted areas, is properly secured. Operators ensure that loaded ion exchange resin, slurry, drummed yellowcake, and byproduct material are properly stored. If licensed material is found outside a restricted area, the operator will ensure that it is secured, locked, moved to a restricted area, or kept under constant surveillance by direct observation by site personnel or surveillance camera. (CBR, 2009)

The office building includes the reception area at the main entrance. All other entrances are locked during off-shift hours. A limited number of traceable keys to the office are given to select employees. The main door and the door to the central plant facility are equipped with an access keypad. Visitors entering the office are greeted by the receptionist and announced to the receiving party. All visitors are required to sign the access log and indicate the purpose of their visit. The person being visited is responsible to supervise the visitors at all times when they are on site.

Staff reviewed NRC inspection reports dating from 1999 to 2010. During each of these inspections (NRC, 1999-2002, 2003b, 2004-2010), NRC inspectors reviewed various aspects of the applicant's security measures. As a result of these inspections, the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Based on the history of inspections since the last license renewal, NRC staff has determined that the applicant is maintaining security measures consistent with applicable regulations and license conditions and is therefore acceptable. Staff has found nothing to invalidate previous inspection findings; therefore, those findings stand and previous staff conclusions remain valid.

The foregoing inspection history notwithstanding, the NRC staff has determined that the applicant has not adequately documented what security measures are being applied to mine units and header houses. The applicant needs to discuss in further detail how security will be maintained for these areas. NRC staff will include this requirement as a license condition. The license condition can be found in Section 5.6.4 of the SER.

5.6.4 Evaluation Findings

The staff reviewed the security aspects of the proposed Crow Butte facility in accordance with Section 5.6.3 of NUREG 1569 (NRC, 2003a). The applicant described security measures for stored material and control measures for material within the restricted area. The following license condition will require the applicant to describe security measures for the mine units and header houses.

Security measures for the mine units and header houses that address the requirements of 10 CFR Part 20, Subpart I, shall be described in writing to the NRC staff.

The information required by this license condition is due to NRC staff within sixty days of the date of issuance of the license renewal.

Based upon the review conducted by the staff as indicated above, the information provided in the application meets the applicable acceptance criteria of Section 5.6.3 of NUREG 1569 (NRC, 2003a) and the requirements of 10 CFR Part 20, Subpart I.

5.6.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

CBR, 2009, Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2007, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

NRC, 2010. NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, August 20, 2010, ADAMS Accession No. ML102320543.

NRC, 2009. NRC Inspection Report 040-08943/09-001 and Notice of Violation, Arlington, TX, September 24, 2009, ADAMS Accession No. ML092670138.

NRC, 2008. NRC Inspection Report 040-08943/08-001, Arlington, TX, August 28, 2008, ADAMS Accession No. ML082410870.

NRC, 2007. NRC Inspection Report 040-08943/07-001, Arlington, TX, October 16, 2007, ADAMS Accession No. ML072890610.

NRC, 2006. NRC Inspection Report 040-08943/06-001, Arlington, TX, September 8, 2006, ADAMS Accession No. ML062540084.

NRC, 2005. NRC Inspection Report 040-8943/05-001, Arlington, TX, October 20, 2005, Accession No. ML052930434.

NRC, 2004. NRC Inspection Report 040-8943/04-001, Arlington, TX, October 15, 2004, Accession No. ML042920385.

NRC, 2003a. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report.” June.

NRC, 2003b. NRC Inspection Report 040-8943/03-001, Arlington, TX, September 22, 2003, ML032650623.

NRC, 2002. NRC Inspection Report 040-08943/02-01, Arlington, TX, June 17, 2002, ADAMS Accession No. ML021680257

NRC, 2001. NRC Inspection Report 040-08943/01-01, Arlington, TX, May 4, 2001, ADAMS Accession No. ML011280480.

NRC, 2000. NRC Inspection Report 040-08943/00-01, Arlington, TX, April 19, 2000, ADAMS Accession No. ML003705485.

NRC, 1999. NRC Inspection Report 040-8943/99-02, Arlington, TX, November 16, 1999, ADAMS Accession No. ML993300032 Package).

5.7 Radiation Safety Controls and Monitoring

The purpose of this section is to evaluate the techniques the applicant proposes to use to monitor and minimize radiation exposures at the Crow Butte facility.

5.7.1 Standards

As part of its assessment, the staff will present certain standards with which the applicant must comply. These standards are listed below and referenced throughout the remaining portion of Section 5.7. These standards are as follows:

Guidance

- Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) - Effluent Streams and the Environment," Revision 2, issued July 2007
- Regulatory Guide 8.7, "Instructions for Recording and Reporting Occupational Radiation Exposure Data," Revision 2, issued November 2005
- Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection," Revision 1, issued October 1999
- Regulatory Guide 8.22, "Bioassay at Uranium Mills," Revision 1, issued August 1988
- Regulatory Guide 8.25, "Air Sampling in the Workplace," Revision 1, issued June 1992
- Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities," Revision 1, issued May 2002
- Regulatory Guide 8.31, "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable," May 2002
- Regulatory Guide 8.34, "Monitoring Criteria and Methods To Calculate Occupational Radiation Doses," Revision 0, issued July 1992
- Regulatory Guide 8.36, "Radiation Dose to the Embryo/Fetus," Revision 0, issued July 1992
- Regulatory Guide 8.37, "ALARA Levels for Effluents from Materials Facilities", July 1993.

Regulations

- 10 CFR 20, Subpart B - Radiation Protection Programs, § 20.1101
- 10 CFR 20, Subpart C – Occupational Dose Limits: §§ 20.1201 – 20.1208
- 10 CFR 20, Subpart F – Surveys and Monitoring: §§ 20.1501 and 20.1502
- 10 CFR 20, Subpart L – Records: §§ 20.2101 – 20.2110
- 10 CFR 20, Subpart M – Reports: §§ 20.2201 – 20.2207

Numerical Standards

- 10 CFR 20, Appendix B, Table 1 - Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage DAC, Natural Uranium Class W: - 3.0E-10 microcuries per milliliter ($\mu\text{Ci/mL}$) DAC Natural Uranium Class D: - 5E -10 $\mu\text{Ci/mL}$

- 10 CFR 20.1201 – Total Effective Dose Equivalent (TEDE): 5 rem, or the sum of the DDE and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rem
- 10 CFR 20.1201 - Annual Limit to the Eye Lens: 15 rem
- 10 CFR 20.1201 - Annual Limits to the Skin of the Whole Body and Extremity 50 rem
- 10 CFR 20.1201(e) – 10 mg per week limit on intake of soluble uranium

5.7.2 Effluent Control Techniques

During the course of the review, the staff determined that areas of review and acceptance criteria presented in Section 5.7.1 of NUREG 1569 (NRC, 2003), which addresses effluent control techniques, were covered in other sections of this SER. The staff's review of the applicant's proposed effluent control techniques can be found in Section 4.1 and Section 5.7.9 of this SER and are therefore not discussed here.

5.7.2.1 Reference

NRC, 2003. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report.” June.

5.7.3 External Radiation Exposure Monitoring Program

This section discusses the external occupational radiation exposure monitoring program. The purpose of this section is to describe the devices and methods the applicant will use to detect measure, calculate, and/or monitor external radiation exposures to workers.

5.7.3.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that their external radiation exposure monitoring program for the Crow Butte facility meets the requirements of 10 CFR Part 20, Subpart B, 10 CFR 20 Subpart C, 10 CFR 20.1501Subpart F, 10 CFR Part 20, Subpart L, 10 CFR Part 20, Subpart M, and 10 CFR 40.61.

5.7.3.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in Section 5.7.2.3 of NUREG 1569 (NRC, 2003a). Regulatory Guides 8.30 (NRC, 2002a) and 8.31 (NRC, 2002b) provide guidance on how compliance with the regulations can be demonstrated.

5.7.3.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the

site on several occasions during the course of this review to confirm information presented in the application.

5.7.3.3.1 Surveys

The applicant conducts external radiation surveys quarterly in the restricted area and semiannually in unrestricted areas of the plant. The applicant will establish a designated “radiation” area if the gamma survey exceeds the action level of 5 mrem in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates. The applicant indicates that several areas on site have been posted as “radiation” areas. The posted “radiation” areas include the area around the injection filter system, other process filter systems, around selected portions of the ion exchange piping, the waster demister box, the acid wash vat, and the reverse osmosis system. Other areas that have been designated as “radiation” areas include well houses in the field that have scale buildup in the injection manifold piping.

During a March 17, 2011, public meeting between the applicant and NRC staff, the applicant presented its plans to perform monitoring at its facility (NRC, 2011). These plans include an evaluation of gamma and beta dose to workers at the facility. In addition, the applicant stated that beta surveys or evaluations will be performed whenever a change in equipment or procedures has occurred that may significantly affect worker exposures. The staff has determined that the applicant’s proposal is consistent with Regulatory Guide 8.30 (NRC, 2002a) and is therefore acceptable.

Staff also reviewed NRC inspection reports dating from 1999 to 2010. During each of these inspections (NRC, 1999-2002c, 2003b, 2004-2010), NRC inspectors reviewed various aspects of the applicant’s radiation survey program. These reviews included independent verification of exposure rates with an NRC-issued survey meter, a review of survey records, and verification of instrument calibrations. As a result of these inspections, the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Based on the history of inspections since the last license renewal, NRC staff has determined that the applicant’s radiation survey program is consistent with applicable regulations and license conditions and is therefore acceptable. Staff has found nothing to invalidate previous inspection findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.7.3.3.2 Personnel Monitoring

The applicant stated that all employees working in the process facility or wellfield operations who have the potential to receive 10 percent of the annual allowable dose limits are issued dosimeters for determination of external gamma exposure. The applicant indicated that the external exposure at the site is monitored using the Optically-Stimulated Luminescent (OSL) dosimeters provided by Landauer Corp. The applicant stated that Landauer Corp.(Landauer) is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) for the use of this technology for monitoring external exposures as required by 10 CFR 20.1501. Staff observes that NVLAP is administered by the National Institute of Standards and Technology (NIST), a non-regulatory federal agency within the [U.S. Department of Commerce](#). Staff verified the accreditation by examining Landauer’s NVLAP scope of accreditation (Landauer, 2011, NIST 2011) and observes that it is valid from January 1, 2011 through December 31, 2011 for various types of OSL dosimeters. The personnel dosimetry devices are exchanged quarterly.

The applicant provided average and maximum external exposure levels for all employees from 1994 to 2006. The average external exposure levels for that period ranged from 0.033 rem in 1999, to 0.165 rem in 2001 while the maximum external exposure levels for the same period ranged from 0.114 rem in 1999 to 0.495 rem in 1995. The applicant stated that there were noticeable elevations in the maximum exposure levels for the years 2001, 2002, and 2005. The applicant indicated that the most likely cause of these elevated maximum exposures in 2001 and 2002 was the requirement by the applicant to store yellowcake during periods when the yellowcake dryer was unable to maintain production. The applicant also indicated that the maximum exposure in 2005 was received by a maintenance worker that was involved in several significant projects in areas with elevated gamma levels, which included the rebuilding of one set of injection filters and the installation of a new deep disposal well filtering system. NRC reviewed the annual results of external monitoring conducted at the Crow Butte ISR facility. Annual doses were below regulatory limits and Crow Butte Resources administrative limits. Despite historical dose results that have been below the 10 percent criterion for required monitoring, the applicant will continue to implement its external radiation monitoring program.

In addition to the gamma exposure monitoring program, the applicant proposes that beta surveys of specific operations that involve direct handling of large quantities of aged yellowcake will continue to be performed in accordance with Regulatory Guide 8.30. Beta evaluations may be substituted for surveys using radiation survey instruments. As stated above, beta surveys or evaluations will be performed whenever a change in equipment or procedures has occurred that may significantly affect worker exposures.

Staff reviewed NRC inspection reports dating from 1999 to 2010. During each of these inspections (NRC, 1999-2002c, 2003b, 2004-2010), NRC inspectors reviewed various aspects of the applicant's personnel external monitoring program. These reviews included a review of occupational exposure records. As a result of these inspections, the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Based on the history of inspections since the last license renewal, NRC staff has determined that the applicant's personnel external monitoring program is consistent with applicable regulations and license conditions and is therefore acceptable. Staff has found nothing to invalidate previous inspection findings; therefore, those findings stand and previous staff conclusions remain valid.

5.7.3.3.3 Records and Reporting

The applicant describes its records management program in LRA Section 5.4.4. Examples of records that the applicant deems critical to records retention include calibration and maintenance of monitoring equipment and monitoring data. The applicant also states that it complies with the record retention requirements stated in 10 CFR Parts 20 and 40. As indicated in Section 5.1 of the LRA, the Vice President of Operations is responsible for compliance with all regulatory reporting requirements.

Staff reviewed NRC inspection reports dating from 1999 to 2010. During each of these inspections (NRC, 1999-2002c, 2003b, 2004-2010), NRC inspectors reviewed records associated with the applicant's radiation survey and personnel external monitoring programs. As stated above, these reviews included a review of survey and occupational exposure records. As a result of these inspections, the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Based on the history of inspections since the

last license renewal, NRC staff has determined that the applicant's records and reporting program is consistent with applicable regulations and license conditions and is therefore acceptable. Staff has found nothing to invalidate previous inspection findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.7.3.4 Evaluation Findings

NRC Staff reviewed the applicant's external radiation exposure monitoring program in accordance with Appendix A of NUREG-1569 (NRC, 2003a). This included a review of the gamma and beta survey and personnel external dosimetry programs. Based on the information provided in the license renewal application (CBR, 2007), as updated, and detailed reviews of the applicant's program at the Crow Butte ISR facility as noted above, NRC staff has determined that these programs, as discussed above, meet 10 CFR 20 Subpart B and 10 CFR 20 Subpart F.

In addition, NRC staff has found nothing to invalidate the previous findings as discussed above. Therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003a), staff is not reexamining the applicant's discussion of its external radiation exposure monitoring program.

5.7.3.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2007. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

Landauer, 2011. Scope of accreditation, located at: <http://www.landauer.com/Energy/Solutions/Accreditations.aspx>, accessed on May 26, 2011.

NIST, 2011. Directory of Accredited Laboratories, Ionizing Radiation Dosimetry, Landauer, Inc. located at: <http://ts.nist.gov/standards/scopes/1005180.htm>, accessed on May 26, 2011.

NRC, 2011. NRC Memorandum to Bill Von Till, with enclosed Public Meeting Summary and attachments, March 22, 2011, ADAMS Accession No. ML110810041.

NRC, 2010. NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, August 20, 2010, ADAMS Accession No. ML102320543.

NRC, 2009. NRC Inspection Report 040-08943/09-001 and Notice of Violation, Arlington, TX, September 24, 2009, ADAMS Accession No. ML092670138.

NRC, 2008. NRC Inspection Report 040-08943/08-001, Arlington, TX, August 28, 2008, ADAMS Accession No. ML082410870.

NRC, 2007. NRC Inspection Report 040-08943/07-001, Arlington, TX, October 16, 2007, ADAMS Accession No. ML072890610.

NRC, 2006. NRC Inspection Report 040-08943/06-001, Arlington, TX, September 8, 2006, ADAMS Accession No. ML062540084.

NRC, 2005. NRC Inspection Report 040-8943/05-001, Arlington, TX, October 20, 2005, Accession No. ML052930434.

NRC, 2004. NRC Inspection Report 040-8943/04-001, Arlington, TX, October 15, 2004, Accession No. ML042920385.

NRC, 2003a. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report.” June.

NRC, 2003b. NRC Inspection Report 040-8943/03-001, Arlington, TX, September 22, 2003, ML032650623.

NRC, 2002a. “Health Physics Surveys in Uranium Recovery Facilities,” Regulatory Guide 8.30, Revision 1. Washington, DC: May 2002.

NRC, 2002b. “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable,” Regulatory Guide 8.31, Revision 1. Washington, DC: May.

NRC, 2002c. NRC Inspection Report 040-08943/02-01, Arlington, TX, June 17, 2002, ADAMS Accession No. ML021680257

NRC, 2001. NRC Inspection Report 040-08943/01-01, Arlington, TX, May 4, 2001, ADAMS Accession No. ML011280480.

NRC, 2000. NRC Inspection Report 040-08943/00-01, Arlington, TX, April 19, 2000, ADAMS Accession No. ML003705485.

NRC, 1999. NRC Inspection Report 040-8943/99-02, Arlington, TX, November 16, 1999, ADAMS Accession No. ML993300032 Package).

5.7.4 In-Plant Airborne Radiation Monitoring Program

5.7.4.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that its in-plant airborne radiation monitoring program for the Crow Butte facility meets the requirements of 10 CFR Part 20, Subparts B, 10 CFR 20 Subpart C, 10 CFR 20.Subpart F, and 10 CFR 20.1702.

5.7.4.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria presented in Section 5.7.3.3 of NUREG 1569 (NRC, 2003a). Regulatory Guide 8.30 (NRC, 2002a) provides guidance on how compliance with the regulations can be demonstrated.

5.7.4.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application.

The following sections describe and evaluate the in-plant airborne radiation monitoring program proposed by the applicant. The program consists of airborne uranium particulate monitoring, radon daughter concentration monitoring, and the respiratory protection program. The purpose of the in-plant airborne radiation monitoring program is to characterize the airborne uranium and radon daughter levels at various locations in the plant to ensure that workers are adequately monitored for internal radiation exposures and areas are adequately posted in accordance with the applicable sections of 10 CFR 20. The applicant conducts in-plant airborne radiation monitoring at the locations identified in LRA Figure 5.8-5 for airborne uranium and radon daughters.

5.7.4.3.1 Airborne Particulate Uranium Monitoring

The applicant described its airborne uranium monitoring program in LRA Section 5.8.3.1 (CBR,2009). During operation of the dryer, the dryer room is identified as an "Airborne Radioactivity Area" as defined in 10 CFR 20.1003 and access is limited to personnel wearing the proper respiratory protective equipment. A breathing zone sample for the dryer operator is collected during packaging operations and an area air sample is collected outside of the dryer room. The applicant stated that it is using the lapel air samplers to determine internal dose for compliance with 10 CFR 20 Subpart C.(CBR,2009)

In Section 5.8.3.1 of the LRA (CBR,2009), the applicant stated that routine exposure is based upon the monthly average plant airborne uranium concentrations which includes results from area air sampling. Exposure time is determined by worker type (whether assigned to the plant full time or not) and job type (such as routine dryer operations).

Staff reviewed NRC inspection reports dating from 1999 to 2010. During each of these inspections (NRC, 1999a, 2000-2002b, 2003b, 2004-2010a), NRC inspectors reviewed various aspects of the applicant's occupational exposure program including air sampling locations and exposure time calculations for airborne uranium. As a result of these inspections, the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Staff has found nothing to invalidate previous inspection findings; therefore, the original findings stand and previous staff conclusions remain valid.

The applicant stated that the measurement of airborne uranium is performed by gross alpha counting of the air filters using an alpha scaler. The inspection history notwithstanding, the staff observed that the applicant did not demonstrate that gross alpha counting will differentiate all

airborne radioactivity in air samples, including radionuclides that are not uranium, some which may not emit alpha particles and thus will not be detected. The 10 CFR 20, Subpart F requirements specify that adequate surveys be made to demonstrate that the radiation hazard—in this case, airborne radioactivity—is adequately evaluated so that the appropriate Derived Air Concentration (DAC) value will be used to control personnel exposures. Because the applicant has not provided this information, the staff is imposing a license condition to address this issue. The license condition will require the applicant to measure and identify the radionuclides in airborne samples. Analytical results will be compared to mixture requirements in 10 CFR 20.1204(g) to ensure that the appropriate DAC is used. If a mixture of radionuclides exists that does not meet the exclusion rule of 10 CFR 20.1204(g), a sum of fractions method will be used to determine the appropriate DAC. This license condition is presented in Section 5.7.4.4 of this SER.

The applicant has established a lower limit of detection (LLD) at 5.0×10^{-11} uCi/ml. This value is 10 percent of the DAC for natural uranium (inhalation Class D) which is 5.0×10^{-10} uCi/ml. Through site-specific testing of their yellowcake product, the applicant has sufficiently demonstrated that the yellowcake encountered at the facility can be represented by inhalation Class D natural uranium (CBR, 2010a, 2011a, 2011b; NRC, 2011). However, a license condition is being established for the applicant to use inhalation Class W DAC for other natural uranium compounds that may be encountered at the facility (e.g., uranium carbonates) that do not have an assigned (e.g., Appendix B to 10 CFR Part 20) inhalation classification or have not been demonstrated to be represented by another inhalation classification (e.g., inhalation Class D or a mixture of inhalation classes). Staff has determined that assuming inhalation Class W for other uranium compounds encountered at the applicant's facility, mainly in the form of carbonates, is conservative for determining internal radiation exposure and is therefore acceptable. This license condition is presented in Section 5.7.4.4 of this SER. NRC staff has also determined that a LLD of 5.0×10^{-11} uCi/ml represents approximately 17% of the DAC for natural uranium Class W (3.0×10^{-10} uCi/ml) and is consistent with Regulatory Guide 8.30 (NRC, 2002a) and is therefore acceptable.

5.7.4.3.2 Radon Daughter Concentration Monitoring

The applicant describes its locations for monitoring radon daughter concentrations in Section 5.8.3.2 of the application. NRC staff has determined that air sampling locations for radon daughters is consistent with Regulatory Guide 8.25 (NRC, 1992) and is therefore acceptable.

The applicant stated that radon daughter in-plant air samples are collected with a low volume air pump and then analyzed with an alpha scaler using the modified Kusnetz method. Staff observed that the modified Kusnetz method is described in Section 2.3 of Regulatory Guide 8.30 (NRC, 2002a). The applicant stated that the current DAC limit for Rn-222 with daughters present is 0.33 WL. NRC staff observes that under the modified Kusnetz method, the time between the end of the air sampling and the middle of the counting is used to determine a Kusnetz correction factor. This correction factor is used in determining the concentration or working level of the Rn-222 with daughters. NRC staff also observes that the applicant is determining the Rn-222 daughter concentrations by gross alpha counting. Gross alpha counting cannot differentiate the true alpha concentration of the radon daughters that may be present on the air filters from other alpha-emitting radionuclides. Therefore, this method may overestimate the true radon daughter concentration on the air filter and thus the corresponding

calculated occupational dose. NRC staff has determined that the overestimation of the true radon daughter concentrations on the air filters is conservative and therefore acceptable.

The applicant established a lower limit of detection of 0.033 WL which represents 10% of the DAC limit (CBR, 2009). NRC staff has determined that the lower limit of detection is consistent with Regulatory Guide 8.30 (NRC, 2002a) and is therefore acceptable.

The applicant indicated that routine exposure is based on the monthly average of the in-plant radon daughter sampling. The applicant stated that for personnel assigned full time to the plant, a conservative 100 percent occupancy is used to determine exposure. For all other personnel, actual time in the plant is used for exposure calculations. The applicant also stated that exposure received from work performed under a Radiation Work Permit (RWP) is based on the results of monitoring performed during the work and the actual exposure times.

Staff reviewed NRC inspection reports dating from 1999 to 2010. During several of these inspections (NRC, 1999a, 2000-2002b, 2003b, 2004-2006), NRC inspectors reviewed various aspects of the applicant's occupational exposure program including exposure due to radon daughters. These reviews included a review of occupational exposure records and a review of the applicant's procedures. With the exception of the notice of violation in 2010 (NRC, 2010a), the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Based on this history of inspections since the last license renewal, NRC staff has determined that the applicant's personnel radon daughter monitoring program is consistent with applicable regulations and license conditions and is therefore acceptable. Staff has found nothing to invalidate previous findings for this time period; therefore, the original findings stand and previous staff conclusions remain valid.

As a result of the 2010 inspection (NRC, 2010a), a violation was cited against the applicant for using incorrect Kusnetz correction factors when calculating occupational dose from radon progeny. This situation existed from mid-2007 until 2010 (CBR, 2010b). Staff has evaluated the applicant's proposed corrective actions and found them to be acceptable (NRC, 2010b). In addition, future inspections will be performed to determine that full compliance has been achieved and will be maintained.

5.7.4.3.3 Action Limits

In Section 5.8.3 of the LRA (CBR, 2009), the applicant stated that if an airborne uranium sample exceeds 25 percent of the DAC during routine monthly surveys, an investigation of the cause is performed. If a monthly airborne uranium sample exceeds 25 percent 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 (CBR, 2009).

The applicant includes workers in its radiation monitoring program who are likely to receive doses greater than 10 percent of the occupational limits. The applicant considers the chemical toxicity of uranium and limits individual intakes of soluble uranium to 10 mg (3.5×10^{-4} oz) in a week. The applicant stated in Section 5.8.3 of the LRA (CBR, 2009), that when exposures lead to an individual exceeding 25 percent of the weekly limit, the radiation safety officer conducts an investigation and initiates corrective actions to reduce future exposures.

The applicant conducts radon daughter airborne sampling at twelve locations in the central processing facility. These locations are shown in application Figure 5.8-5. The radon daughter airborne samples are collected monthly at each location. The applicant indicated that if the results are greater than 0.08 Working Levels (WL), which represents 25 percent of the DAC, then the monitoring frequency would increase to weekly until the levels are below the action level for four consecutive weeks.

The NRC staff has determined that the applicant has established ALARA goals for airborne natural uranium and radon daughter concentrations that are consistent with Regulatory Guide 8.31 and are therefore acceptable. In addition, staff reviewed NRC inspection reports dating from 1999 to 2010. During each of these inspections (NRC, 1999a, 2000-2002b, 2003b, 2004-2010a), NRC inspectors reviewed various aspects of the applicant's occupational exposure program including action limits for airborne uranium and radon daughters. As a result of these inspections, the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Staff has found nothing to invalidate previous inspection findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.7.4.3.4 Records and Reporting

The applicant describes its records management program in LRA Section 5.4.4. The applicant is currently required by license condition to document sampling, analyses and surveys or monitoring and to maintain this documentation for at least five years (refer to license condition 11.6 of NRC, 2010c). This license condition will not change except for the requirement to maintain these records until license termination unless otherwise specified in another license condition or NRC regulation. As indicated in Section 5.1 of the application, the Vice President of Operations is responsible for compliance with all regulatory reporting requirements.

Staff reviewed NRC inspection reports dating from 1999 to 2010. During each of these inspections (NRC, 1999a, 2000-2002b, 2003b, 2004-2010a), NRC inspectors reviewed records associated with the applicant's occupational exposure programs. As stated above, these reviews included a review of survey and occupational exposure records associated with airborne uranium and radon daughter concentrations. As a result of the previous inspections, the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Based on the history of inspections since the last license renewal, NRC staff has determined that the applicant's records and reporting program is consistent with applicable regulations and license conditions and is therefore acceptable. Staff has found nothing to invalidate previous inspection findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.7.4.3.5 Respiratory Protection Program

The applicant stated that respiratory protective equipment is supplied for activities where engineering controls may not be adequate to maintain acceptable levels of airborne radioactive materials. The applicant also stated that the respirator program is designed to implement the guidance contained in Regulatory Guide 8.15 (NRC, 1999b).

Staff reviewed NRC inspection reports dating from 1999 to 2010. During several of these inspections (NRC, 2001, 2003b, 2005), NRC inspectors reviewed various aspects of the

applicant's respiratory protection program. As a result of these inspections, the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Staff has found nothing to invalidate previous inspection findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.7.4.3.6 Historical Monitoring Results

The Total Effective Dose Equivalent represents the sum of the effective dose equivalent (external) and the committed effective dose (internal). The internal dose represents facility-wide airborne exposure from both uranium particulate and radon daughters. Table 5.7-1 below presents the applicant's results of all the annual average and maximum exposures as well as the total average and maximum TEDE for each year.

Table 5.7-1: Average and Maximum Exposure and TEDE between 1994 and 2006

	Average	Average	Average	Average	Maximum	Maximum	Maximum	Maximum
Year	External	Uranium	Radon	TEDE	External	Uranium	Radon	TEDE
1994	0.053	0.018	0.23	0.301	0.315	0.045	0.52	0.88
1995	0.057	0.020	0.26	0.337	0.495	0.054	0.71	1.259
1996	0.098	0.013	0.40	0.511	0.222	0.024	0.66	0.906
1997	0.089	0.027	0.58	0.696	0.231	0.042	0.80	1.073
1998	0.101	0.029	0.31	0.440	0.216	0.041	0.45	0.707
1999	0.033	0.026	0.45	0.509	0.114	0.039	0.67	0.823
2000	0.084	0.022	0.23	0.336	0.258	0.041	0.41	0.709
2001	0.165	0.023	0.25	0.438	0.428	0.053	0.52	1.001
2002	0.129	0.016	0.23	0.375	0.448	0.039	0.46	0.947
2003	0.092	0.026	0.26	0.378	0.238	0.064	0.50	0.802
2004	0.121	0.020	0.25	0.391	0.276	0.046	0.39	0.712
2005	0.118	0.029	0.13	0.277	0.425	0.097	0.27	0.792
2006	0.088	0.035	0.20	0.323	0.252	0.107	0.35	0.709

*All results expressed in rem

Based on the maximum total effective dose equivalent presented in Table 5.7-4, NRC staff observes that no individual exceeded the occupational dose limit as defined in 10 CFR 20 Subpart C.

5.7.4.4 Evaluation Findings

NRC staff reviewed the in-plant airborne radiation monitoring program of the Crow Butte facility in accordance with NUREG 1569 (NRC, 2003a). The applicant did not make any changes to their in-plant air sampling program (CBR, 2009) from their previous approved in-plant air sampling program (CBR, 1997). The applicant plans to conduct in-plant airborne monitoring consistent with Subpart B, "Radiation Protection Programs," of 10 CFR 20, which defines the radiation protection program. This program includes monitoring for the two primary contaminants and the instruments that it will use to collect and analyze the results of the air samples. Upon implementation of the license conditions noted below, NRC staff has reasonable assurance that the applicant will have adequate methods to fully evaluate the in plant airborne radiation monitoring. The applicant has identified methods that will meet the occupational dose limit requirements of Subpart C of 10 CFR 20. If the applicant identifies that a "mixture" exists which does not meet the exclusion rule of 10 CFR 20.1204(g), a sum of

fractions method will be used to determine the appropriate DAC. NRC staff is imposing the following license condition to ensure compliance with 10 CFR 20.1204(g):

The licensee shall conduct isotopic analyses for alpha- and beta-emitting radionuclides on airborne samples at each in-plant air particulate sampling location at a frequency of once every six months for the first two years and annually thereafter to ensure compliance with 10 CFR 20.1204(g). For any changes to operations, the licensee shall conduct an evaluation to determine if more frequent isotopic analyses are required for compliance with 10 CFR 20.1204(g).

The applicant must demonstrate that uranium compounds encountered at the facility, other than yellowcake, can be represented as inhalation Class D for natural uranium. NRC staff is imposing the following license condition to ensure compliance with Subpart C of 10 CFR 20:

Uranium compounds that have no assigned inhalation classification, or for which no site-specific data is available, such as uranium carbonates, shall be assigned to inhalation class W for radiation protection purposes.

Based upon the review conducted by NRC staff as indicated above, the information provided in the application as supplemented by information submitted in accordance with the noted license condition, meet the applicable acceptance criteria of NUREG 1569 (NRC, 2003a) and the requirements of 10 CFR 20 Part 20, Subparts B and C, 10 CFR 20.1501, and 10 CFR 20.1702.

5.7.4.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

CBR, 2011a. E-mail dated September 13, 2011 transmitting Cameco memo dated September 9, 2011 regarding Solubility of SmithRanch-Highland and Crow Butte Operation Uranium Ore Concentrate Samples in Simulated Lung Fluid, ADAMS Accession No. ML11257A104.

CBR, 2011b. E-mail dated April 5, 2011 transmitting Crow Butte Lung Study Clarification. ADAMS Accession No. ML111020132.

CBR, 2010a. Response to Letter dated June 30, 2010, Open Issues, License Amendment, Crow Butte Resources, Inc. , ADAMS Accession No. ML102640195.

CBR, 2010b. Reply to Notice of Violation, Cameco Resources, Crow Butte Operation, October 21, 2010, ADAMS Accession No. ML102990448.

CBR, 2009, Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2007, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

CBR, 1997. Crow Butte Uranium Project, Dawes County Nebraska, Response to Request for Additional Information - License Renewal, Source Materials License SU-1534, June 1997, ADAMS Accession No. ML080800215.

NRC, 2011. March 17, 2011 Public Meeting Summary. ADAMS Accession No. ML110810041.

NRC, 2010a. NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, August 20, 2010, ADAMS Accession No. ML102320543.

NRC, 2010b. NRC staff letter to Crow Butte Resources, Inc., Response to NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, December 15, 2010, ADAMS Accession No. ML103490123.

NRC, 2010c. License Amendment No. 25, Crow Butte Resources In Situ leach Facility, License No. SUA-1534, April 20, 2010, ADAMS Accession No. ML100830012.

NRC, 2009. NRC Inspection Report 040-08943/09-001 and Notice of Violation, Arlington, TX, September 24, 2009, ADAMS Accession No. ML092670138.

NRC, 2008. NRC Inspection Report 040-08943/08-001, Arlington, TX, August 28, 2008, ADAMS Accession No. ML082410870.

NRC, 2007. NRC Inspection Report 040-08943/07-001, Arlington, TX, October 16, 2007, ADAMS Accession No. ML072890610.

NRC, 2006. NRC Inspection Report 040-08943/06-001, Arlington, TX, September 8, 2006, ADAMS Accession No. ML062540084.

NRC, 2005. NRC Inspection Report 040-8943/05-001, Arlington, TX, October 20, 2005, Accession No. ML052930434.

NRC, 2004. NRC Inspection Report 040-8943/04-001, Arlington, TX, October 15, 2004, Accession No. ML042920385.

NRC, 2003a. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report.” June.

NRC, 2003b. NRC Inspection Report 040-8943/03-001, Arlington, TX, September 22, 2003, ML032650623.

NRC, 2002a. “Health Physics Surveys in Uranium Recovery Facilities,” Regulatory Guide 8.30, Revision 1. Washington, DC: May 2002.

NRC, 2002b. NRC Inspection Report 040-08943/02-01, Arlington, TX, June 17, 2002, ADAMS Accession No. ML021680257

NRC, 2001. NRC Inspection Report 040-08943/01-01, Arlington, TX, May 4, 2001, ADAMS Accession No. ML011280480.

NRC, 2000. NRC Inspection Report 040-08943/00-01, Arlington, TX, April 19, 2000, ADAMS Accession No. ML003705485.

NRC, 1999a. NRC Inspection Report 040-8943/99-02, Arlington, TX, November 16, 1999, ADAMS Accession No. ML993300032 Package).

NRC, 1999b. “Acceptable Programs for Respiratory Protection,” Revision 1, Regulatory Guide 8.15. Washington, DC: October 1999.

NRC, 1992. “Air Sampling in the Workplace,” Regulatory Guide 8.25, Revision 1. Washington, DC: June 1992.

5.7.5 Exposure Calculations

This section discusses the exposure calculations to be performed by the applicant. Workers may be exposed to radioactive material in the air or loose surface contamination within the restricted area that may result in an intake of radioactive material into the body. In addition to general exposure calculations for workers, this section also addresses exposure calculations for female workers who declare pregnancy and the calculation of dose to the embryo/fetus.

5.7.5.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the proposed exposure calculations for the Crow Butte facility meet the requirements of Subparts C, F, L, and M of 10 CFR Part 20. Specific regulations that must be followed include: 10 CFR 20.1201(e), 10 CFR 20.1204(f), 10 CFR 20.1204(g), and 10 CFR 20.1502.

5.7.5.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria presented in Section 5.7.4.3 of NUREG 1569 (NRC, 2003a).

5.7.5.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application.

Occupational workers may be exposed externally and internally to radioactive material in a number of ways. This may include radioactive material in the air, loose surface contamination, or radioactive material that may be stored or processed inside equipment or components. In addition to exposure calculations applicable to the occupational workers, this section also addresses exposure calculations for female workers who declare pregnancy and the calculation of radiation dose to the embryo/fetus. The following sections discuss the exposure calculations, which include internal and external occupational radiation dose as well as radiation doses to the embryo/fetus.

5.7.5.3.1 Exposure Calculation

The applicant stated that the exposure calculations are determined from the intake and exposure calculation methods described in Regulatory Guide 8.30 (NRC, 2002a) for natural uranium and radon daughters. The applicant calculates the intakes for these radionuclides using the following equations:

Natural Uranium

$$I_U = b \sum_{i=1}^n \frac{X_i \times t_i}{PF}$$

Where:

I_U = Uranium intake, ug or uCi
 t_i = Time the worker is exposed to concentrations X_i in hours
 X_i = Average concentration of uranium in breathing zone, ug/m³, uCi/m³, with "i" representing the number of sampling events for uranium

- b = Breathing rate (1.2 m³ per hour)
- PF = Respirator protection factor, if applicable
- n = Number of exposure periods during the week or quarter

Radon Daughters

$$I_r = \frac{1}{170} \sum_{i=1}^n \frac{W_i \times t_i}{PF}$$

Where:

- I_r = Radon daughter intake in working level months (WLM)
- t_i = Time that the worker is exposed to the concentrations, W_i, in hours
- W_i = Average number of working levels in the air near the worker's breathing zone during the time, t_i.
- 170 = Number of hours in a working month
- PF = Respirator protection factor, if applicable
- n = Number of exposure periods during the year

The applicant calculates the occupancy time for routine operations based on actual hours worked (12-hour shift period for plant personnel) for both natural uranium and radon daughters. This is considered to be 100% occupancy in the average work area airborne concentration. For exposures during non-routine work task, such as maintenance or cleanup activities, measured exposures are based on actual time for a given work activity. For additional information, see Sections 5.7.4.3.1 and 5.7.4.3.2 of this SER.

The applicant determines the committed effective dose equivalent (CEDE) from the equation in Regulatory Guide 8.30 (NRC, 2002a) for natural uranium and radon daughters. The committed effective dose equivalent is determined from the equation below:

Natural Uranium

$$H_{iE} = (I_i / ALI_{iE}) \times 5$$

Where:

- H_{iE} = The CEDE from radionuclide i, in rem.
- I_i = The intake of radionuclide, i, by inhalation during the calendar year
- ALI_{iE} = The annual limit of intake. Value of the stochastic inhalation ALI for natural uranium as defined in 10 CFR 20 Appendix B, Table 1
- 5 = Committed effective dose equivalent from intake of one ALI (expressed in rem)

As a result of site-specific testing on their yellowcake product, the applicant proposed using the ALI for Class D natural uranium in Appendix B to 10 CFR Part 20. As described in Section 5.7.4.4 of this SER, staff has imposed a license condition for the applicant to justify that Class D is the correct value to use for other uranium compounds that may be encountered at the facility.

Radon Daughters

$$H_{iE} = (I_i/ALI_{iE}) \times 5$$

Where:

H_{iE}	=	The CEDE
I_i	=	Intake in Working Level Month (WLM) for Radon-222 and its associated progeny
ALI_{iE}	=	Value of the stochastic inhalation ALI for radon-22 with progeny present from Column 2 of Table 1 in Appendix B to Part 20 (4 WLM).
5	=	CEDE from intake of one ALI

NRC staff previously evaluated this information and found it acceptable (NRC, 1998). Except for using the Class D ALI for uranium compounds other than yellowcake, staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid for the calculation methodologies for exposure to airborne uranium and radon daughters. In addition, staff has reviewed NRC inspection reports dating from 1999 to 2010. During each of these inspections (NRC, 1999a-2002b, 2003b, 2004-2010a), NRC inspectors reviewed various aspects of the applicant's occupational exposure monitoring program, including methods for calculating exposure to airborne radioactive materials. Staff observes that several of these inspections (NRC, 2008-2010a) also specifically addressed the applicant's program for ensuring compliance with 10 CFR 20.1201(e) related to the chemical toxicity of uranium. As a result of these inspections, the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Aside from using the Class D ALI for uranium compounds other than yellowcake, staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.7.5.3.2 Prenatal and Fetal Dose

The applicant described its program for monitoring the exposure of a declared pregnant woman. The applicant explained that dosimeters for declared pregnant women are exchanged more frequently (monthly) until the end of gestation. If personal monitoring was not performed prior to notification of the pregnancy, the applicant estimates the exposure using available information, such as surveys and area monitoring results. The applicant indicated that the exposure calculations for the embryo/fetus will be performed in accordance with Regulatory Guide 8.36 (NRC, 1992). Dose estimates for the embryo/fetus include contributions of radionuclides from prior occupational intakes. In Section 5.6 of the application, the applicant stated that their training program is consistent with Regulatory Guide 8.13 (NRC, 1999b).

NRC staff has determined that the applicant's prenatal and fetal radiation exposure program is consistent with Regulatory Guides 8.36 (NRC, 1992) and 8.13 (NRC, 1999b) and is therefore acceptable. In addition, staff has reviewed NRC inspection reports dating from 1999 to 2010. During several of these inspections (NRC, 2000, 2009, 2010a), NRC inspectors reviewed various aspects of the applicant's occupational exposure monitoring program, including methods for calculating exposure to the embryo/fetus. As a result of these inspections, the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.7.5.3.3 Records and Reporting

The applicant describes its records management program in application Section 5.4.4. The applicant is currently required by license condition to document sampling, analyses and surveys or monitoring and this documentation will be maintained for at least five years (refer to license condition 11.6 of NRC, 2010b). This license condition will not change except for the requirement to maintain these records until license termination unless otherwise specified in another license condition or NRC regulation. The applicant also stated that it complies with the record retention requirements stated in 10 CFR Parts 20, Subparts L and M. As indicated in Section 5.1 of the application, the Vice President of Operations is responsible for compliance with all regulatory reporting requirements.

Staff reviewed NRC inspection reports dating from 1999 to 2010. During each of these inspections (NRC, 1999a-2002b, 2003b, 2004-2010a), NRC inspectors reviewed records associated with the applicant's occupational exposure monitoring programs. These reviews included a review of survey and occupational exposure records associated with airborne uranium and radon daughter concentrations, including methods for calculating exposure to airborne radioactive materials. As a result of these inspections, the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Based on the history of inspections since the last license renewal, NRC staff has determined that the applicant's records and reporting program is consistent with applicable regulations and license conditions and is therefore acceptable. Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.7.5.3.4 Historical Exposure Results

The applicant discussed its historical exposure results for airborne uranium and radon daughters for the time period 1994 – 2006. In Sections 5.8.3 and 5.8.4 of the LRA, the applicant discussed long-term trends and short-term deviations from these trends. For example, the applicant explained that the maximum uranium exposure increased in 2006 due to receiving additional yellowcake slurry from the Smith Ranch Project for drying. Staff has determined that the applicant's discussion of historical exposure results is consistent with Acceptance Criteria 5.7.4.3(9) of NUREG 1569 (NRC, 2003a) and is therefore acceptable.

5.7.5.4 Evaluation Findings

The staff reviewed the exposure calculations for the proposed Crow Butte facility in accordance with the NUREG-1569, Section 5.7.4.3 (NRC, 2003a). NRC staff has determined that no individual will exceed the occupational dose limit as defined in 10 CFR 20 Subpart C. The applicant has identified techniques for exposure calculations at the Crow Butte facility to determine intake of radioactive materials by personnel in work areas. Acceptable exposure calculations for natural uranium and airborne radon daughter exposure are provided in the application. The respiratory protection program as a whole was found to be acceptable by the NRC staff. NRC staff also determined that the Exposure Calculation Program meets the applicable acceptance criteria of Section 5.7.4.3 of NUREG 1569 (NRC, 2003a) and the requirements of 10 CFR Part 20, Subpart C, F, L, and M..

Based on the information provided in the license renewal application and detailed reviews of the applicant's program at the Crow Butte ISR facility as noted above, NRC staff concludes that the exposure calculations are consistent with the applicable acceptance criteria of Section 5.7.4.3 of NUREG 1569 (NRC, 2003a) and the requirements of 10 CFR Part 20, Subparts C, F, L, and M and therefore acceptable.

5.7.5.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

CBR, 2007. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

NRC, 2010a. NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, August 20, 2010, ADAMS Accession No. ML102320543.

NRC, 2010b. License Amendment No. 25, Crow Butte Resources In Situ leach Facility, License No. SUA-1534, April 20, 2010, ADAMS Accession No. ML100830012.

NRC, 2009. NRC Inspection Report 040-08943/09-001 and Notice of Violation, Arlington, TX, September 24, 2009, ADAMS Accession No. ML092670138.

NRC, 2008. NRC Inspection Report 040-08943/08-001, Arlington, TX, August 28, 2008, ADAMS Accession No. ML082410870.

NRC, 2007. NRC Inspection Report 040-08943/07-001, Arlington, TX, October 16, 2007, ADAMS Accession No. ML072890610.

NRC, 2006. NRC Inspection Report 040-08943/06-001, Arlington, TX, September 8, 2006, ADAMS Accession No. ML062540084.

NRC, 2005. NRC Inspection Report 040-8943/05-001, Arlington, TX, October 20, 2005, Accession No. ML052930434.

NRC, 2004. NRC Inspection Report 040-8943/04-001, Arlington, TX, October 15, 2004, Accession No. ML042920385.

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NRC, 2003b. NRC Inspection Report 040-8943/03-001, Arlington, TX, September 22, 2003, ML032650623.

NRC, 2002a. "Health Physics Surveys in Uranium Recovery Facilities," Regulatory Guide 8.30, Revision 1. Washington, DC: May 2002.

NRC, 2002b. NRC Inspection Report 040-08943/02-01, Arlington, TX, June 17, 2002, ADAMS Accession No. ML021680257

NRC, 2001. NRC Inspection Report 040-08943/01-01, Arlington, TX, May 4, 2001, ADAMS Accession No. ML011280480.

NRC, 2000. NRC Inspection Report 040-08943/00-01, Arlington, TX, April 19, 2000, ADAMS Accession No. ML003705485.

NRC, 1999a. NRC Inspection Report 040-8943/99-02, Arlington, TX, November 16, 1999, ADAMS Accession No. ML993300032 Package).

NRC, 1999b. "Instruction Concerning Prenatal Radiation Exposure," Regulatory Guide 8.13. Washington, DC: June 1999.

NRC, 1998. Safety Evaluation Report for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., Crow Butte Uranium Project, Dawes County, Nebraska, February 1998, ADAMS Accession No. ML081080325.

NRC, 1992. "Radiation Dose to the Embryo/Fetus," Regulatory Guide 8.36. Washington, DC: July 1992.

5.7.6 Bioassay Program

This section discusses and evaluates the applicant's proposed bioassay program. The bioassay program monitors and documents potential internal uptakes and radiation exposures, and confirms the results of the airborne uranium particulate monitoring program.

5.7.6.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that their bioassay program for the Crow Butte facility meets the requirements of Subparts C, L, and M of 10 CFR Part 20.

5.7.6.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria presented in Section 5.7.5.3 of the NUREG-1569 (NRC, 2003a). Regulatory Guides 8.9 (NRC, 1993), 8.22 (NRC, 1988), 8.30 (NRC,2002a), and 8.34 (NRC,1992) provide guidance on meeting the applicable regulations.

5.7.6.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application.

The applicant's proposed bioassay program (CBR,2009) does not make any changes from their previous approved bioassay program (CBR, 1997). The applicant's bioassay program consists of the following:

- Requires all new employees to submit a baseline urinalysis prior to the start of employment at the facility,
- During operations, urine sample are collected quarterly from workers whose routine work assignment requires them to enter areas where the potential for inhalation of yellowcake exists.
- During operations, urine samples are collected monthly from workers whose have the potential to be exposed to dried yellowcake.
- The action levels for urinalysis are based on Table 1 in Regulatory Guide 8.22 (NRC, 1988).
- In vivo measurements are performed in accordance with the recommendations identified in Regulatory Guide 8.22 (NRC, 1988).

The applicant is conducting quality control on bioassay samples. Blind samples, spike samples, and control samples using synthetic urine are introduced into the sampling system when submitting samples to the vendor analytical laboratory.

NRC staff previously evaluated this information and found it acceptable (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In addition, staff has reviewed NRC inspection reports dating from 1999 to 2010. During several of these inspections (NRC, 1999-2002b, 2003b, 2004-2006), NRC inspectors reviewed various aspects of the applicant's occupational exposure monitoring program including elements of their bioassay program. As a result of these inspections, the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.7.6.4 Records and Reporting

The applicant describes its records management program in application Section 5.4.4. The applicant is required by license condition to document sampling, analyses and surveys or monitoring and this documentation will be maintained for at least five years. This license condition will not change except for the requirement to maintain these records until license termination unless otherwise specified in another license condition or NRC regulation. The applicant also stated that it complies with the record retention requirements stated in 10 CFR Parts 20, Subparts L and M. As indicated in Section 5.1 of the application, the Vice President of Operations is responsible for compliance with all regulatory reporting requirements.

Staff reviewed NRC inspection reports dating from 1999 to 2010. During each of these inspections (NRC, 1999-2002b, 2003b, 2004-2010), NRC inspectors reviewed records associated with the applicant's occupational exposure monitoring programs. These reviews included a review of survey and occupational exposure records associated with airborne uranium, including bioassay results. As a result of these inspections, the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Based on the history of inspections since the last license renewal, NRC staff has determined that the applicant's records and reporting program is consistent with applicable regulations and license

conditions and is therefore acceptable. Staff has found nothing to invalidate previous inspection findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.7.6.5 Historical Bioassay Program Results

The applicant discussed its historical bioassay program results for uranium for the time period 1990 – 2006. In Section 5.8.5.2 of the application, the applicant discussed long-term trends and short-term deviations from these trends. For example, the applicant described actions taken after bioassay results indicated higher than normal levels in the years 1999, 2002 - 2004, and 2006. Staff has determined that the applicant's discussion of historical bioassay program results is consistent with Acceptance Criteria 5.7.5.3(6) of NUREG-1569 (NRC, 2003a) and is therefore acceptable.

5.7.6.6 Evaluation Findings

NRC staff reviewed the bioassay program for the proposed Crow Butte facility in accordance with the NUREG 1569 (NRC, 2003a). Based on the information in the license renewal application and the detailed review of the bioassay program at the Crow Butte ISR facility as noted above, NRC staff concludes that the bioassay program is acceptable and is in compliance with 10 CFR 20.1204, which provides requirements for determining internal exposure, and 10 CFR Part 20, Subpart L, which specifies record keeping requirements.

5.7.6.7 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

CBR, 2009, Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2007, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

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NRC, 1998. Safety Evaluation Report for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., Crow Butte Uranium Project, Dawes County, Nebraska, February

NRC, 1993, Regulatory Guide 8.9, Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program, Revision 1, July 1993.

NRC, 1992. Regulatory Guide 8.34, “Monitoring Criteria and Methods To Calculate Occupational Radiation Doses,” July 1992.

NRC, 1988. “Bioassay at Uranium Mills,” Regulatory Guide 8.22, Revision 1. Washington, DC: August 1988, ADAMS Accession No. ML081080325.

5.7.7 Contamination Control Program

The following sections discuss and evaluate the applicant's proposed contamination control program. This program is designed to detect radiological contaminants that have escaped the boundary of process equipment. Contamination can take the form of loose surface contamination and may be found on structures, materials, or personnel. The purpose of the program is to ensure that contamination is identified, confined, and monitored in known areas and prevent movement of contamination to unrestricted areas.

5.7.7.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that its proposed contamination control program for the Crow Butte facility meets the requirements of Subparts B, C, and F of 10 CFR Part 20.

5.7.7.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria presented in Section 5.7.6.3 of NUREG 1569 (NRC, 2003a). Regulatory Guide 8.30 (NRC, 2002a) provides guidance on how compliance with the applicable regulations can be demonstrated.

5.7.7.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application. The applicant has stated (CBR, 2009) that they will continue with the same contamination control program that is currently in use. Staff has determined that the applicant is not proposing changes to its contamination control program.

Natural uranium refers to processed uranium (*i.e.*, uranium which has been separated from its longer half-life decay products by extraction of the uranium from the naturally occurring ore state). In terms of release levels for uranium recovery facilities, natural uranium is therefore considered to be composed of U-238, U-235, U-234 and the short half-life daughters of U-238 (*i.e.*, Th-234, Pa-234 and Pa-234m) in secular equilibrium with the U-238. Since these short half-life daughters are beta-gamma emitters, separate beta-gamma release limits apply to them. Separate alpha release limits throughout the uranium recovery process will also apply to other isotopes if they are present, such as Ra-226 and Th-230.

Regulatory Guide 8.30 (NRC, 2002a) is the standard by which the NRC staff evaluates alpha contamination control for personnel monitoring and releasing material for unrestricted use. The NRC staff is currently revising Regulatory Guide 8.30. When Regulatory Guide 8.30 (NRC, 2002a) is revised, a draft revision will be issued for public review and comment. If the alpha contamination control limits are revised in the update to Regulatory Guide 8.30, the standard

license condition discussed in Section 5.3.4 of this SER requires the applicant to adopt the revised limits.

5.7.7.3.1 Area Contamination Surveys

In section 5.8.6.2 of the LRA (CBR, 2009) the applicant stated that surveys for surface contamination are conducted in the operating and clean areas of the facilities. Surveys for alpha contamination in clean areas, such as lunch rooms, change rooms, and offices, are conducted weekly. The applicant uses an action level of 25 percent of the recommended contamination limits presented in Table 2 of Regulatory Guide 8.30 (NRC, 2002a).

The applicant also indicated in Table 5.8-16 of the LRA (CBR, 2009) that surface contamination surveys in yellowcake areas will be performed with daily walkthroughs of the area. NRC staff concludes that the applicant is conducting the frequency for area surface contamination surveys consistent with the frequency recommended in Regulatory Guide 8.30 (NRC, 2002a) and is therefore acceptable.

The applicant indicated in Section 5.8.2 of the LRA (CBR, 2009) that radium scale can build up in the injection manifold piping. NRC staff observes that beta-gamma contamination may also be present as a result of the in-growth of uranium and radon daughter products. NRC staff has determined that the applicant has not demonstrated that its contamination control program adequately accounts for the different types of isotopic contamination (e.g., Ra-226) that may be found at the site. The applicant shall develop an appropriate survey program consistent with 10 CFR 20 Subpart F. Therefore, NRC staff is imposing a license condition to ensure compliance with Subpart F of 10 CFR Part 20 during operations. This license condition can be found in Section 5.7.7.4 of this SER.

5.7.7.3.2 Contamination Surveys of Skin and Personal Clothing

In Section 5.8.6.2 of the LRA (CBR, 2009) the applicant states that all personnel leaving the restricted area are required to perform and document alpha contamination monitoring. Personnel who come in contact with potentially contaminated solutions outside a restricted area, such as the wellfields, are required to monitor themselves prior to leaving the area. The applicant states that quarterly unannounced spot checks of personnel are conducted to verify the effectiveness of the surveys for personnel contamination (CBR, 2009).

The NRC staff has determined that the surface contamination surveys for operating and clean areas of the facilities are consistent with Regulatory Guide 8.30 (NRC, 2002a) for alpha contamination. The NRC staff concludes, however, that the applicant did not address surveys for beta/gamma contamination on personnel leaving a restricted area that may result from in-growth of uranium and radon daughter products from operations. The applicant shall develop an appropriate survey program consistent with 10 CFR 20 Subpart F. The NRC staff is imposing a license condition to this effect to ensure compliance with Subpart F of 10 CFR Part 20 during operations. This license condition can be found in Section 5.7.7.4 of this SER.

5.7.7.3.3 Contamination Surveys for Items Released from Restricted Areas

In Section 5.8.6.3 of the LRA (CBR, 2009), the applicant stated that personnel are allowed to conduct contamination surveys of small hand-carried items. For all other items, the applicant stated that the radiation safety officer (RSO), radiation safety staff, and properly trained employees can survey all items from the restricted area. The qualified person for conducting these surveys would be the Lead Operator or a Plant/Wellfield operator. The applicant states that the Lead Operator and the Plant/Wellfield operator will receive operator training, general radiation safety training, and hands-on training for the survey instrument and procedures. (CBR, 2009)

Consistent with Regulatory Guide 8.31 (NRC, 2002b) and Inspection and Enforcement Circular 81-07 (NRC, 1981), the NRC staff has determined that for items other than hand-carried personal effects (e.g., notebooks and flashlights), only individuals meeting the qualifications as health physics technicians (HPTs) or RSO as defined in Regulatory Guide 8.31 are allowed to release items from restricted areas or for unrestricted use. The NRC staff has determined that the applicant's proposed program does not provide a level of contamination control consistent with these NRC guidance documents. Therefore, the NRC staff is imposing a license condition to ensure compliance with Subpart F of 10 CFR Part 20 during operations. This license condition can be found in Section 5.7.7.4 of this SER.

5.7.7.3.4 Instrumentation for Contamination Surveys

The applicant identified the following equipment for total surface activity:

- Ludlum Model 2241 Scaler with a Model 43-65 or Model 43-5 Alpha Scintillation Probe
- Ludlum Model 177 Ratemeter with a Model 43-65 or Model 43-5 Alpha Scintillation Probe
- Portable GM survey meter with a beta/gamma probe with an end window thickness not to exceed 7 mg/cm²
- Ludlum Model 3 survey meter with a Ludlum 44-38 probe

The applicant stated that survey equipment will be calibrated annually or at the manufacturer's recommended frequency, whichever is more frequent and surface contamination instruments are checked daily when in use. Alpha survey meters for personnel monitoring are response checked before each use with other checks performed weekly. NRC staff observes that the applicant is required by license condition to follow the guidance in Regulatory Guide 8.30 (NRC, 2002a). This license condition will not change with this renewal. Regulatory Guide 8.30 (NRC, 2002a) recommends that all survey instruments be checked for constancy of operation with a radiation check source prior to each usage, which may be more frequent than daily.

The NRC staff has determined that the applicant has not adequately described that the proposed instrumentation will be capable of measuring the levels of radioactive contamination consistent with its contamination control program. Specifically, the applicant has not provided the detection sensitivity of its instrumentation used for contamination surveys. Therefore, the staff is imposing a license condition, presented in SER Section 5.7.7.4, to address this issue. The applicant shall provide the survey instrumentation sensitivity (e.g., minimum detectable concentration (MDC)), including scan MDC for portable instruments, of survey instruments as

recommended in NUREG 1569 (NRC, 2003a). Methods for determining the scan MDC are described in NUREG-1575 (NRC, 2000a).

5.7.7.3.5 Records and Reporting

The applicant describes its records management program in application Section 5.4.4. The applicant is required by license condition to document sampling, analyses and surveys or monitoring and this documentation will be maintained for at least five years. This license condition will not change except for the requirement to maintain these records until license termination unless otherwise specified in another license condition or NRC regulation. The applicant also stated that it complies with the record retention requirements stated in 10 CFR Part 20, Subparts L and M. As indicated in Section 5.1 of the application, the Vice President of Operations is responsible for compliance with all regulatory reporting requirements.

Staff reviewed NRC inspection reports dating from 1999 to 2010. During each of these inspections (NRC, 1999, 2000b, 2001, 2002c, 2003b, 2004-2010), NRC inspectors reviewed records associated with the applicant's contamination control program. These inspections included a review of contamination records associated with area and personnel surveys as well as surveys for the release of items for unrestricted use. In addition, calibration records associated with the applicant's instrumentation were reviewed. As a result of these inspections, the NRC inspectors determined that the applicant met applicable regulatory and license requirements. Based on the history of inspections since the last license renewal, NRC staff has determined that the applicant's records and reporting program is consistent with applicable regulations and license conditions and is therefore acceptable. Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.7.7.4 Evaluation Findings

NRC staff reviewed the contamination control program for the proposed Crow Butte facility in accordance with Section 5.7.6.3 of NUREG 1569 (NRC, 2003a). The applicant has identified controls for preventing contamination from leaving a restricted area using appropriate survey equipment and instrumentation. Contamination surveys will be conducted in clean areas and personnel and equipment exiting the restricted area will be monitored. Furthermore, the range and calibration of monitoring equipment will protect the health and safety of employees during the full scope of facility operations. However, the applicant has not provided the methods that will be used to detect beta/gamma contamination at the facility. Therefore, the staff is imposing a license condition to ensure compliance with Subpart F of 10 CFR Part 20 during operations.

The licensee shall develop a survey program for beta/gamma contamination for personnel exiting from restricted areas, and beta/gamma contamination in unrestricted and restricted areas that will meet the requirements of 10 CFR Part 20, Subpart F and submit to NRC for review and written verification.

The applicant identified the radiation instrumentation used to conduct contamination control. NRC staff could not determine the sensitivity of these instruments. Therefore, staff is imposing the following license condition:

The licensee shall provide for NRC review and written verification the surface contamination detection capability (minimum detection concentration (MDC)) for radiation survey instruments, including scan MDC for portable instruments, used for contamination surveys to release equipment and materials for unrestricted use and for personnel contamination surveys. The detection capability in the scanning mode for the alpha and beta radiation expected shall be provided in terms of dpm per 100 cm².

NRC staff reviewed personnel who will conduct surveys of items leaving the restricted area and releasing items for unrestricted use. NRC staff has determined that the applicant's proposal is not consistent with either: 1) the guidance provided in Regulatory Guide 8.31 (NRC, 2002b), which indicates that the RSO or radiation safety staff office staff are responsible for performing all routine and special radiation surveys required by license condition and 10 CFR Part 20, or 2) Inspection and Enforcement Circular 81-07 (NRC, 1981) which recommends that only qualified radiation safety individuals perform these tasks. Therefore, staff is imposing the following license condition:

Release of superficially contaminated equipment, materials, or packages for unrestricted use shall be in accordance with the NRC guidance document "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," (the Guidelines) dated April 1993 (ADAMS Accession No. ML003745526), or in accordance with a suitable alternative program which shall be approved by NRC prior to any such release.

The Guidelines or approved alternative program shall also apply to the removal of equipment, materials, or packages from restricted areas that have the potential for accessible surface contamination levels above background regardless of the intent to release these items for unrestricted use. The licensee shall document their surveys of equipment, materials, or packages prior to removing them from a restricted area.

Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established in the Guidelines for alpha- and beta-gamma-emitting nuclides shall apply independently.

Personnel performing these contamination surveys for items released for unrestricted use or from restricted areas shall meet the qualifications for health physics technicians or radiation safety officer as defined in Regulatory Guide 8.31, except as provided in an alternative program submitted under one of the last two paragraphs of this license condition. Personal effects (e.g., notebooks and flash lights) which are hand carried need not be surveyed by personnel meeting the above qualifications, but these items should be subjected to the same survey requirements as the individual possessing the items.

For release to unrestricted areas, the licensee may provide an alternative program for releasing equipment, materials, or packages that have the potential for accessible surface contamination levels above background (i.e., "controlled release") to the NRC headquarters staff for review and written verification. The alternative program for controlled release shall demonstrate how the licensee will maintain radiological controls over the equipment, materials, or packages that have the potential for accessible surface contamination levels above background until they have been released for unrestricted

use as specified in the first paragraph above, and shall describe the methods that will be used to limit the spread of contamination to unrestricted areas. An alternative program proposed under this paragraph shall not be implemented without written verification from NRC headquarters staff.

For releases with a final destination to one of the licensee's restricted areas, whether through an unrestricted area or not, the licensee may, as part of an alternative program, identify one or more qualified designees to perform the surveys associated with releasing equipment, materials, or packages that have the potential for accessible surface contamination levels above background. The qualified designees shall have completed education, training, and experience, in addition to general radiation worker training as specified by the licensee. The licensee must submit the education, training, and experience requirements for qualified designees to the NRC headquarters staff for review and written verification, and must receive written verification of those requirements prior to allowing qualified designees to perform these surveys.

Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented by information submitted in accordance with the noted license conditions, NRC staff concludes that the applicant meets the applicable acceptance criteria of Section 5.7.6.3 of NUREG 1569 (NRC, 2003a) and the requirements of Subparts B, C, and F, of 10 CFR Part 20.

5.7.7.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

CBR, 2009, Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2007, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

NRC, 2010. NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, August 20, 2010, ADAMS Accession No. ML102320543.

NRC, 2009. NRC Inspection Report 040-08943/09-001 and Notice of Violation, Arlington, TX, September 24, 2009, ADAMS Accession No. ML092670138.

NRC, 2008. NRC Inspection Report 040-08943/08-001, Arlington, TX, August 28, 2008, ADAMS Accession No. ML082410870.

NRC, 2007. NRC Inspection Report 040-08943/07-001, Arlington, TX, October 16, 2007, ADAMS Accession No. ML072890610.

NRC, 2006. NRC Inspection Report 040-08943/06-001, Arlington, TX, September 8, 2006, ADAMS Accession No. ML062540084.

NRC, 2005. NRC Inspection Report 040-8943/05-001, Arlington, TX, October 20, 2005, Accession No. ML052930434.

NRC, 2004. NRC Inspection Report 040-8943/04-001, Arlington, TX, October 15, 2004, Accession No. ML042920385.

NRC, 2003a. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report.” June.

NRC, 2003b. NRC Inspection Report 040-8943/03-001, Arlington, TX, September 22, 2003, ML032650623.

NRC, 2002a. “Health Physics Surveys in Uranium Recovery Facilities,” Regulatory Guide 8.30, Revision 1. Washington, DC: May 2002.

NRC, 2002b. “Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will be As Low As Reasonably Achievable,” Regulatory Guide 8.31, Revision 1. Washington, DC: May 2002.

NRC, 2002c. NRC Inspection Report 040-08943/02-01, Arlington, TX, June 17, 2002, ADAMS Accession No. ML021680257

NRC, 2001. NRC Inspection Report 040-08943/01-01, Arlington, TX, May 4, 2001, ADAMS Accession No. ML011280480.

NRC, 2000a. NUREG-1575, Revision 1, Multi-Agency Radiation Survey and Site Investigation Manual, August.

NRC, 2000b. NRC Inspection Report 040-08943/00-01, Arlington, TX, April 19, 2000, ADAMS Accession No. ML003705485.

NRC, 1999. NRC Inspection Report 040-8943/99-02, Arlington, TX, November 16, 1999, ADAMS Accession No. ML993300032 Package).

NRC, 1993. “Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material,” U.S. Nuclear Regulatory Commission, April 1993, ADAMS accession No. ML003745526.

NRC, 1981. “IE Circular No. 81-07: Control of Radioactively Contaminated Material,” U.S. Nuclear Regulatory Commission, May 14, 1981, ADAMS accession No. ML082490470.

5.7.8 Airborne Effluent and Environmental Monitoring Program

The following sections discuss and evaluate the applicant’s proposed airborne effluent and environmental monitoring program. This program includes radiation monitoring outside of the plant area during operations and environmental monitoring around the facility.

5.7.8.1 Regulatory Requirements

The staff will determine if the applicant has demonstrated that the proposed airborne effluent and environmental monitoring program for the Crow Butte facility meets the requirements of 10 CFR 20.1003, 10 CFR 20.1301, 10 CFR 20.1302, 10 CFR 20.1101(d), 10 CFR 20.1501 10 CFR 40.65, and Criteria 7 and 8 of Appendix A to 10 CFR Part 40.

5.7.8.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in Section 5.7.7.3 of NUREG 1569 (NRC, 2003). Regulatory Guide 4.14 (NRC, 1980) provides guidance on how compliance with the applicable regulations can be demonstrated.

5.7.8.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007a) and as updated. NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application. The applicant conducts radon, air particulate (when the dryer is in operation), groundwater, surface water, direct radiation, and sediment sampling. The applicant's current airborne effluent and environmental monitoring program is summarized in application Table 5.8-5. This program was approved by NRC staff with License Amendment No. 3 (NRC, 1999). NRC staff is evaluating proposed changes to this program (CBR, 2011b). The current airborne effluent and environmental monitoring program will remain in place until such time as the NRC staff finds an alternate program acceptable and provides written verification of this acceptance to the applicant. The applicant reports the results of this program to the NRC through its semiannual radiological effluent and environmental monitoring reports (CBR, 2000 a,b, 2001a,b, 2002a,b, 2003a,b, 2004a,b, 2005a,b, 2006 a,b, 2007b,c, , 2008a,b, 2009 a,c, 2010 a,b, 2011a).

Staff reviewed NRC inspection reports dating from 1999 to 2010. During each of these inspections (NRC, 1999 - 2010), NRC inspectors reviewed the applicant's airborne effluent and environmental monitoring program. As a result of these inspections, the NRC inspectors determined that the applicant was conducting its airborne effluent and environmental monitoring program consistent with its license requirements. Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. However, staff has determined that additional information is necessary to ensure regulatory compliance. These license conditions are discussed below.

5.7.8.3.1 Radon

The applicant has established seven environmental air monitor (AM) stations with one location (AM-6) as the background location. The location of these AM stations can be found on Figure 1 of the applicant's latest semiannual radiological effluent and environmental monitoring report (CBR, 2011a). Radon samples are collected with Track-Etch devices (detectors) at these AM locations. The applicant stated that the air radon detectors are exchanged every six months

(semi-annual) to achieve the required lower limit of detection (LLD). NRC staff previously evaluated this exchange rate and found it acceptable (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

Radon monitoring results ranged from 0.2 pCi/L to 3.7 pCi/L for the period 1997 to 2007. The highest concentration was detected at location AM-8 during the second half of 2003. The applicant states that the concentrations at three locations ranged from 34 to 37 percent of the effluent concentration limit from 10 CFR Part 20, Appendix B, Column 2. These locations were AM-1, AM-2, and AM-8 during the second half of 2003. The applicant indicated that it could not determine the cause of the elevated Rn-222 concentrations in 2003. The ALARA Review conducted by the applicant in 2003 indicated that one possible cause for the anomalous results from the second half of 2003 was sampling or analytical error. The applicant conducted duplicate air radon sampling in 2004 and 2005. The results are reported in Table 5.8-7 of the application. Overall, NRC staff has determined that the radon monitoring results were in reasonable agreement for the period 1997 to 2007.

NRC staff has determined that comparison of the applicant's radon monitoring results with 10 CFR Part 20 effluent concentration limits has no relevance as the monitor stations are far removed from the effluent source(s). To obtain more relevant data to assess occupational and public dose throughout the license area and to verify compliance with 10 CFR 40.65 reporting requirements, NRC staff is imposing a license condition. This license condition is presented in SER Section 5.7.8.4.

For calculations of dose to members of the public, (see Appendix F of CBR, 2011a), the applicant compares the measured radon concentrations with the 10 CFR Part 20, Appendix B, Column 2 effluent concentration value for Rn-222 "With daughters removed". NRC staff cannot conclude that Rn-222 daughters (progeny) have been removed from the point of public exposure. Rn-222 daughters, if present, provide significantly more dose than the radon gas itself. Therefore, NRC staff is imposing a license condition to ensure that Rn-222 daughters, if present, are accounted for in the applicant's public dose determination. This license condition is presented in SER Section 5.7.8.4.

5.7.8.3.2 Air Particulate

The applicant stated that composite airborne particulate samples for natural uranium, Ra-226 and Pb-210 are obtained quarterly from seven air monitoring stations. The type of sample is continuous and the required frequency is a minimum of two weeks per month when dryer is in use (NRC, 1999). In Section 5.8.7.3 of the LRA, (CBR, 2009b) the applicant stated that it determined in early 2001 that increasing the sample frequency to continuously during dryer operation would provide monitoring data that would be more complete and has been performing continuous particulate monitoring for natural uranium, radium-226 and lead-210 since 2001 (CBR,2009b). Since continuous sampling is more frequent than two weeks per month when dryer is in use, NRC staff finds this frequency acceptable.

NRC staff has determined, however, that the current air particulate data obtained by the applicant is not sufficient to demonstrate compliance for determining occupational and public dose obtained throughout the entire license area or to verify compliance with 10 CFR 40.65

reporting requirements. Therefore, NRC staff is imposing a license condition. This license condition is presented in SER Section 5.7.8.4.

5.7.8.3.3 Soil

The applicant's license was originally approved (NRC, 1989) with an environmental monitoring program that did not require operational soil sampling. NRC staff has determined that without reviewing annual soil samples taken throughout the operating phase of the applicant's facility, staff does not have the ability to confirm the applicant's ability to comprehensively evaluate environmental impacts or detect potential long-term effects of its operations as required by 10 CFR Part 40, Appendix A, Criterion 7. Therefore, staff is imposing a license condition to address this requirement. This license condition is presented in SER Section 5.7.8.4.

5.7.8.3.4 Sediment Sampling

The applicant stated that sediment samples are collected in Squaw (S) and English (E) Creeks and the impoundments (I) annually. The sediment samples are analyzed annually for natural uranium, Ra-226, and Pb-210. In addition, samples taken from locations that are upstream and downstream from the Crow Butte Facility are analyzed for Th-230. The results of sediment sampling from 1991 to 2006 are presented in application section 5.8.7.

NRC staff observes that the applicant is not required to include Th-230 in its sediment sampling program as recommended by Regulatory Guide 4.14 (NRC, 1980). This aspect of the applicant's environmental monitoring program was previously approved by NRC staff (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.7.8.3.5 Vegetation Sampling

Vegetation sampling was discontinued with the license renewal in 1998. Based on dose projections consistent with Regulatory Guide 4.14 (NRC, 1980), NRC staff previously determined (NRC, 1998) that the applicant could discontinue vegetation sampling and analysis. Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.7.8.3.6 Food and Fish Sampling

The applicant's license was originally approved (NRC, 1989) with an environmental monitoring program that did not require operational food and fish sampling. Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

5.7.8.3.7 Ground Water and Surface Water

The ground water and surface water environmental monitoring program are presented in Section 5.7.9 of the SER.

5.7.8.3.8 Direct Radiation

The applicant measured environmental gamma radiation levels continuously at seven air particulate sampling stations using environmental dosimeters. The applicant exchanged the dosimeters quarterly for laboratory analysis. The results of gamma radiation monitoring from 1991 to 2007 are presented in LRA Section 5.8.7.

The quarterly direct radiation dose ranged from 18.2 mrem at Location AM-4 during the 04/01/1997 collection period to 62.6 mrem at Location AM-6 during the 04/03/2003 collection period. Location AM-6 is the background (control) monitoring station located north of the site near the Crawford community.

5.7.8.3.9 Historical Airborne Effluent and Environmental Monitoring Results

The applicant discussed its historical airborne effluent and environmental monitoring program results for various radionuclides. In Section 5.8.7 of the LRA, the applicant discussed long-term trends and short-term deviations from these trends. Staff has determined that the applicant's discussion of historical airborne effluent and environmental monitoring program results is consistent with Acceptance Criteria 5.7.7.3(5) of NUREG 1569 (NRC, 2003) and is therefore acceptable.

5.7.8.4 Evaluation Findings

The staff reviewed the airborne effluent and environmental monitoring program of the proposed Crow Butte Project in accordance with Section 5.7.7.3 of NUREG 1569 (NRC, 2003). The applicant proposes to demonstrate compliance with the 10 CFR 20.1301 annual public dose limit by using the results from environmental monitoring in accordance with 10 CFR 20.1302 (b)(2). The applicant proposes to use the average annual results of environmental monitoring for air particulates, direct radiation and sediment, and compare this information to the 10 CFR 20 Appendix B, Table 2, Effluent Concentration, and will include consideration of Note 4 in Appendix B.

The staff has determined that applicant has not demonstrated that its radon and air particulate monitoring program for releases from the facility provide sufficient information for staff to determine regulatory compliance for effluent releases and occupational and public dose. Therefore, the staff is including the following license conditions to ensure that an adequate effluent and environmental monitoring program is in place consistent with Regulatory Guide 4.14 (NRC, 1980);

The licensee shall provide the following information for the airborne effluent and environmental monitoring program for which it shall develop written procedures for NRC written verification to:

- A. Discuss how, in accordance with 10 CFR 40.65, the quantity of the principal radionuclides from all point and diffuse sources will be accounted for, and verified by, surveys and/or monitoring.

- B. Evaluate the member(s) of the public likely to receive the highest exposures from licensed operations consistent with 10 CFR 20.1302.
- C. Discuss and identify how radon (radon-222) progeny will be factored into analyzing potential public dose from operations consistent with 10 CFR Part 20, Appendix B, Table 2.
- D. Discuss how, in accordance with 10 CFR 20.1501, the occupational dose (gaseous and particulate) received throughout the entire License Area from licensed operations will be accounted for, and verified by, surveys and/or monitoring.

NRC staff has determined that it cannot confirm the applicant's ability to demonstrate compliance with 10 CFR Part 40, Appendix A, Criterion 7. Specifically, without reviewing annual soil samples taken throughout the operating phase of the applicant's facility, NRC staff does not have the ability to confirm the applicant's ability to comprehensively evaluate environmental impacts or to detect potential long-term effects of its operations. Therefore, the staff is including the following license condition to ensure that an adequate environmental monitoring program is in place consistent with Regulatory Guide 4.14 (NRC, 1980);

The licensee shall provide for NRC written verification an operational soil sampling program consistent with Regulatory Guide 4.14 or justification for an alternate program.

Based upon the review conducted by the staff as indicated above, the information provided in the application as supplemented by information submitted in accordance with the noted license conditions meets the applicable acceptance criteria of NUREG 1569 (NRC, 2003) and the requirements of Subparts B, D, and F, of 10 CFR Part 20 and 10 CFR Part 40.

5.7.8.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2011a. Semi-Annual Radiological Effluent and Environmental Monitoring Report for Crow Butte Uranium Project, February 24, 2011, ADAMS Accession No. ML110840124.

CBR, 2011b. Comments on Draft Crow Butte Resources License, e-mail from John Schmuck (Cameco) to Ronald Burrows (US NRC), July 13, 2011, ADAMS Accession No. ML111950068 (Package).

CBR, 2010a. Semiannual Radiological Effluent and Environmental Monitoring Report for Third and Fourth Quarters 2009 - Cameco's Crow Butte Operation. February 19, 2010, ADAMS Accession No. ML100700508.

CBR, 2010b. Semiannual Radiological Effluent and Environmental Monitoring Report for Crow Butte Resources, August 25, 2010, ADAMS Accession No. ML102730113.

CBR, 2009a. Submittal of Semiannual Radiological Effluent and Environmental Monitoring Report for the 3rd and 4th Qtrs. 2008, February 18, 2009, ADAMS Accession No. ML090630411.

CBR, 2009b. Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2009c. Semiannual Radiological Effluent and Environmental Monitoring Report for First and Second Quarters 2009 for Crow Butte Uranium Project, August 20, 2009, ADAMS Accession No. ML092400473.

CBR, 2008a. Cameco Resources, Crow Butte Operation Semiannual Radiological Effluent and Environmental , Monitoring Report Source Materials License No. SUA-1534, Docket No. 40-8943, February 25, 2008, ADAMS Accession No. ML080710479.

CBR, 2008b. Crow Butte Uranium Project - Semi-Annual Radiological Effluent and Environmental Monitoring, Crow Butte Operation, August 20, 2008, ADAMS Accession No. ML092570555.

CBR, 2007a, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

CBR, 2007b. Crow Butte Resources, Inc. Ltr dated 02/22/2007 Regarding Semiannual Radiological Effluent and Environmental Monitoring Report, February 22, 2007 ADAMS Accession No. ML070650290.

CBR, 2007c. Semiannual Radiological Effluent and Environmental Monitoring Report for First and Second Quarters 2007 for Crow Butte Resources, August 14, 2007, ADAMS Accession No. ML072400396.

CBR, 2006a. Letter from Licensee to NRC, Region IV, Enclosing Semiannual Radiological Effluent and Environmental Monitoring Report for Crow Butte Uranium Project - Docket 40-8943, February 21, 2006, ADAMS Accession No. ML060660122.

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CBR, 2005a. Semiannual Radiological Effluent and Environmental Monitoring Report for the Crow Butte Uranium Project for the third and fourth quarters of 2004, February 19, 2005, ADAMS Accession No. ML052730075.

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CBR, 2003b. Semiannual Radiological Effluent & Environmental Monitoring Report Source Materials License No.SUA-1534, Docket No.40-8943, August 7, 2003, ADAMS Accession No. ML032370508.

CBR, 2002a, Crow Butte Resources, Inc. Docket. No. 40-8943, License Number SUA-1534, Semi-annual Radiological Effluent and Environmental Monitoring Report for the Crow Butte Uranium Project, February 28, 2002, ADAMS Accession No. ML020640628.

CBR, 2002b. Crow Butte Resources, Inc., Semiannual Radiological Effluent & Environmental Monitoring Report Source Materials License No. SUA-1534, Docket No. 40-8943, August 9, 2002, ADAMS Accession No. ML022260637.

CBR, 2001a. Crow Butte Resources Inc. Docket. No. 040-08943, License No. SUA-1534, Semiannual Radiological Effluent and Environmental Monitoring Report for the third and fourth quarters of 2000, February 10, 2001, ADAMS Accession No. ML010510403.

CBR, 2001b. Semiannual Radiological Effluent and Environmental Monitoring Report - First Half of 2001, August 15, 2001, ADAMS Accession No. ML020310110.

CBR, 2000a. Letter forwarding semiannual radiological effluent and environmental monitoring report for Crow Butte Uranium project, February 2, 2000, ADAMS Accession No. ML003685594.

CBR, 2000b. Crow Butte Uranium Project, Radiological Effluent and Environmental Monitoring Report for First and Second Quarters, 2000, August 8, 2000, ADAMS Accession No. ML072080461.

NRC, 2003. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

NRC, 1999. License Amendment 3, Completion of Review of Request to Amend the Groundwater Environmental Sampling Condition of Source Material License SUA-1534 Crow Butte Uranium Project, Nebraska, March 30, 1999, Accession No. 9904070140 (Legacy record).

NRC, 1998. Environmental Assessment for Renewal of Source Material License No. SUS-1534, Crow Butte Resources, Incorporated, Crow Butte Uranium Project, Dawes County, Nebraska, February 1998, ADAMS Accession No. ML071520242.

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5.7.9 Ground Water and Surface Water Monitoring Programs

5.7.9.1 Regulatory Requirements

In this section, the staff determines if the applicant has demonstrated that the ground water and surface water monitoring program for the CBR facility meets the requirements of 10 CFR 40.32(c), 10 CFR 40.41(c), 10 CFR Part 40, Appendix A, Criterion 5B(5), and 10 CFR Part 40, Appendix A, Criterion 5D.

5.7.9.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria for wellfield monitoring presented in Section 5.7.8.3 and for environmental monitoring in Section 5.7.7.3 of NUREG 1569 (NRC, 2003a).

5.7.9.3 Staff Review and Analysis

Unless otherwise stated, information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application.

In the LRA, the applicant described the ground water and surface water monitoring programs implemented at the CBR facility during operations. Preoperational monitoring, which was conducted as part of the site characterization or mine unit baseline data acquisition, is discussed in Chapter 2 of this SER. Restoration monitoring, which is conducted during ground water restoration of a mine unit, is discussed in Section 6.1 of this SER. The following sections address mine unit operational ground water monitoring, new mine unit hydrologic packages, and license area ground water and surface water environmental monitoring programs.

5.7.9.3.1 Mine Unit Operational Ground Water Monitoring

The applicant indicated in Section 5.8.8.2 of the application that the operational monitoring program for all mine units consists of excursion monitoring at designated wells in the surrounding perimeter monitoring well ring and in the overlying aquifer (CBR, 2007). NRC staff observes the purpose for the perimeter monitoring well ring is to provide early detection of the movement of production fluids (horizontal excursion) from the mineralized zone (i.e., Basal Chadron Sandstone) in the wellfield. The purpose for the monitoring wells in the overlying aquifer is the early detection of movement of production fluids (vertical excursion) from the mineralized zone. The applicant has designated the upper part of the Brule Formation as the

overlying aquifer. The applicant stated in Section 5.8.8.2 of the application that it has not installed monitoring wells in the underlying aquifer due to the presence of a thick and effective confining layer (Pierre Shale) below the ore-bearing aquifer (CBR, 2007). Staff has previously concluded that the number and location of the monitoring wells in the perimeter well ring and overlying aquifer were satisfactory during the prior license renewal review (NRC, 1998). NRC staff also found that excluding monitoring wells from underlying aquifer is acceptable for the monitoring programs (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

Since the 1998 license renewal, the applicant has evaluated the adequacy of the monitoring program for mine units brought into production through its SERP process. NRC staff reviews the SERPS and standard operating procedures for conducting the monitoring program as part of the routine compliance inspection program. During the previous renewal period, the hydrologic packages for mine units 7 through 10 were approved by the SERP process. Staff has reviewed NRC inspection reports dating from 1999 to 2010. During several of these inspections (NRC, 1999, 2002, 2003c, 2004, 2007), NRC inspectors reviewed various aspects of the applicant's management organization and controls, including the results of the applicant's SERP process. NRC inspectors determined that the applicant met applicable SERP license requirements under LC 9.4 (NRC, 2010b).

5.7.9.3.2 Historical Excursion Monitoring Program and Data

In license condition 11.2 (NRC, 2010b), the applicant is required to perform excursion monitoring which consists of biweekly monitoring of wells in the perimeter ring and overlying aquifer. The program consists of measuring three excursion indicators, alkalinity, conductivity and chloride, in each monitoring well and comparing the levels to Upper Control Limits (UCLs) established for the monitoring wells in each mine unit during the baseline (pre-mining) sampling. During the past license period, the parameters included in the excursion monitoring program were modified to the current three indicators by License Amendment 16 (NRC, 2003b). The indicators sodium and sulfate were removed from the list of parameters through review and approval of NRC staff at that time.

Under the applicant's current license (NRC, 2010b), if the indicators monitored during the excursion monitoring program exceed the UCL threshold, an excursion is suspected. The UCL threshold is the exceedance of UCLs for two excursion indicators or the UCL for any one indicator by more than 20 percent. Once the exceedance is confirmed, the well is placed on excursion status. The applicant must increase the monitoring from biweekly to weekly for all wells on excursion status. The excursion status is terminated if the levels of the excursion parameters for three consecutive weekly sampling events are below the UCLs. If the excursion is confirmed by a second or third set of samples, the applicant is required to notify NRC and begin corrective actions to eliminate the excursion. Corrective actions typically include pumping nearby wells to pull the excursion back into the wellfield, terminating injection near the well on excursion or a combination of both.

The staff reviewed the excursion monitoring program of the Crow Butte facility in accordance with NUREG 1569 (NRC, 2003a) and through onsite inspections. For this review, NRC examined the inspection reports (NRC 1999, 2001a, 2002, 2003c, 2004 – 2010a) and numerous excursion monitoring reports. The excursion monitoring program currently consists of biweekly sampling at 333 wells and weekly sampling at wells on excursion. During that time, the applicant reported that 13 perimeter monitoring wells had been on excursion status at one time

or another and 12 monitoring wells in the overlying aquifer had 16 excursion events (SER Table 5.7-10). NRC staff observes the corrective actions for the perimeter ring wells on excursions consisted primarily of adjusting flow in nearest mine units to capture any outward flow. These corrective actions proved adequate in controlling the excursions in a timely manner for ten perimeter wells. For three other wells (PR-8, PR-15, and IJ-13), the corrective action proved less effective. These wells are located in Mine Unit 1, which was the first mine unit in production. MU1 has undergone ground water restoration and the restoration was approved by the NRC. After restoration, these three wells were converted to perimeter monitoring wells for the subsequent mine units which completely encircle Mine Unit 1. In Table 7.4.1 in the license application (CBR, 2007), the applicant attributed the cause of the excursions to the bordering mine units whose combined operation causes fluids to be drawn into MU-1. NRC staff finds this explanation to be acceptable. NRC observes that at the completion of operations, the ground water in all mine units must be restored to the required standards, including any ground water contaminated at mine unit monitoring wells.

The NRC staff found the mine units experienced several vertical excursion events in the overlying aquifer. In Table 7.4.1 in the license application (CBR, 2007), the applicant attributed the vertical excursion events for wells SM6-12, SM6-18, SM6-20, SM6-23, SM6-28, SM8-6, and SM8-28, in the shallow overlying aquifer, to natural fluctuations in water quality. In an excursion report on well 6-28 (CBR, 2005), the applicant offered several lines of evidence to support that this well and the other wells in MUs 6-8 were subject to natural fluctuations in water quality. The applicant claimed: (1) the wells with excursions in the overlying aquifer are located in close proximity of the headwaters (including groundwater seeps) for English Creek; (2) the ground water in the overlying (shallow) aquifer is under the influence of surface water; and (3) the increased excursion indicator concentrations correlate with a rise in ground water levels and typically occur after rain fall events. For all excursions in the shallow overlying aquifer, the applicant also noted the events generally terminate within 90 days without corrective actions by the applicant.

At the request of the applicant during the prior license period, NRC approved two license amendments to modify the excursion event reporting criteria to eliminate "false positives" for the shallow overlying aquifer based on applicant's contention that these excursion events were due to natural fluctuations in water quality. The first was License Amendment 8 (NRC, 2001b), which allowed the applicant to revise the methodology to calculate UCLs of indicators for parameters with concentrations below 50 mg/l. This modification was requested because the applicant reported the ambient chloride and sulfate concentration in the upper aquifer at Mine Unit 6 were quite low. The applicant stated this low threshold resulted in a calculated UCL that causes false positive exceedance for these indicators when the aquifer water quality varied under natural influence, such as seasonal fluctuations. NRC agreed and allowed the applicant to change the method of UCL to be calculated to account for greater variance (NRC, 2001b). The second was License Amendment 16 (NRC, 2003b) which allowed the applicant to remove sodium and sulfate from the list of UCL indicators. The applicant had requested this change to eliminate the reporting of false positive excursion events due to natural fluctuations in the aquifer.

NRC staff observes that excursions continue to be routinely reported in the shallow aquifer, particularly in Mine Units 6 and 8. As of May 30, 2011, the applicant reported that monitoring wells SM6-20, SM6-28, SM8-6, and SM8-28 have returned to excursion status (CBR, 2011a, b, c, d). Given that NRC has twice amended the license to lower the number of excursion events

triggered by natural water quality fluctuations, NRC staff finds the lines of evidence offered by applicant that the excursions may be attributed to natural fluctuations in water quality of the shallow aquifer may not be sufficient to account for these continued excursion events. NRC staff finds no evidence for the influence of English Creek on the shallow excursion events. The applicant has provided no analysis that flow from English Creek enters the shallow aquifer in sufficient quantity or causes a change in water quality required to produce an excursion. NRC staff agrees that the increase in indicator concentrations appears to correlate with precipitation events; however, the precipitation events may create recharge which causes temporary pulses of ground water impacted by spills or leaks to migrate to the area. As an example, a large surface spill in 2000 in MU-6 from nearby injection well I-1274 was shown to directly impact shallow monitoring well SM6-12 (CBR, 2000) as a consequence of rapid migration to the shallow water table. NRC staff observes this spill was remediated in the groundwater, but some contamination may remain absorbed by soils in the vadose zone and be released to the water table during precipitation events or when the water table rises.

The NRC staff agrees with the applicant that the vertical excursions to date for monitoring wells in the overlying shallow aquifer are not likely to be a consequence of the migration of lixiviant from the production aquifer. NRC staff also agrees that some of the excursions are coincidental with precipitation events. However, NRC staff cannot exclude the possibility that spills or unintended releases of production fluids may move as pulses with precipitation events and may have affected the water quality of the shallow aquifer. Ground water impacted by these spills and releases may migrate along preferred paths (e.g., gravel beds to the trunk lines) and be the source of the excursions in the shallow aquifer. NRC staff observes that time series plots provided by the applicant of UCL indicators in the ground water at wells on excursion in the shallow aquifer often show a gradual increasing trend for an extended period of time which is indicative of a pulse (CBR, 2001, 2010).

As a consequence of the continued number of excursions in the shallow overlying aquifer and the lack of evidence to support that all such excursions are a result of natural fluctuations, NRC staff will therefore impose a new license condition for the monitoring wells placed on excursion in the shallow overlying aquifer in Mine Units 6 and 8. This license condition will require the applicant to test all shallow overlying aquifer wells in Mine Unit 6 and Mine Unit 8 that are placed on excursion status weekly for Natural Uranium and Ra 226 in addition to the required indicators of Alkalinity, Conductivity, and Chloride. The addition of these parameters will allow NRC staff to evaluate if these excursions are a consequence of natural fluctuations or are related to release or migration of ISR production fluids. This license condition is presented in SER Section 5.7.9.4.

Table 5.7-2: Summary of Excursions

Well	Mine Unit	Aquifer	Excursion Dates		Comments	Accession No.
			Initiation	Termination		
Horizontal Excursion						
PR-8	1,2	P	12/23/2003	Present	Wellfield geometry	ML041140333
PR-15	1,2	P	1/13/2000	2/4/2011	Wellfield geometry	ML110460666
IJ-13	1,3	P	12/26/200	4/5/2011	Wellfield geometry	ML11109A096

			2			
CM5-19	5	P	5/2/2005	7/27/2005		ML052280359
CM5-11	5	P	9/10/2002	6/3/2003	Upper zone for production	ML031640167 ML023540532
CM6-7	6	P	4/4/2002	4/29/2002		ML021640176
CM6-6	6	P	7/2/1999	2/2/2000		ML090890010 ML003685594
CM8-8	8	P	3/15/2011	7/5/2011		ML11196A042
CM8-12	8	P	7/8/2010	8/20/2010		ML102520624
CM8-21	8	P	1/18/2006	4/7/2006		ML061220279
CM9-3	9	P	5/30/2008	7/16/2008		ML082130050
CM9-4	9	P	6/11/2009	7/22/2009		ML092220670
CM9-5	9	P	5/15/2008	6/30/2008		ML082050098
CM9-16	9	P	8/4/2005	11/14/2005		ML053270239
Vertical Excursions						
			6/27/2005	9/1/2005	Reported to be attributed to Natural Fluctuations/Precipitation	ML052280353 ML052430391
SM6-12	6	O	9/8/2000	11/7/2000	Pressure relief valve failure on nearby injection well	ML003769667
SM6-13	6	O	3/1/2001	4/23/2001		ML011200146
SM6-18	6	O	3/6/2000	4/23/2001	Reported to be attributed to Natural Fluctuations/Precipitation	ML011200152
SM6-20	6	O	5/23/2011 4/27/2009	7/28/2011 8/27/2009	Reported to be attributed to Natural Fluctuations/Precipitation	ML11215A029 ML092520329
SM6-23	6	O	6/16/2010	7/30/2010	Reported to be attributed to Natural Fluctuations/Precipitation	ML102250173
			5/26/2011 6/16/2010			ML11166A043 ML101870407 ML052220108
SM6-28	6	O	6/16/2005	9/1/2005	Reported to be attributed to Natural Fluctuations/Precipitation	ML052430411
SM7-23	7	O	4/27/2000		No excursion; attributed to drilling fluid in new ISR operation	ML023050009
SM8-6	8	O	5/23/2011 4/12/2010	8/25/2011 8/31/2010		ML11244A025 ML102571451
SM8-28	8	O	5/26/2011 6/16/2010	7/22/2011 8/13/2010		ML11215A033 ML102360287
Source: ADAMS as of December 20, 2011						
P - Production Zone Monitoring Well						

5.7.9.3.3 Environmental Ground Water and Surface Water Monitoring Programs

In accordance with its current license, the applicant is required to monitor groundwater quality at private water wells located within 1 kilometer of a wellfield as part of the environmental monitoring program (NRC,2010b). The parameters analyzed for this program are natural uranium (U-nat) and radium-226. NRC staff previously concluded that the radius for the monitoring private water wells was satisfactory (NRC, 1998). NRC staff observes that the number of wells included in the environmental monitoring program changed from the preceding renewal period primarily because additional wellfields were added to the operations extending the number of wells within one kilometer of a wellfield. In 2010, the program consisted of monitoring ground water quality at 19 private water wells. NRC staff concludes that the sampling locations selected for the environmental ground water monitoring by the applicant have been and are satisfactory to meet the applicable acceptance criteria of Section 5.7.7.3 of NUREG 1569 (NRC, 2003a).

NRC staff reviewed the environmental groundwater monitoring program as part of the routine annual inspections performed during the past renewal period and for this renewal application. The staff finds that no discernable trends exist in the data which are attributable to impacts from the CBR facility, and that observed concentrations are consistent with background levels. Staff observes that the radium concentration at one well, Well #61, was higher than that reported in groundwater at the other wells; however, (1) the higher levels are consistent with background for this well and (2) this well differs from the other wells because it is screened in the Basal Chadron Formation sand whereas the other wells are screened in the overlying Brule Formation. Therefore, staff finds that the applicant has performed the environmental ground water monitoring in accordance with its current license and has shown no measureable impacts to the environment at the nearby private water wells.

In accordance with its current license, the applicant is required to monitor surface water quality at two locations, one upstream and one downstream of a mine unit in streams that flow through a wellfield area, and all surface water impoundments within the wellfield areas (NRC, 2010b). The parameters analyzed for this program are natural uranium (U-nat) and radium-226. NRC staff observes that the surface water sampling locations included in the environmental monitoring program have changed from the preceding renewal period because additional wellfields were added to the operations. Based on information the applicant included in the application supplemented with information from the semi-annual reports from 2000 to 2010, changes to the surface water locations are summarized as follows:

Squaw Creek: Three sampling locations (S-1, S-2 and S-3) remain constant throughout the renewal period.

English Creek: Sampling location E-1 was the designated upstream location until the first quarter of 2005; after that event, the upstream location was a combined sample from locations E-1 and E-2

Sampling location E-4 was the designated downstream location until the third quarter of 2002; after that event sampling location E-5 was the designated downstream location

Impoundments on English Creek: Impoundments I-3 and I-4 were added to the monitoring program in 2002. Impoundment I-5 was added to the monitoring program in 2006.

NRC staff reviewed the environmental surface water monitoring program as part of the routine annual inspections performed during the past renewal period and for this renewal application. NRC staff concludes that the sampling locations selected for the surface water monitoring by the applicant have been and are satisfactory to meet the applicable acceptance criteria of Section 5.7.7.3 of NUREG 1569 (NRC, 2003a).

In its review of the surface monitoring data for the Squaw Creek sampling locations, the staff finds that no discernable trends exist in the surface water quality data which are attributable to impacts from the CBR facility, and that observed concentrations are consistent with background levels. For the downstream English Creek sampling locations and the surface impoundments, the staff finds that no discernable trends exist in the data which are attributable to impacts from the CBR facility, and that observed concentrations are consistent with background levels.

For the upstream English Creek sampling locations and the surface impoundments, the staff finds that no discernable trends exist in the data; however, the observed levels at times exceeded the range of background levels. Staff observes and agrees with the applicant that the baseline concentrations in surface water at the upstream locations in English Creek are elevated with respect to levels observed in surface water in Squaw Creek. The headwaters for English Creek are located within the license area, in particular within Mine Unit 6, and are likely fed by the discharge of ground water. As discussed above in Section 5.7.9.3.2 of this SER, several monitoring wells in the overlying aquifer within Mine Unit 6 have been recently on excursion status. The applicant attributes the excursion status to natural fluctuations of the water quality within the overlying aquifer associated in part with above average precipitation. The excursion status of these wells is typically terminated after a short time without corrective actions by the applicant. As described in Section 5.7.9.3.2, the NRC staff can not verify that the excursions are the result of natural fluctuations in water quality and is therefore imposing a license condition described in SER Section 5.7.9.4. The NRC staff will continue to monitor the status of these excursions and continue to work with the applicant to assess their source and if there is any impact to water quality in English Creek.

5.7.9.4 Evaluation Findings

The staff reviewed the ground water and surface water monitoring programs of the CBR facility in accordance with Sections 5.7.8.3 and 5.7.7.3 of NUREG 1569 (NRC, 2003a). The applicant has defined a sampling program for the following environs:

- Any surface water body that lies within the facility boundary, including downstream sampling locations.
- Well field baseline water quality sampling programs, including the number and timing of samples, constituents sampled, and appropriate statistical methods.
- Operational ground water monitoring programs, including the appropriate location and spacing of monitoring wells, monitoring frequency, and criteria for determining the presence of an excursion.

Based upon the review conducted by the staff as indicated above, the information provided in the application meets the applicable acceptance criteria of Section 5.7.8.3 of NUREG 1569 and are in compliance with the following regulations:

- 10 CFR 40.32(c), which requires the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life and property;
- 10 CFR 40.41(c), which requires the applicant to confine source or byproduct material to the location and purposes authorized in the license;
- 10 CFR Part 40, Appendix A, Criterion 5B(5), which provide concentration limits for hazardous constituents ; and
- 10 CFR Part 40, Appendix A, Criterion 5D, which requires a ground water corrective action program.
- 10 CFR Part 40, Appendix A. Criteria 7 and 7A, which require ground water monitoring.

NRC staff finds that the applicant has not adequately demonstrated that the continued number of excursions in the shallow overlying aquifer are a result of natural fluctuations in water quality. NRC staff is therefore imposing the following license condition that will allow NRC staff to evaluate if these excursions are a consequence of natural fluctuations or are related to release or migration of ISR production fluids:

If an overlying aquifer monitoring well in Mine Unit 6 or Mine Unit 8 is placed on excursion status per LC 11.5, the licensee shall test it weekly for natural uranium in addition to the required indicators of Alkalinity, Conductivity, and Chloride. The natural uranium data from wells on excursion status in the overlying aquifer in Mine Units 6 or 8 shall be maintained in the on-site records. If a well in these specific mine units remains on excursion for more than 60 days, the licensee shall provide the natural Uranium data with the UCL indicator data in the required sixty day excursion report in accordance with LC 11.5.

Based on the detailed review of the groundwater and surface water monitoring at the Crow Butte ISR facility and the information in the license renewal application and the noted license condition, NRC staff concludes that groundwater and surface water monitoring programs are acceptable and are in compliance with 10 CFR 40.32(c), which requires the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property.

5.7.9.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR 2011a. SM 8-6 Monitor Well Excursion for Cameco Resources. Crow Butte Operation, May 27, 2011, ADAMS Accession No. ML11166A042

CBR 2011b. SM 6-28 Monitor Well Excursion for Cameco Resources. Crow Butte Operation, May 27, 2011, ADAMS Accession No. ML11166A043

CBR 2011c. SM 8-28 Monitor Well Excursion for Cameco Resources. Crow Butte Operation, May 27, 2011, ADAMS Accession No. ML11165A143

CBR 2011d. SM 6-20 Monitor Well Excursion for Cameco Resources. Crow Butte Operation, May 25, 2011, ADAMS Accession No. ML11165A144

CBR 2010. SM6-23 , SM6-28 and SM8-28 Monitor Well Excursions for Cameco Resources. Crow Butte Operation, June 18, 2010, ADAMS Accession No. ML101870407

CBR, 2007, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

CBR, 2005, Crow Butte Resources, Inc, SM6-28 Monitor Well Excursion, June 22, 2005, ADAMS Accession No. ML051800471

CBR , 2001. Crow Butte Resources, Inc. Shallow Monitor Excursion Data Analysis, January 30, 2001, ADAMS Accession No. ML010450296

CBR, 2000. Monitor Well SM6-12 Upper Control Limit Exceedance, 60 Day Report, November 7, 2000, ADAMS Accession No. ML003769667.

NRC, 2010a. NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, August 20, 2010, ADAMS Accession No. ML102320543.

NRC, 2010b. License Amendment No. 25- Revised Surety Estimate for Crow Butte Resources, Inc, April 20, 2010, ADAMS Accession No. ML100830012.

NRC, 2009. NRC Inspection Report 040-8943/09-001, Arlington, TX, September 28, 2009, Accession No. ML092670138.

NRC, 2008. NRC Inspection Report 040-8943/08-001, Arlington, TX, August 28, 2008, Accession No. ML082410870.

NRC, 2007. NRC Inspection Report 040-8943/07-001, Arlington, TX, October 16, 2007, Accession No. ML072890610.

NRC, 2006. NRC Inspection Report 040-8943/06-001, Arlington, TX, September 8, 2006, Accession No. ML062540084.

NRC, 2005. NRC Inspection Report 040-8943/05-001, Arlington, TX, October 20, 2005, Accession No. ML052930434.

NRC, 2004. NRC Inspection Report 040-8943/04-001, Arlington, TX, October 15, 2004, Accession No. ML042920385.

NRC, 2003a. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report.” June.

NRC, 2003b. License Amendment 16, Crow Butte Resources In Situ Leach facility, License No. SUA-1534, License Condition (LC) 10.4 Excursion Monitoring Parameters and Annual Surety Update, October 20, 2003, Accession No. ML032940073.

NRC, 2003c. NRC Inspection Report 040-8943/03-001, Arlington, TX, September 22, 2003, Accession No. ML032650623.

NRC, 2002. NRC Inspection Report 040-08943/02-01, Arlington, TX, June 17, 2002, ADAMS Accession No. ML021680257

NRC, 2001a. NRC Inspection Report 040-08943/01-01, Arlington, TX, May 4, 2001, ADAMS Accession No. ML011280480.

NRC, 2001b. License Amendment 8, Crow Butte Resources In Situ Leach facility, License No. SUA-1534, January 19, 2001, Accession No. ML010590206.

NRC, 2000a. NRC Inspection Report 040-08943/00-01, Arlington, TX, April 19, 2000, ADAMS Accession No. ML003705485.

NRC, 1999. NRC Inspection Report 040-8943/99-02, Arlington, TX, November 16, 1999, ADAMS Accession No. ML993300032 Package).

NRC, 1998a. Environmental Assessment for Renewal of Source Material License No. SUS-1534, Crow Butte Resources, Incorporated, Crow Butte Uranium Project, Dawes County, Nebraska, February 1998, ADAMS Accession No. ML071520242.

5.7.10 Quality Assurance

5.7.10.1 Regulatory Requirements

In this section, the Staff determines if the applicant has demonstrated that the proposed quality assurance program for the Crow Butte facility meets the requirements of 10 CFR 20.1101, and 10 CFR 20 Subparts L and M.

5.7.10.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 20 using the acceptance criteria presented in Section 5.7.9.3 of NUREG 1569 (NRC, 2003). Regulatory Guide 4.15 (NRC, 2007) provides guidance on demonstrating compliance with the applicable regulations.

5.7.10.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. NRC staff visited the site on several occasions during the course of this review to confirm information presented in the application.

This section discusses the proposed quality assurance (QA) and quality control (QC) programs for radiological and non-radiological monitoring activities. QA comprises all those planned and

systematic actions that are necessary to provide adequate confidence in the assessment of monitoring results. QC, which is included in QA, comprises those actions that provide a means to measure and control the characteristics of measurement equipment and processes to meet established standards. QA is necessary to ensure that all radiological and non-radiological measurements that support the radiological and non-radiological monitoring programs are reasonably valid and of a defined quality.

In the application, the applicant stated that a quality assurance program is in place at the Crow Butte Project for all relevant operational monitoring and analytical procedures. However, NRC staff cannot conclude that the applicant's QA program is consistent with Regulatory Guides 4.14 (NRC, 1980) and 4.15 (NRC, 2007).

As an example, in LRA Section 5.4.3, the applicant states that the Radiation Safety Officer has the primary responsibility for implementation of the radiological QA/QC programs. However, specific responsibilities are not described as recommended in Regulatory Guide 4.15 (NRC, 2007). In addition, the applicant does not describe QA responsibilities for its management in its discussion of corporate organization in LRA Section 5.1.

Although the applicant has demonstrated that it maintains some aspects of a QA/QC program, such as using blank samples for urinalysis and duplicate radon measurements, NRC staff cannot conclude that there is a facility-wide QA/QC program addressing all measurement programs.

Two recent inspections (NRC, 2009, 2010) have resulted in Notices of Violation in areas that are addressed by Regulatory Guide 4.15 (NRC, 2007). In both of these inspections, the applicant was found to be utilizing employees that were not properly trained as required by regulation and license condition. Not only were these longstanding violations, they were in different program areas. In the most recent inspection (NRC, 2010), the applicant was found to be performing radon dose calculations with faulty spreadsheet data over the course of several years.

NRC staff requires additional information to conclude that the applicant's QA/QC program is consistent with Regulatory Guide 4.15 (NRC, 2007). Therefore, staff is imposing a license condition requiring the applicant to submit this information. This license condition is presented in SER Section 5.7.10.4.

5.7.10.4 Evaluation Findings

The staff reviewed the quality assurance program of the Crow Butte ISR facility in accordance with NUREG 1569, Section 5.7.9.3. The applicant has not provided adequate documentation of the elements of a QA program as outlined in Regulatory Guide 4.15 (NRC, 2007). Therefore, the staff is imposing the following license condition related to the submission of a QAP:

The licensee shall submit a Quality Assurance Program (QAP) to the NRC for review and approval. The QAP will address the topics recommended in Regulatory Guide 4.15 (as revised).

The information required by this license condition is due to NRC staff within sixty days of the date of issuance of the license renewal.

Based upon the review conducted by the staff as indicated above and the information provided in the application, as supplemented by information submitted in accordance with the noted license condition, the NRC staff concludes that the QAP will meet the applicable acceptance criteria of NUREG 1569 (NRC, 2003), Section 5.7.9.3 and will meet the requirements of 10 CFR 20.1101, 10 CFR 20 Subpart L, and Subpart M.

5.7.10.5 Reference

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

NRC, 2010. NRC Inspection Report 040-08943/10-001 and Notice of Violation, Arlington, TX, August 20, 2010, ADAMS Accession No. ML102320543.

NRC, 2009. NRC Inspection Report 040-08943/09-001 and Notice of Violation, Arlington, TX, September 24, 2009, ADAMS Accession No. ML092670138.

NRC, 2007. "Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) - Effluent Streams and the Environment," Revision 2, Regulatory Guide 4.15, Washington, DC: July 2007.

NRC, 2003. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

NRC, 1980. "Radiological Effluent and Environmental Monitoring at Uranium Mills," Regulatory Guide 4.14, Revision 1. Washington, DC, April 1980.

6. GROUND WATER QUALITY RESTORATION, SURFACE RECLAMATION, AND FACILITY DECOMMISSIONING

6.1 Plans and Schedules for Ground Water Quality Restoration

6.1.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the proposed plans and schedules for ground water quality restoration for the Crow Butte facility meet the requirements of 10 CFR 40.32(c), 10 CFR 40.42, and Criterion 5B(5) of Appendix A to 10 CFR Part 40.

6.1.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 6.1.3 of NUREG-1569 (NRC, 2003a).

6.1.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated. The staff also visited the site on several occasions during the course of this review to confirm information presented in the application.

This section discusses plans for the ground water quality restoration activities at the Crow Butte facility. The plans include proposed restoration standards, baseline water quality evaluation, restoration methods, restoration stability monitoring, historical activities, and the proposed restoration schedule.

6.1.3.1 Restoration Standards

NRC regulations require the ground water quality in the well field aquifer(s) after uranium extraction is terminated to be restored to the standards identified in 10 CFR Part 40, Appendix A, Criterion 5B(5). According to Criterion 5B(5), the concentration of each hazardous constituent may not exceed (a) the background concentration, (b) the maximum values for ground water protection in the Criterion 5C Table, if the constituent is listed in the table and if the background level is lower than the value in the table, or (c) an alternate concentration limit (ACL) proposed by a licensee and established by the NRC in accordance with Criterion 5B(6) of Appendix A to 10 CFR Part 40.

NRC staff observes that the current license for CBR allows for a secondary restoration goal, referred to as "class of use" (NRC, 2010b). The use of this secondary restoration goal was contemplated by the guidance supplied in NUREG-1569 (NRC, 2003a). The NRC has since determined that the primary and secondary restoration goals outlined in NUREG-1569 are inconsistent with the restoration standards in 10 CFR Part 40, Appendix A, Criterion 5B(5). The

NRC notified licensees and applicants in Regulatory Information Summary (RIS), RIS 09-05 (NRC, 2009b), that the restoration standards listed in NUREG-1569 (NRC, 2003a), Section 6.1.3(4), are not consistent with those listed in 10 CFR Part 40, Appendix A, Criterion 5B(5), and licensees and applicants must commit to achieve the restoration standards in Criterion 5B(5).

As stated above, the applicant may request to use ACLs as the ground water restoration standard. In order for a licensee to receive approval to use ACLs, the applicant must first demonstrate that for the constituents of concern in the well field being restored, it has made a reasonable effort to return those constituents to pre-operational baseline levels or to the respective Appendix A Table 5C value (if applicable), whichever level is higher. To establish ACLs, the licensee must request a license amendment which is subject to a safety and environmental review. A licensee can only propose ACLs that present no significant hazards for NRC's consideration. The NRC may establish a well field-specific ACL for a constituent only if it finds that the proposed limit is ALARA, after considering practicable corrective actions, and that the proposed limit would not pose a substantial present or potential hazard to human health or the environment as long as the ACL is not exceeded. The factors that the NRC must consider in reviewing an ACL license amendment request are set forth in 10 CFR Part 40, Appendix A, Criterion 5B(6). For ISR facilities located in Nebraska, the State's "class of use" standard is one factor, among several, that is considered in evaluating ACL requests, in accordance with Criterion 5B(6)(a)(v-vi) and (b)(vi-vii).

The applicant reported in Section 6.1.3 of the LRA (CBR, 2007) that the primary restoration goal is to return the quality to the pre-operational baseline values on a parameter-by-parameter basis for each mine unit. The applicant then stated that if baseline cannot be achieved after diligent application of the best practicable technology, the applicant commits to returning the ground water to the secondary "class of use" values set by NDEQ in the UIC permit in Section 6.1.3 of the LRA (CBR, 2007). The applicant also stated that it recognized that NRC no longer accepted the "class of use" restoration standard, and committed in application Section 6.1.3 to meeting the regulations in Criterion 5B(5). The staff reviewed the applicant's discussion of restoration standards and finds this commitment to be consistent with the regulations. However, because the applicant has committed in the application to one restoration standard for the NDEQ UIC program and another restoration standard for NRC, there is insufficient clarity. Therefore, NRC staff will impose a license condition to ensure the implementation of Appendix A Criterion 5B(5) and 5B(6) regulations. This license condition is presented in SER Section 6.1.4 (1).

6.1.3.2 Baseline Water Quality

The guidance in NUREG-1569 (NRC, 2003a) recommends the applicant evaluate the baseline water quality of the ore zone aquifer, overlying aquifer, underlying aquifer and perimeter monitoring well ring. NRC staff notes the ore zone aquifer baseline water quality is used to establish the background concentrations for hazardous constituents under Criterion 5B(5) for the ground water in the mine unit ore zone aquifer. Likewise, the overlying aquifer and perimeter monitoring well ring baseline water quality is used to establish the background concentrations for hazardous constituents that must be met under Appendix A Criterion 5B(5) for the ground water in these aquifers if restoration is required due to excursions or spills.

The applicant stated in Section 6.1.3.1 that the baseline water quality of the ore zone aquifer in a new mine unit would be established by taking three samples every two weeks from each baseline well for all constituents of concern listed in application Table 6.1-1 (CBR, 2007). The

applicant stated it would sample at least one baseline well in every four acres of the mine unit. The applicant then stated that it will evaluate all the well data together for outliers. Once outliers are removed, the applicant will average the remaining data from all the wells together to determine the average baseline water quality for each constituent. NRC staff notes this method of baseline sampling and calculating the average baseline water quality was found acceptable for the current license(NRC, 2010b) ; however, NRC now concludes that this sampling approach does not provide a sufficient number of samples or adequate analysis to ensure baseline water quality is established on a rigorous statistical basis (EPA, 2009a).

Specifically, NRC finds that the applicant must demonstrate whether it is appropriate to combine the data from the wells to determine the water quality on a wellfield interwell average (using all wells) as opposed to an intrawell average (well by well). To use an interwell average, as proposed, the applicant must first demonstrate there is no significant spatial variation across the ore zone aquifer in the mine unit (EPA, 2009a). If spatial variation exists, the mean and variance of a set of samples will vary with well location. If there is no spatial variation, the mean and variance will show no significant difference between wells. Therefore, the applicant can only average the data from many different wells (interwell) if it can be shown that the water quality values compared between individual wells have the same mean and variance.

In Section 5.8.8.2 of the application (CBR, 2007) the applicant stated the baseline water quality for the overlying aquifer and the perimeter monitoring ring wells will be established. The applicant stated the individual wells selected for the baseline water quality assessment will each be sampled three separate times. The samples at each well will be taken at least two weeks apart. The first, second and third samples will be tested for the excursion indicator parameters of chloride, conductivity and alkalinity. One set of samples will be tested for all constituents of concern.

This proposed method for establishing the average baseline water quality for the overlying aquifer and perimeter ring monitoring wells was found acceptable for the current license (NRC, 2010b). However, NRC now concludes that this sampling approach does not provide baseline water quality for all constituents of concern as listed in application Table 6.1-1 as required in Criterion 5B(5). It also does not provide a sufficient number of samples or analysis to ensure baseline water quality is established on a rigorous statistical basis (EPA, 2009a) as explained above.

NRC staff therefore concludes the methods proposed in the LRA to establish mine unit baseline water quality are not satisfactory. NRC will therefore impose a license condition to ensure the baseline water quality is assessed in the ore zone aquifer, overlying aquifer and perimeter ring monitoring wells in a mine unit for all constituents of concern as required by Criterion 5B(5) and established in a statistically rigorous manner (EPA, 2009a). This license condition is presented in SER Section 6.1.4 (2).

6.1.3.3 Restoration Methods

The applicant stated in Section 6.1.4.1 of the application that the restoration process consists of ground water transfer, ground water sweep, ground water treatment and ground water recirculation phases (CBR, 2007). The degree to which a phase is incorporated into the restoration process for a particular mine unit is determined by the applicant.

NRC staff notes the first phase, ground water transfer, consists of the exchange of ground water between a new mine unit and that of a mine unit at the end of production. For this to occur, a new mine unit must be ready at the time that restoration begins for an existing mine unit. The second phase, ground water sweep, consists of pumping ground water from the mine unit without any corresponding injection back into the mine unit under restoration. This purpose of this phase is to draw in impacted ground water from the perimeter of the wellfield. The applicant stated in Section 6.1.4.2 of the application (CBR, 2007) that the duration of the sweep phase depends upon the presence of mine units along the mine unit perimeter, capacity of the wastewater disposal system and success of the transfer phase to lower the total dissolved solids concentration. The third phase is the ground water treatment phase, which consists of pumping ground water from a mine unit, treating the ground water to remove the constituents mobilized during the production, and injecting some or all the treated water back to the mine unit. The treatment consists of ion exchange (IX), reverse osmosis (RO) or electro Dialysis Reversal (EDR). A reductant may be added during the treatment phase. The last phase the applicant may employ is groundwater recirculation, which is simply recirculating water pumped from the aquifer back into the aquifer to homogenize the ground water quality.

The applicant's stated in Section 6.1.4.2 of the application (CBR, 2007) that the restoration of a typical mine unit consists of a variable number of pore volumes of ground water sweep, 6 pore volumes of ground water treatment and 2 pore volumes of ground water recirculation. A pore volume is defined by the applicant as the quantity of water contained in the pore spaces of the ore zone aquifer to be restored. The pore volume is calculated by multiplying the area of the ore zone aquifer by the aquifer thickness and the porosity. The applicant stated that the 6 pore volumes for ground water treatment may consist of reverse osmosis and/or ion exchange treatment. The applicant indicated this restoration approach is based on experience during restoration of wellfields at the former R&D site and approved restoration at Mine Unit 1.

The applicant stated in Section 6.1.4.2 of the application (CBR, 2007) that it has used and proposes to use chemical reductants during the groundwater treatment phase to improve the restoration performance. NRC staff notes chemical reductants change the oxidation/reduction potential of the ground water in the wellfield to induce precipitation of uranium and other constituents to lower their concentration in the groundwater. The applicant has also performed a pilot study using bioremediation to improve restoration performance. The applicant defines bioremediation as the injection of organic compounds in the groundwater in the wellfield to induce biological reduction to change the oxidation/reduction potential of the ground water in the wellfield to induce precipitation of uranium and other constituents. Specifically, the applicant has performed a limited trial of bioremediation on a 6-production-unit pattern at Wellhouse 9 in Mine Unit 4. The system was installed in December 2008 and the study is now complete (CBR, 2011a). Results of the bioremediation trial will be reviewed during a future NRC inspection.

NRC staff finds the restoration methods used and proposed by the applicant are consistent with the previous license renewal applications and are based, in part, on restoration activities conducted for the approved restoration at the R&D wellfield and Mine Unit 1. NRC staff evaluated the restoration methods in the prior license renewal (NRC, 1998) and has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not reexamining this issue.

6.1.3.4 Restoration Stability Monitoring

NRC staff noted that once restoration is completed for a mine unit, the applicant must conduct restoration stability monitoring to ensure that chemical species of concern (i.e., hazardous constituents) do not increase in concentration above the Criterion 5B(5) restoration standards subsequent to restoration. The applicant has committed in Section 6.1.5 of the application (CBR, 2007) that once the restoration standards are met for a mine unit, a 6-month stability monitoring period will be initiated in which monthly samples will be collected from specified ore zone aquifer wells to demonstrate that restoration is stable and that there are no significant increasing trends in any of the constituents of concern. Based on the restoration plan, the applicant stated that it will determine the start of the stabilization period through the SERP process. The applicant indicated that it anticipates that the stabilization period for restored mine units may extend beyond the anticipated 6-month period based on its experience with prior restorations.

NRC staff notes that the aforementioned stability monitoring practice proposed by the applicant was previously found to be acceptable by the staff and incorporated into the current license (NRC, 2010b). However, NRC staff finds to demonstrate statistical rigor, the stability monitoring must continue until at least the most recent four consecutive quarters of data indicate that constituent concentrations do not demonstrate any statistically significant increasing trend (EPA, 2009b). Therefore, NRC staff is imposing a license condition which will require quarterly monitoring of all constituents of concern at the specified ore zone aquifer wells until stability for all constituents of concern is established over at least four quarters. This license condition is presented in SER Section 6.1.4 (3).

6.1.3.5 Historical Restoration Results

NRC staff has determined as of May 2011, the applicant has production operations in Mine Units 6 through 10. Mine Unit 1 has been restored to the required ground water quality standards; the restoration was approved by NRC in 2003 (NRC, 2003b). Mine Units 2-5 have been in restoration since 1996, 1999, 2003 and 2005, respectively. Mine Unit 11 is currently under development for future production. In accordance with the requirements of the NDEQ Class III UIC permit for CBR, the applicant can operate a maximum of five mine units, restore a maximum of five mine units, and develop a maximum of three mine units, at any given time (NDEQ, 2009). Therefore, in order to begin production operations in Mine Unit 11, the applicant must place Mine Unit 6 in restoration.

In its May 2011 Monthly Restoration Report (CBR, 2011b), the applicant provided the most recent uranium and conductivity monitoring results from the wells in Mine Units 2-5 that track restoration progress. All of these mine units are currently undergoing RO treatment. In Mine Unit 2, the average uranium value is 1.32 mg/l vs. 0.046 mg/l for baseline. In Mine Unit 3, the average uranium is 2.3 mg/l vs. 0.115 mg/l for baseline. In Mine Unit 4, the average uranium is 10.7 mg/l vs. 0.122 mg/l for baseline. In Mine Unit 5, the average uranium is 9.93 mg/l vs. 0.056 mg/l for baseline. The results indicate that none of these mine units have yet reached their baseline water quality for uranium.

6.1.3.6 Restoration Schedule

The applicant stated in Section 1.7 of the application that the production at the CBR facility is expected to be completed by 2014 and restoration completed by 2023 (CBR, 2007). While NRC has no regulations which specify the time in which restoration must be completed, the applicant was informed by NRC that is required to meet the requirements in 10 CFR 40.42(h)(1) which states the applicant must complete decommissioning within 24 months of initiating decommissioning or submit an alternate schedule for decommissioning for NRC review and approval in accordance with 10 CFR 40.42(i) (NRC, 2008). For an ISR, NRC defines that decommissioning begins when the applicant permanently ceases the injection of lixiviant in a wellfield (NRC, 2008).

NRC notes that in the September 2009 inspection report, the applicant received a Security Level IV violation for its failure to request an alternate decommissioning schedule for Mine Units 2-5 (NRC, 2009a). The applicant was cited for failing to meet the requirements in 10 CFR 40.42 which required the applicant to complete decommissioning 24 months after the cessation of lixiviant into these mine units or submit an alternate schedule for decommissioning for NRC review and approval. On July 24, 2009, to address this violation, the applicant requested an alternate schedule for restoration of Mine Units 2 through 5 (CBR, 2009). The alternate schedule indicated that the restoration including regulatory approval should be completed by July 2012, July 2013, Jan. 2015 and July 2016 for Mine Unit 2, 3, 4 and 5, respectively. The alternate schedule was approved by NRC (NRC, 2010a) and the inspection issue was closed.

In December 2010, the applicant provided NRC with notification of the cessation of lixiviant injection in Mine Unit 6. NRC considers this action to be the starting point of decommissioning for an ISR wellfield. The applicant also provided a restoration plan and alternate schedule for decommissioning for Mine Unit 6 (CBR, 2010). This request for an alternate schedule is currently under review by NRC staff. The alternate schedule indicated that the restoration for Mine Unit 6 should be completed by Dec. 31, 2019. Apart from staff's review of the above-referenced request for an alternate schedule, NRC staff finds that the applicant's schedule for restoration (CBR, 2007) is acceptable and meets the regulatory requirements.

6.1.4 Evaluation Findings

Based on the information provided in the license renewal application as coupled with the corresponding detailed review by the NRC staff of the applicant's plans and schedules for ground water quality restoration at the Crow Butte ISR facility, the staff concludes that the applicant's plans and schedules for ground water quality restoration are in compliance with 10 CFR 40.32(c), requiring the applicant's proposed equipment, facilities, and procedures to be adequate to protect health and minimize danger to life or property.

However, as previously discussed, to ensure the applicant: (1) meets the restoration standards for groundwater quality which are covered listed in Criterion 5B(5) of Appendix A in 10 CFR Part 40, (2) conducts an acceptable baseline water quality assessment, and (3) performs sufficient restoration stability monitoring, the NRC staff determined that the following license conditions are necessary:

- 1) Ground Water Restoration. The licensee shall conduct ground water restoration activities in accordance with the approved license application. Permanent cessation of lixiviant injection in a well field would signify the licensee's intent to shift from the principal activity of uranium production to the initiation of ground water restoration. Prior to initiation of ground water restoration activities, the licensee shall determine the restoration schedule. If the licensee determines that these activities are expected to exceed 24 months, then the licensee shall submit an alternate schedule request that meets the requirements of 10 CFR 40.42.

Restoration Standards. Hazardous constituents in the ground water shall be restored to the numerical ground water protection standards as required by 10 CFR 40, Appendix A, Criterion 5(B)(5). In submitting any license amendment application requesting review of proposed alternate concentration limits (ACLs) pursuant to Criterion 5(B)(6), the licensee must also show that it has first made practicable efforts to restore the specified hazardous constituents to the background or maximum contaminant levels (whichever is greater).

Restoration Stability Monitoring. The licensee shall conduct sampling of all constituents of concern on a quarter year basis during restoration stability monitoring. The sampling shall include the specified ore zone aquifer wells. The applicant shall continue the stability monitoring until the data show the most recent four consecutive quarters indicate no statistically significant increasing trend for all constituents of concern which would lead to an exceedance above the respective Criterion 5B(5) standard.

Changes to ground water restoration or post-restoration monitoring plans shall be submitted to the NRC for review and approval at least 60 days prior to ground water restoration in a well field.

The restoration schedule for mine units two through five shall be as described in the request dated July 24, 2009, (ADAMS Accession No. ML092220668) and as approved in NRC staff's letter dated February 18, 2010(ADAMS Accession No. ML092510030).

- 2) Establishment of Background Water Quality. Prior to injection of lixiviant for each mine unit, the licensee shall establish background ground water quality data for the ore zone and overlying aquifers. The background water quality will be used to define the background ground water protection standards required to be met in 10 CFR 40, Appendix A, Criterion 5B(5), for the ore zone aquifer and surrounding aquifers. Water quality sampling shall provide representative background ground water quality data and restoration criteria as described in Sections 5.8.8 and 6.1.3 of the approved license application.

The data shall consist, at a minimum, of the following sampling and analyses:

- A. Four samples shall be collected from production and injection wells at a minimum density of one production or injection well per four acres. These samples shall be collected at least 14 days apart.

- B. Four samples shall be collected from each designated monitoring well at a minimum density of: 1) one upper aquifer monitoring well per five acres of mine unit area, and 2) all perimeter monitoring wells. These samples shall be collected at least 14 days apart. The results of these analyses shall constitute the baseline for each designated well.
- C. The samples shall be analyzed for ammonia, arsenic, barium, cadmium, calcium, chloride, copper, fluoride, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, nitrate, pH, potassium, radium-226, selenium, sodium, sulfate, total carbonate, total dissolved solids, uranium, vanadium, and zinc.
- D. Prior to operation of a mine unit, representative background concentrations shall be established on a parameter-by-parameter basis using either the mine unit or well-specific mean value.
- E. The licensee shall submit all mine unit hydrologic test packages to the NRC for review.

6.1.5 References

10 CFR Part 40. *Code of Federal Regulations*, Title 10, Energy, Part 40, "Domestic Licensing of Source Material."

CBR, 2011a, Letter to NDEQ, Class III UIC Permit NE0122611, April 2011 Monthly Restoration Report, May 18, 2011, ADAMS Accession No. ML11146A015.

CBR, 2011b, Letter to NDEQ, Class III UIC Permit NE0122611, May 2011 Monthly Restoration Report, June 13, 2011, ADAMS Accession No. ML11172A219.

CBR, 2010, Notice of Cessation of Mining in Mine Unit #6; Request for an Alternate Decommissioning (Groundwater Restoration) Schedule, Dec. 21, 2010, ADAMS Accession No. ML110040422.

CBR, 2009, Request for Alternate Decommissioning (Groundwater Restoration) Schedule, July 24, 2009, ADAMS Accession No. ML092220668.

CBR, 2007, Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

EPA, 2009a. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Chapter 5, Establishing and Updating Background, EPA 530-R09-007, March 2009.

EPA, 2009b. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Chapter 17, ANOVA, Tolerance Limits and Trend Tests, EPA 530-R09-007, March 2009.

Nebraska Department of Environmental Quality, 2009. Modification to UIC Permit Number NE0122611, Department of Environmental Quality Authorization for Underground Injection and Mineral Production Wells. Document Number 20091329462.

NRC, 2010a. NRC Letter to Crow Butte Resources, Inc., Request for Alternate Decommissioning (Groundwater Restoration) Schedule, Crow Butte Resources, Inc., Crawford Nebraska, Source Materials License SUA-1534, February 18, 2010, ADAMS Accession No. ML092510030.

NRC, 2010b, License Amendment No. 25- Revised Surety Estimate for Crow Butte Resources, Inc, April 20, 2010, ADAMS Accession No. ML100830012.

NRC, 2009a. NRC Inspection Report 040-8943/09-001, Arlington, TX, September 28, 2009, ADAMS Accession No. ML092670138.

NRC, 2009b. NRC Regulatory Issue Summary 2009-05 Uranium Recovery Policy Regarding: (1) The Process for Scheduling License Reviews of Applications for New Uranium Recovery Facilities and (2) The Restoration of Groundwater at Licensed Uranium In Situ Recovery Facilities, April 29, 2009, ADAMS Accession No. ML083510622.

NRC, 2008. NRC letter to Crow Butte Resources, Inc., Compliance with 10CFR40.42's Timely Decommissioning Requirements, July 7, 2008, ADAMS Accession No. ML081480259.

NRC, 2003a. "Standard Review Plan for *In-Situ* Leach Uranium Extraction License Applications - Final Report," NUREG-1569. Washington, DC: June 2003.

NRC, 2003b. License Amendment 15, Crow Butte Resources In Situ Leach facility, License No. SUA-1534, Wellfield #1 Restoration Acceptance, February 12, 2003, ADAMS Accession Number ML030440055.

NRC, 1998. Environmental Assessment for Renewal of Source Material License No. SUS-1534, Crow Butte Resources, Incorporated, Crow Butte Uranium Project, Dawes County, Nebraska, February 1998, ADAMS Accession No. ML071520242.

6.2 Plans for Reclaiming Disturbed Lands

6.2.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant has demonstrated that the proposed plans for reclaiming disturbed lands for the Crow Butte facility will meet the requirements of 10 CFR 40.42 and Criterion 6(6) of Appendix A to 10 CFR Part 40.

6.2.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 6.2.3 of NUREG-1569 (NRC, 2003).

6.2.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated.

In the LRA (CBR, 2007), the applicant described general surface reclamation procedures involving topsoil replacement, backfilling and contouring of disturbed lands, revegetation, facility site reclamation, evaporation and pond decommissioning, and well field decommissioning including well plugging and abandonment. The applicant noted that it has no plans for treating and discharging the evaporation pond water under a National Pollutant Discharge Elimination System permit. The applicant indicated that pond water will be disposed by evaporation, treatment and deep well disposal, or transportation to another licensed disposal facility.

The applicant commits to surveying and sampling all facilities and processing related equipment and materials onsite to determine contamination levels and to identify the potential for personnel exposure during decommissioning. At the end of decommissioning, the applicant will survey and release uncontaminated materials and equipment for reuse. Contaminated materials will be relocated and disposed at NRC-approved licensed facilities. In Section 6.4 of the application, (CBR, 2007), the applicant is committed to surveying excavation areas for contamination and to performing a final site soil radiation survey.

The applicant noted that records of information important to CBR's decommissioning will be maintained in the office of the onsite radiation safety officer. The applicant is required to submit a detailed decommissioning plan for NRC approval at least 12 months before final decommissioning begins. Decommissioning will be accomplished in accordance with an approved decommissioning plan, permit, and license provisions and amendments in effect at the time of the decommissioning activity.

NRC staff finds the plans for reclaiming disturbed lands proposed by the applicant are consistent with the previous license renewal application. NRC staff previously concluded that the plans for reclaiming disturbed lands proposed by the applicant in the prior license renewal application were acceptable (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid.

6.2.4 Evaluation Findings

The staff reviewed the plans for reclaiming disturbed lands of the proposed Crow Butte ISR Project in accordance with Section 6.2.3 of the standard review plan. The applicant has described in application Section 6.2 various aspects of reclamation activities at the site on a general, site-wide basis. The staff considers this current level of detail, the financial assurance information provided, and the commitment to providing a final decommissioning plan at least 12 months before decommissioning to be appropriate at this stage of facility operations. Based on the information provided in the license renewal application and the detailed review of plans for reclaiming disturbed lands at the Crow Butte ISR facility, NRC staff concludes that the plans for reclaiming disturbed lands meet the applicable acceptance criteria of Section 6.2.3 of the standard review plan and the requirements of 10 CFR 40.42 and Criterion 6(6) of Appendix A to 10 CFR Part 40.

6.2.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2007. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

NRC, 2003. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

NRC, 1998. Environmental Assessment for Renewal of Source Material License No. SUS-1534, Crow Butte Resources, Incorporated, Crow Butte Uranium Project, Dawes County, Nebraska, February 1998, ADAMS Accession No. ML071520242.

6.3 Removal and Disposal of Structures, Waste Material, and Equipment

6.3.1 Regulatory Requirements

The staff determines if the applicant has demonstrated that the proposed plans for removal and disposal of structures, waste material and equipment for the Crow Butte facility meet the requirements of 10 CFR 40.42.

6.3.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 6.3.3 of NUREG-1569 (NRC, 2003).

6.3.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated.

In Section 6.3 of the LRA (CBR, 2009) the applicant stated that it is committed to submitting a detailed decommissioning plan for structures and equipment for NRC review and approval at least 12 months before decommissioning begins. The applicant noted that the decommissioning plan: (i) will describe the structures and equipment to be decommissioned, planned decommissioning activities, methods that will be implemented to ensure protection of workers and environment against radiation hazards and the planned final radiation survey and (ii) will provide an updated detailed cost estimate (CBR, 2009).

The applicant noted that a detailed plan and methods to measure radioactivity on the interior surfaces of pipes, drain lines, and ductwork at all traps and other access points will be included in the decommissioning plan. Decontamination of surfaces will comply with the applicant's as-low-as-is-reasonable-achievable policy to reduce surface contamination as far below the limits as practical.

In Section 6.3 of the LRA (CBR, 2009), the applicant stated that all surfaces of premises, equipment, or scrap likely to be contaminated but that cannot be measured will be assumed to be contaminated in excess of limits and will be treated accordingly. For all premises, equipment, or scrap contaminated in excess of specified limits, detailed, specific information describing the premises, equipment, or scrap in terms of extent and degree of radiological contamination will be provided. The applicant will provide a detailed health and safety analysis that reflects that the contamination and any use of the premises, equipment, or scrap will not result in an unacceptable risk to the health and safety of the public or the environment. The applicant plans to conduct a comprehensive radiation survey (for alpha and beta contamination) to establish that any contamination is within limits specified before the release of the premises, equipment, or scrap. (CBR, 2009)

As discussed in SER Section 4.2, the applicant maintains an agreement for disposal of byproduct material with a licensed byproduct disposal facility. Its current agreement is with the operator of the White Mesa Mill, near Blanding, Utah. NRC staff has reviewed the applicant's byproduct disposal agreement and found it acceptable (NRC, 2010). The applicant is committed to handling transportation of all contaminated waste materials and equipment from the site to NRC-approved disposal facility or other licensed sites in accordance with the Department of Transportation Hazardous Materials Regulations and the NRC transportation regulations.

6.3.4 Evaluation Findings

NRC staff finds the plans for removal and disposal of structures, waste material and equipment proposed by the applicant are consistent with the previous license renewal application. Staff previously concluded that operation of the Crow Butte Project is protective of health and safety (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff has not identified any unreviewed safety-related concerns and therefore is not reexamining the applicant's program for the removal and disposal of structures, waste material and Equipment.

6.3.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2009, Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2007. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

NRC, 2010. NRC letter to Crow Butte Resources, Inc., License Condition 9.7 to Source Material License SUA-1534 -11e.(2) Byproduct Material Disposal Agreement, September 13, 2010, ADAMS Accession No. ML102510131.

NRC, 2003. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

NRC, 1998. Environmental Assessment for Renewal of Source Material License No. SUS-1534, Crow Butte Resources, Incorporated, Crow Butte Uranium Project, Dawes County, Nebraska, February 1998, ADAMS Accession No. ML071520242.

6.4 Methodologies for Conducting Postreclamation and Decommissioning Radiological Surveys

6.4.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant has demonstrated that the proposed methodologies for conducting post reclamation and decommissioning radiological surveys for the Crow Butte facility will meet the requirements of Criterion 6(6) of Appendix A to 10 CFR Part 40.

6.4.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 6.4.3 of NUREG-1569 (NRC, 2003).

6.4.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007a) and as updated.

6.4.3.1 Cleanup Criteria and ALARA Goals

In the LRA, the applicant discusses its plans for conducting post-reclamation and decommissioning radiological surveys to verify that the concentration limits of 10 CFR Part 40 Appendix A Criterion 6(6) are met. The applicant stated that surface soils will be cleaned up in accordance with the requirements of 10 CFR Part 40 Appendix A, including the consideration of ALARA goals and the chemical toxicity of uranium. The proposed limits and ALARA goals for cleanup of surface and subsurface soils are summarized in LRA Table 6.4-1 (CBR, 2009).

The limits for Ra-226 in surface and subsurface soils are defined in 10 CFR Part 40 Appendix A, Criterion 6(6). The applicant applied this criterion to derive a dose criterion for cleanup of byproduct materials. The applicant used the RESRAD computer code (DOE, 2001), Version 6.22, to model the site and to calculate the annual dose.

The applicant determined that the benchmark dose from 5 pCi/g of Ra-226 in soil is equivalent to 42.4 mrem per year based on a residential farmer scenario. The applicant also calculated a natural uranium concentration of 537 pCi/g in the top 15 cm of soil for the residential farmer scenario that would be equivalent to the Benchmark Dose derived from 5 pCi/g of Ra-226 in soil. The applicant also took into consideration the toxicity of uranium in soil and determined that the natural uranium concentration should not exceed 230 pCi/g. NRC staff has determined that the applicant's dose approach using the residential farmer scenario is reasonable as this scenario is expected to result in the highest predicted lifetime dose (Section 2.4 of DOE, 2001) and is therefore acceptable. The applicant established ALARA goals of 150 pCi/g and 230 pCi/g for natural uranium in surface and subsurface soils, respectively. NRC staff has determined that the applicant's proposed radium benchmark dose approach is consistent with Appendix E of NUREG-1569 (NRC, 2003) and is therefore acceptable.

The applicant indicated that spills of process solutions are not likely to contain substantial amounts of Th-230 and therefore the development of a soil cleanup criterion for Th-230 is not appropriate at this time. However, in the event that Th-230 is present in significant quantities, a cleanup criterion will be developed using the radium dose benchmark method and submitted to the NRC for approval. Additional NRC reviews would be conducted on the decommissioning plan submitted to NRC by the applicant, as required. NRC staff finds this commitment reasonable and acceptable.

6.4.3.2 Surface Soil Cleanup Verification and Sampling Plan

The applicant expects that the cleanup of surface soils will be restricted to a few areas where spills have occurred and those areas around wellheads where small spills could develop. Final GPS-based gamma survey will be conducted by the applicant in potentially contaminated areas, including 10 m buffer area. According to the Wellfield Decommissioning Plan (CBR, 2007b) the applicant stated that a gamma ray survey will be conducted over the entire license area, including the buffer zone.

The applicant indicated that it will divide the license area systematically into 100 m² grid blocks and sample all grid blocks containing gamma count rates exceeding the gamma action level. The samples will be five-point composites, and analyzed at an offsite laboratory for Ra-226 and natural uranium. In Section 6.4.3 of the LRA, (CBR, 2009) the applicant stated that it will sample the remaining grid blocks with average gamma count rates ranking in the top 10 percent. The applicant states that if any grid blocks within the top 10 percent fail the cleanup criteria, the applicant will sample the second ten percent of grid blocks. This will continue until all grid blocks pass within a 10 percent grouping.

The applicant previously stated (CBR, 2004) that it will use the Wellfield Decommissioning Plan "...to provide instructions for interim reclamation and decommissioning steps that will ultimately be part of the final decommissioning plan submitted before the end of active mining..." Use of the Wellfield Decommissioning Plan for any final decommissioning steps, such as a final status survey, will require NRC approval. NRC staff has determined that the use of the gamma action level for radionuclides other than radium has not been sufficiently justified by the applicant. In addition, background levels for radionuclides such as uranium have not been established. These and other technical issues were transmitted to the applicant by letter dated January 5, 2005 (NRC, 2005). Therefore, NRC staff is imposing a license condition to enable NRC staff to evaluate the applicant's Wellfield Decommissioning Plan for use during its interim reclamation and decommissioning steps. This license condition can be found in Section 6.4.4 of the SER. The applicant stated that to meet the cleanup criterion, each of the sampled grid blocks must satisfy the following inequality,

$$\sum C_i/C_c < 1$$

Where

C_i = concentration of the constituent

C_c = concentration of the benchmark dose equivalent

NRC staff has determined that the inequality equation, also known as the unity rule or sum of fractions, is consistent with 10 CFR Part 40 Appendix A, Criterion 6(6) and is therefore acceptable.

6.4.3.3 Subsurface Soil Cleanup Verification and Sampling Plan

The applicant stated that for subsurfaces, it will adopt different survey and sample protocols, depending on the type and size of the excavation. The applicant will rely more on sampling for Ra-226 and natural uranium analysis over surveying to verify cleanup of subsurface excavations. NRC staff notes that the applicant is required by a license condition to submit a detailed decommissioning plan to NRC for review and approval at least 12 months prior to the planned shutdown of mine unit extraction operations.

6.4.4 Evaluation Findings

The staff reviewed the methodologies for conducting post-reclamation and decommissioning radiological surveys for the Crow Butte facility in accordance with NUREG-1569 (NRC, 2003). The applicant has developed methodologies for verification of cleanup (final status survey plan) that will verify that the radium concentration will not exceed 5 pCi/g in the upper 15 cm (5.9 inches) of soil and will not exceed 15 pCi/g in subsequent 15-cm (5.9-inch) layers. In order to determine that the cleanup of other residual radionuclides in soil will meet the criteria developed with the radium benchmark dose approach, including a demonstration of ALARA and the application of the unity test of Criterion 6(6) of Appendix A to 10 CFR Part 40, where applicable, NRC staff is imposing the following license condition:

The licensee shall submit for NRC written verification additional information on its Wellfield Decommissioning Plan for Crow Butte Uranium Project, dated June 2004 regarding the ability to detect radionuclides other than radium. Specifically, the licensee shall provide a technical basis for applying the gamma action level derived from radium to radionuclides other than radium and provide background levels that will be utilized for radionuclides other than radium (e.g., uranium).

Based upon the review conducted by NRC staff as indicated above the information provided in the application as supplemented by information submitted in accordance with the noted license condition, is consistent with the applicable acceptance criteria of NUREG-1569 (NRC, 2003) and the requirements of Criterion 6(6) of Appendix A to 10 CFR Part 40.

6.4.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2009, Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

CBR, 2007a. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

CBR, 2007b. Application for Amendment of USNRC Source Material License SUA-1534, North Trend Expansion Area, Environmental Report – Volume II, Appendix E, May 30, 2007, ADAMS Accession No. ML071870307.

CBR, 2004. Withdrawal of License Amendment Request, Source Materials License SUA-1534, Docket Number 40-8943, Crow Butte Resources, Inc., August 10, 2004, ADAMS Accession No. ML042310506.

DOE, 2001. "User's Manual for RESRAD Version 6." ANL/EAD-4. Washington, DC: US Department of Energy. July 2001. <http://web.ead.anl.gov/resrad/documents/resrad6.pdf>, accessed December 14, 2011.

NRC, 2005. Wellfield Decommissioning Plan Review, January 10, 2005, ADAMS Accession No. ML050110170.

NRC, 2003. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

6.5 Financial Assurance

6.5.1 Regulatory Requirements

The purpose of this section is to determine whether the applicant has demonstrated that the proposed financial assurance for the Crow Butte facility meets the requirements of Criterion 9 of Appendix A to 10 CFR Part 40.

6.5.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for consistency with applicable regulations of 10 CFR Part 40 using the acceptance criteria presented in Section 6.5.3 of NUREG-1569 (NRC, 2003).

6.5.3 Staff Review and Analysis

Unless otherwise stated, the information reviewed in this section is from information, data, and maps submitted by CBR in their application (CBR, 2007) and as updated.

The applicant maintains an irrevocable standby letter of credit issued by the Royal Bank of Canada in favor of the State of Nebraska (NDEQ, 2012) to cover restoration, decontamination, and reclamation estimated costs for all areas affected by Crow Butte ISR Project. Specifically, these estimated costs include groundwater restoration; equipment removal and disposal; building demolition and disposal; wellfield building and equipment removal and disposal; well abandonment; wellfield surface reclamation; evaporation pond decommissioning; soil excavation and disposal; topsoil replacement and revegetation; soil surveying and analyses; administration; overhead; contingency; and other miscellaneous costs. These activities are discussed in application Sections 6.1 to 6.5 (CBR, 2007).

During the past renewal period, CBR submitted timely annual updates for the financial assurance to reflect changes in the above-referenced surety-related estimated costs as required by standard license provisions (NRC, 2010) that ensure compliance with Criterion 9 in Appendix A to 10 CFR Part 40. The annual updates to the surety estimate have included a breakdown of costs and the basis for cost estimates that generally follow the outline in Appendix C of NUREG-1569 (NRC, 2003). Staff observes that NRC's previous approval annual surety estimates have demonstrated that the applicant has maintained sufficient funds in the surety for completion of the above-referenced activities by an independent contractor (NRC, 2010). Staff also observes that following the approval of previous annual surety estimates by the NRC and the Nebraska Department of Environmental Quality (NDEQ), the above-referenced irrevocable letter of credit has been updated annually and submitted to the Nebraska Department of Environmental Quality (NDEQ) with a copy to the NRC.

In application Section 6.6 (CBR, 2007), the applicant has committed to continue annual adjustments of the surety value and maintain a surety instrument as required by a standard license condition (NRC, 2010) that ensures compliance with 10 CFR 40, Appendix A, Criterion 9 to cover the above-referenced surety-related estimated costs. Staff finds these commitments coupled with standard license provisions (NRC, 2010) to be consistent with acceptance criteria in Section 6.5 of NUREG-1569 (NRC, 2003).

6.5.4 Evaluation Findings

Based on the information provided in the license renewal application and the detailed review of financial surety at the Crow Butte ISR facility, NRC staff concludes that the amount of the financial surety and its methods of estimation are acceptable and meets the requirements of 10 CFR Part 40, Appendix A, Criterion 9, which requires that financial surety arrangements be established by each operator.

6.5.5 References

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 2007. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

NDEQ, 2012. Nebraska Department of Environmental Quality e-mail, Crow Butte Letter of Credit, October, 11, 2012, ADAMS Accession No. ML12290A193.

NRC, 2010. License Amendment No. 25, 2010 Surety Update, Crow Butte Resources, Inc., Crawford, Nebraska, Source Materials License SUA-1534 (TAC No. J00607), April 20, 2010, ADAMS Accession No. ML100830017 (Package).

NRC, 2003. NUREG-1569, "Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report." June.

7. ACCIDENTS

7.1 Regulatory Requirements

The staff determines if the applicant has addressed potential accidents at the Crow Butte facility and demonstrated that the facility will meet the requirements of 10 CFR 40.32(c), which requires that the applicant's proposed procedures be adequate to protect public health and minimize danger to life or property should an accident occur.

7.2 Regulatory Acceptance Criteria

Unless specifically stated otherwise, changes to the current licensing basis were reviewed for compliance with the applicable requirements of 10 CFR Part 40 using the acceptance criteria presented in Section 7.5.3 of the NUREG-1569 (NRC, 2003).

7.3 Staff Review and Analysis

This section addresses potential accidents that could occur at the Crow Butte facility, the designs and measures proposed by the applicant to prevent those accidents, and the plans (including training) proposed by the applicant to cope with the possible occurrence of those accidents. Unless specifically stated otherwise, the information reviewed for this section consists of the narrative and data submitted by Crow Butte Resources in Section 7.14 of the application (CBR, 2007).

In the LRA, the applicant provided information on the potential accidents that could occur at the facility, including potential health and safety impacts should an accident occur involving radiological and non-radiological materials. In the LRA, the applicant also identified the procedures and training programs to mitigate or lessen the likelihood of an accident. The staff reviewed the applicant's information to identify any changes to the types of accidents that could occur at the facility. The following sections address specific information on impacts due to chemical accidents, radiological release accidents, transportation accidents, fires and explosions.

7.3.1 Chemical Accidents

In Section 3.2.2.1 of the LRA (CBR, 2007), the applicant presented a list of ISR process-related chemicals stored in bulk on site, accompanied by a summary of the hazards associated with the use and storage of those chemicals. Those chemicals consist of carbon dioxide, hydrogen peroxide, oxygen, sodium hydroxide, hydrochloric acid, sodium carbonate, sodium bicarbonate, sodium chloride and sodium sulfide. Figure 3.2-1 of the LRA shows that the storage vessels for the more hazardous chemicals (hydrochloric acid, hydrogen peroxide, carbon dioxide, oxygen and sodium carbonate (soda ash)) are located outside of the plant and segregated from areas in which licensed materials are stored. For chemicals which have the potential to spill onto the ground surface, the applicant stated that appropriately sized secondary containment structures surround individual storage vessels as well as the entire central processing plant. The applicant

stated that the operating procedures, safety precautions and hazards associated with the handling and use of the above chemicals are discussed in CBR's Industrial Safety Manual. In section 3.2.2.1 of the LRA, the applicant identified that hydrochloric acid was the most hazardous chemical used at the facility with the greatest potential for impacts to chemical and/or radiological safety.

In Section 5.1.7 of the LRA (CBR, 2007), the applicant stated that the safety supervisor is responsible for the health and safety programs not related to radiation safety. The safety supervisor is responsible for the development and implementation of health and safety programs for compliance with OSHA, including the training of new and existing employees and maintaining records.

The staff reviewed the aforementioned information provided by the applicant in the LRA and notes that most of the chemicals discussed by the applicant were evaluated in NUREG/CR-6733 (Mackin et al., 2001). NUREG/CR-6733 assessed the risk of common ISR process chemicals. Staff finds that the applicant has adequately identified probable consequences of possible accidents involving the discussed chemicals as well as corresponding appropriate mitigation measures. Because the chemical storage and handling procedures and precautions, including training for employees, described by the applicant are consistent with standard industry practices and are designed to cope with a range of potential chemical accidents, the staff finds that such procedures and precautions will be protective of worker health and safety as well as that of the public. Moreover, the analyses of effects of accident sequences involving chemicals provided by the applicant are consistent with the acceptance criteria of NUREG-1569 (NRC, 2003), Section 7.5.3.

7.3.2 Radiological Release Accidents

In section 7.14 of the LRA, the applicant provided a discussion on the effects of accidents at ISR facilities. In regard to accidents that may lead to radiological releases, the applicant stated that those accidents that might occur would typically manifest themselves slowly and would therefore be easily detected and mitigated. The applicant also stated that the remote location of the facility and the low level of radioactivity associated with the ISR process decrease the potential hazards of a radiological accident to the general public. During inspections in 2006 (NRC, 2006) and 2011 (NRC, 2011), staff reviewed the Crow Butte facility's plans for emergency preparedness, fire protection, and emergency procedures. Staff found CBR had established emergency preparedness procedures that addressed fires, spills, and accidents. Staff determined that CBR's emergency procedures were adequate for emergencies that could involve radioactive material. These procedures decrease the potential hazards of a radiological accident to workers at the Crow Butte facility.

In section 7.14 of the LRA, the applicant identified several accident scenarios in which a release of radiological material might occur. Within the central processing plant, those identified scenarios include process fluid tank and piping failure. The applicant has identified several measures that are used to minimize the effects of these accidents inside the central processing plant. The applicant stated that process fluid tanks and piping are located within the plant or for several storage vessels, immediately outside the plant building within designated bermed storage areas. These tanks include venting to outside if warranted (for radon, carbon dioxide or oxygen release) and level/pressure monitoring with alarms and automatic shut-off controls. The plant has been designed for monitoring and controlling the potential for a significant release of

process fluids. The tanks located within the plant are constructed of fiberglass or steel and the applicant states an instantaneous failure is unlikely; the most likely tank failure would occur as a small leak which would be readily observed during operations. The plant building structure includes a perimeter concrete berm which would direct any release from a tank or piping to the floor sump within the building. Any material collected in the sump will be returned to the process circuit or disposed of at the deep disposal well.

In section 7.14 of the LRA, the applicant addressed accident scenarios that might occur outside of the central processing plant. These potential accident scenarios include a process piping leak in a wellfield, leakage from a solution pond, and an excursion of lixiviant outside of the wellfield. The applicant has identified measures to be used to prevent such accidents. To address the possibility of an accident from a piping leak in a wellfield, the applicant has a preventative maintenance program. The applicant described the inspection program that is used to detect leaks in the event of a pond failure. This program includes daily, weekly, monthly, and quarterly inspections as well as measurements of the amount of fluid in the leak detection system. Additionally, the applicant described the practices that are used to prevent an excursion of lixiviant from the well field. The applicant maintains an inward gradient (withdrawing more water than is injected), and has monitoring wells located around and above each wellfield.

The staff reviewed the applicant's information on the potential radiological releases within and outside central processing plant. Staff previously concluded that operation of the Crow Butte Project is protective of public health and safety (NRC, 1998). Additionally, staff reviewed the Crow Butte facility's plans for emergency preparedness, fire protection, and emergency procedures during inspections in 2006 (NRC, 2006) and 2011 (NRC, 2011). During these inspections, staff determined that CBR's emergency procedures were adequate for emergencies that could involve radioactive material. Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not re-examining the applicant's discussion of radiological release accidents. Staff's review of the applicant's reporting program can be found in SER section 5.7.3.3.3.

7.3.3 Transportation Accidents

The applicant identified potential radiological releases from transportation accidents in Section 7.14.5 of the LRA. The applicant considered the potential for transportation accidents involving shipments of ion exchange resins, yellowcake, process chemicals, fuels, and byproduct material. Several procedures and actions were identified by the applicant to prevent transportation accidents, including maintaining vehicles in good operating condition, using properly trained and licensed drivers, inspecting vehicles prior to shipment, following DOT hazardous materials shipping provisions, and having emergency response procedures.

The staff reviewed the applicant's information on transportation accidents and did not identify any proposed changes by the applicant when compared to the previous license renewal submittal (CBR, 1995). Staff previously concluded that operation of the Crow Butte Project is protective of health and safety (NRC, 1998). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not reexamining the applicant's discussion of transportation accidents.

7.3.4 Fires and Explosions

In Section 3.2.2 of the LRA, the applicant identified the risk of fire and explosion from handling oxygen at the facility. The applicant also identified several fire prevention methods associated with the storage and use of flammable materials (e.g., propane and motor vehicle fuel) as well as other materials that contributed to a fire or explosion (e.g., oxygen). The applicant stated that the storage of the materials of concern will be isolated, minimizing the potential for impacts. The applicant has prepared an emergency response plan that includes descriptions of notification and evacuation procedures, personal protective equipment, general fire fighting safety rules, reporting procedures, and provisions addressing electrical and gas emergencies. The staff reviewed the applicant's information related to potential fires and explosions at the facility. The staff observes that the applicant's isolation of flammable materials and development of an emergency response plan is consistent with standard industry practices. The staff finds that the applicant's identification of mitigation measures is consistent with the acceptance criteria of NUREG-1569 (NRC, 2003) Section 7.5.3. Therefore, the staff finds the information presented in the application acceptable.

7.3.5 Natural Events

Staff reviewed the applicant's information on natural events at the Crow Butte facility. In Section 2.5.5 of the LRA (CBR, 2009), the applicant identified the probability of a tornado in the region near the Crow Butte facility is approximately 4.8×10^{-4} per year. Staff previously concluded that the applicant had established emergency procedures related to natural disasters. These procedures identified personnel to contact, decontamination procedures, and area cleanup methods (NRC, 1998). Additionally, staff reviewed the Crow Butte facility's plans for emergency preparedness, fire protection, and emergency procedures during inspections in 2006 (NRC, 2006) and 2011 (NRC, 2011). During these inspections, staff determined that CBR's emergency procedures were adequate for emergencies that could involve natural events. These events include the potential for wildfires to impact CBR's proposed operations. In July 2006, a wildfire occurred east of the Crow Butte facility (CBR, 2006). In response to this event, the applicant called the NRC's Emergency Operations Center and the NRC project manager to provide notification of a potential evacuation. NRC staff inspected the applicant's program for responding to wildfires and found it acceptable (NRC, 2006).

Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not re-examining the applicant's discussion of natural events.

7.4 Evaluation Findings

The staff has completed its review of the applicant's description of the effects of accidents for the Crow Butte ISR facility. This review included an evaluation of the methods that will be used by the applicant to evaluate effects of accidents using the review procedures in Section 7.5.2, the acceptance criteria in Section 7.5.3, and the guidance in Appendix A of NUREG-1569 (NRC, 2003).

The applicant has acceptably described all likely significant effects of accidents from facility operations by providing an acceptable analysis of probable accidents and their consequences consistent with the facility design, site features and planned operations. The applicant discussed mitigation measures, preventative procedures, and training for personnel to implement adequate response and remedial measures.

During inspections in 2006 (NRC, 2006) and 2011 (NRC, 2011), the staff reviewed the Crow Butte facility's plans for emergency preparedness, fire protection, and emergency procedures. The staff found CBR had established emergency preparedness procedures that addressed fires, spills, and accidents. The staff determined that CBR's emergency procedures were adequate for emergencies that could involve radioactive material.

Based on information provided in the application (CBR, 2007), the detailed review conducted by staff, and the results of the 2006 and the 2011 inspections, the staff finds that the applicant's proposed equipment, facilities and procedures will be adequate to protect health and minimize danger to life or property, as required by 10 CFR 40.32(c). Staff has found nothing to invalidate previous findings; therefore, the original findings stand and previous staff conclusions remain valid. In accordance with Appendix A of NUREG-1569 (NRC, 2003), staff is not reexamining the applicant's discussion of the effects of accidents.

7.5 References

10 CFR Part 20. Code of Federal Regulations, Title 10, Energy, Part 20, "Standards for Protection Against Radiation."

10 CFR Part 40. Code of Federal Regulations, Title 10, Energy, Part 40, "Domestic Licensing of Source Material".

CBR, 1995. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., December 1995, ADAMS Accession No. ML082060561 (Package).

CBR, 2006. Email from CBR to NRC staff regarding wildfires near Crow Butte Resources. ADAMS Accession No. ML062160033.

CBR, 2007. Application for Renewal of Source Material License No. SUA-1534, Crow Butte Resources, Inc., November 27, 2007, ADAMS Accession No. ML073480264 (Package).

CBR, 2009. Responses to NRC Request for Additional Information: Technical Review: License Renewal Amendment Request: Source Material License No. SUA-1534, Crow Butte Resources, Inc., May 12, 2009, ADAMS Accession No. ML091470116 (Package).

Mackin, P.C., D. Daruwalla, J. Winterle, M. Smith, and D.A. Pickett, 2001. NUREG/CR-6733, "A Baseline Risk-Informed Performance-Based Approach for *In-Situ* Leach Uranium Extraction Licensees." Washington, DC: NRC, September 2001.

NRC, 1998. Safety Evaluation Report (SER) for Renewal of Source Material License SUA-1534, Crow Butte Project, February 1998, ADAMS Accession No. ML081080325.

NRC, 2003. NUREG–1569, “Standard Review Plan for In Situ Leach Uranium Extraction License Applications—Final Report.” June.

NRC, 2006. NRC Inspection Report 040-08943/06-001, Source Material License SUA-1534, Crow Butte Project, September 2006, ADAMS Accession No. ML062540084

NRC, 2011. NRC Inspection Report 040-08943/11-001, Source Material License SUA-1534, Crow Butte Project, August 2011, ADAMS Accession No. ML11216A179

APPENDIX A

Table of Standard License Conditions

Administrative Conditions	
9.1	Authorized place of use shall be the licensee's Crow Butte uranium recovery and processing facilities in Dawes County, Nebraska as described in the license application dated November 27, 2007 (Agencywide Documents Access and Management System (ADAMS) package ML073480264).
9.2	<p>The licensee shall conduct operations in accordance with the commitments, representations, and statements contained in the license application dated November 27, 2007 (ADAMS package ML073480264), which is supplemented by submittals dated August 28, 2008 (ML082410902), May 12, 2009 (ML091470116), July 13, 2009 (ML091980473), September 17, 2010 (ML102640195), September 28, 2010 (ML102740030), February 8, 2012 (ML120450518), April 19, 2012 (ML121170487), August 16, 2012 (ML12235A355), August 30, 2012 (ML12250A421), October 4, 2012 (ML12285A075), March 4, 2014 (ML14064A143), May 15, 2014 (ML14135A414) and any commitments submitted for verification specified in this license. The approved application, supplements, and information submitted for verification are hereby incorporated by reference, except where superseded by license conditions below.</p> <p>Whenever the word "will", "shall", or "would" is used in the above referenced documents, it shall denote a requirement.</p>
9.3	All written notices and reports sent to the U.S. Nuclear Regulatory Commission (NRC) as required under this license and by regulation shall be addressed as follows: ATTN: Document Control Desk, Director, Office of Federal and State Materials and Environmental Management Programs, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001. An additional copy shall be submitted to: Deputy Director, Decommissioning and Uranium Recovery Licensing Directorate, Division of Waste Management and Environmental Protection, Office of Federal and State Materials and Environmental Management Programs, U.S. Nuclear Regulatory Commission, Mail Stop T-8F5, 11545 Rockville Pike, Two White Flint North, Rockville, MD 20852-2738. Incidents and events that require telephone notification shall be made to the NRC Operations Center at (301) 816-5100 (collect calls accepted).
9.4	<p>Change, Test and Experiment License Condition</p> <p>A) The licensee may, without obtaining a license amendment pursuant to 10 CFR 40.44, and subject to conditions specified in (B) of this condition:</p> <ul style="list-style-type: none"> i Make changes in the facility as described in the license application (as updated); ii Make changes in the procedures as described in the license application (as updated); and iii Conduct test or experiments not described in the license application (as updated).

- B) The licensee shall obtain a license amendment pursuant to 10 CFR 40.44 prior to implementing a proposed change, test, or experiment if the change, test, or experiment would:
- i Result in more than a minimal increase in the frequency of occurrence of an accident previously evaluated in the license application (as updated);
 - ii Result in more than a minimal increase in the likelihood of occurrence of a malfunction of a facility structure, equipment, or monitoring system (SEMS) important to safety previously evaluated in the license application (as updated);
 - iii Result in more than a minimal increase in the consequences of an accident previously evaluated in the license application (as updated);
 - iv Result in more than a minimal increase in the consequences of a malfunction of an SEMS previously evaluated in the license application (as updated);
 - v Create a possibility for an accident of a different type than any previously evaluated in the license application (as updated);
 - vi Create a possibility for a malfunction of an SEMS with a different result than previously evaluated in the license application (as updated);
 - vii Result in a departure from the method of evaluation described in the license application (as updated) used in establishing the final safety evaluation report (FSER), environmental impact statement (EIS), environmental assessment (EA) or technical evaluation reports (TERs) or other analyses and evaluations for license amendments.
 - viii For purposes of this paragraph as applied to this license, SEMS means any SEMS that has been referenced in a staff SER, TER, EA, or EIS and supplements and amendments thereof.
- C) Additionally, the licensee must obtain a license amendment unless the change, test, or experiment is consistent with NRC's previous conclusions, or the basis of, or analysis leading to, the conclusions of actions, designs, or design configurations analyzed and selected in the site or facility SER, TER, and EIS or EA. This would include all supplements and amendments, and TERs, EAs, EISs issued with amendments to this license.
- D) The licensee's determinations concerning (B) and (C) of this condition, shall be made by a Safety and Environmental Review Panel (SERP). The SERP shall consist of a minimum of three individuals. One member of the SERP shall have expertise in management (e.g., Plant Manager) and shall be responsible for financial approval for changes; one member shall have expertise in operations and/or construction and shall have responsibility for implementing any operational changes; and one member shall be the radiation safety officer (RSO) or equivalent, with the responsibility of assuring changes conform to radiation safety and environmental requirements. Additional members may be included in the SERP, as appropriate, to address technical aspects such as ground water or surface water hydrology, specific earth sciences, and other technical disciplines. Temporary members or permanent members, other than the three above-

specified individuals, may be consultants.

- E) The licensee shall maintain records of any changes made pursuant to this condition until license termination. These records shall include written safety and environmental evaluations made by the SERP that provide the basis for determining changes are in compliance with (B) of this condition. The licensee shall furnish, in an annual report to the NRC, a description of such changes, tests, or experiments, including a summary of the safety and environmental evaluation of each. In addition, the licensee shall annually submit to the NRC changed pages, which shall include both a change indicator for the area changed, e.g., a bold line vertically drawn in the margin adjacent to the portion actually changed, and a page change identification (date of change or change number or both), to the operations plan and reclamation plan of the approved license application (as updated) to reflect changes made under this condition.

- 9.5 Financial Assurance. The licensee shall maintain an NRC-approved financial surety arrangement, consistent with 10 CFR 40, Appendix A, Criterion 9, adequate to cover the estimated costs, if accomplished by a third party, for decommissioning and decontamination, which includes offsite disposal of radioactive solid process or evaporation pond residues, and ground-water restoration as warranted. The surety shall also include the estimated costs associated with all soil and water sampling analyses necessary to confirm the accomplishment of decontamination.

Proposed annual updates to the financial assurance amount, consistent with 10 CFR Part 40, Appendix A, Criterion 9, shall be provided to the NRC by October 1 of each year. If the NRC has not approved a proposed revision 30 days prior to the expiration date of the existing financial assurance arrangement, the licensee shall extend the existing arrangement, prior to expiration, for one year. Along with each proposed revision or annual update of the financial assurance estimate, the licensee shall submit supporting documentation, showing a breakdown of the costs and the basis for the cost estimates with adjustments for inflation, maintenance of a minimum 15-percent contingency, changes in engineering plans, activities performed, and any other conditions affecting the estimated costs for site closure.

Within 90 days of NRC approval of a revised closure (decommissioning) plan and its cost estimate, the licensee shall submit, for NRC review and approval, a proposed revision to the financial assurance arrangement if estimated costs exceed the amount covered in the existing arrangement. The revised financial assurance instrument shall then be in effect within 30 days of written NRC approval of the documents.

At least 90 days prior to beginning construction associated with any planned expansion or operational change that was not included in the annual financial assurance update, the licensee shall provide, for NRC approval, an updated estimate to cover the expansion or change. The licensee shall also provide the NRC with copies of financial assurance-related correspondence submitted to the State of Nebraska, a copy of the State's financial assurance review, and the final approved financial assurance arrangement. The licensee also must ensure that the financial assurance instrument, where authorized to be held by the State, identifies the NRC-related portion of the instrument and covers the aboveground decommissioning and decontamination, the cost of offsite disposal of solid byproduct material, soil, and water sample analyses, and ground water restoration associated with the site. The

basis for the cost estimate is the NRC-approved site closure plan or the NRC-approved revisions to the plan. Reclamation or decommissioning plan cost estimates and annual updates should follow the outline in Appendix C to NUREG-1569 (NRC, 2003), entitled "Recommended Outline for Site-Specific In Situ Leach Facility Reclamation and Stabilization Cost Estimates."

Crow Butte Resources, Inc., shall continuously maintain an approved surety instrument for the Crow Butte project, in favor of the State of Nebraska, in the amount of no less than \$43,223,280 for the purpose of complying with 10 CFR 40, Appendix A, Criterion 9, until a replacement is authorized by both the State of Nebraska and NRC.

- 9.6 Release of superficially contaminated equipment, materials, or packages for unrestricted use shall be in accordance with the NRC guidance document "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," (the Guidelines) dated April 1993 (ADAMS Accession No. ML003745526), or in accordance with a suitable alternative program which shall be approved by NRC prior to any such release.

The Guidelines or approved alternative program shall also apply to the removal of equipment, materials, or packages from restricted areas that have the potential for accessible surface contamination levels above background regardless of the intent to release these items for unrestricted use,. The licensee shall document their surveys of equipment, materials, or packages prior to removing them from a restricted area.

Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established in the Guidelines for alpha- and beta-gamma-emitting nuclides shall apply independently.

Personnel performing these contamination surveys for items released for unrestricted use or from restricted areas shall meet the qualifications for health physics technicians or radiation safety officer as defined in Regulatory Guide 8.31, except as provided in an alternative program submitted under one of the last two paragraphs of this license condition. Personal effects (e.g., notebooks and flash lights) which are hand carried need not be surveyed by personnel meeting the above qualifications, but these items should be subjected to the same survey requirements as the individual possessing the items.

For release to unrestricted areas, the licensee may provide an alternative program for releasing equipment, materials, or packages that have the potential for accessible surface contamination levels above background (i.e., "controlled release") to the NRC headquarters staff for review and written verification. The alternative program for controlled release shall demonstrate how the licensee will maintain radiological controls over the equipment, materials, or packages that have the potential for accessible surface contamination levels above background until they have been released for unrestricted use as specified in the first paragraph above, and shall describe the methods that will be used to limit the spread of contamination to unrestricted areas. An alternative program proposed under this paragraph shall not be implemented without written verification from NRC headquarters staff.

For releases with a final destination to one of the licensee's restricted areas, whether through an unrestricted area or not, the licensee may, as part of an alternative program, identify one or more qualified designees to perform the surveys associated with releasing equipment, materials, or packages that have the potential for accessible surface contamination levels above background. The qualified designees shall have completed education, training, and experience, in addition to general radiation worker training as specified by the licensee. The licensee must submit the education, training, and experience requirements for qualified designees to the NRC headquarters staff for review and written verification, and must receive written verification of those requirements prior to allowing qualified designees to perform these surveys.

9.7 The licensee shall follow the guidance set forth in NRC Regulatory Guides 8.22, "Bioassay at Uranium Mills" (as revised), and 8.30, "Health Physics Surveys in Uranium Recovery Facilities" (as revised), or NRC-approved equivalent.

The licensee shall follow the guidance set forth in Regulatory Guide 8.31, "Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be as Low as Is Reasonably Achievable" (as revised), or NRC approved equivalent, with the following exception:

The licensee may identify one or more qualified designees to perform daily inspections in the occasional absence of the radiation safety officer (RSO) and health physics technicians (HPTs). A qualified designee will meet the minimum qualifications and perform only those duties as outlined for a qualified Designated Operator as specified in the licensee's submittals dated March 4, 2014 (ML14064A143) and May 15, 2014 (ML14135A414).

A qualified designee may perform daily inspections on weekends, holidays, and times when both the RSO and HPTs must both be absent (e.g., illness or offsite training). With the exceptions of those instances when a Federal holiday falls on a Friday or Monday, the Thanksgiving holiday, or a site closure due to weather or other safety or security related event, qualified designees will not conduct the daily inspections for more than a total of two days per week. When a Federal holiday falls on a Friday or Monday, qualified designees may perform the daily inspections for a total of three consecutive days. For the Thanksgiving holiday only, qualified designees may perform the daily inspections for a total of four consecutive days. When weather or other safety or security related event causes a site closure, a qualified designee, if available, will continue performing the daily inspections until the RSO or HPT can access the site after such an event. The licensee will also have the RSO or HPT available by telephone while a qualified designee is performing the daily inspections.

Reports generated by a qualified designee will be reviewed by the RSO or an HPT as soon as practicable, but not later than the close of business of the next work day following an absence (including site closure due to weather or other safety or security related event), weekend, or holiday. The RSO or HPT review shall be annotated with date and time on the report or other document that can be inspected upon request.

9.8	<p>Cultural Resources. Before engaging in any developmental activity not previously assessed by the NRC, the licensee shall administer a cultural resource inventory if such survey has not been previously conducted and submitted to the NRC. All disturbances associated with the proposed development will be completed in compliance with the National Historic Preservation Act (as amended) and its implementing regulations (36 CFR Part 800), and the Archaeological Resources Protection Act (as amended) and its implementing regulations (43 CFR Part 7) to the extent applicable.</p> <p>In order to ensure that no unapproved disturbance of cultural resources occurs, any work resulting in the discovery of previously unknown cultural artifacts shall cease. The artifacts shall be inventoried and evaluated in accordance with 36 CFR Part 800, and no disturbance of the area shall occur until the licensee has received authorization from the NRC to proceed.</p> <p>Prior to any developmental activity in the immediate vicinity of the six “potentially eligible” sites identified in Section 2.4 of the approved license application, the licensee shall provide documentation of its coordination with the Nebraska State Historical Society to NRC.</p>
9.9	<p>The licensee shall dispose of solid byproduct material from the Crow Butte Project at a site that is authorized by NRC or an NRC Agreement State to receive byproduct material. The licensee’s approved solid byproduct material disposal agreement must be maintained on site. In the event that the agreement expires or is terminated, the licensee shall notify the NRC within seven working days after the date of expiration or termination. A new agreement shall be submitted for NRC review within 90 days after expiration or termination, or the licensee will be prohibited from further lixiviant injection.</p>
9.10	<p>The results of the following activities, operations, or actions shall be documented: sampling; analyses; surveys or monitoring; survey/ monitoring equipment calibrations; reports on audits and inspections; all meetings and training courses; and any subsequent reviews, investigations, or corrective actions required by NRC regulation or this license. Unless otherwise specified in a license condition or applicable NRC regulation, all documentation required by this license shall be maintained until license termination, and is subject to NRC review and inspection.</p>
9.11	<p>The licensee is hereby exempted from the requirements of 10 CFR 20.1902(e) for areas within the facility, provided that all entrances to the facility are conspicuously posted with the words, "CAUTION: ANY AREA WITHIN THIS FACILITY MAY CONTAIN RADIOACTIVE MATERIAL."</p>
<p><i>The following information for compliance with LC 9.12 shall be provided to NRC staff within sixty days of the effective date of this license. Upon acceptance by NRC staff, such information will become part of the licensing basis.</i></p>	
9.12	<p>The licensee shall submit a Quality Assurance Program (QAP) to the NRC for review and approval. The QAP will address the topics recommended in Regulatory Guide 4.15 (as revised).</p>
<p style="text-align: center;">Operations, Controls, Limits, and Restrictions</p>	
10.1	<p>The licensee shall use a lixiviant composed of native groundwater, with added sodium carbonate/bicarbonate, carbon dioxide, oxygen and/or hydrogen peroxide, as described in the approved license application.</p>

10.2	<p><u>Emission Controls (Dryer)</u>. The licensee shall maintain effluent control systems as specified in Sections 4.1 and 5.8.1 of the approved license application, with the following exceptions:</p> <p>A. If any of the yellowcake emission control equipment fails to operate within specifications set forth in the standard operating procedures, the drying and packaging room shall immediately be closed-in as an airborne radiation area and heating operations shall be switched to cooldown, or packaging operations shall be temporarily suspended. Packaging operations shall not be resumed until the vacuum system is operational to draw air into the system.</p> <p>B. The licensee shall, during all periods of yellowcake drying operations, assure that the negative pressure specified in the standard operating procedures for the dryer heating chamber is maintained. This shall be accomplished by (1) performing and documenting checks of air pressure differential approximately every four hours during operation, or (2) installing instrumentation which will signal an audible alarm if the water flow or air pressure differential falls below the recommended levels. If an audible alarm is used, its operation shall be checked and documented at the beginning and end of each drying cycle when the differential pressure is lowered.</p>
10.3	<p>The licensee shall ensure that written standard operating procedures (SOPs) exist that address: (1) all operational activities involving radioactive and non-radioactive materials associated with licensed activities that are handled, processed, stored, or transported by employees; (2) all non-operational activities involving radioactive materials including in-plant radiation protection and environmental monitoring; and (3) emergency procedures for potential accident/unusual occurrences including significant equipment or facility damage, pipe breaks and spills, loss or theft of yellowcake or sealed sources, significant fires, and other natural disasters. The SOPs shall include appropriate radiation safety practices to be followed in accordance with 10 CFR Part 20. SOPs for operational activities shall enumerate pertinent radiation safety practices to be followed. A copy of the current written procedures shall be kept in the area(s) of the production facility where they are utilized.</p>
10.4	<p>Production zone monitor wells drilled after April 1999 shall be spaced no greater than 300 feet from a well field unit and no greater than 400 feet between the wells.</p>
10.5	<p><u>Mechanical Integrity Tests</u>. The licensee shall construct all wells in accordance with methods described in Section 3.1.2 of the approved license application. Mechanical integrity tests shall be performed on each injection and production well before the wells are utilized and on wells that have been serviced with equipment or procedures that could damage the well casing. Additionally, each well shall be retested at least once each five (5) years it is in use. The integrity test shall pressurize the well to 125 pounds per square inch and shall maintain 90 percent of this pressure for 20 minutes to pass the test. A single point resistance test may be used only in conjunction with another approved well integrity testing method. If any well casing failing the integrity test cannot be repaired, the well shall be plugged and abandoned.</p>
10.6	<p><u>Ground Water Restoration</u>. The licensee shall conduct ground water restoration activities in accordance with the approved license application. Permanent cessation of lixiviant injection in a well field would signify the licensee's intent to shift from the principal activity of uranium production to the initiation of ground water restoration. Prior to initiation of ground water restoration activities, the licensee shall determine</p>

the restoration schedule. If the licensee determines that these activities are expected to exceed 24 months, then the licensee shall submit an alternate schedule request that meets the requirements of 10 CFR 40.42.

Restoration Standards. Hazardous constituents in the ground water shall be restored to the numerical ground water protection standards as required by 10 CFR 40, Appendix A, Criterion 5(B)(5). In submitting any license amendment application requesting review of proposed alternate concentration limits (ACLs) pursuant to Criterion 5(B)(6), the licensee must also show that it has first made practicable efforts to restore the specified hazardous constituents to the background or maximum contaminant levels (whichever is greater).

Restoration Stability Monitoring. The licensee shall conduct sampling of all constituents of concern on a quarter year basis during restoration stability monitoring. The sampling shall include the specified ore zone aquifer wells. The applicant shall continue the stability monitoring until the data show the most recent four consecutive quarters indicate no statistically significant increasing trend for all constituents of concern which would lead to an exceedance above the respective Criterion 5B(5) standard.

Changes to ground water restoration or post-restoration monitoring plans shall be submitted to the NRC for review and approval at least 60 days prior to ground water restoration in a well field.

The restoration schedule for mine units two through five shall be as described in the request dated July 24, 2009, (ADAMS Accession No. ML092220668) and as approved in NRC staff's letter dated February 18, 2010(ADAMS Accession No. ML092510030).

10.7	The licensee shall maintain an overall inward hydraulic gradient within the perimeter monitor well ring starting when lixiviant is first injected into the production zone and continuing until the initiation of the stabilization period.
10.8	The licensee shall conduct isotopic analyses for alpha- and beta-emitting radionuclides on airborne samples at each in-plant air particulate sampling location at a frequency of once every six months for the first two years and annually thereafter to ensure compliance with 10 CFR 20.1204(g). For any changes to operations, the licensee shall conduct an evaluation to determine if more frequent isotopic analyses are required for compliance with 10 CFR 20.1204(g).
10.9	Uranium compounds that have no assigned inhalation classification, or for which no site-specific data is available, such as uranium carbonates, shall be assigned to inhalation class W for radiation protection purposes.
10.10	If hydrogen sulfide is used, the storage and handling procedures to prevent impacts to radiological and worker safety shall be provided to the NRC for review and approval.
10.11	The licensee shall submit a detailed decommissioning plan to NRC for review and approval at least 12 months prior to the planned final shutdown of mine unit extraction operations.
10.12	Security measures for the mine units and header houses that address the requirements of 10 CFR Part 20, Subpart I, shall be described in writing to the NRC staff.

Monitoring, Recording, and Bookkeeping Requirements

11.1	<p>In addition to reports required to be submitted to NRC or maintained on-site by Title 10 of the Code of Federal Regulations, the licensee shall prepare the following reports related to operations at the facility:</p> <ul style="list-style-type: none">A. A quarterly report that includes a summary of the weekly excursion indicator parameter values, corrective actions taken, and the results obtained for all wells that were on excursion status during that quarter. This report shall be submitted to NRC within 60 days following completion of the reporting period.B. A semi-annual report that discusses: status of well fields in operation (including last date of lixiviant injection), progress of well fields in restoration, status of any long term excursions and a summary of MITs during the reporting period. This report shall be submitted to NRC within 60 days following completion of the reporting period.C. Quarterly report summarizing daily flow rates for each injection and production well and injection manifold pressures on the entire system. This report shall be made available for inspection upon request.D. Consistent with Regulatory Position 2 of Regulatory Guide 4.14, a semiannual report that summarizes the results of the operational effluent and environmental monitoring program. The licensee shall submit this report consistent with the terms of Regulatory Guide 4.14.
11.2	<p>The licensee shall submit the results of the annual review of the radiation protection program content and implementation performed in accordance with 10 CFR 20.1101(c). These results shall include an analysis of dose to individual members of the public consistent with 10 CFR 20.1301 and 10 CFR 20.1302 and a land use survey.</p>
11.3	<p><u>Establishment of Background Water Quality.</u> Prior to injection of lixiviant for each mine unit, the licensee shall establish background ground water quality data for the ore zone and overlying aquifers. The background water quality will be used to define the background ground water protection standards required to be met in 10 CFR 40, Appendix A, Criterion 5B(5), for the ore zone aquifer and surrounding aquifers. Water quality sampling shall provide representative background ground water quality data and restoration criteria as described in Sections 5.8.8 and 6.1.3 of the approved license application.</p> <p>The data shall consist, at a minimum, of the following sampling and analyses:</p> <ul style="list-style-type: none">A) Four samples shall be collected from production and injection wells at a minimum density of one production or injection well per four acres. These samples shall be collected at least 14 days apart.B) Four samples shall be collected from each designated monitoring well at a minimum density of: 1) one upper aquifer monitoring well per five acres of mine unit area, and 2) all perimeter monitoring wells. These samples shall be collected at least 14 days apart. The results of these analyses shall constitute the baseline for each designated well.

	<p>C) The samples shall be analyzed for ammonia, arsenic, barium, cadmium, calcium, chloride, copper, fluoride, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, nitrate, pH, potassium, radium-226, selenium, sodium, sulfate, total carbonate, total dissolved solids, uranium, vanadium, and zinc.</p> <p>D) Prior to operation of a mine unit, representative background concentrations shall be established on a parameter-by-parameter basis using either the mine unit or well-specific mean value.</p> <p>E) The licensee shall submit all mine unit hydrologic test packages to the NRC for review.</p>
11.4	<p><u>Establishment of UCLs.</u> The licensee shall establish upper control limits (UCLs) in designated upper aquifer and perimeter monitoring wells before lixiviant is injected in each mine unit. The UCLs shall be established by collecting and analyzing groundwater samples from those designated wells according to the following criteria:</p> <p>A) Four samples shall be collected from each designated monitoring well at a minimum density of: 1) one upper aquifer monitoring well per five acres of mine unit area, and 2) all perimeter monitoring wells. These samples shall be collected at least 14 days apart.</p> <p>B) The samples shall be analyzed for the following indicator parameters: chloride, conductivity, and total alkalinity.</p> <p>C) The UCLs shall be calculated for each indicator parameter, in each monitoring well, as equal to 20 percent above the maximum concentration measured for that parameter, among the four baseline samples. For those indicator parameters with baseline concentrations that average 50 mg/L or less, the UCL for that parameter may be calculated as equal to 20 percent above the maximum baseline concentration, the baseline average plus five standard deviations, or the baseline average plus 15 mg/L.</p>
11.5	<p><u>Excursion Monitoring.</u> All designated perimeter and upper aquifer monitor wells shall be sampled and tested no more than 14 days apart, except in the event of the situations identified in the licensee's submittal dated March 19, 1998. If a designated monitor well is not sampled within 14 days of a previous sampling event, the reasons for the postponement of sampling shall be documented. Sampling shall not be postponed for greater than five days.</p> <p>If two UCLs are exceeded in a well, or if a single UCL is exceeded by 20 percent, the licensee shall take a confirming water sample within 48 hours after the results of the first analyses are received and analyze the sample for the indicator parameters. If the second sample does not indicate an exceedance, a third sample shall be taken and analyzed in a similar manner within 48 hours after the second sample was acquired. If neither the second nor the third sample indicates an exceedance, the first sample shall be considered in error.</p> <p>If either the second or third sample confirms that a UCL(s) has been exceeded, the well in question shall be placed on excursion status. Upon confirmation of an excursion, the licensee shall notify NRC in accordance with LC 11.6, as discussed below, implement corrective action, and increase the sampling frequency for the</p>

indicator parameters at the excursion well to once every seven (7) days. Corrective actions for confirmed excursions may be, but are not limited to, those described in Section 5.8.8 of the approved license application. An excursion is considered concluded when the concentrations of the indicator parameters are below the concentration levels defining an excursion for three (3) consecutive weekly samples.

For all mine units, if an excursion is not corrected within 60 days of confirmation, the licensee shall either: (a) terminate injection of lixiviant within the affected area of the mine unit containing the excursion until the excursion is corrected; or (b) increase the surety in an amount to cover the full third-party cost of correcting and cleaning up the excursion. The surety increase shall remain in force until the NRC has verified that the excursion has been corrected and cleaned up. The written 60-day excursion report shall identify which course of action the licensee is taking. Under no circumstances does this condition eliminate the requirement that the licensee must remediate the excursion to meet ground water protection standards as required by LC 10.6 for all constituents established per LC 11.3.

The licensee shall notify the NRC Project Manager (PM) by telephone or email within 24 hrs of confirming a lixiviant excursion, and by letter within 7 days from the time the excursion is confirmed, pursuant to LC 11.6. A written report describing the excursion event, corrective actions taken, and the corrective action results shall be submitted to the NRC within 60 days of the excursion confirmation. For all wells that remain on excursion after 60 days, the licensee shall submit a report as discussed in LC 11.1(A).

11.6 Until license termination, the licensee shall maintain documentation on unplanned releases of source or byproduct materials (including process solutions) and process chemicals. Documented information shall include, but not be limited to: date, spill volume, total activity of each radionuclide released, radiological survey results, soil sample results (if taken), corrective actions, results of post remediation surveys (if taken), a map showing the spill location and the impacted area, and an evaluation of NRC reporting criteria.

The licensee shall have written procedures for evaluating consequences of the spill or incident/event against 10 CFR 20, Subpart M, and 10 CFR 40.60 reporting criteria. If the reporting criteria are met, the license shall report the spill or incident/event to the NRC Operations Center as required.

If the licensee is required to report any well field excursions and spills of source, byproduct material, and process chemicals that may have an impact on the environment, or any other incidents/events, to any State or other Federal agency, a report shall be made to the NRC Headquarters Project Manager by telephone or electronic mail (e-mail) within 24 hours. This notification shall be followed, within 30 days of the notification, by submittal of a written report to NRC Headquarters, as per LC 9.3, detailing the conditions leading to the spill or incident/event, corrective actions taken, and results achieved.

11.7 Any time uranium in a worker's urine specimen exceeds 15 micrograms per liter (ug/l), the annual ALARA audit will indicate what corrective actions were considered or performed.

11.8 Any time a uranium action level of 35 ug/l for two consecutive urine specimens or 130 ug/l for any one specimen is reached or exceeded, the licensee shall provide

	documentation, within 30 days, to the NRC, indicating what corrective actions have been performed.
11.9	<p>The licensee shall perform and document inspections in accordance with the February 5, 1996, revision to its Evaporation Pond Onsite Inspection Program.</p> <p>Any time 6 inches or more of fluid is detected in a commercial pond standpipe, it shall be analyzed for specific conductance. If the water quality is degraded beyond the action level, the water shall be further sampled and analyzed for chloride, alkalinity, sodium, and sulfate. Any time 6 inches or more of fluid is detected in an R&D pond standpipe, it shall be analyzed for specific conductance, chloride, alkalinity, sodium, and sulfate.</p> <p>Upon verification of a liner leak, the licensee shall notify NRC in accordance with LC 11.6, lower the fluid level sufficiently to eliminate the leak by transferring the pond's contents to an alternate cell or approved destination, and undertake repairs, as needed. Water quality in the affected standpipe shall be analyzed for the five parameters listed above once every 7 days during the leak period and once every 7 days for at least 14 days following repairs. The licensee shall submit a corrective action plan within 30 days to NRC for review. The corrective action plan will document steps to adequately address the leak and procedures used to verify that the leak has been adequately addressed and permanently fixed. The corrective action plan should also evaluate how much and for how long the diminished waste disposal capacity will impact operations.</p>
<p><i>The following information shall be provided to NRC staff within sixty days of the effective date of this license. Upon acceptance by NRC staff, such information will become part of the licensing basis.</i></p>	
11.10	<p>The licensee shall develop a survey program for beta/gamma contamination for personnel exiting from restricted areas, and beta/gamma contamination in unrestricted and restricted areas that will meet the requirements of 10 CFR Part 20, Subpart F and submit to NRC for review and written verification.</p> <p>The licensee shall provide for NRC review and written verification the surface contamination detection capability (minimum detection concentration (MDC)) for radiation survey instruments, including scan MDC for portable instruments, used for contamination surveys to release equipment and materials for unrestricted use and for personnel contamination surveys. The detection capability in the scanning mode for the alpha and beta radiation expected shall be provided in terms of dpm per 100 cm².</p>

11.11 The licensee shall provide the following information for the airborne effluent and environmental monitoring program for which it shall develop written procedures for NRC written verification to:

- A) Discuss how, in accordance with 10 CFR 40.65, the quantity of the principal radionuclides from all point and diffuse sources will be accounted for, and verified by, surveys and/or monitoring.
- B) Evaluate the member(s) of the public likely to receive the highest exposures from licensed operations consistent with 10 CFR 20.1302.
- C) Discuss and identify how radon (radon-222) progeny will be factored into analyzing potential public dose from operations consistent with 10 CFR Part 20, Appendix B, Table 2.
- D) Discuss how, in accordance with 10 CFR 20.1501, the occupational dose (gaseous and particulate) received throughout the entire License Area from licensed operations will be accounted for, and verified by, surveys and/or monitoring.

11.11 The licensee shall provide the following information for the airborne effluent and environmental monitoring program for which it shall develop written procedures for NRC written verification to:

- A) Discuss how, in accordance with 10 CFR 40.65, the quantity of the principal radionuclides from all point and diffuse sources will be accounted for, and verified by, surveys and/or monitoring.
- B) Evaluate the member(s) of the public likely to receive the highest exposures from licensed operations consistent with 10 CFR 20.1302.
- C) Discuss and identify how radon (radon-222) progeny will be factored into analyzing potential public dose from operations consistent with 10 CFR Part 20, Appendix B, Table 2.
- D) Discuss how, in accordance with 10 CFR 20.1501, the occupational dose (gaseous and particulate) received throughout the entire License Area from licensed operations will be accounted for, and verified by, surveys and/or monitoring.

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