CBRLicenseRenPEm Resource

From: Stephen Cohen
Sent: Monday, March 30, 2009 2:26 PM
To: CrowButte-LicenseRenewal Resource
Attachments: 1998 Renewal SER.pdf; 1997 Renewal RAI.pdf; 1998 Letter from S Collings.pdf; 1998 Renewal EA.pdf

Stephen J. Cohen
Team Leader - New Facility Licensing
Office of Federal and State Materials
and Environmental Management Programs
U.S. Nuclear Regulatory Commission
Mailstop T8F5
Washington, DC 20555
301-415-7182
stephen.cohen@nrc.gov

Hearing Identifier: CrowButteUR_LicenseRenewal_Public
Email Number: 54

Mail Envelope Properties (3AF7DEF82ADA8944AD8247B7ED7FD65183A097F77B)

Subject:
Sent Date: 3/30/2009 2:26:26 PM
Received Date: 3/30/2009 2:31:08 PM
From: Stephen Cohen

Created By: Stephen.Cohen@nrc.gov

Recipients:
"CrowButte-LicenseRenewal Resource" <CrowButte-LicenseRenewal.Resource@nrc.gov>
Tracking Status: None

Post Office: HQCLSTR01.nrc.gov

Files	Size	Date & Time
MESSAGE	278	3/30/2009 2:31:08 PM
1998 Renewal SER.pdf	2104090	
1997 Renewal RAI.pdf	3064098	
1998 Letter from S Collings.pdf	221048	
1998 Renewal EA.pdf	4594963	

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

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

DOCKET NO. 40-8943

U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
Division of Waste Management

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ALARA	As low as is reasonably achievable
CBR	Crow Butte Resources, Inc.
CRSO	Corporate Radiation Safety Officer
DAC	Derived Air Concentration
EA	Environmental Assessment
FEN	Ferret Exploration Company of Nebraska, Inc.
HPT	Health Physics Technician
ISL	*in situ* leach
IX	ion exchange
LRA	license renewal application
MU	mine unit
NRC	U.S. Nuclear Regulatory Commission
PBLC	Performance-Based License Condition
PM	Plant Manager
QA	quality assurance
R&D	research and development
RWP	Radiation Work Permit
SER	Safety Evaluation Report
SERP	Safety and Environmental Review Panel
SOP	standard operating procedure
TLD	thermoluminescent dosimeter

1.0 INTRODUCTION

On December 20, 1995, Crow Butte Resources, Inc. (CBR) submitted a License Renewal Application (LRA) (CBR, 1995) for Source Material License SUA-1534 for the Crow Butte Uranium Project, which is located in Dawes County, Nebraska. In response to comments and requests for additional information from the U.S. Nuclear Regulatory Commission staff, CBR provided supplementary information by letters dated April 1, June 25, and October 31, 1997 (CBR, 1997e, 1997d, and 1997b). By letter dated July 28, 1997 (CBR, 1997c), CBR also requested several amendments to SUA-1534; the NRC staff decided, with CBR's approval, to address these requests as part of the overall license renewal process.

The information and discussion in this safety evaluation report (SER) are based on information contained in the LRA and supplements, NRC licensing actions approved since December 1995, annual "as low as is reasonably achievable" (ALARA) audit reports, and NRC inspection reports generated during the period of commercial operations at the Crow Butte site. The inspection history, conclusions, and license conditions presented here are based on NRC staff evaluations and reviews in support of performance-based licensing for the proposed license renewal.

With this license renewal, NRC will be authorizing the continuation of commercial operations under the performance-based license condition (PBLC) format. Under a performance-based license, the licensee has the burden of ensuring the proper implementation of the PBLC. The licensee may:

- Make changes in the facility or process, as presented in the application,
- Make changes in the procedures presented in the application, or
- Conduct tests or experiments not presented in the application, without prior NRC approval, if the licensee ensures that the following conditions are met:

  (1) The change, test, or experiment does not conflict with any requirements specifically stated in this license (excluding material referenced in the PBLC), or impair the licensee's ability to meet all applicable NRC regulations.

  (2) There is no degradation in the essential safety or environmental commitments in the license application, or provided by the approved reclamation plan.

  (3) The change, test, or experiment is consistent with the NRC conclusions regarding actions analyzed and selected in the accompanying environmental assessment (EA).

If these conditions are not met, the licensee is required to submit an application for a license amendment to NRC. The licensee's determinations whether the above conditions are satisfied will be made by a Safety and Environmental Review Panel (SERP).

The SERP shall consist of a minimum of three individuals employed by the licensee, with one of these designated as the SERP chairman. One member of the SERP shall have expertise in management and shall be responsible for managerial and financial approval changes; one member shall have expertise in operations and/or construction and shall be responsible for implementation of any changes; and one member shall be the corporate radiation safety officer (CRSO) or equivalent. Additional members may be included in the SERP as appropriate, to address technical aspects in several areas, such as health physics, groundwater hydrology, surface water hydrology, geology, geochemistry, and others. Temporary members, or permanent members other than the three identified above, may be consultants.

The licensee shall maintain records until license termination of any changes made pursuant to the PBLC. These records shall include written safety and environmental evaluations, made by the SERP, that provide the basis for determining that the change complies with the requirements referred to in the above conditions. The licensee shall furnish an annual report to NRC that describes such changes, tests, or experiments, including a summary of the safety and environmental evaluation of each. In addition, the licensee shall annually submit any pages of its license application that have been revised to reflect changes made under this condition.

By letter dated October 31, 1997, CBR submitted draft standard operating procedures (SOPs) for operation of the SERP. Based on its review, the staff considers that the procedures specified in these SOPs, when finalized, will provide reasonable assurance that the SERP and the PBLC process will function as NRC intends

The inspection role of NRC remains unchanged with the administration of performance-based licensing. Operational changes, regulatory commitments, and record keeping requirements implemented by CBR through the PBLC are subject to NRC inspection and possible enforcement actions.

1.1 Description of the Proposed Action

The proposed action is to renew Source Material License SUA-1534 for the continued commercial operation of the Crow Butte Uranium Project. The renewed license would authorize the facility to be operated such that the plant throughput does not exceed a maximum flow rate of 18,930 liters per minute (lpm) [5000 gallons per minute (gpm)], exclusive of restoration flow. Yellowcake production will not be authorized to exceed 907,185 kilograms (2 million pounds) annually.

1.2 Background Information

By letter dated December 20, 1995, CBR applied for a license renewal to authorize continued commercial operations at its Crow Butte *in situ* leach (ISL) facilities, located approximately eight kilometers five miles) southeast of Crawford, Nebraska. CBR submitted page changes to the LRA by letters dated April 1, June 25, and October 31, 1997. In addition, by letter dated July 28, 1997, CBR requested several amendments to SUA-1534; the NRC staff decided, with CBR's approval, to address these requests as part of the overall license renewal process.

SUA-1534 was issued initially to Ferret Exploration Company of Nebraska, Inc. (FEN) on December 29, 1989, for the commercial operation of the Crow Butte Uranium Project. FEN operated the project until May 1994 when the company name was changed to Crow Butte Resources, Inc.. This change was only a name change and did not involve a change in ownership. CBR conducts its operations within a permit area that encompasses all or portions of Sections 11, 12, and 13 of Township 31N, Range 52W and in Sections 18, 19, 20, 29, and 30 of Township 31N, Range 51W, Dawes County, Nebraska. The process plant is located in Section 19 of Township 31N, Range 51W.

Since 1989, CBR has used *in situ* methods in a commercial operation to leach and recover uranium contained in the Basal Chadron Sandstone, at depths ranging from 122 to 244 meters (400 to 800 feet) over the permit area. The overall width of the mineralized area varies from approximately 305 to 1525 m (1000 to 5000 ft). The orebody ranges in grade from less than 0.05 to greater than 0.5 percent U_3O_8 and 0.31 percent chemical U_3O_8. The permit area covers approximately 1130 hectares (ha) (2800 acres), while the surface area to be affected over the projected life of the project is estimated at 200 ha (500 acres). Figure 1-1 is a regional location map. Figure 1-2 is a map of the project area.

1.3 Review Scope

The safety review of CBR's request for license renewal included evaluations of (1) the renewal application dated December 20, 1995; (2) supplementary information submitted by letters dated April 1, June 25, July 28, and October 31, 1997; (3) the compliance history for the Crow Butte facility since the issuance of SUA-1534 in December 1989; and (4) the monitoring data required under SUA-1534.

CBR's proposed programs were evaluated also against NRC regulations, as specified in 10 CFR Parts 20 and 40, and applicable NRC staff guidance.

2.0 AUTHORIZED ACTIVITIES

Currently, CBR is authorized to recover uranium from the orebody, at a maximum rate of 18,930 lpm (5000 gpm), exclusive of restoration flow, using a lixiviant composed of native groundwater, with added sodium carbonate/bicarbonate and oxygen or hydrogen peroxide.. CBR's yellowcake production is limited to 907,185 kg (2 million pounds) per year

2.1 Facility Description

The CBR facility and associated wellfields are located in west-central Dawes County, Nebraska, just north of the Pine Ridge area, approximately eight km (five mi) southeast of the town of Crawford, via Squaw Creek Road. Research and development (R&D) operations were conducted between July 1986 and December 1988. Commercial operations commenced in December 1989, and to date, five mine units (MUs) have been developed, with a sixth constructed and ready to operate. The surface area of the project site is approximately 1130 ha (2800 acres), of which an estimated 200 ha (500 acres) will be disturbed during the life of the project.

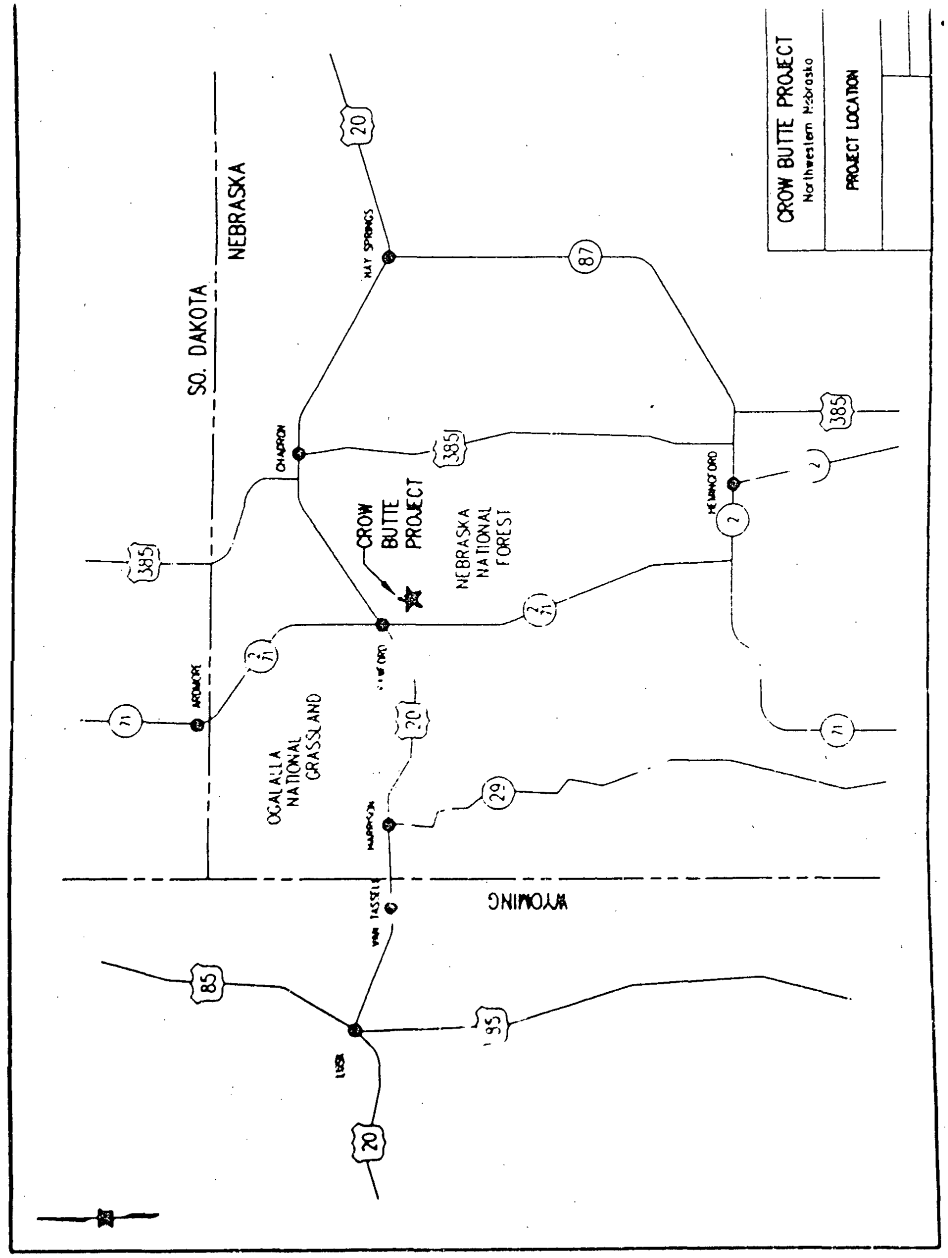


Figure 1-1. Location of the Crow Butte uranium *in situ* leach project (from CBR, 1995)

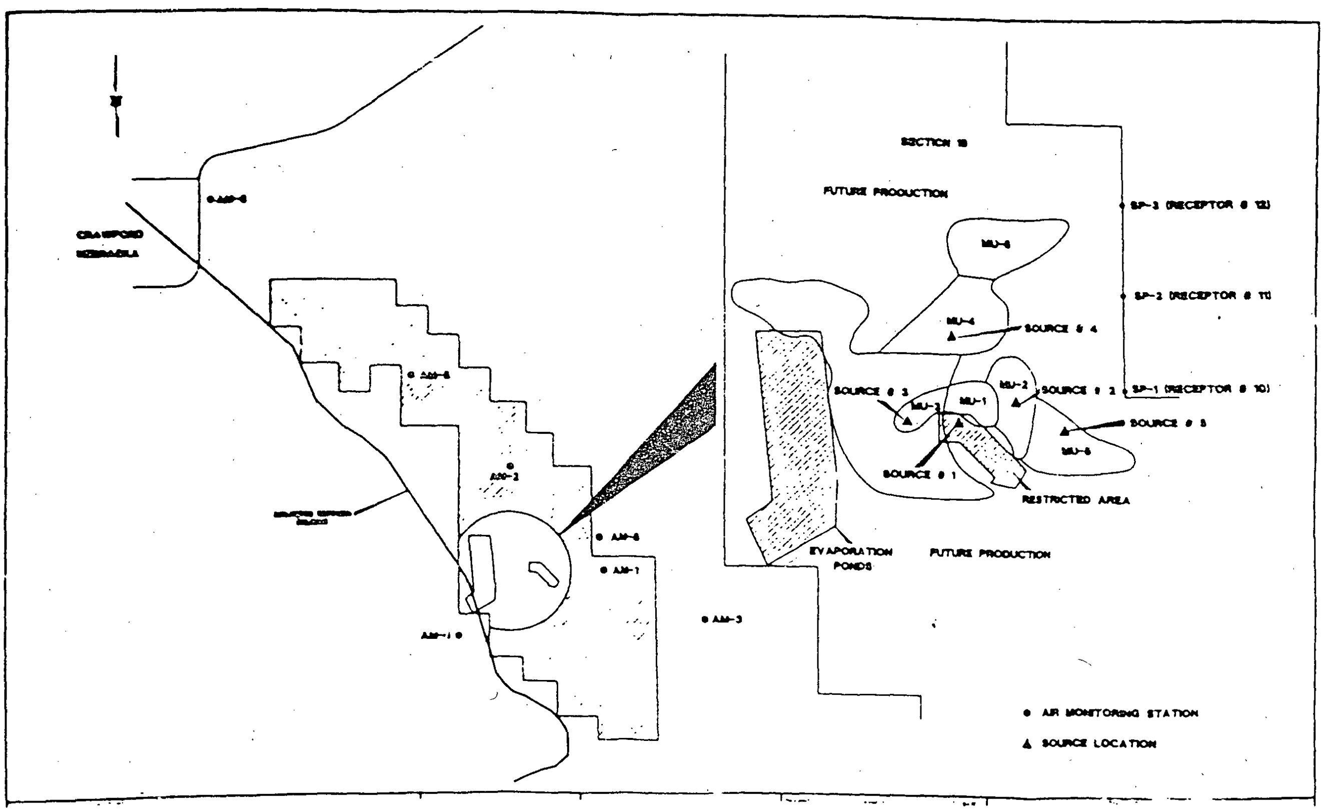


Figure 1-2. Locations of mine units 1 through 5 at the Crow Butte uranium *in situ* leach project (from CBR, 1995)

Liquid wastes produced by operations may be disposed by any of three approved methods: (1) in solar evaporation ponds, (2) through land application, or (3) down a deep injection well. Solid wastes (e.g., piping, valves, filters) are decontaminated, if possible, and released for unrestricted use, or, if unable to be decontaminated, sent to a facility licensed to accept 11e.(2) byproduct material for disposal.

2.2 Operations

During commercial operations, injection, recovery, and monitoring wells are installed in the ore zone. Within an MU, the geometric arrangement of the injection and recovery wells depends on the orebody configuration, aquifer permeability, and operator preference. The ore is extracted typically through the use of a series of five- or seven-spot patterns installed over the mineralized section of the formation. A single five-spot pattern is roughly rectangular in shape and consists of four injection wells surrounding a single central recovery well. The distance between the wells in any five-spot pattern will range from 12 to 36 m (40 to 100 ft), depending on the topography and ore characteristics. Each MU contains a number of wellfield houses (from two to seven per MU) where trunklines from the processing plant and injection and recovery solutions are distributed to the wells.

CBR injects local groundwater, with an added oxidant (oxygen or hydrogen peroxide) and a complexant (sodium carbonate/bicarbonate), into the mineralized zone through the injection wells. With slight pH adjustments, the uranium in the formation is oxidized and dissolved by complexation with the carbonate, and the resultant uranium-rich solution is drawn to the recovery wells, where it is pumped to the surface and transferred to the processing plant. In the plant, the uranium is removed from the solution by adsorption onto ion exchange (IX) resin, which is contained in IX columns. The now barren solution is recharged with oxidant and carbonate and reinjected into the ore zone for additional uranium recovery.

Once the majority of the IX sites on the resin have been filled with uranium, the column is taken off-stream. The loaded column is then stripped of uranium through an elution process in which the uranium-carbonate complex is eluted from the resin beads using a concentrated chloride solution. After the uranium has been stripped, the resin is rinsed with a sodium bicarbonate solution to convert the resin to a carbonate form and to control the chloride buildup in the processing circuit. The product of elution is a so-called "pregnant" (i.e., uranium-rich) eluant that is discharged into a holding tank. When a sufficient volume of pregnant eluant is held in storage, it is acidified to break down the uranyl carbonate complex ion that has been created. The solution is agitated to remove the resulting carbon dioxide gas (CO_2), and then hydrogen peroxide is added to precipitate the uranium. The precipitated uranyl peroxide slurry (yellowcake) is pH-adjusted and allowed to settle. The yellowcake is further dewatered and washed using a vacuum belt filter, and then dried in a vacuum dryer and packaged in 208-liter (55-gallon) drums for future shipment.

The general process circuit configuration is shown in Figure 2-1. The general layout of the processing plant is shown in Figure 2-2. The configuration of this process circuit has been reviewed by the NRC staff, and it represents a typical circuit for this type of operation.

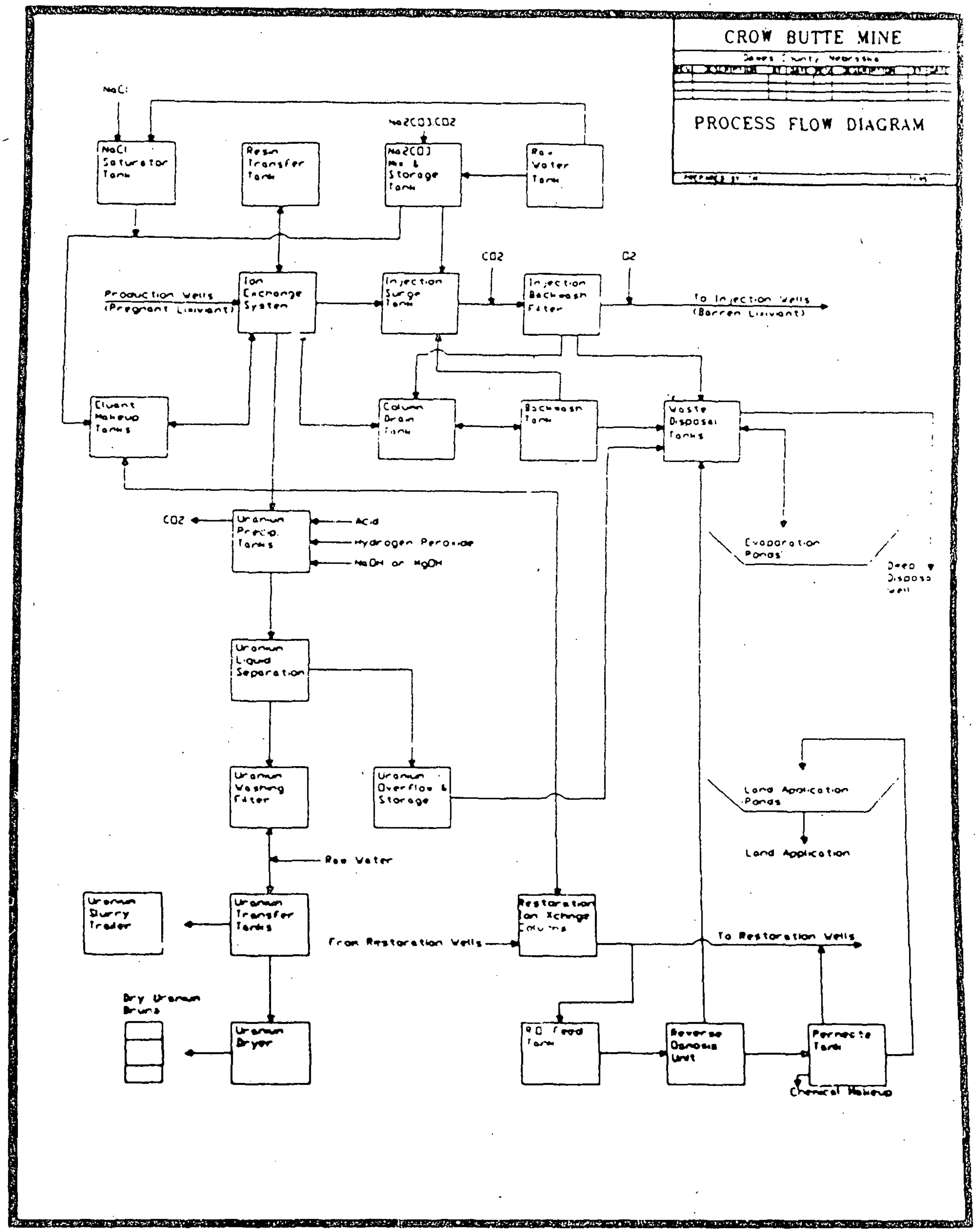


Figure 2-1. Process flow sheet (CBR, 1995)

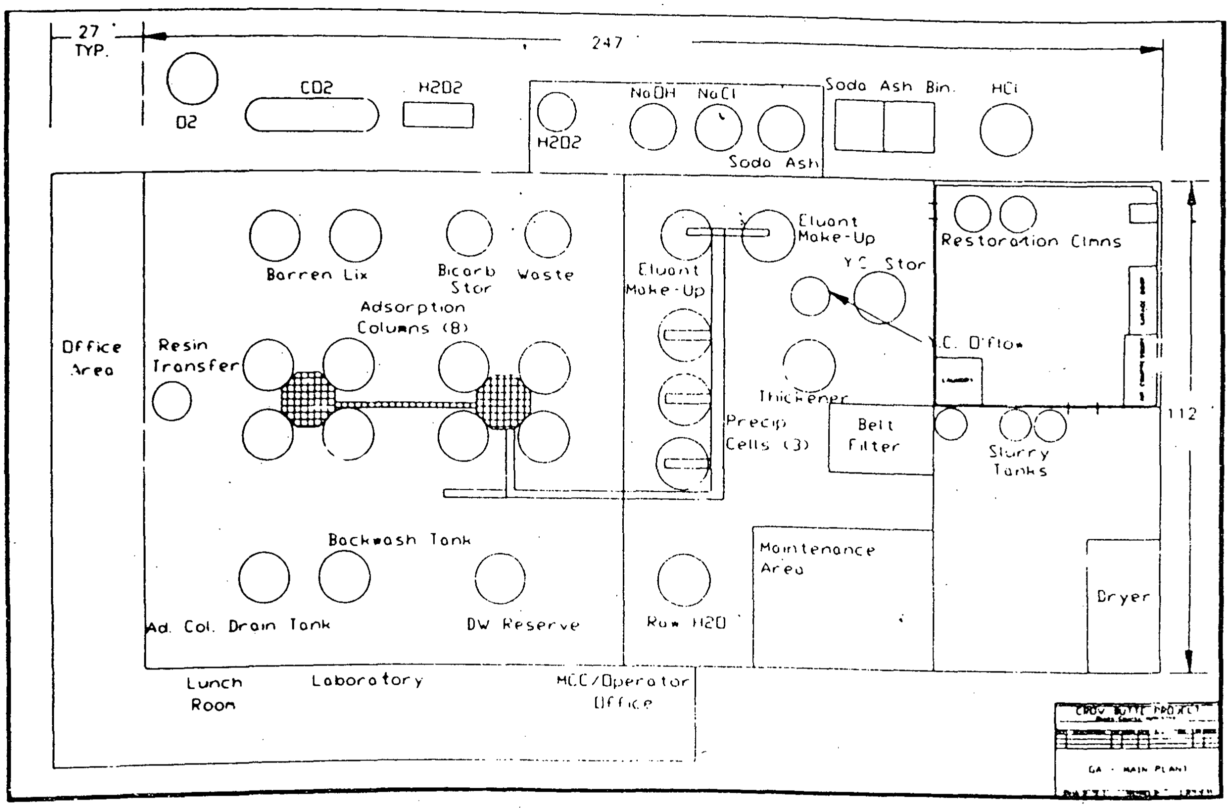


Figure 2-2. General arrangement: main processing facility (CBR, 1995)

CBR may make changes to the process circuit in accordance with the PBLC, as long as the changes do not degrade the essential safety commitments made in the LRA and do not impair CBR's ability to meet all applicable NRC regulations.

3.0 FACILITY ORGANIZATION AND ADMINISTRATIVE PROCEDURES

3.1 Organization

A partial organization chart of CBR which depicts the relationships of the organizational components responsible for operations, environmental protection, and radiation safety at the Crow Butte site is shown in Figure 3-1.

The overall responsibility for the radiation protection, environmental, and safety activities at the Crow Butte facility, as well as for all company commercial production facilities, resides with the president of CBR. This individual also is responsible for license development and modifications.

The CBR vice president is responsible for all uranium production activity at the project site. The vice president reports directly to the president, and will perform the duties of the president in the event of absence or disability of the president.

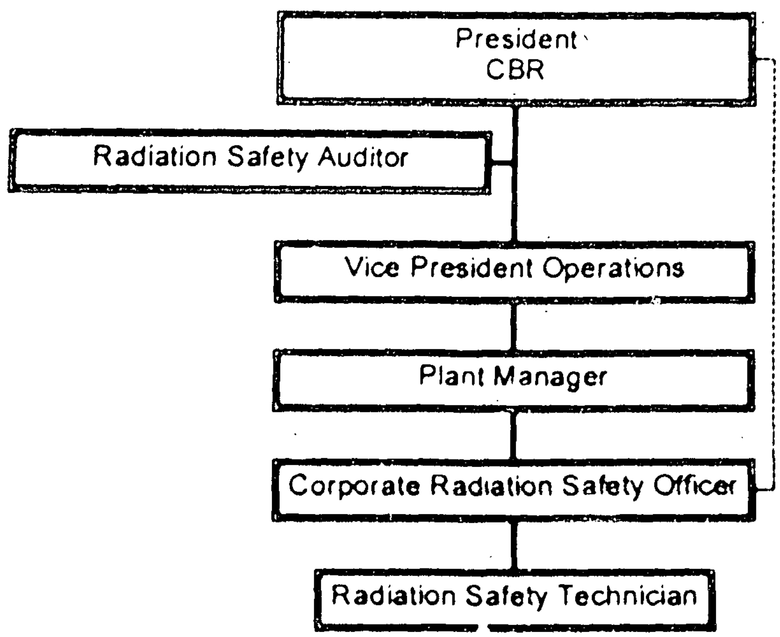


Figure 3-1. Crow Butte Resources organizational chart (CBR, 1997b)

The plant manager (PM) has direct oversight of the facility operations, including yellowcake handling procedures. The PM also is responsible for ensuring that any procedures or actions implemented by the Corporate Radiation Safety Officer (CRSO) or the vice president to correct or prevent radiation hazards are carried out. The PM supervises the CRSO to ensure that radiation safety programs are conducted in a manner consistent with regulatory requirements.

The CRSO is responsible for the development, administration, and enforcement of all radiation safety programs and the implementation of all on-site environmental and safety programs, including emergency procedures. This individual also makes recommendations to improve any and all radiological safety-related controls. The CRSO reports to the PM, but also has the responsibility to advise the President on matters involving radiation safety and to implement changes and/or corrective actions involving radiation safety, which have been authorized by the President.

The staff previously reviewed this organizational structure and found it to be in accordance with 10 CFR Part 20 and within the staff's recommendations in Regulatory Guide 8.31 (NRC, 1983a) (see Amendment 26 to SUA-1534; December 29, 1994). The staff will continue to require, by license condition, that any organizational change that affects assignments or reporting responsibilities of the radiation safety staff conform to the staff's recommendations in Regulatory Guide 8.31.

3.2 Radiation Safety Staff and Responsibilities

As stated above, the CRSO is responsible for the development, administration, and enforcement of all radiation protection programs and the implementation of all on-site environmental and safety programs, including emergency procedures at the Crow Butte site. In addition, the CRSO is authorized to conduct inspections and to immediately order any change necessary to preclude or eliminate radiation safety hazards and/or maintain regulatory compliance. The CRSO has overall responsibility for the collection and interpretation of employee exposure-related monitoring data, which includes data from both the radiological and industrial safety monitoring programs. The CRSO also makes recommendations to the PM to improve safety-related controls. The CRSO has no direct production-related responsibilities.

The Health Physics Technician (HPT) assists the CRSO with implementation of the radiological and industrial safety programs. The HPT is responsible for the collection and interpretation of data related to the environmental and radiological safety monitoring programs. The HPT assists the CRSO in the regular inspections of the facility as part of the radiation safety monitoring program. The HPT reports to the CRSO.

The staff finds that the radiation safety staff positions and responsibilities are in accordance with guidance in Regulatory Guide 8.31 and are therefore acceptable. However, due to the importance of these positions, the staff will continue to require, by license condition, that the CRSO and HPT meet initial specified qualifications and receive appropriate refresher training.

3.3 Minimum Technical Qualifications for Radiation Safety Staff

CBR proposes the following minimal qualifications and experience for personnel engaged in developing, conducting, and administering the Crow Butte Uranium Project radiation safety program.

3.3.1 Corporate Radiation Safety Officer

CBR states that the CRSO will meet certain minimum qualifications. The qualifications identified by the licensee are identical to those recommended by NRC in Regulatory Guide 8.31. RSO qualifications in Regulatory Guide 8.31 include: (1) a bachelor's degree in the physical sciences, industrial hygiene, or engineering, or an equivalent combination of training and relevant experience in uranium mill radiation protection; (2) appropriate health physics experience; (3) specialized classroom and biannual refresher training; and (4) appropriate specialized knowledge.

3.3.2 Health Physics Technician

CBR proposes that HPTs have either of two specific combinations of education, specialized training, and appropriate work experience. As with the required qualifications for the CRSO, the combinations identified by CBR are consistent with the staff's recommended combinations of education, training, and experience for HPTs in Regulatory Guide 8.31.

The staff finds the above qualifications for the CRSO and the HPT to meet its recommendations in Regulatory Guide 8.31, and to be, therefore, acceptable.

3.4 Administrative and Operation Procedures

Process activities, including those involving radioactive materials, are conducted in accordance with written standard operating procedures (SOPs). SOPs have been developed also for non-process activities addressing environmental monitoring, health physics procedures, emergency procedures, and general safety. SOPs are revised as necessary to meet changes in operations or regulatory requirements. The CRSO and appropriate management supervisors review and approve all SOPs prior to their implementation, with the CRSO's focus specifically on the radiological protection aspects of the proposed SOP. In addition, the CRSO reviews all SOPs on an annual basis. Up-to-date copies of the applicable SOPs are kept in the plant areas where they are used for easy access by company employees.

Due to the importance placed on SOPs, NRC will continue to require, by license condition, that CBR establish and follow written SOPs for all operational process activities involving radioactive materials that are handled, processed, or stored, and for non-operational activities which address in-plant and environmental monitoring, bioassay analyses, and instrument calibrations. The CRSO will continue to be required to document the review of all existing operating procedures on at least an annual basis.

The CRSO, or an appropriately trained designee, will issue Radiation Work Permits (RWPs) whenever non-routine work or maintenance activities to be carried out involve the potential for radiation exposure. The RWP will specify the necessary radiological safety precautions, equipment, and/or specialized clothing, and any radiological surveys required for performing the activity. CBR's current license also requires that the RWP describe the scope of the work to be performed, and that all RWPs be accompanied by a breathing zone air sample or an applicable area air sample. Due to the potential health and safety hazards associated with non-routine operations, NRC will retain these conditions in the renewal license.

During 1996, CBR issued 16 RWPs, with the majority issued for maintenance of the yellowcake dryer or for repairs to the manifold systems in the IX columns.

The staff finds that CBR's commitments regarding administrative and operating procedures, as well as RWPs, are in accordance with Regulatory Guide 8.31, and are therefore acceptable.

3.5 Audits and Inspections

3.5.1 Inspections

On a daily basis, CBR proposes that the CRSO, HPT, or a qualified designated operator, conduct a visual walk-through inspection of the plant facility to check for compliance issues and any other problems. The results of this inspection are reviewed with the PM. Monthly, the CRSO will document in a report a review of all monitoring and exposure data for the month, a summary of all pertinent radiation survey records, a discussion of any trends in the ALARA program, and a review of the adequacy of the implementation of the NRC license conditions. In addition, the CRSO will make recommendations for any corrective actions or improvements in the process or safety programs. An audit of the ALARA program (see Section 3.5.2) and of the Quality Assurance/Quality Control program will be conducted on an annual basis.

In addition to the inspections and reviews proposed by CBR, the staff, in Regulatory Guide 8.31, recommends weekly inspections by the CRSO and plant superintendent to observe general radiation practices and to review required changes in procedures and equipment. All daily and weekly inspections should be documented, and the monthly summaries should review the results of the weekly, as well as the daily, inspections. Therefore, the NRC staff will require, by license condition, that CBR conduct these inspections, in addition to its proposed program, and document them as discussed above. CBR agreed to this condition, by telephone, on February 20, 1998.

In addition, NRC will continue to require, by license condition, that the results of sampling, analyses, surveys and monitoring, reports on audits and inspections, and investigations and corrective actions all be documented. All such documentation will continue to be required to be maintained for a period of at least five years.

The staff finds that CBR's proposed in-plant inspection program, as modified by the staff, is in accordance with Regulatory Guide 8.31. Therefore, the program is acceptable to the staff.

3.5.2 ALARA Audit

CBR commits to conducting an annual audit of the radiation protection and ALARA program, in accordance with the recommendations in NRC Regulatory Guide 8.31. This audit may be performed by an outside radiation safety auditing service. The auditing service will be qualified in radiation safety procedures as well as the environmental aspects of ISL mining operations. The results of the audit will provided to corporate management, who will implement recommendations in the audit report, as necessary, after consultation with the auditor and the CRSO. The CRSO may accompany the auditor, but will not participate in the audit.

Currently, CBR is required, by license condition, to submit a copy of the annual ALARA audit to NRC. In the renewal license, NRC will require instead that a copy of the audit be retained on-site for NRC inspection. However, NRC will continue to require, by license condition, that the audit report contain a summary of the daily walk-through inspections.

Therefore, the staff finds CBR's proposed annual ALARA audit program, as modified, to be in accordance with Regulatory Guide 8.31; and therefore acceptable.

3.6 Radiation Safety Training

All site employees and contracted personnel (when present at the Crow Butte Uranium Project) are administered a training program based upon the CBR radiation safety training plan covering radioactive material handling and radiological emergency procedures. Topics identified in the LRA as being addressed in this training program are generally consistent with the topics recommended by the staff to be covered in Regulatory Guide 8.31. The training will address topics in the areas of facility-provided protection, health protection measurements, radiation protection regulations, and emergency procedures. However, CBR did not identify appropriate fundamentals of health protection topics to be included in the training program. As recommended in Regulatory Guide 8.31, these should include (1) the radiologic and toxic hazards of exposure to uranium and its daughter products, (2) the ways in which uranium and its daughters can enter the body, and (3) the reasons why exposures to uranium and its daughters should be kept ALARA. Because these topics are essential to a radiation safety training program, the staff will require, by license condition, that CBR's training program address the topics identified in Regulatory Guide 8.31. CBR agreed to this license condition, by telephone, on February 20, 1998.

The technical content of the training program is the responsibility of the CRSO. Training is conducted by the CRSO or by a qualified designee. All new workers, including supervisors, are given specialized instruction on the health and safety aspects of the specific jobs they will perform. This instruction is done in the form of individualized on-the-job training. Retraining is done annually and is documented. Every two months, all workers attend a general safety meeting. Additionally, the licensee is required to document all training and maintain the records on file for a period of at least five years.

The staff finds CBR's radiation safety training program, as modified, to be in accordance with Regulatory Guide 8.31, and is therefore acceptable.

4.0 RADIATION SAFETY CONTROLS AND MONITORING

4.1 Ventilation and Effluent Control

At the Crow Butte site, radon from the production solutions is the only radioactive gaseous effluent. Radon gas will be released primarily from solution in the IX columns and in the injection surge tanks. At the processing facility, radon-222 is vented from recovery surge tanks and the IX columns into a manifold that is exhausted to the atmosphere outside the plant via an induced draft fan. In addition, the plant building is equipped with general area exhaust fans to avoid the buildup of radon gas in working areas. Radon exposures in working areas are monitored (see Section 4.2) to ensure exposures are in compliance with 10 CFR Part 20 limits. No uranium particulate emissions are expected from drying operations, because CBR uses vacuum dryer technology.

The staff considers the in-plant ventilation and effluent control systems to be acceptable for maintaining employee exposures ALARA.

4.2 In-Plant Monitoring Data

Area airborne sampling for uranium particulates is conducted, on a monthly basis, at the four locations shown in Figure 4-1. In addition, samples are taken in the dryer room during dryer operations and when RWPs are issued for this area. Average annual and maximum monthly gross alpha activity results from 1990 to 1996 were below 25 percent of the Maximum Permissible Concentration or the Derived Air Concentration (DAC) (after January 1, 1994) specified in 10 CFR Part 20.

Currently, CBR is required, by license condition, to increase the sampling frequency to weekly in any area that meets the definition of an "airborne radioactivity area" as defined in 10 CFR 20.1003, to investigate the cause of the elevated uranium levels, and to report the results of the investigations to NRC. The only area that presently meets this definition at the Crow Butte processing facility is the dryer room during yellowcake packaging operations. Due to consistently low airborne radioactivity levels in the plant over the period of commercial operations, NRC will drop this condition from the renewal license.

CBR conducts radon daughter surveys on a monthly basis at 11 in-plant sampling locations (Figure 4-1) and at an additional location in the reverse osmosis building. During commercial operations, the action level of 0.08 WL has been exceeded on several occasions. CBR conducted appropriate investigations and corrective actions to address these situations. Average monthly and annual radon daughter activities during the period of commercial operations have been less than 25 percent of the maximum permissible exposure limit or the DAC (after January 1, 1994).

4.3 Personnel Monitoring Data

CBR's calculation of its employee's internal exposure to radon or its daughters and to uranium is based on a time-weighted exposure calculation incorporating a consideration of both occupancy time and average airborne concentration. Occupancy factors are determined from

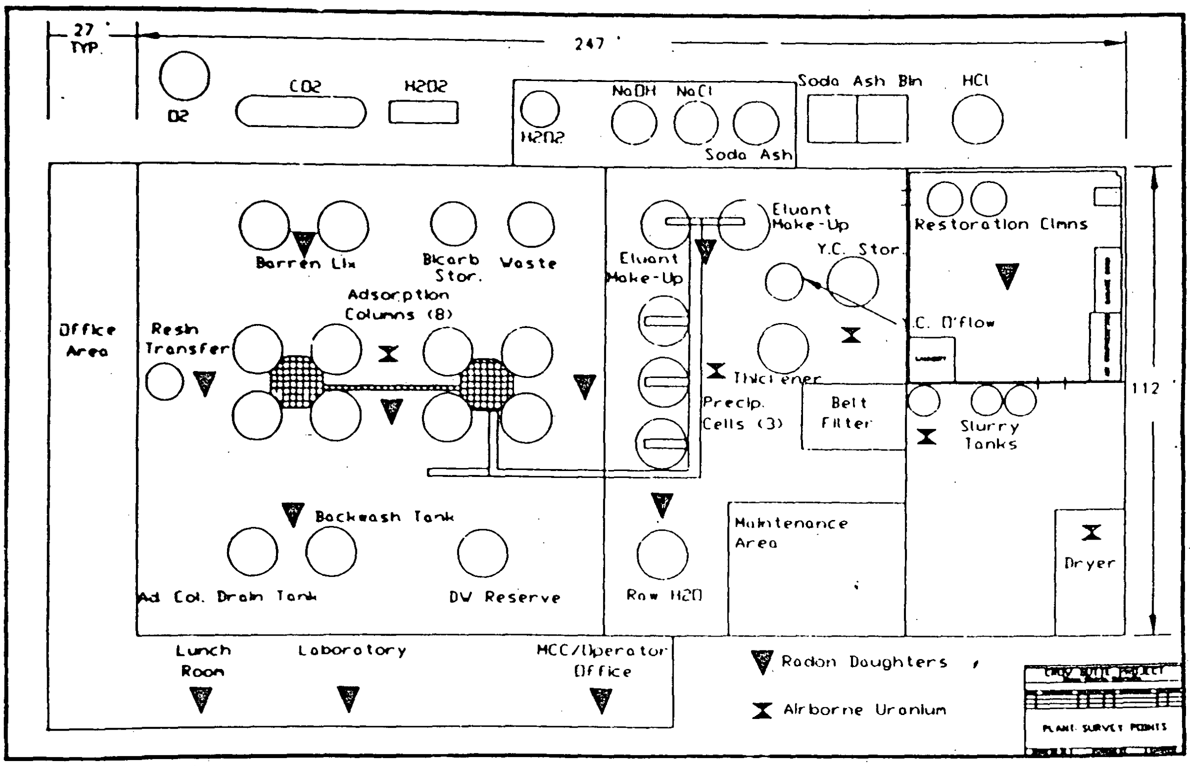


Figure 4-1. Proposed survey and sampling locations (CBR, 1997d)

actual time card data or may be based upon a time study approach. CBR assumes 100 percent occupancy times in determinations of routine worker exposures, and exposures during non-routine work are based on the actual time spent in completing the work. As described in Section 4.2, average airborne concentrations of uranium and of radon or its daughters will be determined based upon monthly air samples.

The licensee currently is required, by license condition, to perform and document internal occupational exposure calculations within one week of the end of each monitoring period, as specified in 10 CFR 20.1201. Furthermore, routine radon daughter and particulate samples were to be analyzed in a timely manner to allow exposure calculations to be performed. Finally, non-routine samples were required to be analyzed and results will be reviewed by the CRSO within two working days after sample collection. With this license renewal, NRC will drop these conditions as the requirements concerning internal occupational dose calculations are specified in 10 CFR Part 20.

CBR is required currently, by license condition, to have the HPT investigate an employee's work record and exposure history to identify the source of an exposure that reaches or exceeds 25 percent of the maximum permissible exposure limits specified in 10 CFR Part 20. CBR also is required to take the necessary corrective actions to the ensure reduction of future exposures to ALARA, to maintain records of these investigations, and to furnish the results to NRC in the annual ALARA audit report. With this renewal, NRC will drop this condition from the license, as licensees are required already under 10 CFR 20.1101 to implement a program that maintains occupational doses ALARA.

The staff finds that CBR's program to assess personnel internal exposures is acceptable for maintaining exposures ALARA and demonstrating compliance with the exposure limits in 10 CFR Part 20, Subpart B. CBR's exposure calculation methodologies are in accordance with Regulatory Guide 8.30, "Health Physics Surveys in Uranium Mills" (NRC, 1983b), and are therefore acceptable.

4.4 External Radiation Control Program

4.4.1 External Radiation Surveys

Gamma surveys are performed quarterly in designated radiation areas and semiannually in all other areas of the plant. A radiation area is established if results of the gamma survey exceed an action level of 5.0 mR/hr for worker-occupied stations. If this action level is exceeded, an investigation is performed to determine the source of the radiation, and the gamma survey frequency is increased to quarterly. Access to radiation areas is limited, and the areas are posted as required in 10 CFR 20.1902. Currently, within the processing plant and the reverse osmosis building, there are a total of five areas that are designated as radiation areas.

The staff finds that CBR's gamma survey program is in accordance with Regulatory Guide 8.30 and is therefore acceptable.

4.4.2 **Exposure to External Radiation**

Until the end of 1995, all full-time employees working in the process facility or wellfield operations were issued thermoluminescent dosimeters (TLDs) for determination of personal gamma exposure. However, based on operational data since 1990, which indicated that maximum individual annual exposures were less than 10 percent of the limits in 10 CFR 20.1201(a), CBR discontinued issuing TLDs to employees who do not regularly enter the process facility, while continuing to issue TLDs to process workers. TLDs are exchanged and read on a quarterly basis.

10 CFR 20.1502(a)(1) requires licensees to monitor occupational exposures to radiation and to supply and require the use of individual monitoring devices by adults likely to receive, in one year from sources external to the body, a dose in excess of 10 percent of the limits in 10 CFR 20.1201(a) (i.e., a limit of 0.005 Sieverts (Sv) [500 millirems (mrem)] per year). Operational data from 1990 to 1996 indicates that the highest annual external occupational exposure at the Crow Butte Uranium Project was 0.00495 Sv (495 mrem), which is just below the 10 percent limit. CBR proposes to continue monitoring workers in the process plant who are likely to receive higher doses than wellfield construction workers and other employees who do not enter the process plant regularly.

The staff finds that CBR's program to monitor external radiation exposures to personnel is in accordance with 10 CFR 20.1502(a)(1) and Regulatory Guide 8.30 and therefore is acceptable.

4.5 Internal Radiation Control Program

4.5.1 **Airborne Radiation Surveys**

As discussed in Section 4.2, area airborne sampling for uranium particulates is conducted, on a monthly basis, at the four locations shown in Figure 4-1. In addition, samples are taken in the dryer room during dryer operations and when RWPs are issued for this area. CBR collects samples in accordance with an applicable SOP using a regulated air sampler, which is calibrated every six months. Measurements are made by performing gross alpha counting of a glass fiber filter. CBR also takes breathing zone samples using an MSA pump or equivalent, to assess individual exposures to airborne uranium during certain operations. The sample results are compared with the DAC for soluble natural uranium (classification D). CBR has instituted an action level of 25 percent of the DAC, such that if sample results exceed this value, an investigation is implemented.

CBR conducts radon daughter surveys on a monthly basis at the 11 in-plant sampling locations shown in Figure 4-1, and at an additional location in the reverse osmosis building. Samples are collected using a low-volume air pump and analyzed with an alpha scaler using the Modified Kusnetz method (ANSI-N 13.8-1973). The samplers are calibrated every six months. CBR has established an action level of 25 percent of the DAC, or 0.08 Working Levels, for the in-plant locations. Survey results in excess of the action level will result in an investigation of the cause and an increase of sampling frequency to weekly until radon daughter levels do not exceed the action level for four consecutive weeks.

The staff finds that CBR's program for airborne particulate monitoring is in accordance with Regulatory Guide 8.25, "Air Sampling in the Workplace" (NRC, 1992), and therefore is acceptable.

4.5.2 Exposure to Internal Radiation

Radiation exposures at the various work stations are primarily a function of the time spent at the station and the concentration of radioactive material present. As previously discussed, the licensee has provided venting of the facility and uses a vacuum dryer to significantly reduce the concentration of airborne radioactivity. A vacuum dryer has the advantage that the product is isolated from the operator, as well as from the environment, through the utilization of a negative pressure chamber that is not connected with a heat source. As discussed in Section 4.2, CBR has proposed monthly sampling for uranium particulates in the processing plant. Additionally, general air sampling and breathing zone samples are taken during operations in the dryer room and the packaging area to estimate possible internal radiation exposure.

Exposure calculations are made using the intake method given in Section 2 of Regulatory Guide 8.30. Historical data taken during the period of commercial operations (1990-1996) indicate that the maximum annual individual internal exposure from airborne natural uranium and, separately from radon and its daughter elements, were less than five percent and fifteen percent, respectively, of the applicable regulatory limits.

The staff finds that CBR's internal radiation control program is in accordance with Regulatory Guide 8.30, and is therefore acceptable.

4.5.3 Respiratory Protection Program

CBR has implemented a respiratory program in accordance with the staff's guidance provided in Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection" (NRC, 1976) and has developed a series of implementing SOPs which address, among other things:
(1) respirator selection, (2) fit testing, and (3) maintenance, cleaning, decontamination, and storage of respirators. The program is administered by the CRSO. RWPs for non-routine work or maintenance also may require the use of respirators.

The staff finds that CBR's respiratory protection program is in accordance with Regulatory Guide 8.15 and is therefore acceptable.

4.6 <u>Bioassay</u>

CBR has implemented a bioassay program to meet the staff's guidance provided in NRC Regulatory Guide 8.22 (Rev. 1), "Bioassay at Uranium Mills" (NRC, 1988). The primary purpose of the bioassay program is to detect uranium intake by employees who are exposed regularly to uranium. CBR's program involves: (1) the collection of baseline urinalysis samples from all new employees; (2) the quarterly collection and analysis of urine samples from workers whose routine work assignments require them to enter areas where there is a potential for yellowcake inhalation; (3) the analysis of samples collected from workers who have the potential for exposure to dried yellowcake on a monthly basis; (4) annual sampling of wellfield construction and operations personnel with little or no potential for exposure to airborne uranium; and (5) an exit bioassay upon termination of employment.

The samples are analyzed by an outside analytical laboratory, with blank and spiked samples submitted along with the employee samples as part of CBR's quality assurance (QA) program. CBR has committed to using the action levels for urinanalysis specified in Table 1 of Regulatory Guide 8.22.

CBR is required currently to perform all *in vivo* measurements in accordance with Revision 1 of Regulatory Guide 8.22. Because CBR did not address these measurements in the LRA, NRC will retain this condition in the renewal license.

Currently under SUA-1534, CBR is required to document the corrective actions taken if urinanalysis or *in vivo* action levels have been reached or exceeded, and to submit this documentation to NRC within 30 days of reaching or exceeding the action level. With this renewal, NRC will drop this condition. Instead, the staff will review bioassay results and any follow-on actions during site inspections.

Historical bioassay data taken during commercial operations show that all but five samples were below the detection limit of 5 µg/L; the highest value of 13.9 µg/L was recorded in 1994. Followup resamples for those exceeding the detection limit were below 5 µg/L.

The staff finds that CBR's bioassay program, as modified by the staff, is in accordance with Regulatory Guide 8.22, and is therefore acceptable.

4.7 Contamination Control

4.7.1 Personnel Contamination

CBR requires all employees leaving the restricted area to monitor themselves for alpha contamination, in accordance with NRC Regulatory Guide 8.30. Employees are trained in the methods for performing surveys of skin and clothing. As currently required under SUA-1534, employees are required to decontaminate themselves and re-survey, if monitor results indicate that alpha levels are above 1000 disintegrations per minute per 100 square centimeters (dpm/cm^2). In addition, if decontamination to below 1000 dpm/100 cm^2 cannot be accomplished, the employee is required to report the incident to the CRSO for investigation. CBR did not specifically address the current conditions in the LRA. Therefore, the staff will retain these conditions in the renewal license.

In accordance with Regulatory Guide 8.30, CBR also conducts and documents quarterly unannounced spot checks of personnel to verify the effectiveness of the personnel contamination program.

The staff finds that CBR's proposed personnel contamination control program is in accordance with Regulatory Guide 8.30, and is therefore acceptable.

4.7.2 Surface Contamination

CBR states that it conducts surveys for surface contamination in operating areas, designated eating areas, change rooms, and office areas, in accordance with NRC Regulatory Guide 8.30. In addition, CBR has set action levels for non-operating areas at 25 percent of the limits specified in Table 1 of Regulatory Guide 8.30.

Because the staff recommends in Regulatory Guide 8.30 that operating areas with surface contamination levels exceeding specified limits be cleaned promptly and CBR has committed to conducting its surveys in accordance with the regulatory guide, the staff will drop from the renewal license a current license condition requiring CBR to initiate and document cleanup efforts within 24 hours in the event that action levels are exceeded.

The staff finds that CBR's surface contamination control program is in accordance with Regulatory Guide 8.30, and is therefore acceptable.

4.7.3 Disposal of Contaminated Equipment

With the exception of small hand-carried items, which are surveyed during personnel surveys, CBR conducts surveys of all items leaving the restricted area. These surveys are performed by the CRSO, the radiation safety staff, or by properly trained employees. As specified in the LRA, release limits for all items from the restricted area are set in accordance with "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct or Source Materials" (NRC, 1984). This guidance document was updated in May 1987 (NRC, 1987), and therefore, the licensee will be required to follow this more recent version, or a suitable alternative procedure approved by NRC prior to any such release. CBR agreed to this license condition, by telephone, on November 10, 1997.

Records of equipment and corresponding contamination levels will be maintained for all items released from the site. Any item having contamination levels that exceed regulatory limits will be disposed of at a site licensed to receive byproduct waste materials. Transportation of all material to the byproduct disposal facility will be handled in accordance with U.S. Department of Transportation and NRC regulations (49 CFR 173.389 and 10 CFR Part 71, respectively).

The staff finds that CBR's program for release of contaminated equipment is in accordance with NRC guidelines and is therefore acceptable.

4.8 <u>Quality Assurance and Calibration</u>

By license condition, CBR is required currently to calibrate all radiation and environmental monitoring, sampling, and detection equipment (1) following any repairs, and (2) as recommended by the manufacturer or semiannually whichever is more frequent. With this renewal, the licensee has proposed modifying the second part of this requirement to allow recalibration on an annual basis, rather than semiannually. The staff finds CBR's proposal to be consistent with the staff's guidance provided in Regulatory Guide 8.30, and therefore, acceptable. CBR will continue to be required, by license condition, to have all radiation survey instruments operationally checked with a radiation source each day when in use.

CBR also will continue to be required, by license condition, to establish and follow written SOPs for instrument calibration, and separately, to document and maintain records of radiation detection and environmental monitoring equipment calibration for a period of at least five years

The CBR QA and instrument calibration program proposes procedures and policies for the effluent and radiological monitoring programs. The QA program is based on guidance provided in Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations)—Effluent Streams and the Environment," Revision 1 (NRC, 1979).

The staff finds that the CBR QA and instrument calibration programs are in accordance with Regulatory Guides 4.15 and 8.30, and are therefore acceptable.

5.0 RESTRICTED AREA MARKINGS AND ACCESS CONTROL

CBR controls access to the site by way of fences, posted warning signs, and gates. The gate along the access route to the plant can be locked, and the site perimeter is posted in accordance with 10 CFR 20.1902(e). Security for the site is provided by personnel working at the facility, with access to the restricted area limited to authorized personnel only. All plant personnel are instructed to immediately report any suspected unauthorized persons to their supervisors. The supervisors are responsible for verifying that the person(s) have been authorized for entry, and unauthorized persons are escorted off the site.

All visitors entering the restricted area are required to register at the main office and are not permitted inside the plant area without authorization from designated supervisory personnel. Visitors who have not received formal training will be escorted while on-site by properly trained personnel. The current boundaries of the restricted area are shown in Figure 5-1.

The licensee will continue to be exempted, by license condition, from the requirements of 10 CFR 20.1902(e) for areas within the facility, provided that all entrances to the facility are conspicuously posted in accordance with 10 CFR 20.1902(e) with the words, "ANY AREA WITHIN THE FACILITY MAY CONTAIN RADIOACTIVE MATERIAL."

6.0 EMERGENCY PROCEDURES AND PREVENTATIVE MEASURES

CBR has established emergency procedures for natural disasters, significant equipment or facility damage, uncontrolled plant shutdowns, yellowcake spills, loss or theft of yellowcake or sealed sources, employee overexposure, and unauthorized discharges of radioactive materials. The procedures to be followed specify appropriate individuals to contact, health and decontamination procedures, and area cleanup methods.

Accidents involving the uncontrolled discharge of waste solutions would be unlikely. CBR conducts daily inspections of the solution disposal system and of the other areas of the facility.

The staff finds that the CBR emergency procedures and preventative measures are acceptable for maintaining employee and public exposures ALARA as required by the requirements of 10 CFR 20.1101.

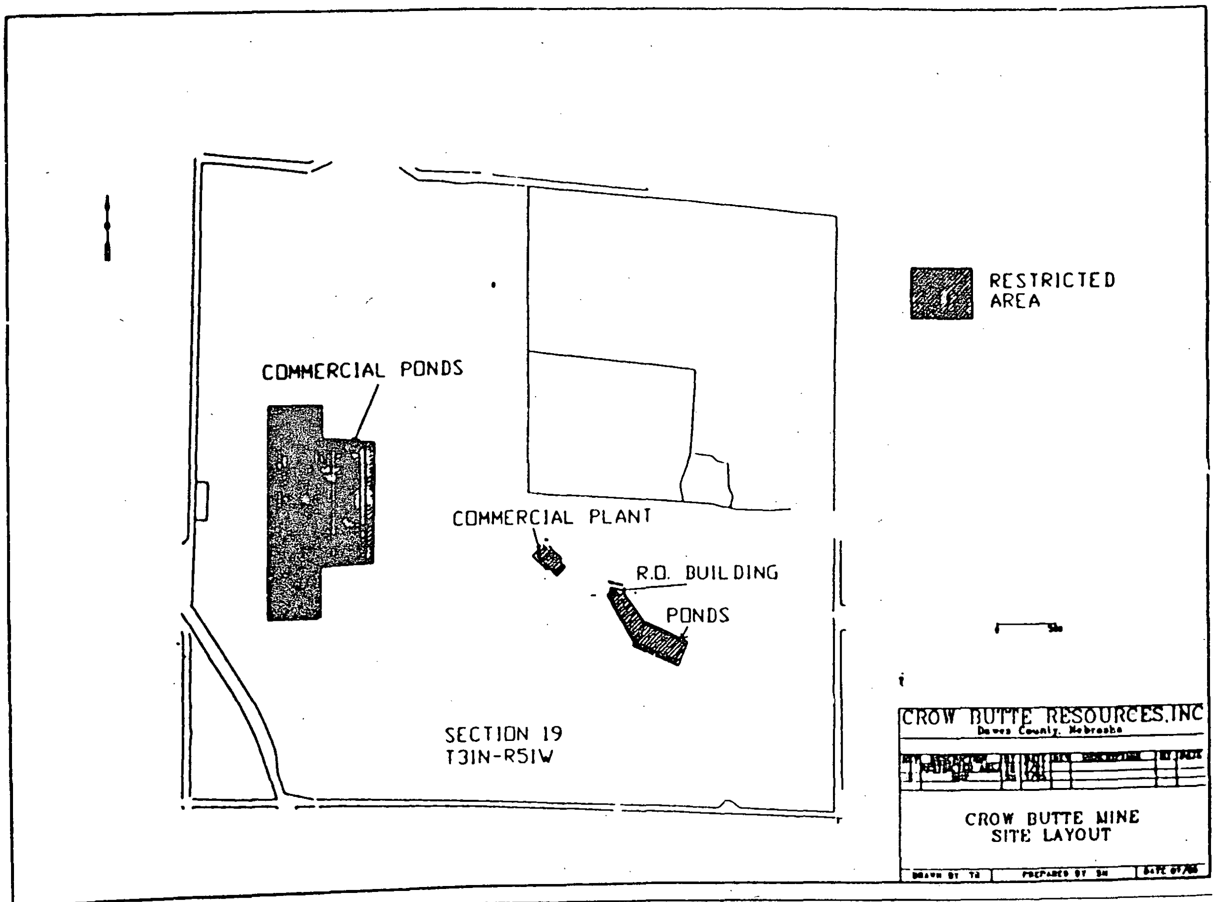


Figure 5-1. Restricted area boundaries at the Crow Butte uranium *in situ* leach project (from CBR, 1996)

7.0 EVAPORATION POND EVALUATION

CBR employs solar evaporation ponds as one disposal option for liquid wastes generated by its process operations. NRC has approved two other disposal options for these wastes: land application and deep well injection. A complete discussion of these disposal methods is contained in the accompanying EA.

8.0 DECOMMISSIONING AND RECLAMATION

CBR will continue to be required, by license condition, to decommission and reclaim the site to meet applicable radiation protection standards. Currently applicable standards include limits for reclamation of soil contamination consistent with those in Appendix A to 10 CFR Part 40, and the decommissioning requirements of 10 CFR 40.42. Additionally, the wellfields will be abandoned in accordance with the State of Nebraska's standards. Additional site decommissioning, reclamation, and aquifer restoration information is contained in the accompanying EA.

CBR will continue to be required, by license condition, to submit a final site decommissioning plan for NRC review and approval at least 12 months prior to a planned final shutdown of mining operations.

9.0 SURETY REQUIREMENTS

Under 10 CFR Part 40, Appendix A, Criterion 9, licensees are required to establish a financial surety arrangement adequate to cover the estimated costs, if accomplished by a third party, for completion of the NRC-approved site closure plan including: decommissioning and decontamination of the aboveground facilities, the cost of offsite disposal of radioactive solid process or evaporation pond residues, soil and water analyses, and groundwater restoration as warranted. The surety is based on an estimate which must account for the total costs that would be incurred if an independent contractor were contracted to perform the work. The surety estimate must be approved by NRC and based on an NRC-approved decommissioning and reclamation plan. The licensee must also provide the surety arrangement through a financial instrument acceptable to NRC. The licensee's surety mechanism will be reviewed by NRC annually to ensure that sufficient funds are available to complete site decommissioning and reclamation. Additionally, the amount of the surety should be adjusted to recognize any increases or decreases in liability resulting from inflation changes, engineering plan changes, or other conditions affecting costs.

CBR has maintained an acceptable surety mechanism throughout the course of commercial operations at the Crow Butte Uranium Project. The current surety level to cover aboveground decommissioning and decontamination, offsite disposal of radioactive solid process wastes or evaporation pond residues, and groundwater restoration is $8,950,827, held as an Irrevocable Standby Letter of Credit issued by Colorado National Bank, in favor of the State of Nebraska. This surety amount was reviewed and approved by NRC on January 7, 1998. CBR will continue to be required, by license condition, to maintain a financial surety arrangement in accordance with the requirements of 10 CFR Part 40, Appendix A, Criterion 9. The surety requirements will be reviewed at least annually by NRC to ensure that the funds and surety arrangements are acceptable.

10.0 INSPECTION HISTORY

The NRC has conducted routine announced, routine unannounced, and reactive inspections of the Crow Butte Uranium Project since commercial operations commenced in late 1989. NRC has cited CBR for a total of five violations, each of Severity Level IV, during the 18 inspections which have been conducted to date. A discussion of inspection and enforcement actions, including severity of violations is provided in NUREG-1600 (NRC, 1995). Minor violations are cited at Severity Level IV, and major violations are cited at Severity Level I. Typically, Severity Level IV violations are cited for not performing required surveys or for incomplete documentation. All cited violations have been acceptably addressed and corrective measures have been enacted by the licensee. A summary of the inspection history for the facility during commercial operations is provided in Table 10-1.

On July 2, 1996, the Commission approved increasing the license term for qualified uranium recovery licensees from the current five-year period to a ten-year period. As discussed in SECY-96-112 (issued on May 21, 1996), the criteria to be used in determining whether a licensee is "qualified" are as follows:

(1) the licensee must have performed well;

(2) the licensee must have a successful inspection record, with no violations more serious than Severity Level IV;

(3) the licensee must have had no serious operational problems or reports during the previous two years; and

(4) the license in question must currently have a specific term of renewal (uranium mills currently undergoing reclamation would not meet this criteria).

Based on its review, the staff finds that CBR is a qualified licensee, and therefore, a ten-year license term is appropriate.

Table 10-1. Summary of NRC inspections of the Crow Butte Uranium Project				
Date	Type*	Number of Violations	Severity Level	Comments/Results
5/17/90	U	None	–	
4/4/91	R	None	–	Inspection prompted by potentially significant solution spill from a production well. Water and soil samples indicated that contamination of an unrestricted area was unlikely.
6/3–6/91	U	1	IV	Soils used for evaporation pond construction routinely placed at moisture contents below levels required by license condition. Violation Closed.
6/16–18/92	U	None	–	
9/28–29/92	A	None	–	
10/14/92	U	None	–	
11/17/92	A	None	–	
1/14/93	R	2	IV, IV	Inspection prompted by pipeline failure and subsequent release of 23,000 gallons of lixiviant from the process circuit. Unknown amount of lixiviant escaped offsite. CBR cited for lack of SOPs to address construction, testing, operation, and maintenance of pipelines. Violations Closed.
8/10–12/93	A	None	–	
8/26–27/93	A	None	–	
3/18/94	A	None	–	
5/23–26/94	A	None		
4/25–27/95	A	1	IV	Failure to assign TLDs to plant personnel at all times while working in the plant, as required by license condition. Violation Closed.
9/12–14/95	A	None	–	
4/8–11/96	A	1	IV	Failure to establish written SOPs for some environmental monitoring activities, and failure to keep current copies of applicable SOPs in certain areas, as required by license condition. Violation Closed.
9/23–25/96	A	None	–	
4/14-17/97	A	None	–	
8/12-14/97	A	None	–	
* A = Routine, Announced; R = Reactive; U = Unannounced				

11.0 CONCLUSION INCLUDING SAFETY LICENSE CONDITIONS

Upon completion of the safety review of CBR's license renewal application, the NRC staff concludes that the continuation of commercial operations at the Crow Butte Uranium Project, in accordance with the following license conditions, is protective of health and safety and fulfills the requirements of 10 CFR Parts 20 and 40. The NRC staff, therefore, recommends renewal of Source Material License SUA-1534, subject to the following conditions:

1. A. The licensee may, without prior NRC approval, and subject to the conditions specified in Part B of this condition:

   (1) Make changes in the facility or process, as presented in the approved application.

   (2) Make changes in the procedures presented in the approved application.

   (3) Conduct tests or experiments not presented in the approved application.

   B. The licensee shall file an application for an amendment to the license, unless the following conditions are satisfied:

   (1) The change, test, or experiment does not conflict with any requirement specifically stated in this license (excluding information referenced in the approved license application), or impair the licensee's ability to meet all applicable NRC regulations.

   (2) There is no degradation in the essential safety or environmental commitments in the license application, or provided by the approved reclamation plan.

   (3) The change, test, or experiment is consistent with the conclusions of actions analyzed and selected in the accompanying EA.

   C. The licensee's determinations concerning Part B of this condition, shall be made by a "Safety and Environmental Review Panel" (SERP). The SERP shall consist of a minimum of three individuals employed by the licensee, and one of these shall be designated as the SERP chairman. One member of the SERP shall have expertise in management and shall be responsible for approval of managerial and financial 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 site corporate radiation safety officer (CRSO) or equivalent, with the responsibility for 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 health physics, groundwater hydrology, 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.

D. 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 that changes are in compliance with the requirements referred to in Part B of this condition. The licensee shall furnish, in an annual report to 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 NRC page changes to the approved license application to reflect changes made under this condition.

2. Written standard operating procedures (SOPs) shall be established and followed for all operational process activities involving radioactive materials that are handled, processed, or stored. SOPs for operational activities shall enumerate pertinent radiation safety practices to be followed. Additionally, written procedures shall be established for non-operational activities to include in-plant and environmental monitoring, bioassay analyses, and instrument calibrations. An approved, up-to-date copy of each written procedure shall be kept in the process area to which it applies.

   All written procedures for both operational and non-operational activities shall be reviewed and approved in writing by the CRSO before implementation and whenever a change in procedure is proposed to ensure that proper radiation protection principles are being applied. In addition, the CRSO shall perform a documented review of all existing SOPs at least annually.

3. Any corporate organization changes affecting the assignments or reporting responsibilities of the radiation safety staff as described in Section 5 of the approved license application shall conform to Regulatory Guide 8.31.

4. The licensee shall have a training program for all site employees as described in Regulatory Guide 8.31 and as detailed in the approved license application. The training program shall cover the topics identified in Section 2.5 of Regulatory Guide 8.31.

   The Site Corporate Radiation Safety Officer (CRSO), or their designee, shall have the education, training and experience as specified in Regulatory Guide 8.31. The CRSO shall also receive 40 hours of related health and safety refresher training every two (2) years.

   Individuals designated as the Health Physics Technician (HPT) shall report directly to the CRSO on matters dealing with radiological safety. In addition, the CRSO shall be accessible to the HPT at all times. The HPT shall have the qualifications specified in Regulatory Guide 8.31, or equivalent. Any person newly hired as an HPT shall have all work reviewed and approved by the CRSO as part of a comprehensive training program until appropriate course training is completed, and at least for six (6) months from the date of appointment.

5. The licensee is hereby exempted from the requirements of Section 20.1902(e) of 10 CFR Part 20 for areas within the facility, provided that all entrances to the facility

are conspicuously posted in accordance with Section 20.1902(e) and with the words, "ANY AREA WITHIN THIS FACILITY MAY CONTAIN RADIOACTIVE MATERIAL."

6. The boundaries of the licensee's restricted area shall be those identified in the submittal dated April 22, 1996.

7. The licensee shall be required to use a Radiation Work Permit (RWP) for all work or non-routine maintenance jobs where the potential for significant exposure to radioactive material exists and for which no standard written operating procedure exists. All RWPs shall be accompanied by a breathing zone air sample or an applicable area air sample. The RWP shall be issued by the CRSO, or designee qualified by way of specialized radiation protection training, and RWPs shall include, as a minimum, the information described in Section 2.[illegible] of Regulatory Guide 8.31.

8. The licensee shall conduct the in-plant radiological inspection program described in Section 5.3 of the license renewal application, with the following modifications:

   A. The licensee shall document problems observed during the daily visual walk-through inspections in writing; and

   B. The CRSO and plant manager, or qualified designees, shall perform weekly inspections to observe general radiation control practices and to review required changes in procedures and equipment.

9. In-plant radiological monitoring for airborne uranium and radon daughters shall be conducted at the locations shown in Figure 5.7-1 in the approved license application.

10. Employees shall monitor themselves with an alpha survey instrument prior to exiting the restricted area. Should the results of monitoring exceed an action level of 1000 dpm/100 cm^2, employees shall decontaminate themselves to less than the action level. If decontamination cannot be accomplished, the employee shall report the incident to the CRSO for investigation.

11. In addition to the bioassay program discussed in Section 5.7.5 of the approved license application, the licensee also shall perform *in vivo* measurements in accordance with the recommendations contained in Revision 1 of Regulatory Guide 8.22.

12. The licensee shall maintain effluent control systems as specified in Sections 4.1 and 5.7.1.1 of the approved license application, with the following exceptions:

   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.

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 either (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.

13. All radiation monitoring, sampling, and detection equipment shall be recalibrated after each repair and as recommended by the manufacturer, or at least annually, whichever is more frequent. In addition, all radiation survey instruments shall be operationally checked with a radiation source each day when in use.

14. An annual ALARA audit of the radiation safety program shall be performed in accordance with Regulatory Guide 8.31 and Section 5.3 of the approved license application. The CRSO shall accompany the audit team. A report of this audit shall be retained on-site for NRC inspection. The report also shall summarize the results of the daily walk-through inspections.

15. The results of the following activities, operations, or actions shall be documented: sampling; analyses; surveys and monitoring; survey/monitoring equipment calibrations; reports on audits and inspections; all meetings and training courses required by this license; and any subsequent reviews, investigations, or corrective actions. Unless otherwise specified in the NRC regulations, all such documentation shall be maintained for a period of at least five (5) years.

16. The licensee shall maintain an NRC-approved financial surety arrangement, consistent with 10 CFR 40, Appendix A, Criterion 9, adequate to cover the estimated reclamation and closure costs, if accomplished by a third party, for all existing operations and any planned expansions or operational changes for the upcoming year. Reclamation includes all cited activities and ground water restoration, as well as off-site disposal of all 11e.(2) byproduct material.

Within 3 months of NRC approval of a revised closure plan and cost estimate, the licensee shall submit for NRC review and approval, a proposed revision to the financial surety arrangement if estimated costs in the newly approved site closure plan exceed the amount covered in the existing financial surety. The revised surety shall then be in effect within 3 months of written NRC approval.

Annual updates to the surety amount, required by 10 CFR 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 surety arrangement, the licensee shall extend the existing arrangement, prior to expiration, for one year. Along with each proposed revision or annual update of the surety, 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 estimated costs for site closure.

The licensee shall provide an updated surety for NRC approval for any planned expansion or operational change which has not been included in the annual surety update. This surety update shall be provided to the NRC at least 30 days prior to the commencement of the planned expansion or operational change.

The licensee shall also provide the NRC with copies of surety-related correspondence submitted to the State of Nebraska, a copy of the State's surety review, and the final approved surety arrangement. The licensee must also ensure that the surety, where authorized to be held by the State, identifies the NRC-related portion of the surety and covers the above-ground decommissioning and decontamination, the cost of offsite disposal, soil and water sample analyses, and groundwater 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/decommissioning plan, cost estimates, and annual updates should follow the outline in Appendix E to NUREG-1569 (NRC, 1997), entitled "Recommended Outline for Site-Specific *In Situ* Leach Facility Reclamation and Stabilization Cost Estimates."

Crow Butte Resources, Inc.'s currently approved surety instrument, an Irrevocable Standby Letter of Credit issued by Colorado National Bank, in favor of the State of Nebraska, shall be continuously maintained in the sum total amount of no less than $8,950,827 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 the NRC.

17. Release of equipment, materials, or packages from the restricted area shall be in accordance with the NRC guidance document entitled, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," dated May 1987, or suitable alternative procedures approved by NRC prior to any such release.

18. The licensee shall submit a detailed decommissioning plan to NRC for review and approval at least twelve (12) months prior to planned final shutdown of mining operations.

Additional license conditions addressing environmental issues can be found in the EA, which accompanies this licensing action.

12.0 REFERENCES

Crow Butte Resources, Inc. (CBR), 1997a, "1998 Surety Estimate - Revision 3," transmitted by letter from Stephen P. Collings (CBR) to Joseph J. Holonich (NRC), dated November 10, 1997.

CBR, 1997b, "Standard Operating Procedures for Safety and Environmental Review Panel and Revised Section 5 Operations of the Renewal Application," transmitted by letter from Stephen P. Collings (CBR) to Joseph J. Holonich (NRC), dated October 31, 1997.

CBR, 1997c, "Request to amend Source Material License SUA-1534," transmitted by letter from Stephen P. Collings (CBR) to Joseph J. Holonich (NRC), dated July 28, 1997.

CBR, 1997d, "Response to Request for Additional Information - License Renewal," transmitted by letter from Steve Collings (CBR) to Joseph J. Holonich (NRC), dated June 25, 1997.

CBR, 1997e, "Response to Acceptance Review Comments for the Renewal of Source Material License No. SUA-1534," transmitted by letter from Steve Collings (CBR) to Joseph J. Holonich (NRC), dated April 1, 1997.

CBR, 1996, Amendment request transmitted by letter from Stephen P. Collings (CBR) to Joseph Holonich (NRC), dated April 22, 1996.

CBR, 1995, "Crow Butte Uranium Project, Dawes County, Nebraska. Application for Renewal of USNRC Radioactive Source Material License SUA-1534," dated December 1995 and submitted by letter from Stephen P. Collings (CBR) to Joseph J. Holonich (NRC), dated December 20, 1995.

U.S. Nuclear Regulatory Commission (NRC), 1997, "Draft Standard Review Plan for *In Situ* Leach Uranium Extraction License Applications," NUREG-1569, October 1997.

NRC,1996, "Ten-Year License Terms for Uranium Recovery Licensees," SECY-96-112, issued May 21, 1996.

NRC, 1995, "General Statement of Policy and Procedures for NRC Enforcement Actions (Enforcement Policy)," Office of Enforcement, NUREG-1600, July 1995.

NRC, 1992, "Air Sampling in the Workplace," Regulatory Guide 8.25, Rev. 1, June 1992.

NRC, 1989a, "Environmental Assessment by the Uranium Recovery Field Office in Consideration of an Application for a Source Material License for Ferret Exploration Company of Nebraska Crow Butte Commercial In Situ Leach Operation, Dawes County, Nebraska," Docket No. 40-8943, issued on December 12, 1989.

NRC, 1989b, "Safety Evaluation Report for Issuance of Source Material License, Ferret Exploration Company of Nebraska, Inc., Crow Butte Project, Dawes County, Nebraska," Docket No. 40-8943, issued on December 12, 1989.

NRC, 1988, "Bioassay at Uranium Mills," Regulatory Guide 8.22, Rev. 1, August 1988.

NRC, 1987, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," Division of Fuel Cycle, Medical, Academic, and Commercial Use Safety, May 1987.

NRC, 1983a, "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Will Be As Low As Is Reasonably Achievable," Regulatory Guide 8.31, May 1983.

NRC, 1983b, "Health Physics Surveys in Uranium Mills," Regulatory Guide 8.30, June 1983.

NRC, 1979, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) Effluent Streams and the Environment," Regulatory Guide 4.15, Rev. 1, February 1979.

NRC, 1976, "Acceptable Programs for Respiratory Protection," Regulatory Guide 8.15, October 1976.

CROW BUTTE RESOURCES, INC.
216 Sixteenth Street Mall, Suite 810 **(303) 825-2266**
Denver, Colorado 80202 **(303) 825-1544 - FAX**

June 25, 1997

Joseph J. Holonich, Chief
Uranium Recovery Branch
Division of Waste Management,
NMSS (T-7-J9)
Office of Nuclear Material Safety
and Safeguards
U.S. NUCLEAR REGULATORY COMMISSION
11545 Rockville Pike
Rockville, MD 20850

Re: Docket No. 40-8943
License No. SUA-1534
Response to Request for Additional Information - License Renewal

Dear Mr. Holonich:

On June 2, 1997 Crow Butte Resources received a request for additional information regarding the renewal of Source Material License No. SUA-1534 for the Crow Butte in situ leach mine. Enclosed are two copies of CBR's responses to the questions and comments. Corrected pages are included as appropriate. I have sent one copy directly to Mr. Pat Mackin at the Southwest Research Institute to facilitate his review.

If you have any questions or require further information, please do not hesitate to contact me.

Sincerely,

Steve Collings

Steve Collings
President

NL05/1

Enclosures

c: Pat Mackin
Ross Scarano

Request 1. *Technical support should be provided for proposed changes to the in-plant monitoring programs.*

Response: CBR has not proposed any change to the in-plant monitoring programs or monitoring locations noted in the text accompanying this Request for additional information. In order to provide clarification, CBR is providing the following information for each of the three monitoring programs noted in Request 1.

Airborne Uranium: On page 5-23 of the License Renewal Application (LRA) under the section entitled "Proposed In-Plant Airborne Uranium Monitoring Program", CBR states that they "propose to institute the same airborne uranium monitoring program at Crow Butte Uranium Project that has been performed to date with the following changes." The monitoring locations shown in Figure 5.7-1 are the same that are currently in use at the plant. These locations were submitted to and approved by NRC prior to commercial plant start-up. CBR proposes no change in airborne uranium sampling locations from the current program.

Radon Daughter: On page 5-25 of the LRA under the section entitled "Proposed In-Plant Radon Daughter Monitoring Program", CBR states that they "propose to institute the same radon daughter monitoring program at Crow Butte Uranium Project that has been performed to date with the following changes." The monitoring locations shown in Figure 5.7-1 are the same that are currently in use at the plant and submitted to and approved by NRC prior to commercial plant start-up with two exceptions.

1.) The radon daughter sampling location shown in Figure 5.7-1 in the Dryer area has been deleted under Amendment Number 33 of SUA-1534. The request to eliminate this location was submitted on October 5, 1995.

2.) A radon daughter monitoring location near the Raw Water tank was inadvertently left out of Figure 5.7-1 during preparation of the LRA. A revised Figure 5.7-1 with the noted changes is attached for inclusion with the LRA. CBR proposes no change in radon daughter sampling locations from the current program.

Gamma: On page 5-18 of the LRA under the section entitled "Proposed Gamma Survey Program", CBR states that they "propose to institute the same gamma exposure monitoring program at the Crow Butte Uranium Project that has been performed to date with the following changes." The text indicates that the locations are indicated in Figure 5.7-1. In actuality, the figure does not depict gamma survey locations since there are no specified gamma survey locations at CBR other than the requirement that they be performed in "work areas". Gamma surveys are performed throughout the plant to monitor gamma radiation levels under changing operational conditions. No specific locations are required in SUA-1534.

Request 2. *Technical support should be provided for the proposed discontinuation of vegetation sampling.*

Response: USNRC Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills" requires vegetation sampling "if dose calculations indicate that the ingestion pathway from grazing animals is a potentially significant exposure pathway". "Potentially significant" is defined as exceedance of 5 percent of the applicable radiation protection standard (footnote (o) to Table 2).

MILDOS modeling performed for the Crow Butte Uranium project estimates individual doses from the ingestion pathway from grazing animals to be well below the 5 percent criteria. For Case 1 and Case 2, MILDOS has estimated the following meat ingestion and milk ingestion effective doses to the most affected resident.

Case 1:

Meat Ingestion Effective Annual Dose:	9.18 E^{-5} mRem/yr
Milk Ingestion Effective Annual Dose:	2.58 E^{-5} mRem/yr

Case 2:

Meat Ingestion Effective Annual Dose:	1.67 E^{-4} mRem/yr
Milk Ingestion Effective Annual Dose:	4.67 E^{-5} mRem/yr

These estimated doses are well below the criteria from Regulatory Guide 4.14.

Request 3. *Techniques used in defining hydrologic connection/isolation on a wellfield basis should be discussed.*

Response: The regional geology of northwestern Nebraska has been studied extensively, and is well documented and understood. Based on that information, the Brule/Chadron Formation (the confining zone overlying the Basal Chadron Sandstone) and the Pierre Shale (the underlying confining zone) are expected to occur in the vicinity of the Crow Butte Project. Drilling and electric logging information related to the mining operations have verified the presence, continuity, and thickness of the overlying and underlying confining zones. Field and laboratory tests have demonstrated the integrity of the confining zones with regard to vertical and horizontal permeability, hydraulic resistance, and travel times.

It is important to note that the mining zone (the Basal Chadron Formation) is a confined aquifer, which, as expected, has a low storage coefficient. As such, pressure transients created during mining activities or pumping tests, are transmitted over great distances in a short period of time. This is useful for two reasons: (1) pumping tests have been conducted using widely spaced monitoring wells to evaluate formation characteristics (and continuity) over large distances; and (2) pressure transients related to mining activities have proven to be readily detected, in a short period of time, in perimeter monitoring wells.

Analysis of pumping tests performed at the site have repeatedly demonstrated the integrity of the confining zones. Of significance, Pumping Test #2, conducted and analyzed according to the Neuman-Witherspoon method, demonstrated that there was no hydraulic response in monitoring wells completed within the upper or lower confining zones as a result of pumping in the mining zone. In addition, no hydraulic response has been observed in Brule Formation (i.e., the aquifer overlying the Brule/Chadron confining zone) monitoring wells during either (1) performance of conventional pumping tests, or (2) during mining operations.

In summary:

- The horizontal connection between perimeter monitoring wells in the mining zone and the mining/production unit has been, and will continue to be, demonstrated by a direct and rapid hydraulic response observed in the monitoring wells as a result of mining operations. For example, upon startup of a new mining unit, a hydraulic response is typically observed in the perimeter monitoring wells within six hours or less.

- The isolation of the upper monitoring wells (i.e., in the Brule Formation) has been, and will continue to be, demonstrated by (1) correlation of geologic information from drillholes, (2) comparison of water levels in the Brule wells to those in the mining zone.

Request 4. *The effectiveness of site excursion monitoring and control should be documented.*

Response: In response to this request, the following summary is provided of exceedances of excursion parameters in wells at CBR.

Problems with well construction of shallow monitor wells in Mine Unit 4 resulted in exceedances of excursion parameters in three wells. Two-inch monitor wells were installed in order to lower sampling volumes required in this very low yield aquifer. Baseline was difficult to establish because of ineffective well clean-up. SM 4-5 went on excursion status on January 25, 1995. It was determined that poor water production and cement contamination caused high sulfate in the well. A replacement well was drilled with a four-inch diameter and sampling indicated baseline conditions. USNRC approved the replacement well on May 5, 1995 as Amendment 29 to SUA-1534.

Two additional wells in Mine Unit 4 had similar problems. SM4-2 and SM4-7 went on excursion status April 13 and December 29, 1995 respectively. It was determined that the exceedances of the UCL's for these wells was not related to excursions of mining fluids. The water quality sampled by these wells was approaching the average baseline values for the mine unit as a whole. In other words, the UCL's for these two wells were set too low. New UCL's were calculated for these wells based on the mine unit basis. This method was approved by USNRC in Amendment 36 to SUA-1534 on February 20, 1997 and the wells were removed from excursion status.

In addition to the shallow monitor wells in Mine Unit 4, two wells have been placed on excursion status since the license renewal application was submitted on December 7, 1995.

A casing leak was discovered in well I196-5 of Mine Unit 2 during the routine 5-year Mechanical Integrity Test (MIT) of that well on March 29, 1996. Testing isolated the leak at the casing coupling 40 feet below ground level. Fifteen shallow test wells were drilled to delineate the contaminated area. Nine of these wells were uncontaminated and effectively delineated the excursion as covering an area of about 25,000 square feet. The contaminated area averaged about 2600 µmhos/cm conductivity or about four to five times baseline. Continuous pumping from one to three of the contaminated wells at a rate of 1 to 6 gpm has reduced the conductivity of the contaminated area to an average of 660 µmhos/cm as of April 1997 which is below drinking water standards and is approaching baseline. Plans are to continue pumping from these wells in accordance with the remediation plan as long as progress is being made.

A small leak was discovered on November 8, 1996 in a plugged and abandoned well, I752-14 in Mine Unit 5. Apparently the plugging material was washed into the ore zone during mining in the nearby replacement well I752a-14. It was determined that mining solutions leaked into a shallow aquifer at 100 feet below ground surface. Two wells were installed to delineate the leak. These wells showed no contamination. Remediation began December 30, 1996 by pumping from I752-14 at a rate of about 1 gpm. As of April, 1997 the water had been returned to baseline conditions.

No excursions have occurred in the Chadron Sandstone which is the mining unit.

Request 5. *Experience to date in mine unit groundwater restoration should be documented.*

Response: Mine Unit 1 was placed in restoration on March 14, 1994. Initially a bleed or ground water sweep was maintained to control mining solutions. Baseline quality water was transferred from Mine Unit 4 into Mine Unit 1 during the period May 30, 1994 to May 26, 1995. Approximately 0.78 pore volumes (13.5 mm gals) were transferred. Ground water treatment with ion exchange (IX) to lower uranium levels began on September 12, 1994 and has continued to the present. Ground water treatment with reverse osmosis (RO) began September 28, 1995 and continues to the present. Approximately 2.28 pore volumes (39.1 mm gals) have been treated to date. Reductant addition to lower uranium and trace metals began April 17, 1996 with the addition of Na_2S to the RO permeate injection. As of May 31, 1997, 20 of the 39 original well patterns in Mine Unit 1 had been returned to baseline conductivity. The conductivity in the remaining patterns has also been reduced significantly. It is expected that the conductivity of the remaining patterns will be returned to baseline by April 30, 1998. It is expected that most other parameters will meet baseline or secondary restoration target values once the conductivity has reached baseline levels. An evaluation of additional treatment that may be required will take place at that time.

Mine Unit 2 was placed in restoration on January 2, 1996. Restoration to date has consisted of IX treatment to lower uranium levels. RO treatment of Mine Unit 2 will follow completion of restoration of Mine Unit 1 and is expected to begin in 1998 and take approximately two years.

Request 6. *Discussion of groundwater restoration target values should reflect NRC source material license requirements.*

Response: CBR recognizes that USNRC Source Material License SUA-1534 states that the "...goal of restoration shall be returning ground-water quality, on a mine unit average, to baseline conditions". As stated in Section 6.1.3, returning ground-water quality to baseline on a mine unit average is CBR's primary restoration goal. However, should it not be possible to achieve baseline for all parameters on a mine unit average, the secondary goal is to achieve the secondary restoration goals based upon the State of Nebraska Department of Environmental Quality drinking water standards.

CBR has revised Section 6.1.3 and Table 6.1-1 to clarify restoration target values. The affected pages from this revision are attached.

Request 7. *Fundamental conversion factors for radon release calculations should be clarified.*

Response: The calculations found in Tables 7-3(A) and 7-3(A)-5 follow the format found on pages 31 through 34 of NUREG/CR-4088, Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations, June 1985. These pages from NUREG/CR-4088 are attached.

There are some constants in this format that are not fully explained and these are:

(a) Equation (8) has a constant of 1.44. This constant is based on the number of minutes in a day (1440) divided by the number of liters in a cubic meter (1000). The units for Equation 8 then cancel out and the yearly Radon release will be expressed in curies/year.

(b) Equation 9, on page 32, discusses Radon Release from Soaking. Crow Butte does not soak the mining units and there will be no release due to removal of a soak solution.

(c) The calculation of the residence time is based on the time required to remove one pore volume from a cell or wellfield. A pore volume (PV) for a cell is calculated as follows:

$$PV = \text{Area} \cdot \text{Screened Interval} \cdot 7.48 \text{ gallons/ft}^3 \cdot \text{porosity}$$
$$PV = 10{,}000 \text{ ft}^2 \cdot 15.1 \text{ ft} \cdot 7.48 \text{ gallons/ft}^3 \cdot 0.29$$
$$PV = 327{,}549 \text{ gallons}$$

The time required to remove one pore volume will be:

$$327{,}549 \text{ gallons} \cdot \frac{1}{32 \text{ gal/min}} \cdot \frac{1 \text{ day}}{1440 \text{ min}} = 7.1 \text{ days}$$

Where 32 gal/min is the average cell flow rate. See Table 7.3(A)-1 for cell area, screened interval and average cell flow rate.

The above calculation is the basis for the estimated 7 days of residence time during mining.

(d) The residence time during restoration will be significantly longer due to the lower flow. The restoration flow is 1000 gpm as compared to the production flow of 5000 gpm. This means that the average cell flow rate will be approximately one fifth of the production flow. One-fifth of 32 gpm will be 6.4 gpm. With a pore volume of 327,549 gallons, the time required to remove a pore volume will be

$$327{,}549 \text{ gallons} \bullet \frac{1}{6.4 \text{ gal/min}} \bullet \frac{1 \text{ day}}{1440 \text{ min}} = 35.5 \text{ days}$$

Based on the above, an estimate of 35 days was used for the residence time for restoration.

(e) The request for additional information asks for an explanation of the selection of times for evaluating the remaining Radon fraction.

We would like to note that equations (8) and (10) contain an equilibrium factor defined as $1\text{-}e^{-\lambda\tau}$ where λ is the Radon decay constant and τ is the residence time. The equilibrium factor is not evaluating Radon decay but rather the amount of Radon going into the lixiviant solution. Please note that as τ increases the term $1\text{-}e^{-\lambda\tau}$ approaches one and that the longer residence time means that the estimated Radon concentration in the production or restoration solution will be higher.

Request 8. *The process for estimating the agricultural parameters used in radiological dose calculations should be discussed.*

Response: The estimates found in Table 7-3(A)-6: Miscellaneous Data were based on discussions with the land owners and with the Sioux

County Agricultural Extension Educator located in Harrison, Nebraska (Ms. Jenny Nixon). The estimates were reviewed with Ms. Nixon on June 12, 1997 and she recommended that the fraction of the year during which cattle graze locally should be increased from 33 percent to 67 percent and that the fraction of locally-produced meat which is consumed locally should be reduced from 50 percent to ten percent. Table 7-3(A)-6: Miscellaneous Data has been revised to reflect these changes. A revision of the table is attached. CBR repeated MILDOS run for Cases 1 and 2 with the changes recommended by Ms Nixon and found no significant changes in the radiological dose.

During review of Appendix 7-3(A), CBR noted a typographical error in Table 7-3(A)-2 of the LRA. A revised Table 7-3(A)-2 is attached.

Editorial/Clarification Comments

1. *In Table 2.7-1 (p. 2.7-4), the specified units under the column headings for "Mean Discharge" are "inches" and "(cm)". The NRC staff believes these units should be revised to read "cfs" and "(cms)", respectively, to be consistent with the text of Section 2.7.*

Response: The units should be "cfs" and "(cms)". Revised page 2.7-4 is attached.

---

2. *On page 2.9-14, arsenic concentrations in the soil are stated as ranging from "0.59 mg/g to 3.30 µg/g." However, in Table 2.9-10, the lowest arsenic concentration reported is 0.59 µg/g. The extremely high reported arsenic concentration reported on page 2.9-14 is presumed to be an error. The text should be revised appropriately.*

Response: The units should be µg/g. Revised page 2.9-14 is attached.

---

3. *Table 2.10-14 (page 2.10-32) states that, for sample S-3, the uncertainty range for Th-230 is ± 40. This appears to be a typographical error. CBR should either revise the text appropriately or confirm that this is the correct uncertainty value.*

Response: The reported uncertainty value is a typographical error. Revised page 2.10-32 is attached.

---

4. *On pages 4-5 and 7-6, CBR appears to equate PVC (polyvinyl chloride) with "high density polyethylene" (HDPE). These are two distinctly different materials. CBR should clarify the discussion on these pages.*

Response: The text on pages 4-5 and 7-6 does not equate PVC and HDPE. Rather, it offers either type of pipe as possible types of pipe to be used, or equivalent of either type as the third option.

---

5. *Under "Radon Daughter Concentration Determination" (page 5-32), the reader is referred to "Section 0". This reference should be revised appropriately.*

Response: The appropriate reference has been made. Revised page 5-32 is attached.

---

6. *In Section 5.7.5, reference is made to NRC Regulatory Guide 8.22, "Bioassay in Uranium Mills". This regulatory guide was updated in August 1988, and should be referenced as Revision 1 throughout the text.*

Response: Revised pages 5-34 and 5-35 are attached.

---

7. *No units are provided in Tables 6.1-1 and 6.1-2 (pages 6-7 through 6-9). Appropriate units should be provided.*

Response: Revised Tables 6.1-1 and 6.1-2 are attached as part of the affected pages for the response to Request 6 above.

---

8. *On page 2.7-29 and 2.7-31, reference is made to an "average porosity value" for the upper confining layer and the Pierre Shale, respectively, in the discussion addressing travel times through these units. It is not clear whether the porosity referred to is effective porosity or bulk porosity. For computing travel times, the effective, or kinematic porosity should be used; travel time computations using the bulk*

porosity may be unreasonably long. This text should be revised appropriately.

Response: CBR agrees that this comment is warranted. Porosity of subsurface materials is a function of the size and shape of the matrix particles. Massive clay and shale deposits typically consist of fine-grained materials, and initially contain a high percentage of void space (i.e., porosity). Upon burial and compaction, the porosity decreases, but may still be significant (e.g., greater than 20 percent).

In most groundwater applications, it is assumed that all of the void space is connected (i.e., the total void space [bulk porosity] is equal to interconnected void space [effective porosity]). This assumption, however, is incorrect when applied to shales and clays, especially those at depth. For this reason, effective porosity, rather than bulk porosity is used in the oil and gas industry to describe the interconnected pore space available to transmit fluids.

In terms of the rate of fluid movement (i.e., travel time), effective porosity can be viewed as the cross-sectional area available for flow. For a unit volume of fluid flowing through a unit of rock, the flow velocity (i.e., travel time) is higher for a low porosity case than for a high porosity case.

With regard to the Crow Butte Uranium Project, the overlying confining zone includes the Red Clay and Brule/Chadron Formations. The underlying confining zone is the Pierre Shale (the underlying zone). The engineering and hydrologic characteristics of these zones have been evaluated during previous activities related to CBR operations. As part of those evaluations, the bulk porosity for the Red Clay and the Pierre Shale, respectively, was determined to be 31.8 and 32.5 percent. However, based upon published values and experience with the Pierre Shale in Colorado, the effective porosity of these units is probably on the order of one to three percent. Therefore, CBR has recalculated the referenced travel times based upon the average effective porosity of two percent. The original values for hydraulic conductivity were used. The hydraulic resistance (C), which is independent of porosity, was checked, but did not change.

The revised travel time calculations are shown on the attached revised pages 2.7-13 and 2.7-29 through 2.7-34. Note that, while the revised travel times are shorter, they still range from 16,000 to 638,000 years. As such, the impact with regard to technical and/or regulatory issues related to the Crow Butte Uranium Project is negligible.

9. *Section 2.3 provides 1990 population statistics for the region surrounding the Crow Butte site. However, it is stated in section 7.3.4, "Population Dose" (page 7-12), that 1980 population figures were used in the population dose calculations, rather than the more recent population statistics. It is not clear whether this is a typographical error. CBR should either revise the text appropriately or provide justification that the 1980 data yields valid population dose statistics.*

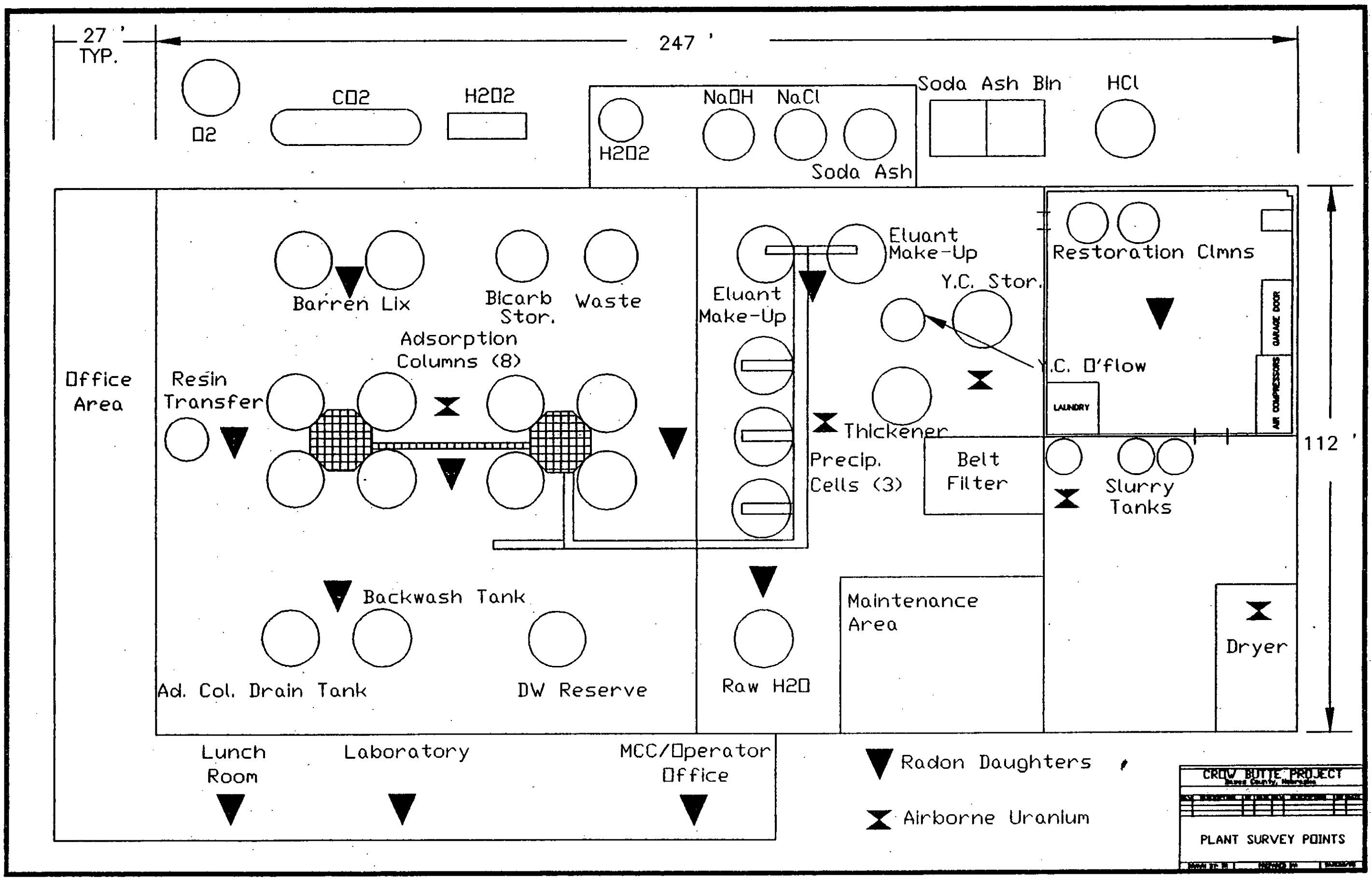
Response: The population figures given in Tables 2.3-1, 2.3-2, and 2.3-3 of the LRA as well as the accompanying discussion are updated 1990 figures. These figures are population numbers for entire counties that have any area that falls within the 80 km radius. Thus, these figures are much higher than the total number of residents that fall within the 80 km radius boundary. The population figures used for the MILDOS run are the 1980 figures and were not updated for the LRA. As can be seen from the data in Table 2.3-1, the population in Dawes County decreased by 0.22% from 1980 to 1990 and the population in Sioux County decreased by 1.60% during the same time period. Since Dawes and Sioux Counties are the most affected counties, it appeared reasonable to use the 1980 data for the population dose calculations.

It should be noted that no county within 80 kilometers of the project site had a population change of greater than 1.60% from 1980 to 1990.

Request 1 Affected Pages

Revised Figure 5.7-1 (page 5-19)

Figure 5.7-1: Proposed Survey and Sampling Locations



Request 6 and Editorial/Clarification Comment 7 Affected Pages

Revised Section 6.1.3 (pages 6-5 through 6-6)

Table 6.1-1 (pages 6-8 and new Page 6-9)

Table 6.1-2 (pages 6-10 through 6-11)

(Revised pages 6-7 and 6-12 through 6-29 attached for pagination change)

oxidant consumption and make uranium leaching a bit more difficult. On longer flow paths, organic material could potentially reprecipitate uranium, should all of the oxidant be consumed and conditions become reducing. Another potential impact of organics could be the coloring and fouling of leach solutions should the organics be mobilized. As the plant is operated in the pH range of 6.5 to 9.0, mobilization of the organics and coloring of the leach solution is avoided.

6.1.3 RESTORATION GOALS

The primary goal of the groundwater restoration program is to return groundwater affected by mining operations to baseline values on a mine unit average. A secondary goal is to return the groundwater to a quality consistent with premining use or uses. The restoration values set by the Nebraska Department of Environmental Quality (NDEQ) are consistent with this secondary goal. Restoration values, secondary goal, for each mine unit have been specified by the NDEQ for groundwater restoration efforts. Prior to mining in each mine unit, baseline groundwater quality data is submitted. This data is established in each mine unit at the following minimal density:

- One production or injection well per four acres;
- One upper aquifer monitor well per five acres; and
- All perimeter monitor wells.

The baseline data support establishment of the upper control limits and restoration standards for each mine unit. The restoration values, secondary goal, are established as the average plus two standard deviations for any parameter that exceeds the applicable drinking water standard. If a drinking water standard exists for a parameter, and baseline is below that standard, the drinking water standard is used to establish the restoration value. If there is no drinking water standard for an element, for example vanadium, the restoration value will be based on best practicable technology. The restoration value for the major cations (Ca, Mg, K) should allow for the concentrations of these cations to vary by as much as one order of magnitude as long as the TDS restoration value is met. The total carbonate restoration criteria should allow for the total carbonate to be less than 50% of the TDS. The TDS restoration value is set at the average plus one standard deviation.

Restoration values, secondary goal, for Mine Units 1 through 5 are given in Table 6.1-1. NDEQ Permit Number NE0122611 requires that Mine Unit be returned to a wellfield average of these restoration values. These concentrations were approved by the NDEQ with the Notice of Intent to Operate submittals. Post mining water quality for Mine Unit 1 can be found in Table 6.1-2.

Crow Butte Resources operated a R&D Pilot Facility starting in July 1986 and initiated restoration activities of its Wellfield No. 2 in February 1987. Wellfield No. 1 was incorporated into Mine Unit 1, thus no restoration took place in that area. The techniques used during that program are the basis for the commercial restoration program outlined in this section. Crow Butte Resources will utilize ion exchange columns, a reverse osmosis unit and reductant addition equipment similar to those used in the R&D restoration during commercial restoration operations.

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

- Groundwater transfer;
- Groundwater sweep;
- Groundwater treatment; and
- Wellfield recirculation

A reductant may be added at anytime during the restoration stage to lower the oxidation potential of the mining zone. A sulfide or sulfite compound will be added to the injection stream in concentrations sufficient to reduce the mobilized species.

The stabilization stage consists of monitoring the restoration wells for six months following successful completion of the restoration stage. Stabilization will begin once restoration activities have returned the average concentration of restoration parameters to acceptable levels. Following the stabilization phase, Crow Butte Resources will make a request to the appropriate regulatory agencies that the wellfield is restored.

6.1.4 RESTORATION STAGE

Restoration activities include four steps which are designed to optimize restoration equipment used in treating groundwater and to minimize the number of pore volumes circulated during the restoration stage. Crow Butte Resources will monitor the quality of selected wells during restoration to determine the efficiency of the operations and to determine if additional techniques are necessary.

Table 6.1-1: Baseline and Restoration Values By Mine Unit

Parameter	Groundwater Standard	MU-1 Baseline	MU-1 Restoration Value	MU-2 Baseline	MU-2 Restoration Value	MU-3 Baseline	MU-3 Restoration Value	MU-4 Baseline	MU-4 Restoration Value	MU-5 Baseline	MU-5 Restoration Value
Ammonium (mg/l)	10.0	≤ 0.372	10.0	≤ 0.37	10.0	≤ 0.329	10.0	0.288	10.0	0.28	10.0
Arsenic (mg/l)	0.05	≤ 0.00214	0.05	≤ 0.001	0.05	≤ 0.001	0.05	≤ 0.00209	0.05	≤ 0.001	0.05
Barium (mg/l)	1.0	≤ 0.996	1.0	≤0.01	1.0	≤ 0.1	1.0	< 0.1	1.0	≤ 0.10	1.0
Cadmium (mg/l)	0.01	≤ 0.00644	0.01	≤0.01	0.01	≤ 0.01	0.01	< 0.01	0.01	≤ 0.01	0.01
Chloride (mg/l)	250.0	203.9	250.0	208.6	250.0	197.6	250.0	217.5	250.0	191.9	250.0
Copper (mg/l)	1.0	≤ 0.0249	1.0	≤0.013	1.0	≤ 0.0108	1.0	≤ 0.0114	1.0	≤ 0.01	1.0
Fluoride (mg/l)	4.0	0.686	4.0	0.67	4.0	0.719	4.0	0.745	4.0	0.64	4.0
Iron (mg/l)	0.3	≤ 0.0441	0.3	≤ 0.05	0.3	< 0.05	0.3	≤ 0.0504	0.3	≤ 0.05	0.3
Mercury (mg/l)	0.002	≤ 0.00067	0.002	≤ 0.001	0.002	< 0.001	0.002	< 0.001	0.002	< 0.001	0.002
Manganese (mg/l)	0.05	≤ 0.00122	0.05	≤0.01	0.05	≤ 0.01	0.05	≤ 0.01	0.05	≤ 0.01	0.05
Molybdenum (mg/l)	1.0	≤ 0.0689	1.0	≤ 0.073	1.0	< 0.1	1.0	< 0.1	1.0	≤ 0.10	1.0
Nickel (mg/l)	0.15	≤ 0.0340	0.15	≤0.05	0.15	< 0.05	0.15	< 0.05	0.15	≤ 0.05	0.15
Nitrate (mg/l)	10.0	≤ 0.050	10.0	≤0.039	10.0	≤0.0728	10.0	≤ 0.114	10.0	≤ 0.10	10.0
Lead (mg/l)	0.05	≤ 0.0315	0.05	≤ 0.05	0.05	< 0.05	0.05	< 0.05	0.05	< 0.05	0.05
Radium (pCi/L)	5.0	229.7	584.0	234.5	1058.0	165.0	611.0	154.0	496.0	166.0	535.00
Selenium (mg/l)	0.01	≤ 0.00323	0.01	≤0.001	0.01	≤ 0.00115	0.01	≤ 0.00244	0.01	≤ 0.002	0.01
Sodium (mg/l)	N/A	412		411		428		416.6	416.6	397.6	397.6
Sulfate (mg/l)	250.0	356.2	375.0	348.2	369.0	377.0	404.0	337.0	375.0	364.5	385.0
Uranium (mg/l)	5.0	0.0922	5.0	0.046	5.0	0.115	5.0	0.118	5.0	0.072	5.0

Table 6.1-1: Baseline and Restoration Values By Mine Unit

Parameter	Groundwater Standard	MU-1 Baseline	MU-1 Restoration Value	MU-2 Baseline	MU-2 Restoration Value	MU-3 Baseline	MU-3 Restoration Value	MU-4 Baseline	MU-4 Restoration Value	MU-5 Baseline	MU-5 Restoration Value
Vanadium (mg/l)	0.2	≤ 0.0663	0.2	≤ 0.1	0.2	< 0.1	0.2	≤ 0.0984	0.2	≤ 0.10	0.2
Zinc (mg/l)	5.0	≤ 0.0384	5.0	≤ 0.025	5.0	≤ 0.0131	5.0	≤ 0.0143	5.00	≤ 0.02	5.0
pH (Std. Units)	6.5-8.5	8.46	6.5-8.5	8.32	6.5-8.5	8.37	6.5-8.5	8.68	9.28	8.5	6.5-8.5
Calcium (mg/l)	N/A	12.5	125.0	13.4	134.0	13.3	133.0	11.2	112.0	12.6	126.0
Total Carbonate (mg/l)	N/A	351.2	585.0	362.0	585.0	377.0	592.0	374.0	610.0	373.0	590.0
Potassium (mg/l)	N/A	12.5	125.0	12.6	126.0	13.9	139.0	16.7	167.0	11.5	115.0
Magnesium (mg/l)	N/A	3.2	32.0	3.5	35.0	3.5	35.0	2.8	28.0	3.4	34.0
TDS (mg/l)	N/A	1170.2	1170.0	1170.4	1170.4	1183.0	1183.0	1221.0	1221.0	1179.0	1202.0

Table 6.1-2: Post Mining Water Quality for Mine Unit 1
Restoration Well Sampling

	PM-1	PM-4	PM-5	PT-5	IJ-6	IJ-13	IJ-25	IJ-28	IJ-45	PR-8	PR-15	PR-19
Ca (mg/l)	87.9	87.1	80.8	87.9	87.6	93.9	89.4	89.6	89.9	85.4	86.7	98.3
Mg (mg/l)	22.6	20.6	22.7	23.8	21.4	23.9	22.5	23.1	24.8	23.2	23.1	23.8
Na (mg/l)	1154	942	1054	1144	1054	1174	1177	1182	1126	1144	1172	1083
K (mg/l)	32.7	26.3	30	30	27.2	31.3	30	31.3	32.7	30	30	28.6
CO_3 (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0
HCO_3 (mg/l)	1099	900	972	981	1057	1086	1111	1207	1104	1170	1170	959
SO_4 (mg/l)	1109	959	1115	1240	1031	1209	1119	1112	1134	1115	1115	1283
Cl (mg/l)	598	455	586	594	544	598	594	619	607	603	603	590
NH_4 (mg/l)	0.33	0.67	0.14	0.33	0.44	0.07	< 0.05	< 0.05	0.33	0.27	0.15	0.49
NO_2 (mg/l)	< 0.01	0.02	0.09	< 0.01	0.11	< 0.01	< 0.01	< 0.01	0.04	0.05	< 0.01	0.05
NO_3 (mg/l)	1.06	< 0.1	0.97	0.99	1.29	0.74	0.86	1.3	1.25	1.46	1.6	0.46
F (mg/l)	0.37	0.26	0.54	0.45	0.45	0.37	0.38	0.45	0.43	0.43	0.4	0.35
SiO_2 (mg/l)	25.7	18.2	35.3	24.7	33.3	34.3	26.4	31.6	28.3	33.2	30	22.2
TDS (mg/l)	3694	3121	3756	3851	3515	3899	3751	3886	3873	3820	3807	3765
Cond (μmho/cm)	5843	4841	5590	5964	5445	6012	5807	6025	5916	5819	5940	5819
$CaCO_3$ (mg/l)	901	738	797	804	866	890	911	989	905	959	959	786
pH (Std. units)	7.65	6.87	6.85	7.28	7.16	7.35	7.65	7.81	7.37	7.46	7.78	6.92
Trace Metals												
Al (mg/l)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.29
As (mg/l)	0.018	0.007	0.018	0.017	0.031	0.028	0.02	0.028	0.023	0.028	0.024	0.011
Ba (mg/l)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

Table 6.1-2: Post Mining Water Quality for Mine Unit 1 Restoration Well Sampling

	PM-1	PM-4	PM-5	PT-5	IJ-6	IJ-13	IJ-25	IJ-28	IJ-45	PR-8	PR-15	PR-19
B (mg/l)	1.17	1.44	1.09	1.36	1.06	1.26	1.13	1.19	1.15	1.23	1.25	1.17
Cd (mg/l)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cr (mg/l)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cu (mg/l)	< 0.01	< 0.01	0.05	< 0.01	0.02	< 0.01	< 0.01	< 1	< 0.01	< 0.01	< 0.01	< 0.01
Fe (mg/l)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.38
Pb (mg/l)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mn (mg/l)	0.02	0.11	0.05	0.04	0.14	0.15	0.08	0.06	0.06	0.02	< 0.01	0.16
Hg (mg/l)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Mo (mg/l)	0.6	0.2	0.42	0.53	0.47	0.5	0.56	0.54	0.53	0.59	0.53	0.37
Ni (mg/l)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.12	0.12	0.12	< 0.05	< 0.05	< 0.05	< 0.05
Se (mg/l)	0.139	0.012	0.129	0.24	0.112	0.122	0.1	0.138	0.149	0.154	0.148	0.041
V (mg/l)	1	0.1	0.38	1.15	1.12	1.18	1.03	1.24	1.29	1.23	1.56	0.28
Zn (mg/l)	< 0.01	0.14	0.11	0.01	0.11	0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Radionuclides												
U (mg/l)	8.63	6.29	54.52	9.3	13.9	9.31	9.9	2.52	14.83	5.24	5.18	6.78
Ra-226 (pCi/l)	370	126	329	1139	1113	1558	1258	1147	681	417	109	1182

6.1.4.1 GROUNDWATER TRANSFER

Prior to commencing restoration activities, the regulatory agencies will be notified that mining has ceased in a given mine unit and Crow Butte Resources will proceed to establish post mining water quality data for all of the required parameters listed in Table 6.1-1. The designated wells will be sampled and may be split with the NDEQ if requested.

During the groundwater transfer step, water may be transferred between the mine unit commencing restoration and a mine unit commencing operations. Baseline quality water from the mine unit starting production may be pumped and injected into the mine unit in restoration. The higher TDS water from the mine unit in restoration may be recovered and injected into the mine unit commencing production. The direct transfer of water will act to lower the TDS in the mine unit being restored by displacing water affected by mining with baseline quality water.

The goal of groundwater transfer is to blend the water in the two mine units until they become similar in conductivity. The recovered water may be passed through ion exchange columns and filtration during this step if suspended solids are sufficient in concentration to present a problem with blocking the injection well screens. For the groundwater transfer to occur, a newly constructed mine unit must be ready to commence mining.

The advantage of using the groundwater transfer technique is that it reduces the amount of water that must be ultimately be sent to the waste disposal system during restoration activities.

6.1.4.2 GROUNDWATER SWEEP

During groundwater sweep, water is pumped without injection from the wellfield causing an influx of baseline quality water from the perimeter of the mining unit which sweeps the affected portion of the aquifer. The cleaner baseline water has lower ion concentrations that act to strip off the cations that have attached to the clays during mining. The plume of affected water near the edge patterns of the wellfield is also drawn into the boundaries of the mine unit.

The number of pore volumes transferred during groundwater sweep is dependent upon the capacity of the waste water disposal system and the success of the groundwater transfer step in lowering TDS.

6.1.4.3 GROUNDWATER TREATMENT

Following the groundwater sweep step water is pumped from production wells to treatment equipment and then reinjected into the wellfield. Ion exchange and reverse osmosis treatment equipment is utilized during this stage as shown in Figure 6.1-1. Depending upon the final configuration of the main plant following the capacity increase to 5,000 gpm, the ion exchange step may utilize the existing fixed bed downflow columns located at the main plant, or may be relocated.

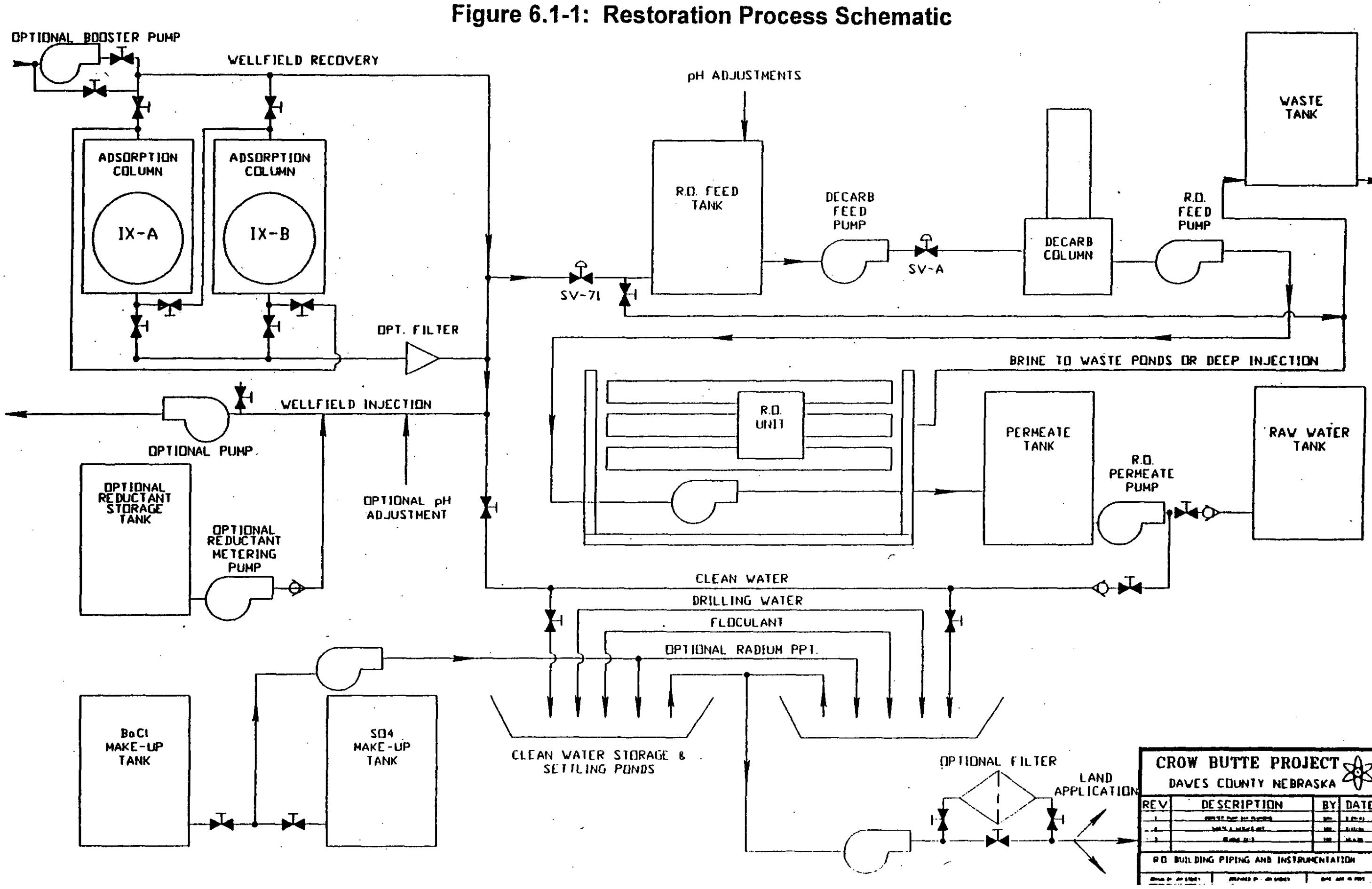
Water recovered from restoration containing a significant amount of uranium is passed through the ion exchange system. The ion exchange columns exchange the majority of the contained soluble uranium for chloride or sulfate. Once the solubilized uranium is removed, a small amount of reductant may be metered into the restoration wellfield injection to reduce any pre-oxidized minerals. The concentration of reductant injected into the formation is determined by the concentration and type of trace elements encountered. The goal of reductant addition is to reduce those minerals that are solubilized by carbonate complexes to prevent build-up of dissolved solids which would increase the time required to complete restoration.

A portion of the restoration recovery water can be sent to the reverse osmosis unit. The use of a reverse osmosis unit has several effects:

- Reduces the total dissolved solids in the contaminated groundwater;
- Reduces the quantity of water that must be removed from the aquifer to meet restoration limits;
- Concentrates the dissolved contaminates in a smaller volume of brine to facilitate waste disposal; and
- Enhances the exchange of ions from the formation due to the large difference in ion concentration.

Before the water can be processed by the reverse osmosis unit, the soluble uranium must be removed by the ion exchange system. The water is then filtered, the pH lowered for decarbonation to prevent calcium carbonate plugging of the membranes, and then pressurized by a pump. The reverse osmosis unit contains membranes which pass about 60 to 75 percent of the water through, leaving 60 to 90 percent of the dissolved salts in the water that will not pass the membrane. Table 6.1-3 shows typical manufacturers specification data for removal of ion constituents. The clean water, called permeate, will be re-injected, sent to storage for use in the mining process, or

Figure 6.1-1: Restoration Process Schematic



sent to the waste disposal system. The twenty-five to forty percent of water that is rejected, referred to as the brine, contains the majority of dissolved salts that contaminate the groundwater and is sent for disposal in the wastewater system.

The sulfide reductant that may be added to the injection stream during this stage will reduce the oxidation-reduction potential (Eh) of the aquifer. During mining operations certain trace elements are oxidized. By adding a reductant, the Eh of the aquifer is lowered thereby decreasing the solubility of these elements. A comprehensive safety plan regarding reductant use will be implemented should it be utilized.

The number of pore volumes treated and re-injected during the groundwater treatment stage will depend on the efficiency of the reverse osmosis unit in removing total dissolved solids and the reductant in lowering the uranium and trace element concentrations.

6.1.5 STABILIZATION PHASE

Upon completion of restoration, a groundwater stabilization monitoring program will begin in which the restoration wells and any monitor wells on excursion status during the mining operations will be sampled and assayed. Sampling frequency will be one sample per month for a period of six months, and if all six samples show that restoration values for all wells are maintained during the stabilization period, restoration shall be deemed complete.

6.1.6 REPORTING

The initial step in the restoration process is to determine post-mining water quality in the mine unit by sampling all designated restoration wells for the required constituents listed in Table 6.1-1. These samples may be split with the NDEQ if required. Assay results will be submitted to both the NDEQ and the USNRC as required.

During the restoration process, Crow Butte Resources will perform daily, weekly, and monthly analysis as needed to track restoration progress. These analysis will be provided to NDEQ in Monthly Restoration Reports and the USNRC in the Semiannual Radiological Effluent and Environmental Monitoring Report. This information will also be included in the final restoration report.

Upon completion of restoration activities and prior to stabilization, all designated restoration wells in the mine unit will be sampled for the required constituents listed in Table 6.1-1. These samples may be split with NDEQ if

Table 6.1-3: Typical Membrane Rejection
Source: Osmonics, Inc.

NAME	SYMBOL	PERCENT REJECTION
	Cations	
Aluminum	Al^{+3}	99+
Ammonium	NH_4^{+1}	88-95
Cadmium	Cd^{+2}	96-98
Calcium	Ca^{+2}	96-98
Copper	Cu^{+2}	98-99
Hardness	Ca and Mg	96-98
Iron	Fe^{+2}	98-99
Magnesium	Mg^{+2}	96-98
Manganese	Mn^{+2}	98-99
Mercury	Hg^{+2}	96-98
Nickel	Ni^{+2}	98-99
Potassium	K^{+1}	94-96
Silver	Ag^{+1}	94-96
Sodium	Na^{+}	94-96
Strontium	Sr^{+2}	96-99
Zinc	Zn^{+2}	98-99
	Anions	
Bicarbonate	HCO_3^{-1}	95-96
Borate	$B_4O_7^{-2}$	35-70
Bromide	Br^{-1}	94-96
Chloride	Cl^{-1}	94-95
Chromate	CrO_4^{-2}	90-98
Cyanide	CN^{-1}	90-95
Ferrocyanide	$Fe(CN)_6^{-3}$	99+
Fluoride	F^{-1}	94-96
Nitrate	NO_3^{-1}	95
Phosphate	PO_4^{-3}	99+
Silicate	SiO_2^{-1}	80-95
Sulfate	SO_4^{-2}	99+
Sulfite	SO_3^{-2}	98-99
Thiosulfate	$S_7O_3^{-2}$	99+

required. Assay results will be submitted to NDEQ and USNRC as required. If restoration activities have returned the wellfield average of restoration parameters to concentrations at or below those approved by the regulatory agencies, Crow Butte Resources will notify the regulatory agencies it is commencing the stabilization phase of restoration.

During stabilization all designated restoration wells will be sampled monthly for the required constituents listed in Table 6.1-1. At the end of a six month stabilization period Crow Butte Resources will compile all water quality data obtained during restoration and stabilization and submit a final report to the regulatory agencies. At that time, Crow Butte Resources would request that the mine unit be declared restored.

6.1.7 CURRENT RESTORATION STATUS

The approval of the Notice of Intent to Operate for Mine Unit 4 was received from the NDEQ on March 11, 1994. With the approval, active mining operations ceased in Mine Unit 1 and restoration was initiated. On March 23, 1994 the baseline restoration wells were sampled to establish the post mining water quality. The results of this sampling are given in Table 6.1-2.

Groundwater transfer was performed for the Mine Unit 1 restoration by transferring water between Mine Unit 1 and Mine Unit 4. Uranium recovery was accomplished through the two fixed bed downflow columns located in the main process plant. Some groundwater treatment utilizing the reverse osmosis unit located in the R&D building has also been initiated.

6.2 DECONTAMINATION AND DECOMMISSIONING

The following sections address the final decommissioning of process facilities, evaporation ponds, wellfields and equipment which will be used on the Crow Butte site. It discusses general procedures to be used, both during final decommissioning, as well as the decommissioning of a particular phase or production unit area.

Decommissioning of wellfields and process facilities, once their usefulness has been completed in an area, will be scheduled after agency approval of groundwater restoration and stability. It will be accomplished in accordance with an approved decommissioning plan and the most current applicable NDEQ and USNRC rules and regulations, permit and license stipulations and amendments in effect at the time of the decommissioning activity.

The following is a list of general decommissioning activities:

- Plug and abandon all wells as detailed per Section 6.2.3.
- Radiological surveys and sampling of all facilities, process related equipment and materials presently on site to determine their degree of contamination and identify the potential for personnel exposure during decommissioning.
- Removal from the site of all contaminated equipment and materials to an approved licensed facility for disposal or reuse, or relocation to an operational portion of the mining operation.
- Decontamination of items to be released for unrestricted use to levels consistent with the requirements of U.S. Nuclear Regulatory Commission.
- Survey excavated areas for earthen contamination and remove same to a licensed disposal facility.
- Backfill and recontour all disturbed areas.
- Perform final site soil radiation background surveys.
- Establish permanent revegetation on all disturbed areas.

The following sections describe in general terms the planned decommissioning activities and procedures for the Crow Butte facilities. Crow Butte Resources will, prior to final decommissioning of an area, submit to the USNRC and NDEQ a detailed plan for their review and approval.

6.2.1 PROCESS BUILDINGS AND EQUIPMENT

Prior to process plant decommissioning, a preliminary radiological survey will be conducted to identify any potential hazards. The survey will also support the development of procedures for dealing with such hazards prior to commencement of decommissioning activities. The majority of the process equipment in the process building will be reusable, as well as the building itself. Alternatives for the disposition of the building and equipment are discussed below.

6.2.1.1 REMOVAL AND DISPOSAL ALTERNATIVES

All process or potentially contaminated equipment and materials at the process facility including tanks, filters, pumps, piping, etc., will be inventoried, listed and designated for one of the following removal alternatives:

- Removal to a new location within the Crow Butte site for further use or storage.
- Removal to another licensed facility for either use or permanent disposal.
- Decontamination to meet unrestricted use criteria for release, sale or other non-restricted use by the landowners and others.

It is most likely that process buildings will be dismantled and moved to another location or to a permanent licensed disposal facility. Cement foundation pads and footing will be broken up and trucked to disposal site or a licensed facility if contaminated. The landowners, however, could request that a building or other structures be left on site for his use. In this case, the building will be decontaminated to meet unrestricted use criteria.

6.2.1.1.1 DISPOSAL AT A LICENSED FACILITY

If a piece of process equipment is to be moved to another licensed area the following procedures may be used.

- Flush inside of tanks, pumps, pipes, etc., with water or acid to reduce interior contamination as necessary for safe handling.
- The exterior surfaces of process equipment will be surveyed for contamination. If the surfaces are found to be contaminated the equipment will be washed down and decontaminated to permit safe handling.
- The equipment will be disassembled only to the degree necessary for transportation. All openings, pipe fittings, vents, etc., will be plugged or covered prior to moving equipment from the plant building.
- Equipment in the building, such as large tanks, may be transported on flatbed trailers. Smaller items, such as links of pipe and ducting material, may be placed in plastic lined covered dump trucks or drummed in barrels for delivery to the receiving facility.
- Contaminated buried process trunk lines and sump drain lines will be excavated and removed for transportation to a licensed disposal facility.

- All other miscellaneous contaminated material will be transported to a licensed disposal facility.

6.2.1.1.2 DISPOSAL TO UNRESTRICTED USE

If a piece of equipment is to be released for unrestricted use it will be appropriately surveyed before leaving the licensed area. Both interior and exterior surfaces will be surveyed to detect potential contamination. Appropriate decontamination procedures will be used to clean any contaminated areas and the equipment resurveyed and documentation of the final survey retained to show that unrestricted use criteria were met prior to releasing the equipment or materials from the site. Criteria to be used for release to unrestricted use will be USNRC's *"Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct or Source Materials, Uranium Recovery Field Office Region IV, Denver, Colorado, September 1984"*, or the most current standards for decontamination at that time.

If a process building is left on site for landowner unrestricted use, the following basic decontamination procedures will be used. Actual corrective procedures will be determined by field requirements as defined by radiological surveys.

- After the building has been emptied, the interior floors, ceiling and walls of the building and exterior surfaces at vent and stack locations will be checked for contamination. Any remaining removable contamination will be removed by washing. Areas where contamination was noted will be resurveyed to ensure removal of all contamination to appropriate levels.

- Process floor sump and drains will be washed out and decontaminated using water and, if necessary, acid solutions. If the appropriate decontamination levels cannot be achieved, it may be necessary to remove portions of the sump and floor to disposal.

- Excavations necessary to remove trunklines or drains will be surveyed for contaminated earthen material. Earthen material that is found to be contaminated will be removed to a licensed disposal facility prior to backfilling the excavated areas.

- The parking and storage areas around the building will be surveyed for surface contamination after all equipment has been removed.

Decontamination of these areas will be conducted as necessary to meet the standards for unrestricted use.

6.2.2 EVAPORATION POND DECOMMISSIONING

6.2.2.1 DISPOSAL OF POND WATER

The volume of water remaining in the lined evaporation ponds after restoration as well as its chemical and radiological characteristics will be considered to determine the most practical disposal program. Disposal options for the pond liquid include evaporation, treatment and disposal or transportation to another licensed facility or disposal site. The pond water from the later stages of groundwater restoration may be treatable to within discharge limits; if this can be accomplished, the water will be treated and discharged under an appropriate NPDES permit. Evaporation of the remaining water may be enhanced by use of sprinkler systems, etc.

6.2.2.2 POND SLUDGE AND SEDIMENTS

Pond sludges and sediments will contain mining process chemicals and radionuclides. Wind blown sand grains and dust blown into the ponds during their active life also add to the bulk of sludges. This material will be contained within the pond bottom and kept in a dampened condition at all times, especially during handling and removal operation to prevent the spread of airborne contamination and potential worker exposure through inhalation. Dust abatement techniques will be used as necessary. The sludge will be removed from the ponds and loaded into dump trucks or drums and transported to a USNRC licensed disposal facility. All equipment and personnel working on sludge and liner removal will be checked prior to leaving the work area to prevent the tracking of sludge into uncontaminated locations.

6.2.2.3 DISPOSAL OF POND LINERS AND LEAK DETECTION SYSTEMS

Pond liners will be kept washed down and intact as much as practical during sludge removal so as to confine sludges and sediments to the pond bottom. Pond liners will be cut into strips and transported to a USNRC licensed disposal facility or will be decontaminated for release to an unrestricted area. After removal of the pond liners, the pond leak detection system piping will be removed. Materials involved in the leak detection system will be surveyed and released for unrestricted use if not contaminated or transported to a USNRC licensed facility for disposal. The earthen material in the pond bottom and leak detection system trenches will be surveyed for soil contamination; any contaminated soil in excess of limits defined in 10 CFR 40, Appendix A, will be removed.

Following the removal of all pond materials and the disposal of any contaminated soils, surface preparation will take place prior to reclamation. Pond surface reclamation will be performed in accordance with the surface reclamation plan, Section 6.3. An additional radiation background survey will be conducted on the recontoured area prior to topsoiling.

6.2.2.4 ON SITE BURIAL

At the present time, on site burial of contaminants is not anticipated. However, depending upon the availability of a USNRC licensed disposal site at the time of decommissioning, on site burial may become a potential alternative. Should this occur, pond locations would be considered initially as the on site disposal locations for contaminated materials. Appropriate licensing with the regulatory agencies would be obtained prior to any on site burial of contaminated wastes.

6.2.3 WELLFIELD DECOMMISSIONING

Wellfield decommissioning will consist of the following steps:

- The first step of the wellfield decommissioning process will involve the removal of surface equipment. Surface equipment primarily consists of the injection and production feed lines, electrical conduit, well boxes, and wellhead equipment. All of the lines are above ground surface lines which will not require excavation for removal. Wellhead equipment such as valves, meters or control fixtures will be salvaged.

- Removal of buried well field piping.

- Wells will be plugged and abandoned according to the procedures described below.

- The well field area may be recontoured, if necessary, and a final background gamma survey conducted over the entire well field area to identify any contaminated earthen materials requiring removal to disposal.

- Final surface reclamation of the well field areas will be conducted according to the surface reclamation plan described in Section 6.3.

- All piping, boxes and wellhead equipment will be surveyed for contamination prior to release in accordance with the USNRC guidelines for decommissioning.

It is estimated that a significant portion of the equipment will meet releasable limits which will allow disposal at an unrestricted area landfill. Other materials which are contaminated will be acid washed or cleansed with other methods until they are releasable. If the equipment still does not meet releasable limits, it will be disposed of at a facility licensed to accept by-product material.

After the Crow Butte aquifer restoration and post-restoration stabilization has been completed and accepted in writing as successful by both the NDEQ and USNRC, the decommissioning of the mine unit wellfields will commence.

Wellfield decommissioning will be an independent ongoing operation throughout the mining sequence at the Crow Butte site. Once a production unit has been mined out and groundwater restoration and stability have been accepted by the regulatory agencies, the wellfield will be scheduled for decommissioning and surface reclamation.

6.2.3.1 WELL PLUGGING AND ABANDONMENT

All wells no longer useful to continued mining or restoration operations will be abandoned. These include all injection and recovery wells, monitor wells and any other wells within the production unit used for the collection of hydrologic or water quality data or incidental monitoring purposes. The only known exception at this time may be a well which could be transferred to the landowner for domestic or livestock use.

The objective of the Crow Butte Resources well abandonment program is to seal and abandon all wells in such a manner as to assure the groundwater supply is protected and to eliminate any potential physical hazard.

The plugging method will be as follows:

- An approved abandonment mud (a mud-polymer mix) will be mixed in a cement unit and pumped down a hose, which is lowered to the bottom of the well casing using a reel.

- When the hose is removed, the casing is topped off and a cement plug placed on top.

- A hole is then dug around the well, and, at a minimum, the top three feet of casing removed.

- The hole is backfilled and the area revegetated.

Records of abandoned wells will be tabulated and reported to the appropriate agencies after decommissioning.

6.2.3.2 BURIED TRUNKLINES, PIPES AND EQUIPMENT

Buried process related piping such as injection and recovery lines will be removed from the production unit undergoing decommissioning. Salvageable lines will be held for use in ongoing mining operations. Lines that are not reusable may either be assumed to be contaminated and disposed of at a licensed disposal site or may be surveyed and, if suitable for release to an unrestricted area, may be sent to a sanitary landfill. If on site burial is an option in the future, lines may be disposed of on site according to conditions of the appropriate licenses/permits.

6.2.4 DECONTAMINATION

After all surface equipment is removed and all wells are properly plugged and abandoned, a gamma survey of the wellfield surfaces will be conducted. Any areas with elevated gamma readings which indicate radium-226 levels in excess of limits in 10 CFR 40, Appendix A, will be resurveyed. Soil samples will be collected from confirmed contaminated locations for the analysis of radium-226 and uranium. Based upon the soil sampling and additional gamma radiation readings, contaminated soil will be removed and transferred to a site licensed to accept by-product materials. Gamma survey results and soil sampling results will be submitted to the USNRC for their review, approval and opportunity to split soil samples. After approval of the soil contamination removal program, revegetation will commence.

The objective of site soil surveys during decommissioning will be to identify and remove to a licensed disposal facility any earthen materials which exceed EPA 40 CFR Part 192.32 standards or other applicable standards at the time of decommissioning. These standards presently require that radium concentrations in surface soils, averaged over areas of 100 square meters, do not exceed background levels by more than 5 pCi/g averaged over the first 15 cm below the surface and 15 pCi/g averaged over any 15 cm thick layer more than 15 cm below the surface.

Three general types of site soil surveys will be conducted on the site during decommissioning:

- Areas of potential surface contamination will be identified using a gross gamma survey on an adequately spaced grid.

- Spot checks of areas around the site of potentially contaminated areas.

- The final soil background survey on areas which have been prepared for surface reclamation using a grid spacing adequate for confirming clean up to applicable standards.

Contaminated soils which are removed from site surfaces will be transported to a licensed disposal site. The primary areas for potential soil contamination include well field surfaces, evaporation pond bottoms and berms, process building areas, storage yards and transportation routes over which product or contaminants have been moved.

6.2.5 DECOMMISSIONING HEALTH PHYSICS AND RADIATION SAFETY

The health physics and radiation safety program for decommissioning will document decommissioning processes and ensure that occupational radiation exposure levels are kept as low as reasonably achievable during decommissioning. The Radiation Safety Officer, Radiation Safety Technician or designee by way of specialized training, will be on site during any decommissioning activities where a potential radiation exposure hazard exists.

Health physics survey conducted during decommissioning will be guided by applicable sections of 10 CFR 20 and USNRC Regulatory Guide No. 8.30 entitled "*Health Physics Surveys in Uranium Mills*" or other applicable standards at the time.

6.2.6 EQUIPMENT AND MATERIAL SURVEYS

Any site equipment to be released for unrestricted use will be surveyed for alpha contamination and beta gamma as necessary to document levels for release, according to USNRC "*Guidelines for Decontamination of Facilities for Byproduct or Source Materials*", *Uranium Recovery Field Office Region IV, Denver, Colorado, September 1984*, or the most current standards for decontamination at that time.

Transportation of all contaminated waste materials and equipment from the site to the approved licensed disposal facility or other licensed sites will be handled in accordance with the Department of Transportation and U.S. Nuclear Regulatory Commission Regulations (49 CFR 173.389)(10 CFR 71).

6.2.7 RECORDS AND REPORTING PROCEDURES

At the conclusion of site decommissioning and surface reclamation, a report containing all applicable documentation will be submitted to the USNRC and NDEQ. Records of all contaminated materials transported to a licensed disposal site will be maintained for a period of five years or as otherwise required by applicable regulations at the time of decommissioning.

6.3 SURFACE RECLAMATION

The following reclamation plan provides procedural techniques for surface reclamation of all disturbances contained in the Crow Butte Resources mine plan. Provided are reclamation procedures for the process plant facilities, evaporation ponds, wellfield production units, access and haul roads. Reclamation techniques and procedures for subsequent satellite facilities, additional ponds and wellfields will follow the same concepts as presented below. Reclamation schedules for wellfield production units will be discussed separately because they are dependent upon the progress of mining and the successful completion of groundwater restoration. Cost estimates for bonding calculations include all activities which are anticipated to complete groundwater restoration, decontamination, decommissioning and surface reclamation of wellfield and satellite plant facilities installed to operate for one year of mining activity.

The principal objective of the surface reclamation plan is to return disturbed lands to production, compatible with the post mining land use, of equal or better quality than its premining condition. The reclaimed lands should therefore be capable of supporting livestock grazing and provided stable habitat for native wildlife species. Soils, vegetation, wildlife and radiological baseline data will be used as guidelines for the design, completion and evaluation of surface reclamation. Final surface reclamation will blend affected areas with adjacent undisturbed lands so as to re-establish original slope and topography and present a natural appearance. Surface reclamation efforts will strive to limit soil erosion by wind and water, sedimentation and re-establish natural through drainage patterns.

6.3.1 WELLFIELD RECLAMATION

Surface reclamation in the wellfield production units will vary in accordance with the development sequence, mining/reclamation time table. Final surface reclamation of each wellfield production units will be after approval of groundwater restoration stability and the completion of well abandonment and decommissioning activities specified in Section 6.2. Surface preparation will be accomplished as needed so as to blend any disturbed areas into the contour of the surrounding landscape. The seed bed will be prepared and reseeded with assistance from the U.S. Soil Conservation Service.

6.3.2 PROCESS FACILITIES RECLAMATION

Subsoils and stockpiled topsoil will be replaced on the disturbances from which they were removed during construction, within practical limits. Areas to be backfilled will be scarified or ripped prior to backfilling to create an uneven surface for application of backfill. This will provide a more cohesive surface to eliminate slipping and slumping. The less suitable subsoil and unsuitable topsoil, if any, will be backfilled first so as to place them in the deepest part of the excavation to be covered with more suitable reclamation materials. Subsoils will be replaced using paddle wheel scrapers, push-cats or other appropriate equipment to transfer the earth from stockpile locations or areas of use and to spread it evenly on the ripped disturbances. Grader blades may be used to even the spread of backfill materials. Backfill compacting will be accomplished by movement of the equipment over the fill area. Topsoil replacement will commence as soon as practical after a given disturbed surface has been prepared. Topsoil will be picked up from storage locations by paddle wheel scrapers or other appropriate equipment and distributed evenly over the disturbed areas. The final grading of topsoil materials will be done so as to establish adequate drainage and the final prepared surface will be left in a roughened condition. There will be no topsoil used for construction of any kind; topsoil will have been salvaged and stockpiled.

6.3.3 CONTOURING OF AFFECTED AREAS

Due to the relatively minor nature of disturbances created by in-situ mining, there are only a few areas disturbed to the extent to which subsoil and geologic materials are removed causing significant topographic changes which need backfilling and recontouring. Generally speaking, solar evaporation pond construction results in redistribution of sufficient amounts of subsurface materials which requires replacement and contour blending during reclamation. The existing contours will only be interrupted in small localized areas; because approximate original contours will be achieved during final surface reclamation, no post mining contour maps have been included in this application.

Changes in the surface configuration caused by construction and installation of operating facilities will be only temporary, during the operating period. These changes will be caused by topsoil removal and storage along with the relocation of subsoil materials used for construction purposes. Restoration of the original land surface, which is consistent with the pre- and post-mining land use, the blending of affected areas with adjacent topography to approximate original contours and re-establishment of drainage patterns will be accomplished by returning the earthen materials moved during construction to their approximate original locations.

Drainage channels which have been modified by the mine plan for operational purposes such as road crossings will be re-established by removing fill materials, culverts and reshaping to as close to pre-operational conditions as practical. Surface drainage of disturbed areas which have been located on terrain with varying degrees of slope will be accomplished by final grading and contouring appropriate to each location so as to allow for controlled surface run off and eliminate depressions where water could accumulate.

6.4 BONDING ASSESSMENT

6.4.1 BOND CALCULATIONS

Cost estimates for the purpose of bond calculations were made for the Crow Butte Project site. The cost assessment includes groundwater restoration, decontamination and decommissioning and surface reclamation costs for all areas to be affected by the installation and operation of the proposed mine plan. The detailed calculation utilized in determining the bonding requirements for the Crow Butte Project are enclosed on Attachment 6.1.

6.4.2 FINAL SURETY ARRANGEMENTS

Crow Butte Resources maintains a NRC-approved financial surety arrangement consistent with 10 CFR 40, Appendix A, Criterion 9 to cover the estimated costs of reclamation activities. Crow Butte maintains an Irrevocable Letter of Credit No. 74504 issued by First Bank N.A. during 1995 in favor of the State of Nebraska in the present amount of $5,543,958.

ATTACHMENT 6.1

Request 7 Clarification

Pages 31 through 34 of NUREG/CR-4088

tailings surface flux (J_t) of 32 $pCi/m^2 \cdot s^1$ for the sand and 112 $pCi/m^2 \cdot s^1$ for the slimes fractions, which is nearly the same as for the previous example (within the error of the graph).

Radon Release During In-Situ Operations

The major source of radon release during in-situ mining operations is the lixiviant, which when exposed to the atmosphere will release radon. The release will occur when the lixiviant arrives at the process recovery surge tanks, ion exchange tanks, or columns or evaporation ponds.

Aquifer restoration that includes ground-water sweeping and clean water circulation is also a source of radon that must be considered.

The key parameters used to determine the average annual radon release are listed in Table 7.

In order to determine a reasonably conservative annual radon release, it is assumed that one mining unit will be mined, one unit soaked, and one unit restored during the year. The radon release from these operations is discussed in the following paragraphs.

Radon Release from Mining

If the radium-226 content of the ore has not been measured, then it is assumed that the uranium-238 is in equilibrium with all its daughters. The radium-226 and radon-222 concentration present in the ore would therefore be

TABLE 7. Parameters Used to Determine Radon Release from In-Situ Mining

Ore grade, % U_3O_8
Radium-226 concentration in the ore body, pCi/g
Mined area per year, m^2
Average lixiviant flow rate, L/min
Average restoration flow rate, L/min
Number of operating days
Formation thickness, T
Formation porosity, %
Rock density, g/cm^3
Residence time for lixiviant, days
Residence time for restoration solution, days
Emanating power of ore

2820 pCi/g per % U_3O_8. The radon emanating power is assumed to average 0.2 unless otherwise determined. The radon release at equilibrium, G, in 1 m^3 of rock may be calculated as:

$$G = R\rho E\ (1 - p)/p \times 10^{-6} \tag{7}$$

where G = radon release, Ci/m^3 of rock
R = radium content, pCi/g
ρ = rock density, g/cm^3
E = emanating power
p = formation porosity.

The yearly radon release, Y, in Ci/yr may be calculated as follows:

$$Y = GM\varepsilon D \times 1.44 \tag{8}$$

where M = lixiviant production rate, L/min
ε = equilibrium factor for radon
D = production days per year.

The equilibrium factor, ε, equals $1 - e^{-\lambda t}$ where λ is the radon decay constant and t is the residence time. This is a conservative estimate since it assumes that the radon immediately goes into the lixiviant solution.

Radon Release from Soaking

In addition to the release of radon from the lixiviant dissolution, it is estimated that one pore volume of nonproduction solution will be removed as each mining unit is put into service. The startup radon release, S, may be calculated as:

$$S = GATp \tag{9}$$

where A = area of mining unit, m^2
T = thickness of ore, m.

For a mining unit that will be soaked for 1 year, it is also assumed that one pore volume of mining solution will be removed when the lixiviant is added. Therefore, the release of radon would be the same as during the startup.

Radon Release During Restoration

The annual radon released during restoration, r, in Ci/yr is calculated using:

$$r = GN\varepsilon D \times 1.44 \tag{10}$$

where G = radon release at equilibrium, Ci/m^3 of rock
N = restoration solution rate, L/min.
E = equilibrium factor
D = restoration days per year.

It is also assumed that one pore volume of solution will be removed before restoration begins, similar to startup.

Example Calculation: Radon Release from an In-Situ Mine

The following is a sample calculation of the total release of radon from a hypothetical in-situ uranium mining operation.

Assumptions:

Ore grade	0.1% U_3O_8
Average area to be mined	10 acres
Average lixiviant flow	4000 L/min
Average restoration flow	400 L/min
Operating days per year	365
Formation thickness	3 m
Formation porosity	0.3
Rock density	1.8 g/cm^3
Residence time for lixiviant	5 days
Residence time for restoration solution	10 days
Emanating power	0.2

From mining and soaking, the radon release per m^3 of the rock is estimated using Equation (7).

The radium content, R is first calculated assuming secular equilibrium between the U^{238} and Ra^{226}.

$$R = 3.33 \times 10^5 \text{ pCi } U^{238}/\text{g U} \times 0.001 \text{ g } U_3O_8/\text{g ore} \times 0.85 \text{ g U/g } U_3O_8$$
$$= 283 \text{ pCi/g ore.}$$

Next the radon release, G, is calculated.

$$G = R\rho E(1 - p)/p \times 10^{-6}$$
$$= 283 \text{ pCi/g} \times 1.8 \text{ g/cm}^3 \times 0.2 \times (1 - 0.3)/0.3 \times 10^{-6}$$
$$= 2.4 \times 10^{-4} \text{ Ci/m}^3.$$

Next the radon release, G, is calculated using Equation (8).

$$Y = GM\varepsilon D \times 1.44$$
$$\varepsilon = 1 - e^{-(0.181/d)(5\ d)} = 0.6$$
$$Y = 2.4 \times 10^{-4}\ Ci/m^3 \times 4000\ L/min \times 0.6 \times 365\ days/yr \times 1.44$$
$$= 303\ Ci/yr.$$

The radon released from the startup solution and soaking is calculated using Equation (9).

$$S = GATp$$
$$= 2.4 \times 10^{-4}\ Ci/m^3 \times 10\ acres \times 4074\ m^2/acre \times 3\ m \times 0.3$$
$$= 8.8\ Ci/yr.$$

The total release of radon from the startup solution, production lixiviant, and soaking solution is:

Startup solution	8.8 Ci/yr
Production	303 Ci/yr
Soaking solution	8.8 Ci/yr
	320.6 Ci/yr

The radon release from the restoration operation is calculated using Equation (10):

$$r = GN\varepsilon D \times 1.44$$
$$\varepsilon = 1 - e^{-(0.181/d)(10\ d)} = 0.84$$
$$r = 2.4 \times 10^{-4}\ Ci/m^3 \times 400\ L/min \times 0.84 \times 365\ d/yr \times 1.44$$
$$= 42.4\ Ci/yr$$

The total radon release from restoration includes a small increment of release similar to that from the startup solution. Therefore, the total release would be:

$$42.4\ Ci/yr + 8.8\ Ci/yr = 51.2\ Ci/yr.$$

The total release from this 10-acre hypothetical in-situ mining operation is then 320.6 + 51.2 = 371.8 Ci/yr.

Request 8 Affected Pages

Table 7-3(A)-6 (page 7-3(A)-10)

Table 7-3(A)-2 (page 7-3(A)-2)

Table 7-3(A)- 6: Miscellaneous Data

Fraction of year during which cattle graze locally	Est. 67%
Fraction of cattle feed obtained by grazing	Est. 90%
Fraction of stored cattle feed grown locally	Est. 90% of the 10% remaining feed
Acreage required to graze 1 animal unit (450 kg) for one month (AUM)	3.5 ha
Length of growing season	4 mo/yr
Fraction of locally produced vegetables consumed locally	Est. 100%
Fraction of locally produced meat consumed locally	Est. 10%
Fraction of locally produced milk consumed locally	Est. 100%

Estimates based on personal communication with the Sioux County, Nebraska Agricultural Extension Educator located in Harrison, Nebraska (Ms. Jenny Nixon).

Table 7-3(A)- 2: Source and Receptor Coordinates Crow Butte Project

Source	East (km)	North (km)	Case 1 Rn-222 (Curies)	Case 2 Rn-222 (Curies)
1. Plant Vent	0	0	3270	2400
2. MU-1	-0.13	0.30	119	119
3. MU-2	0.06	0.27	119	119
4. MU-3	-0.30	0.16	119	119
5. MU-4a	-0.17	0.00	0	159
6. MU-4b	0.33	0.12	445	159
7. MU-5	-0.13	0.74	445	318
8. McDowell WF	1.55	2.80	0	445
9. Raben WF	2.93	3.53	0	445
10. Brott WF	-1.19	1.65	383	0

Editorial/Clarification Comment Number 1

Revised Table 2.7-1 (page 2.7-4)

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

Month	Mean Precipitation [1]		Mean Discharge [2]	
	inches	cm	ft^3/s	m^3/s
January	0.41	1.04	21.0	0.59
February	0.37	0.94	23.4	0.66
March	0.70	1.78	27.2	0.77
April	1.67	4.24	25.3	0.72
May	2.98	7.57	25.3	0.72
June	3.32	8.43	22.2	0.63
July	2.16	5.49	15.4	0.44
August	0.97	2.46	12.6	0.36
September	1.33	3.38	13.3	0.38
October	0.83	2.11	16.6	0.47
November	0.43	1.09	19.4	0.55
December	0.39	0.99	20.2	0.57

1 U.S. Department of Commerce, 1982, Period of Record 1941-1970.
2 U.S. Department of the Interior, 1981, Period of Record 1931-1980.

Editorial/Clarification Comment Number 2

Revised Page 2.9-14

process facility will be located and where maximum surface disturbance will occur. (Figure 2.9-6). Seven sites were also sampled in the proposed restricted area (Figure 2.9-7). At the plant and pond locations, another set of samples will be obtained before commercial construction and also after topsoil removal and excavation is complete.

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

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

Samples from the Permit Area and the specific samples from Section 19 (Figure 2.9-5) were analyzed for arsenic and selenium and the samples from the proposed restricted area (Figure 2.9-7) were analyzed for vanadium.

Results of the soil sampling are found in Tables 2.9-10 and 2.9-11. As can be seen from the data in Table 2.9-10 the arsenic concentration ranges from 0.59 μg/g to 3.30 μg/g and the selenium concentration ranges from <0.01 ug/g to 0.06 μg/g. There does not appear to be any relationship between the soils type and the levels of these elements. The vanadium analysis shown in Table 2.9-11 indicate that the vanadium levels in the restricted area are very consistent with a range of 22 to 29 μg/g.

Soils develop over long periods of time and contain elements that are in equilibrium with the established chemical environment. Several factors govern solubility and stability of elements in soils. These include pH, drainage status, organic content, sulfate content, etc. In addition, many studies have pointed out there is no absolute correlation between the total concentration of an element in the soil and its uptake by plants. However, uptake of arsenic, selenium, and vanadium by plants depends highly on the chemical form and availability of the elements and upon the plant species.

Editorial/Clarification Comment Number 3

Revised Table 2.10-14 (page 2.10-32)

Table 2.10-14: Average Radiometric Analysis of Sediment Samples From Squaw Creek Crow Butte Project

Sample Location	Sample Period	U-Nat x 10^{-9} μCi/ml	Th-230 x 10^{-9} μCi/ml	Ra-226 x 10^{-9} μCi/ml	Pb-210 x 10^{-9} μCu/ml	Po-210 x 10^{-9} μCi/ml
S-2	5/82 - 10/86	4.9 ± 9.43	2.4 ± 4.6	0.9 ± 1.1	0.4 ± 0.3	1.0 ± 0.5
S-3	5/82 - 10/86	2.5 ± 4.2	2.2 ± 4.0	0.8 ± 0.5	0.3 ± 0.4	0.5 ± 0.2

Editorial/Clarification Comment Number 5

Revised Page 5-32

Radon Daughter Concentration Determination

Radon-222 daughter concentrations are determined from surveys performed as described in Section 5.7.3.2.

The working-level months for radon daughter exposure is calculated on Time Weighted Exposure (TWE) forms. The working-level months are totaled and entered onto each employee's Occupational Exposure Record.

Historical Program Results

Table 5.7-5 summarizes the results of radon daughter exposure calculations at Crow Butte Uranium Project since 1990. The data shows that internal exposure due to radon daughters at Crow Butte Uranium Project has been maintained ALARA. The maximum individual internal exposure to radon daughters during the period from 1990 through 1994 was 0.502 working-level months or approximately 12.5% of the allowable regulatory limit of 4 working-level months. The maximum annual average internal exposure to radon daughters was 0.258 working-level months which is approximately 6.5% of the regulatory limit.

Proposed Radon Daughter Exposure Monitoring Program

CBR proposes to institute the same internal radon daughter exposure calculation methods at Crow Butte Uranium Project that have been used to date and which are currently contained in Standard Operating Procedure C-16, "Internal Exposure Control and Calculations". Exposures to radon daughters will be compared to the DAC for radon daughters from Appendix B of 10 CFR §§20.1001 - 20.2401 (0.33 WL).

Editorial/Clarification Comment Number 6

Revised Pages 5-34 through 5-35

5.7.5 BIOASSAY PROGRAM

Program Description

CBR has implemented a urinalysis bioassay program at the Crow Butte Uranium Project facilities that meets the guidelines contained in USNRC Regulatory Guide 8.22, "Bioassay at Uranium Mills, Revision 1." The primary purpose of the program is to detect uranium intake in employees who are regularly exposed to uranium. The bioassay program consisted of the following elements:

1. Prior to assignment to the facility, all new employees are required to submit a baseline urinalysis sample. Upon termination, an exit bioassay is required.

2. During operations, urine samples are collected from workers whose routine work assignment requires them to enter areas where the potential for inhalation of yellowcake exists. Samples from these workers are collected on a quarterly frequency. Workers who have the potential for exposure to dried yellowcake are sampled on a monthly basis. Samples are analyzed by an outside analytical laboratory for uranium content. Blank and spiked samples are also submitted to the laboratory with employee samples as part of the Quality Assurance program. The measurement sensitivity for the analytical laboratory is 5 µg/l.

3. Action levels for urinalysis are established based upon Table 1 in USNRC Regulatory Guide 8.22, "Bioassay at Uranium Mills, Revision 1."

Historical Program Results

Following is a summary of the results of the bioassay program since 1990.

1990

All bioassay samples were reported at less than the 5 µg/l detection limit.

1991

All bioassay samples were reported at less than the 5 µg/l detection limit.

1992

All bioassay samples were reported at less than the 5 μg/l detection limit.

1993

All bioassay samples were reported at less than the 5 μg/l detection limit.

1994

All bioassay samples were reported at or less than the 5 μg/l detection limit with the exception of one sample which was 13.9 μg/l. Resamples of the individual that submitted this sample were less than 5 μg/l.

Bioassay Quality Assurance Program Description and Historical Results

Elements of the Quality Assurance requirements for the Bioassay Program are based upon the guidelines contained in USNRC Regulatory Guide 8.22, "Bioassay in Uranium Mills", Revision 1. These elements included the following:

1. Each batch of samples submitted to the analytical laboratory is accompanied by two blind control samples. The control samples are from persons that have not been occupationally exposed and are spiked to a uranium concentration of 10 to 20 μg/l and 40 to 60 μg/l. The results of analysis for these samples are required to be within ± 30% of the spiked value. CBR has tracked the results of the blind spike analysis since 1990. All analytical results have fallen within the acceptable range.

2. The analytical laboratory spikes 10 to 30% of all samples received with known concentrations of uranium and the recovery fraction determined. Results are reported to CBR. All results have been within ± 30%.

Proposed Bioassay Program

CBR proposes to continue to implement the Bioassay Program described in this section in accordance with the guidance contained in USNRC Regulatory Guide 8.22, "Bioassay in Uranium Mills, Revision 1" and with the instructions currently contained in Standard Operating Procedure C-10, "Bioassay Sampling."

Editorial/Clarification Comment Number 8

Revised Pages 2.7-13 and 2.7-29 through 2.7-34

The integrity of confinement of the ore-zone aquifer (Basal Chadron Sandstone) may be characterized most graphically by the hydraulic resistance factor, c. The hydraulic resistance of the overlying aquiclude is about 53,000 years and that of the underlying aquiclude is about 34,000,000 years. The times needed for a water molecule to travel through the entire thicknesses of the aquicludes, assuming an effective porosity of 2.0 percent, under unit gradient (one foot of head loss per foot of movement in the direction of flow) are about 1,050 years for the overlying aquiclude and about 685,000 years for the underlying aquiclude.

Movement of Groundwater

The piezometric surface of the Basal Chadron Sandstone dips toward the north at a gradient of about 0.04 percent (0.0004) which is equal to one foot per 2500 feet. Using a directional hydraulic conductivity of 10 ft/day, a gradient of $4X10^{-4}$ and a porosity of 29 percent, the average pore velocity across the R&D site was computed to be 5.0 ft/year. The groundwater flux across the site was computed to be $0.16ft^3$/day per unit width of the aquifer.

Second Aquifer Test

A second multiple-well aquifer test was performed in the mineralized area near the northern boundary of Section 19. This test was part of a hydrogeologic investigation of the commercial permit area north of the R&D site. This investigation consisted of: (1) a review of exisiting geologic and hydrogeologic data; (2) design of an appropriate aquifer test; (3) design and construction of an appropriate well array for the aquifer test; (4) laboratory testing of core samples from confining layers; (5) conducting the aquifer test, (6) analyzing the aquifer test data, and (7) interpreting the results. This hydrogeologic investigation was structured to address environmental and operational questions pertinent to ISL uranium mining at the site. Specifically, the requirements outlined by the Nuclear Regulatory Commission (NRC) in Regulatory Guide 3.46, Section 2.7.1 and Draft Staff Technical Position Paper WM-8203, Section 3.1.2. Therefore, this hydrogeologic investigation was oriented toward the characterization of the hydraulic properties of the ore-bearing aquifer, and the hydraulic relationship of the aquifer to the overlying and underlying confining strata and the overlying aquifer. The aquifer test site is located near the north boundary of Section 19, T 31 N, R51 W, Dawes County, Nebraska. This site is approximately 2800 feet north of the R & D site (Figure 0-7).

(8.7 ft/day) to about 66 gpd/ft^2 (8.89 ft/day) Table summarizes the results of the analysis of the aquifer test data.

The Hantush Method For Anisotropic aquifers was used to determine the direction and magnitude of the major and minor axes of transmissivity of the Basal Chadron Sandstone. The major axis of transmissivity in the Basal Chadron Sandstone lies along an azimuth of about 51° and has a magnitude of 2760 gpd/ft (369 ft^2/day) (Figure 0-8). The minor axis of transmissivity has an azimuth of about 141° and a magnitude of 2692 gpd/ft 360 ft^2/day.

Overlying and Underlying Confining Layers

The overlying confining layer piezometer (UCP-1) showed no response to the pumping from the Basal Chadron Sandstone during the aquifer test. However, this piezometer did respond to the rapid changes in barometric pressure that accompanied the passage of a low pressure system and a cold front which confirmed that it was indeed functioning properly. Because UCP-1 did not respond to pumping, it was not possible to use the water level data from UCP-1 to calculate the hydraulic properties of the upper confining layer using the Neuman-Witherspoon Method. Therefore, laboratory data from the consolidation tests of core samples from UCP-1 were used to calculate the hydraulic properties of the overlying confining layer.

Results of the laboratory consolidation test data from three core samples of UCP-1 are shown earlier in Table 0-4 The calculated average coefficient of compressibility, a_v, of the red clay portion of the overlying confining layer, is 3.99×10^{-7} cm^2/g and the calculated average vertical hydraulic conductivity is 3.49×10^{-11} cm/sec. Using these consolidation test data, the calculated specific storage of the red clay portion of the overlying confining layer is 3.08×10^{-7} cm^{-1} and the calculated hydraulic diffusivity is 1.13×10^{-4} cm^2/sec. Analysis of drill cuttings and geophysical logs of UCP-1 and exploration holes in the vicinity of the test site show that the lithology of the strata between the red clay and the overlying Brule aquifer (Upper Chadron and Lower Brule Formations) is similar to the red clay. Therefore, it is reasonable to assume that the hydraulic characteristics of these strata are similar to those of the red clay. Given that the red clay is approximately 30 feet thick and the total overlying confining layer is approximately 325 feet thick, the hydraulic resistance, c, (Kruseman and de Ridder, l979) is about 830,200 years for the red clay and 9,000,000 years for the entire confining layer. Assuming an average effective porosity of the overlying confining layer of 2.0%, the travel time through the red clay portion of the upper confining layer would be about 16,600,000 years and that of the entire upper confining layer would be about 180,000 years under unit gradient.

Table 2.7-6: Summary of Aquifer Test Data Analysis

Jacob Method (Drawdown)

Well	T (gpd/ft)	T (ft^2/day)	S	K (gpd/ft^2)	K (ft/day)
COW-1	2682	359	$8.65x10^{-5}$	67	8.98
COW-2	2687	359	$1.14x10^{-4}$	67	8.98
COW-3	2795	374	$9.73x10^{-5}$	70	9.35
Average	2721	364	$9.93x10^{-5}$	68	9.10

Theis Method (Drawdown)

Well	T (gpd/ft)	T (ft^2/day)	S	K (gpd/ft^2)	K (ft/day)
COW-1	2730	365	$8.44x10^{-5}$	68	9.13
COW-2	2733	365	$1.11x10^{-4}$	68	9.13
COW-3	2724	364	$1.31x10^{-4}$	68	9.10
Average	2729	365	$1.09x10^{-4}$	68	9.12

Theis Recovery Method

Well	T (gpd/ft)	T (ft^2/day)	S	K (gpd/ft^2)	K (ft/day)
COW-1	2659	355		66	8.88
COW-2	2626	351		66	8.78
COW-3	2604	348		65	8.70
Average	2630	351		66	8.79

Average of Jacob and Theis Methods (Drawdown) [1]

Well	T (gpd/ft)	T (ft^2/day)	S	K (gpd/ft^2)	K (ft/day)
COW-1	2706	362	$8.55x10^{-5}$	68	9.05
COW-2	2710	362	$1.13x10^{-4}$	68	9.05
COW-3	2760	364	$1.14x10^{-4}$	69	9.23
Average	2725	364	$1.04x10^{-4}$	68	9.11

Notes: [1] Used in anisotropy calculations.

Table 2.7-7 summarizes the confining layer properties determined by laboratory and field methods as part of this investigation.

The underlying confining layer piezometer (LCP-1) responded to the same rapid changes in barometric pressure which were measured in overlying confining layer piezometer. However, LCP-1 also showed a trend toward a very small amount of drawdown (.06 feet) during the aquifer test.

Because the vertical hydraulic conductivity of the underlying confining layer (Pierre Shale), as determined from the laboratory consolidation tests, is of the same order of magnitude as the vertical hydraulic conductivity of the upper confining layers (10-11 cm/sec), no drawdown was anticipated in LCP-1 during the test. For this reason, it is suspected that the small amount of drawdown observed in LCP-1 is the result of annular leakage between the borehole and the packer which was set to hydraulically isolate the piezometer tip from the overlying Basal Chadron Sandstone. If the packer did not completely seal the borehole above the piezometer tip, the piezometer would be affected by the pressure drop in the pumped aquifer which would be transmitted by the annulus leaks. Thus, the response of the piezometer would be the result of borehole-packer annulus leaks. If this were the case, the Neuman-Witherspoon analysis of the piezometer water levels would only serve to quantify the vertical leakage or hydraulic conductivity of the packer and borehole seal, not the vertical hydraulic conductivity of the underlying confining layer. Recognizing that this problem may exist, a Neuman-Witherspoon analysis was made of the water level data from LCP-1.

Results of the laboratory consolidation test data from two core samples from LCP-1 are shown earlier in Table 2.7-4. The calculated average coefficient of compressibility, a_v, of the Pierre Shale is 5.13 x 10^{-7} cm^2/g and the calculated average vertical permeability is 3.63 x 10^{-11} cm/sec. Using these consolidation test data, the calculated specific storage of the top 5 feet of the underlying confining layer (Pierre Shale) is 2.78 x 10^{-7} cm^{-1} and the calculated hydraulic diffusivity is 5.22 x 10^{-3} cm^2/sec. Applying the Neuman-Witherspoon Method tothe data from the aquifer test and the consolidation test, produces a field vertical hydraulic conductivity of 1.45 x 10^{-9} cm/sec. Oil test holes have shown that the Pierre Shale is approximately 1200 feet thick in the vicinity of the aquifer test site. Therefore, the calculated hydraulic resistance, c, using field measured vertical hydraulic conductivity, is about 799,900 years. The calculated hydraulic resistance using the vertical hydraulic conductivity calculated from the laboratory consolidation tests is about 31,919,000 years. The average effective porosity of the Pierre Shale is estimated to be 2.0%. Therefore, the travel time through the Pierre Shale would be about 16,000 years using field determined vertical hydraulic conductivity

Table 2.7-7: Summary of Confining Layer Properties

Parameters	Red Clay (UCP-1)	Pierre Shale (LCP-1)
Coefficient of compressibility, a_v (cm^2/g)	3.99×10^{-7}	5.13×10^{-7}
Specific storage, S_s', (cm^{-1})	3.08×10^{-7}	2.78×10^{-7}
Diffusivity, (cm^2/sec)	1.13×10^{-4}	5.22×10^{-3}
Formation Thickness, (feet)	30	1200
Vertical hydraulic conductivity, K_v', (cm/sec)		
Lab Data	3.49×10^{-11}	3.63×10^{-11}
Field Data	-----	1.45×10^{-9}
Hydraulic resistance, c, (years)		
Lab Data	830,200 [1]	31,929,000
Field Data	-----	799,300
Bulk Porosity (percent)	31.8	32.5
Assumed Effective Porosity	2.0	2.0
Travel time (years)		
Lab Data	16,600 [2]	638,000
Field Data	-----	16,000

Notes:

1 Red clay member only - total overlying confining layer = 9,000,000.

2 Red clay member only - total overlying confining layer = 180,000.

and about 638,000 years using laboratory determined vertical hydraulic conductivity under unit gradient.

Overlying Aquifer

The overlying aquifer monitor well, BMW-1, showed no response to the pumping from the Basal Chadron Sandstone during the aquifer test. However, this well did respond to barometric changes that occurred during the aquifer test which confirmed that it was functioning properly. Because BMW-1 did not respond to pumping, it is evident that the overlying aquifer is not in hydraulic communication with the Basal Chadron Sandstone. Therefore, no further analysis was made of the test data from BMW-1.

INTERPRETATION OF DATA

Aquifer Response to Pumping

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

The piezometric surface of the Basal Chadron Sandstone is approximately 495 feet above the top of the aquifer. The piezometric surface of the overlying aquifer is about 204 feet above the top of the Brule Sand. The difference between the piezometric surfaces of the two aquifers is about 59 feet. This fact plus the fact that BMW-1 did not respond to pumping from the Basal Chadron Sandstone, are evidence that the Basal Chadron Sandstone is confined and that it is not hydraulically connected to the overlying aquifer.

Integrity of Confinement

Confined aquifers may receive small amounts of water through vertical recharge from the confining layers. Even confining layers formed of very low permeability may yield small amounts of water if the hydraulic gradient in the aquifer-aquitard system is favorable. The aquitards which overlie and underlie the Basal Chadron Sandstone probably yielded some small amount of water as recharge (leakage) to the aquifer during the pumping of the aquifer test. However, the amount of this recharge or leakage was extremely small as evidenced by the piezometer responses and the drawdown analysis of the Basal Chadron Sandstone. The overlying confining layer piezometer did not show any response attributable to the pumping. The underlying confining layer piezometer did show a maximum drawdown of 0.06 feet about 4300 minutes after pumping began. However, it is suspected that this small amount of drawdown is attributable to leakage at the annulus of the packer and borehole rather than to leakage from the confining layer.

The lack of substantial drawdown in the confining layer piezometers is attributable to the extremely low vertical hydraulic conductivity of the confining layers. The vertical hydraulic conductivity of the overlying confining layer is about 3.49×10^{-11} cm/sec., and that of the underlying confining layer is about 1.45×10^{-9} to 3.63×10^{-11} cm/sec. Confining layers with vertical hydraulic conductivities this low are, by definition, called aquicludes, rather than aquitards.

The integrity of confinement of the ore-zone aquifer (Basal Chadron Sandstone) may be characterized most graphically by the hydraulic resistance, c. The calculated hydraulic resistance of the entire thickness of the overlying aquiclude is about 9,000,000 years and that of the underlying aquiclude is between 799,900 years and 31,919,000 years. The times needed for a given water molecule to travel through the entire thicknesses of the aquicludes under unit gradient (one foot of head loss per foot of movement in the direction of flow) are about 180,000 years for the upper aquiclude and about 16,000 years to 638,000 years for the lower. Because the gradients would be much smaller during mining, actual travel times would be much longer than those stated above.

Movement of Groundwater

The piezometric surface of the Basal Chadron Sandstone dips approximately to the north at a gradient of 7.84×10^{-4} which is equal to 1 foot per 1275 feet. Using a directional hydraulic conductivity of 9.11 ft/day, a gradient 7.84×10^{-4} and a porosity of 29 percent, the average pore velocity across this part of the commercial study area is about 9.00 ft/year. The groundwater flux across the test site was computed to be about .29 ft^3/day per unit width of the aquifer. (Darcy, 1856).

Extent of Investigated Area

Using the Cooper-Jacob Distance-Drawdown Method (Cooper and Jacob, 1946), the radius of influence of the aquifer test in the Basal Chadron Sandstone was calculated to be about 5000 feet. Therefore, the area investigated and characterized by this test is approximately 1803 acres.

ATTACHMENT I

CROW BUTTE RESOURCES, INC.

216 Sixteenth Street Mall, Suite 810
Denver, Colorado 80202

(303) 825-2266
(303) 825-1544 - FAX

January 15, 1998

Mr Joseph J Holonich, Chief
Uranium Recovery Branch
Division of Waste Management,
NMSS (T-7-J9)
Office of Nuclear Material Safety and Safeguards
U S Nuclear Regulatory Commission
11545 Rockville Pike
Rockville, MD 20850

Re License No SUA-1534
Docket No 40-8943
License Renewal

Dear Mr Holonich

In your phone call of December 5 and in follow-up discussions with James Park you indicated that the renewal of the Crow Butte license was held up and that USNRC may consider prohibition of new development until a traditional cultural property survey is completed This is in addition to previous archeological surveys conducted in conjunction with the Nebraska State Historical Society as part of the original application CBR has initiated the traditional cultural property survey by contacting seven Indian tribes that may have been in the area Additional contacts have been made with the Bureau of Indian Affairs and the Nebraska Indian Affairs Commission A copy of a letter from the Bureau of Indian Affairs in Aberdeen, South Dakota is attached and indicates that the Oglala Sioux do not have any information on possible cultural resources in the Crow Butte permit area The Oglala Sioux is the nearest tribe to the Crow Butte Mine and is 40-60 miles northeast.

Crow Butte Resources has completed construction of a portion of Mine Unit 6 and is ready to start-up the first well house in March, 1998 Mine Unit 6 is adjacent to existing activity in Mine Units 1-5 Since development is already complete Crow Butte does not consider start-up of Mine Unit 6 to be included in a possible prohibition of new development until the traditional cultural resource survey is complete.

Please advise me as soon as possible on this because it is essential to Crow Butte to start-up Mine Unit 6 in order to maintain production at present levels and to fulfill contractual commitments

Please contact me if you need any additional information

Steve Collings

Stephen P Collings
President

United States Department of the Interior

BUREAU OF INDIAN AFFAIRS
Aberdeen Area Office
115 Fourth Avenue S.E.

IN REPLY REFER TO:
Natural Resources
MC-301

JAN 7 1997

RECEIVED JAN 1 2 1998

Mr. Bartley W. Conroy, Vice President
Resource Technologies Group, Inc.
3900 S. Wadsworth Blvd., Suite 155
Lakewood, Colorado 80235-2205

Dear Mr. Conroy:

The present letter is in response to your letter of December 15, 1997 requesting information on possible Native American traditional cultural use areas within the Crow Butte Uranium Project in Dawes County, Nebraska.

The USDI Bureau of Indian Affairs, Aberdeen Area Office, administers no trust lands in the above referenced region, and we have no records of cultural resources in the vicinity. In addition, inquiries of various members of the Oglala Sioux Tribe in the Pine Ridge Indian Reservation to the north failed to reveal any additional information on possible cultural resources in your area of concern.

If you have any additional questions or if we can be of further assistance to you, please contact Dr. Carson N. Murdy, Aberdeen Area Archaeologist at (605) 226-7621.

Sincerely,

[redacted] Natural Resources Officer

ENVIRONMENTAL ASSESSMENT FOR RENEWAL OF SOURCE MATERIAL LICENSE NO. SUA-1534

CROW BUTTE RESOURCES, INCORPORATED
CROW BUTTE URANIUM PROJECT
DAWES COUNTY, NEBRASKA

FEBRUARY 1998

DOCKET NO. 40-8943

U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
Division of Waste Management

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

TABLE OF CONTENTS
(continued)

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ALARA	As low as is reasonably achievable
CBR	Crow Butte Resources, Inc.
CRSO	Corporate Radiation Safety Officer
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FEN	Ferret Exploration Company of Nebraska
FONSI	Finding of No Significant Impact
ISL	*In situ* leach
IX	ion exchange
LRA	license renewal application
MU	mine unit
NDEC	State of Nebraska Department of Environmental Control
NDEQ	State of Nebraska Department of Environmental Quality
NRC	U.S. Nuclear Regulatory Commission
PBLC	Performance-Based License Condition
PV	pore volume
QA	quality assurance
R&D	research and development
RO	reverse osmosis
SER	Safety Evaluation Report
SERP	Safety and Environmental Review Panel
SOP	standard operating procedure
TDS	total dissolved solids
UCL	upper control limit
UIC	Underground Injection Control

1.0 INTRODUCTION

On December 20, 1995, Crow Butte Resources, Inc. (CBR) submitted a License Renewal Application (LRA) (CBR, 1995) for Source Material License SUA-1534 for the Crow Butte Uranium Project, which is located in Dawes County, Nebraska. In response to comments and requests for additional information from the U.S. Nuclear Regulatory Commission staff, CBR provided page changes to the LRA by letters dated April 1, June 25, and October 31, 1997 (CBR, 1997g, 1997f, and 1997b, respectively). By letter dated July 28, 1997 (CBR, 1997e), CBR requested several amendments to SUA-1534; the NRC staff decided, with CBR's approval, to address these requests as part of the overall license renewal process.

Information and discussion in this environmental assessment (EA) are based principally on information contained in the LRA and supplements, NRC licensing actions approved since December 1995, semiannual environmental monitoring reports submitted by CBR since the issuance of SUA-1534 in 1989, and NRC inspection reports generated during the more than six years of commercial operating experience at the Crow Butte site. The inspection history, conclusions, and license conditions presented here are based on NRC staff evaluations and reviews in support of performance-based licensing for the proposed license renewal.

With this license renewal, NRC will be authorizing the continuation of commercial operations under the performance-based license condition (PBLC) format. Under a performance-based license, the licensee has the burden of ensuring the proper implementation of the PBLC. The licensee may:

- Make changes in the facility or process, as presented in the application,
- Make changes in the procedures presented in the application, or
- Conduct tests or experiments not presented in the application, without prior NRC approval, if the licensee ensures that the following conditions are met:

  (1) The change, test, or experiment does not conflict with any requirements specifically stated in this license (excluding material referenced in the PBLC), or impair the licensee's ability to meet all applicable NRC regulations.

  (2) There is no degradation in the essential safety or environmental commitments in the license application, or provided by the approved reclamation plan.

  (3) The change, test, or experiment is consistent with NRC conclusions regarding actions analyzed and selected in this EA.

If these conditions are not met, the licensee is required to submit an application for a license amendment to NRC. The licensee's determinations of whether the above conditions are satisfied will be made by a Safety and Environmental Review Panel (SERP)

The SERP shall consist of a minimum of three individuals, and one of these shall be designated as the SERP chairman. One member of the SERP shall have expertise in management and shall be responsible for managerial and financial approval changes; one member shall have expertise in operations and/or construction and shall be responsible for implementation of any changes; and one member shall be the corporate radiation safety officer (CRSO) or equivalent. Additional members may be included in the SERP as appropriate, to address technical aspects in several areas, such as health physics, groundwater hydrology, surface water hydrology, geology, geochemistry, and others. Temporary members, or permanent members other than the three identified above, may be consultants.

The licensee shall maintain records until license termination of any changes made pursuant to the PBLC. These records shall include written safety and environmental evaluations, made by the SERP, that provide the basis for determining that the change complies with the requirements referred to in the above conditions. The licensee shall furnish an annual report to NRC that describes such changes, tests, or experiments, including a summary of the safety and environmental evaluation of each. In addition, the licensee shall annually submit any pages of its license application that have been revised to reflect changes made under this condition.

The SERP will operate under standard operating procedures (SOPs) approved by NRC. The inspection role of NRC remains unchanged with the administration of performance-based licensing. Operational changes, regulatory commitments, and record keeping requirements implemented by CBR through the PBLC are subject to NRC inspection and possible enforcement actions.

1.1 Background Information

By letter dated October 7, 1987, Ferret Exploration Company of Nebraska (FEN) applied to NRC for a source material license to authorize commercial operation of the Crow Butte *in situ* leach (ISL) facility, located approximately eight kilometers (five miles) southeast of Crawford, Nebraska. The FEN proposal was to expand the then current research and development (R&D) scale operations at the site conducted under NRC Source Material License SUA-1441. To document its review of the FEN application, NRC staff prepared an EA and a safety evaluation report (SER), both of which were issued on December 12, 1989. Based on its review, the NRC issued Source Material License SUA-1534 to FEN on December 29, 1989, for the commercial operation of the Crow Butte Uranium Project.

FEN operated the project until May 1994, when the company name was changed to Crow Butte Resources, Inc. This was a name change only and did not include a change in ownership. CBR conducts its operations within a permit area that encompasses all or portions of Sections 11, 12, and 13 of Township 31N, Range 52W and Sections 18, 19, 20, 29, and 30 of Township 31N, Range 51W, Dawes County, Nebraska. The process plant is located in Section 19 of Township 31N, Range 51W. The permit area covers approximately 1130 hectares (ha) (2800 acres). The surface area to be affected over the projected life of the project is estimated at 200 ha (500 acres).

Land ownership in the permit area is approximately 90 percent private, with the remainder held by state, local, or federal governments. There are no Indian lands within an eight-km (five-mi) radius of the site. CBR maintains leased mineral rights from the private owners.

Since 1989, CBR has used *in situ* methods in a commercial operation to mobilize and recover uranium contained in the Basal Chadron Sandstone, at depths ranging from 122 to 244 meters (400 to 800 feet) over the permit area. The overall width of the mineralized area varies from approximately 305 to 1525 m (1000 to 5000 ft). The orebody ranges in grade from less than 0.05 to greater than 0.5 percent U_3O_8, with an average grade estimated at 0.26 percent equivalent U_3O_8 and 0.31 percent chemical U_3O_8.

By letter dated December 20, 1995, CBR applied for a renewal of SUA-1534 to authorize continued commercial operations at its ISL facility. CBR submitted revised sections to the LRA by letters dated April 1, June 25, and October 31, 1997. Those portions of an additional license amendment request, submitted by letter dated July 28, 1997, which have not been addressed in previous licensing actions, will be addressed in this license renewal process.

1.2 Proposed Action

The proposed action is to renew Source Material License SUA-1534 to authorize the continued commercial operation of the Crow Butte Uranium Project. The renewed license would authorize the facility to be operated such that the annual throughput does not exceed an average flowrate of 18,930 liters per minute (Lpm) [5000 gallons per minute (gpm)], exclusive of restoration flow, with yellowcake production not to exceed 907,185 kilograms (2 million pounds) annually. This EA discusses the environmental aspects of the CBR proposal. Additional information concerning the radiation safety aspects of the proposed action is provided in the accompanying SER.

1.3 Review Scope

1.3.1 Federal and State Authorities

NRC source material licenses are issued under Title 10, Code of Federal Regulations (CFR), Part 40 (10 CFR Part 40) (Domestic Licensing of Source Material). As stated in 10 CFR 40.3, "A person subject to the regulations in this part may not receive title to, own, receive, possess, use, transfer, provide for long-term care, deliver or dispose of byproduct material or residual radioactive material as defined in this part or any source material after removal from its place of deposit in nature, unless authorized in a specific or general license issued by the Commission..." "Source material" is defined in 10 CFR 40.4 as (1) uranium or thorium, or any combination thereof, in any physical or chemical form; or (2) ores which contain by weight 0.05 percent or more of uranium, thorium, or any combination thereof.

In addition, the Uranium Mill Tailings Radiation Control Act of 1978, as amended (UMTRCA) requires persons who conduct uranium source material operations to obtain a byproduct material license to own, use, or possess tailings and wastes generated by ISL operations (including aboveground wastes). This EA has been prepared in accordance with 10 CFR Part 51 (Environmental Protection Regulations for Domestic Licensing and Related

Regulatory Functions), which implements the NRC environmental protection program under the National Environmental Policy Act of 1969, as amended (NEPA). In accordance with 10 CFR Part 51, an EA serves to (1) briefly provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement (EIS) or a finding of no significant impact (FONSI); (2) facilitate preparation of an EIS when one is necessary; and (3) aid the NRC's compliance with NEPA when an EIS is not necessary.

The U.S. Environmental Protection Agency (EPA) maintains a review role in the aquifer exemption portion of the State of Nebraska Underground Injection Control (UIC) program (40 CFR 146.4). On May 23, 1990, EPA approved the State of Nebraska's request to exempt a portion [1215 ha (3000 surface acres)] of the Chadron Aquifer near Crawford, Nebraska. The boundaries of CBR's permit area are constrained by the boundaries of the approved aquifer exemption area. EPA's approval became effective on June 22, 1990.

The Nebraska Department of Environmental Quality (NDEQ) [formerly the State of Nebraska Department of Environmental Control (NDEC)], administers and implements State of Nebraska rules and regulations for underground injection wells. NDEC originally issued UIC Permit No. NE0122611 to FEN for the commercial operation of the Crow Butte Uranium Project on April 23, 1990. The current modified NDEQ UIC permit was issued to CBR on September 4, 1997.

The commercial operation was previously evaluated in an EA (NRC, 1989a) and an SER (NRC, 1989b) prepared by the NRC staff in support of the issuance of Source Material License SUA-1534 on December 29, 1989. The staff prepared and issued supplemental EAs for specific licensing actions on March 16, 1993; March 14, 1996; July 19, 1996; and June 13, 1997.

A new SER accompanies this EA. In preparing these two documents, the staff will re-evaluate the potential impacts associated with the continued commercial operation of the Crow Butte Uranium Project. Should NRC issue a FONSI, based upon the licensee's application materials (CBR, 1995), previous operational data, and information contained in the earlier EA (NRC, 1989a) and SER (NRC, 1989b), and supplemental EAs, a renewed commercial source material license would be issued to CBR.

1.3.2 Basis for NRC Review

The NRC, Office of Nuclear Material Safety and Safeguards, Division of Waste Management staff has assessed the environmental and safety impacts associated with the renewal of CBR's source material license and documented the results of the assessment in this report. The staff performed this appraisal in accordance with the requirements of 10 CFR Part 51.

In conducting this assessment, the staff considered the following:

- Information contained in the LRA and in additional submittals dated April 1, June 25, July 28, and October 31, 1997;

- Information contained in previous environmental evaluations of the Crow Butte Uranium Project (NRC, 1984; 1989a);
- Information contained in CBR amendment requests since December 1995 and NRC approvals of such requests;
- The operational history of commercial operations since December 29, 1989, as evidenced by semiannual environmental monitoring reports and wellfield restoration information provided by CBR;
- Information derived from NRC site visits and inspections of the Crow Butte facility; and
- Consultations with the U.S. Fish and Wildlife Service, the NDEQ, and the State Historical Preservation Officer for the State of Nebraska.

2.0 SITE DESCRIPTION

2.1 Location

CBR's facility and associated wellfields are located in west-central Dawes County, Nebraska, just north of the Pine Ridge area. Figures 2-1 and 2-2 show the general location of the commercial project site. The project site is approximately eight km (five mi) southeast of the city of Crawford, Nebraska, via Squaw Creek Road. The permit area within which CBR conducts its operations encompasses all or portions of Sections 11, 12, and 13 of Township 31N, Range 52W and Sections 18, 19, 20, 29, and 30 of Township 31N, Range 51W, Dawes County, Nebraska. The main process plant is located in Section 19 of Township 31N, Range 51W.

The total surface area of the project site is approximately 1130 ha (2800 acres). Of this total surface area, it is estimated that approximately 200 ha (500 acres) will be disturbed during the life of the project.

As discussed in Section 1.3.1, CBR's current and future operations are restricted to a permit area whose ultimate boundaries are constrained by the boundaries of the aquifer exemption area approved by EPA and the NDEQ. Currently, CBR is required, by license condition, to obtain NRC approval for any changes to the permit area boundary. NRC will continue to require that CBR obtain staff approval for any permit area boundary modifications, so that it can examine any potential environmental impacts associated with the proposed modification.

In its July 28, 1997, submittal, CBR requested that an additional 16.2-ha (40-acre) area be added to its permit area. The staff finds that the requested area lies within the aquifer exemption area, and further considers that the monitoring programs discussed in Section 3.0 will be sufficient to minimize any environmental impacts to this area. Therefore, the staff finds acceptable CBR's request to enlarge its permit area.

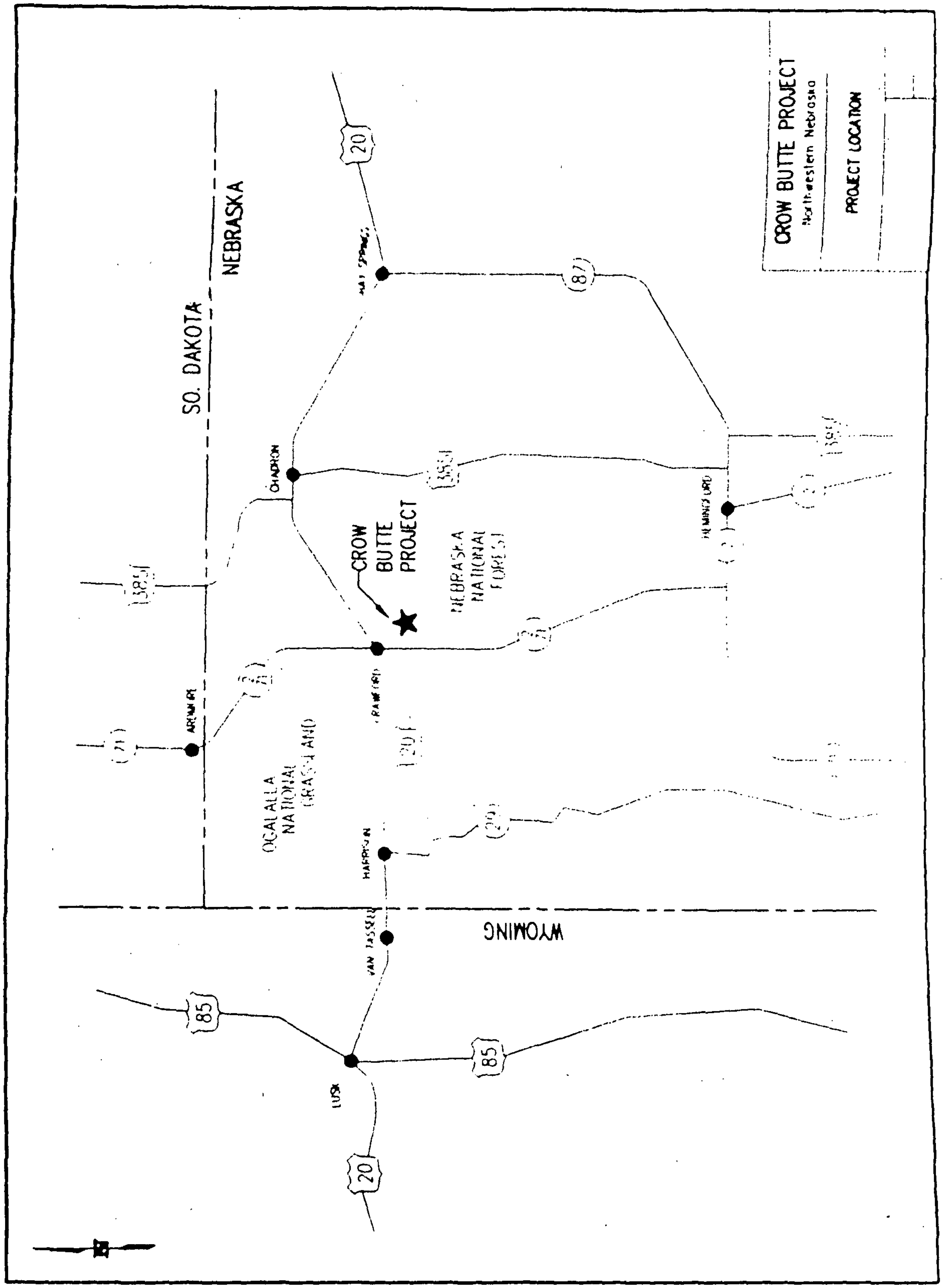


Figure 2-1. Location of the Crow Butte Uranium Project (from CBR, 1997g)

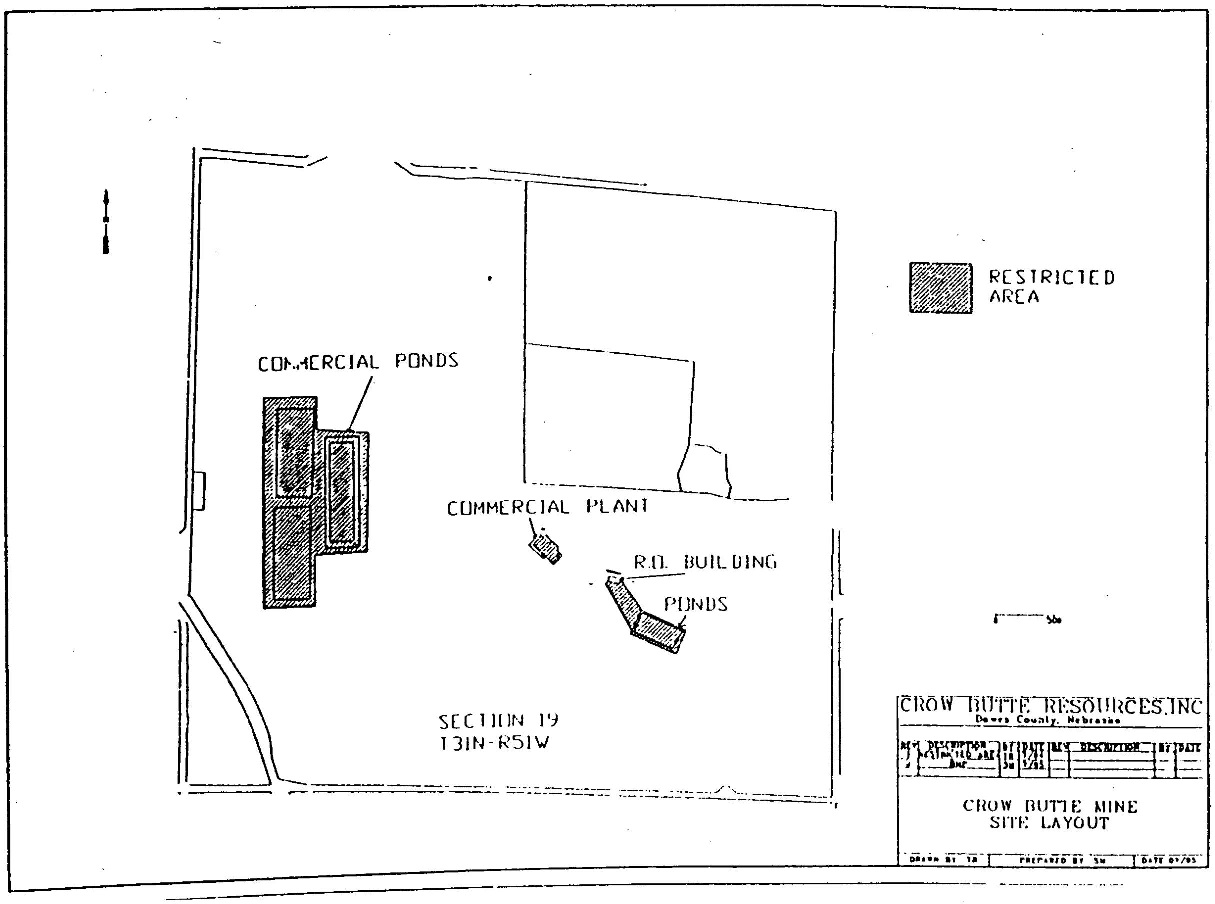


Figure 2-2. Site layout and restricted area of the Crow Butte Uranium Project (from CBR, 1995)

2.2 Climate and Weather

Weather patterns in the vicinity of the site are typical of a semi-arid continental climate: warm summers, cold winters, light precipitation, and frequent weather changes. The area is generally drier than other parts of the Nebraska panhandle due to the presence of the Rocky Mountains to the west, the Black Hills to the north, and a plateau to the south, all of which effectively direct most moisture to areas other than this particular region.

Temperatures generally range between -5.0°C (23°F) and 31°C (87°F), with January the coldest month (average monthly minimum temperature of -12.4°C [9.7°F]) and July the warmest month (average monthly maximum temperature of 31.9°C [89°F]). Precipitation, on the other hand, is heaviest during the late spring/early summer, as showers and thunderstorms increase in number and intensity. Winters are generally dry, with average precipitation during the months of November and February about 1.0 cm (0.4 in.). The average annual precipitation is 39.5 cm (15.6 in.).

Winds at the site are fairly light, with wind speeds usually less than 18.5 km/hr (11.5 mph) and from the south to southwest. On average, the maximum wind speeds come from the northwest, averaging 23.7 km/hr (14.7 mph), while the lightest winds (10.2 km/hr [6.3 mph]) are out of the east-southeast.

2.3 Geology

2.3.1 Regional and Local Geology

The project area is located in the low, rolling hills of the Missouri Plateau and is dominated by a north-facing scarp, locally known as the Pine Ridge. This ridge skirts the south and west sides of the project area and divides the Great Plains into two subdivisions: the High Plains south of the ridge and the unglaciated Missouri Plateau north of the ridge. The major structural feature of the area is the Chadron Dome, which is surficially expressed in northeastern Dawes County. This anticlinal feature strikes northwest-southeast along the northeastern boundary of Dawes County, although over much of the area, the feature is buried by rather flat-lying Miocene-aged rock. Two northeast-trending faults are present in Dawes County. These faults are down-thrown to the north. The closest fault to the project area is the White River Fault. This fault was discovered during the exploration drilling phase of the project, and it follows the White River north of Crawford, approximately 3.2 km (2 mi) from the northern boundary of the project area. Total vertical displacement on the White River Fault is 60 to 100 m (200 to 400 ft) with no strike-slip movement.

Sedimentary strata within the Crawford Basin range in age from late Cretaceous through the Tertiary. Figure 2-3 is the stratigraphic column representing the project area. The basal confining layer is the Cretaceous Pierre Shale, a very extensive and thick [365 to 455 m (1200 to 1500 ft)] marine sediment. The ore zone is the Basal member of the Oligocene Chadron Formation, a 9 to 14 m (30 to 45 ft) thick arkosic sandstone. Over the permit area, the Basal Chadron ranges from 122 to 244 m (400 to 800 ft) below the ground surface due to topographic changes. Above the Basal Chadron are the Middle and Upper members of the

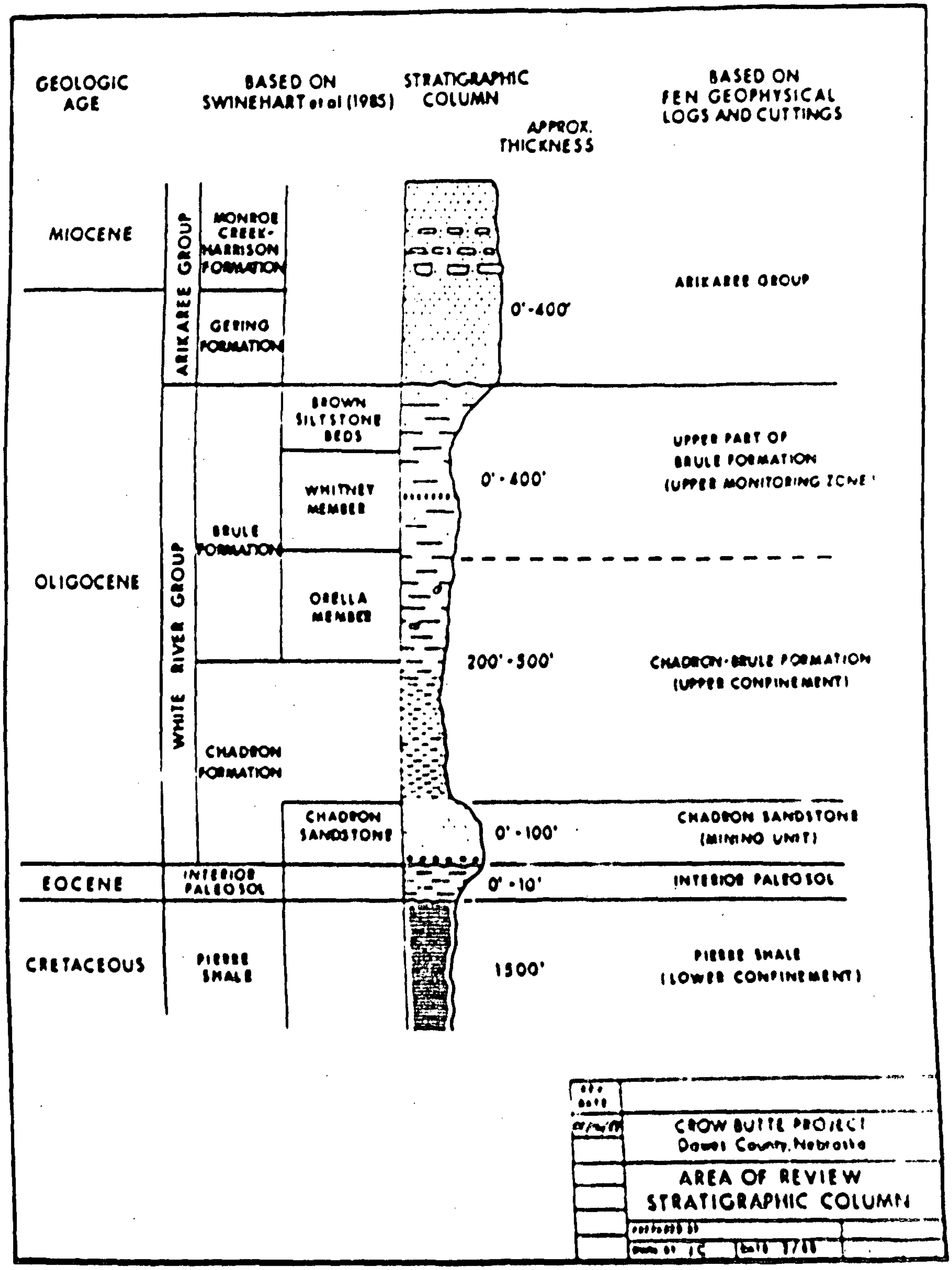


Figure 2-3. General stratigraphy of the Crow Butte Uranium Project (from CBR, 1995)

Chadron Formation, which consist of clay, silt and sandy claystone about 64 m (210 ft) thick in the project area.

The Brule Formation lies conformably on top of the Chadron Formation, and with the Chadron, comprises the Oligocene White River Group. The Brule has been subdivided into the Orella and the Whitney Members. The Orella is comprised of buff to brown siltstones and clays, while the Whitney is comprised of fairly massive buff to brown siltstones. Some moderate to well-defined channel sands can be observed in the Whitney Member in both drill holes and in outcrops. These Upper Brule channel sands are limited in lateral extent and continuity, but may be occasionally saturated with water in the otherwise generally impermeable Brule. Within the project area, these sand units are encountered in the upper 76 m (250 ft) of the drill holes.

2.3.2 Seismicity

The Crow Butte Uranium Project is within Seismic Risk Zone 1, where only minor damage is expected from earthquakes that occur within this area. The nearest area of higher seismic risk to the project is located approximately 483 km (300 mi) from the project, in southeastern Nebraska, within the eastern part of the central Nebraska Basin. Although the project is within an area of low seismic risk, occasional earthquakes have been reported. The strongest earthquakes recorded in northwest Nebraska occurred near Chadron on July 30, 1934, with an intensity of VI (Modified Mercalli Intensity Scale). This earthquake resulted in damaged chimneys, cracked plaster, and to a lesser extent, falling china. Another earthquake occurred near Chadron on March 9, 1963. This earthquake had an intensity of II-III and was not accompanied by any damage or noise. Although the risk associated with major earthquakes in the project area is slight, some low to moderate tectonic activity is occurring. However, this activity is not expected to affect the mining operations.

2.4 Water Resources

2.4.1 Surface Water

Two major watersheds, the White River and Hat Creek, drain the area north of Pine Ridge. The commercial project permit area lies within the White River watershed. Three tributaries of the White River drain the project area: White Clay Creek, Squaw Creek, and English Creek. Squaw Creek is the closest tributary to the current mining areas. Eight different surface water impoundments, seven of which are on these creeks, are located within or near the permit area. These impoundments usually consist of earthen dams constructed across the creeks, with the impounded water used for livestock watering.

2.4.2 Groundwater

2.4.2.1 Aquifer Properties

The Basal Chadron sandstone is the only water-bearing strata in the Chadron Formation that can be considered an aquifer. The Basal Chadron aquifer is artesian, and locally, some free-flowing wells are present. On the other hand, regionally and locally, the Brule Formation is an important aquifer, producing sufficient quantities of water with low total dissolved solids

(TDS), which is suitable for domestic and agricultural purposes. Locally, the direction of flow in the Chadron and Brule aquifers is to the north-northwest.

CBR has conducted three aquifer tests to constrain the hydraulic properties of the ore horizon. The first test was conducted in support of the R&D operations in November 1982, the second in June 1987, at a site located approximately 850 m (2800 ft) north of the initial aquifer test site, and the final test in September 1996 at a location approximately 2630 m (8600 ft) northwest of the second test. The tests have zones of influence which slightly overlap, and therefore, results of these tests adequately define the hydraulic conditions over a majority of the permit area.

The first aquifer analysis was discussed in the EA prepared by NRC for the R&D license (NRC, 1984). Based upon the results of the analysis in the R&D EA, it was concluded that the Basal Chadron Sandstone (the ore zone) was adequately confined and that effects of leakage from the upper aquitard were minimal.

The results of the second aquifer analysis were similar to those of the first. In summary, the results of the second aquifer test indicated that the Basal Chadron Sandstone was a non-leaky, confined, slightly anisotropic aquifer. For the five different analytical methods used, the effective transmissivity ranged from 3.74E-4 to 4.02E-4 m^2/s (348 to 374 ft^2/day). Given the average thickness of the Basal Chadron in the vicinity of the project area (12 m [40 ft] with a range of 9 to 13 m [30 to 44 ft]), the hydraulic conductivity therefore ranged from approximately 3.1E-5 to 3.3E-5 m/s (8.7 to 9.34 ft/day). Based on the results from this pump test, the major axis of transmissivity in the Basal Chadron aquifer lay along an azimuth of about 51 degrees with a magnitude of 3.97E-4 m^2/s (369 ft^2/day), and the minor axis of transmissivity along an azimuth of about 141 degrees with a magnitude of 3.87E-4 m^2/s (360 ft^2/day).

The results of the third aquifer pump test continued to demonstrate favorable hydrogeologic conditions within the Chadron aquifer, including confinement of the aquifer (NDEQ, 1996).

2.4.2.2 Ore Zone Confinement

Lower confinement in the commercial operations area is provided by over 305 m (1000 ft) of Pierre Shale. The upper confinement is composed of the Chadron Formation above the Basal Chadron Sandstone (Middle and Upper Chadron) and that portion of the Brule Formation which underlies the intermittent Brule Sandstones (Orella Member). These units isolate the Basal Chadron Sandstone from overlying aquifers with several hundred feet of clay and siltstones. Thicknesses range from about 30 m (100 ft) in the northeastern part of the permit area, to 150 m (500 ft) in both the southern and northern parts of the area. It is about 60 to 90 m (200 to 300 ft) thick in the current mining area.

From laboratory data, the vertical hydraulic conductivities of the upper confining layers and the underlying Pierre Shale, are approximately 3.5E-13 m/s (9.9E-8 ft/day) and 3.6E-13 m/s (1.0E-7 ft/day), respectively (NRC, 1989a; CBR, 1995). These hydraulic conductivities are very similar to those estimated during R&D operations. Field data from Aquifer Test No. 2 indicate a vertical hydraulic conductivity of 1.5E-11 m/s (4.3E-6 ft/day) for the Pierre Shale. The hydraulic conductivity of the ore zone contrasts sharply with that of the overlying and underlying confining layers. Based upon the measured hydraulic conductivities, the average thickness of the aquitards, and the assumption that these aquitards have an effective porosity of two percent under a unit gradient, approximately 1050 years would be required for water to move through the overlying aquitard (from Aquifer Test No. 1; CBR, 1995, as modified on June 25, 1997) and about 16,000 years would be required for water to penetrate the underlying aquitard (Aquifer Test No. 2, field data; CBR, 1995, as modified on June 25, 1997). The properties of the Basal Chadron and the confining strata are summarized in Table 2-1.

Laboratory testing of the overlying confining layers indicates that these layers may exhibit a minor amount of leakage. However, during the aquifer testing, no loss of pressure occurred that would indicate that leakage was occurring. Similarly, the underlying confining layer response attributable to the aquifer testing indicated no leakage.

The aquifer testing indicates that groundwater flow will be contained by the confining strata and concentrated within the production zone. Vertical control of the mining solutions is reasonably ensured by the confining characteristics, associated hydraulic conductivities, and continuous extent of the confining beds. Finally, vertical excursions detected to date during commercial operations (see Section 5.4.2.1) have resulted from problems with well completion, testing, or abandonment. This supports the aquifer testing results concerning the integrity of the upper confining layers.

Table 2-1. Summary of hydrologic properties (NRC, 1989a)

Unit	Hydrologic Properties
Middle Chadron	Overlying confining layer = 95–100 m (315–325 ft) thick
Red Clay Bed 3 to 8 m (10–25 ft)	Vertical hydraulic conductivity = 3.5E–13 to 2.5E–12 m/s (9.9E-8 to 7.08E-7 ft/day)
Basal Chadron 9 to 13 m (30–44 ft)	Transmissivity = 5.2E-4 m^2/s (480 ft^2/day) Hydraulic conductivity = 3.1E-5 to 3.3E-5 m/s (8.7 to 9.34 ft/day) Storativity = 7E-5 $\text{Transmissivity}_{pump}$ = 3.9E-4 to 4.0E-4 m^2/s (359 to 374 ft^2/day) Storativity = 8.4E-5 to 1.3E-4 $\text{Transmissivity}_{recover}$ = 3.7E-4 to 3.8E-4 m^2/s (348 to 355 ft^2/day)
Pierre Shale 365 m (1,200 ft)	Vertical hydraulic conductivity = 3.4E-11 to 3.6E-11 m/s
	<u>Hydrologic Testing</u>
First Test (1982):	(2°) Transmissivity = 4.3E-4 m^2/s (401 ft^2/day) (92°) Transmissivity = 3.1E-4 m^2/s (290 ft^2/day)
Second Test (1987):	(51°) Transmissivity = 4.0E-4 m^2/s (369 ft^2/day) (141°) Transmissivity = 3.9E-4 m^2s (360 ft^2/day)

2.4.2.3 Groundwater Quality

Table 2-2 summarizes the water quality of the Brule and Chadron Formations from the baseline monitoring wells drilled for the R&D project, prior to any mining activity at the site. These data indicate that the Basal Chadron aquifer is generally of good quality and has been defined by the NDEQ as an underground source of drinking water (NRC, 1989a). However, in the vicinity of the mineralized zone, uranium and radium concentrations are elevated. In the wells that were used to determine baseline water quality in the Basal Chadron, radium-226 values ranged from 0.1 to 619 picocuries per liter (pCi/L), with a mean of 53 pCi/L. Similarly, within the R&D wellfield, radium-226 concentrations had a baseline mean of 859 pCi/L. These values are well above the 5 pCi/L EPA primary drinking water standard. As a result, water drawn from the Basal Chadron Sandstone would not be recommended for human consumption.

Table 2-2. Original (i.e., pre-R&D mining) baseline water quality for the Crow Butte site. All units in mg/l unless otherwise noted. From NRC, 1989a.

	Brule Formation (n=4)		Chadron Formation (n=7)	
Constituent	Range	Mean	Range	Mean
Ca	7.1–98	48	11–41	20
Mg	0.3–16	6.6	0.8–7.2	3.2
Na	12–340	104	340–540	410
K	4.1–15.9	9.9	7.0–19.8	12.4
HCO_3	137–627	364	308–411	368
SO_4	1–23	10	254–620	407
Cl	1.6–192	48	134–250	176
Cond. (mhos)	246–1481	714	1500–2500	1900
pH (std. units)	6.8–8.5	7.8	7.6–8.7	8.2
Total U	0.001–0.021	0.0064	<0.01–2.40	0.092
Ra-226 (pCi/L)	0.1–3.0	0.7	0.1–619	53

Prior to mining within a delineated portion (i.e., "mine unit") of its permit area, CBR establishes baseline water quality within the ore zone, at the ore zone perimeter, and in the first aquifer overlying the ore zone. These water quality data are used to determine groundwater monitoring requirements and restoration standards. Average concentrations of various constituents, as measured in groundwater samples drawn from the Basal Chadron, are provided in Table 2-3 for the five mine units (MUs) operated to-date at the site.

Table 2-3. Average pre-operational mine unit baseline water quality. Units are in mg/L unless otherwise noted. Data from CBR, 1995.

Parameter	MU-1 Avg	MU-2 Avg	MU-3 Avg	MU-4 Avg	MU-5 Avg
Date established	12/31/90 and 3/21/94	1/23/92	11/19/92	2/7/94 and 3/16/95	9/12/95
NH4	≤0.372	≤0.37	≤0.329	0.288	0.28
As	≤0.00214	≤0.001	≤0.001	≤0.00209	≤0.001
Ba	≤0.996	≤0.01	≤0.1	<0.1	≤0.10
Cd	≤0.00644	≤0.01	≤0.01	<0.01	≤0.01
Cl	203.9	208.6	197.6	217.5	191.9
Cu	≤0.0249	≤0.013	≤0.0108	≤0.0114	≤0.01
F	0.686	0.67	0.719	0.745	0.64
Fe	≤0.0441	≤0.05	<0.05	≤0.0504	≤0.05
Hg	≤0.00067	≤0.001	<0.001	<0.001	<0.001
Mn	≤0.00122	≤0.01	≤0.01	≤0.01	≤0.01
Mo	≤0.0689	≤0.073	<0.1	<0.1	≤0.10
Ni	≤0.0340	≤0.05	<0.05	<0.05	≤0.05
NO3	≤0.050	≤0.039	≤0.0728	≤0.114	≤0.10
Pb	≤0.0315	≤0.05	<0.05	<0.05	<0.05
Ra (pCi/L)	229.7	234.5	165.0	154.0	166.0
Se	≤0.00323	≤0.001	≤0.00115	≤0.00244	≤0.002
Na	412	411	428	416.6	397.6
SO4	356.2	348.2	377.0	337.0	364.5
U	0.0922	0.046	0.115	0.118	0.072
V	≤0.0663	≤0.1	<0.1	≤0.0984	≤0.10
Zn	≤0.0384	≤0.025	≤0.0131	≤0.0143	≤0.02
pH(std units)	8.46	8.32	8.37	8.68	8.5
Ca	12.5	13.4	13.3	11.2	12.6
Total CO3	351.2	362.0	377.0	374.0	373.0
K	12.5	12.6	13.9	16.7	11.5
Mg	3.2	3.5	3.5	2.8	3.4
TDS	1170.2	1170.4	1183.0	1221.0	1179.0

As discussed above, the geology is rather uniform over the production area. The production zone and confining strata also are continuous over the commercial area. The lithologic properties vary slightly, but for the most part, the geologic data as well as the aquifer testing and groundwater quality data indicate that similar groundwater responses can be expected over the entire production area.

2.5 Demography

The Crow Butte facility is located in Dawes County, Nebraska, which, with a population of 9021 in 1990 spread over approximately 3618 km^2 (1397 mi^2), had a population density of approximately 2.5 persons per square kilometer (6.5 persons per square mile). By comparison, the statewide density was 7.9 persons per square kilometer (20.6 persons per square mile). Dawes County's population has declined slightly since 1980.

It is estimated that greater than 40,000 people live within 80 km (50 miles) of the Crow Butte facility, of which approximately 1500 live within 10 km (6.2 mi) of the site (CBR, 1995). The nearest Indian reservation is the Pine Ridge Indian Reservation, the nearest borders of which are located approximately 50 km (31 mi) northeast of the Crow Butte facility. Table 2-4 identifies the major population centers within 80 km (50 mi) of the facility.

Table 2-4. Major Population Centers within 80 Kilometers of the Crow Butte Uranium Project

Town	1990 Population	Distance from Site (km)*	Distance from Site (miles)*
Crawford, NE	1115	8	5
Chadron, NE	5588	32	20
Harrison, NE	291	41	25
Hemingford, NE	953	43	27
Hay Springs, NE	693	55	34
Oelrichs, SD	138	61	38
Alliance, NE	9765	73	45
Rushville, NE	1127	74	46

* Approximate distance from facility by air

2.6 Land Use

The predominant land use in Dawes County, as well as the project area, is livestock grazing and associated feed production. The cultivated lands adjacent to the permit area are used primarily for production of winter wheat, alfalfa, and oats. The native grasslands are grazed or harvested for hay. Local cattle graze about 67 percent of the year, and local consumption of locally-produced meat is about 10 percent. CBR has claims or lease-hold interests for the surface and use rights, along with uranium mineral rights, within all of the areas proposed to be mined. After mining, the land will be reclaimed and returned to its original use as livestock grazing land.

There are a several Federal and State parks and recreation areas located within 80 km (50 mi) of the site. Nearby Chadron and Fort Robinson State Parks receive a large number of visitors annually. In 1994, 202,002 people visited Chadron State Park, while in 1994, Fort Robinson State Park welcomed some 342,603 people (State of Nebraska, 1997). Both of these recreational areas have seen an increasing number of visitors since at least 1991.

An additional source of seasonal population is Chadron State College, located approximately 35 km (21.6 mi) from the facility, which has an enrollment of approximately 2600 students.

2.7 Cultural Resources

Surveys for historical and archaeological sites in the vicinity of CBR's proposed R&D and commercial operations were conducted in 1982 and 1987, by the University of Nebraska and the Nebraska State Historical Society (NSHS), respectively (CBR, 1995). A more detailed discussion of the two surveys was provided previously to NRC (CBR, 1987). Within the survey area, there are no sites listed on the National Register or registered as natural or historic landmarks. However, the investigations did identify six sites of potential archaeological data recovery importance or possible architectural interest.

To determine the potential eligibility of any of the six sites for listing on the National Register, further information would need to be collected. In the meantime, CBR has pursued a strategy of avoidance, and CBR's field observations in August 1995 indicated that commercial operations to date have not directly affected any of the sites (CBR, 1995). CBR has stated its commitment to coordinate with the NSHS before any development occurs in the immediate vicinity of these sites (CBR, 1995). The staff will require that CBR provide NRC with documentation of its coordination with NSHS prior to developmental activity in the immediate vicinity of any of the six sites. CBR agreed to this condition, by telephone, on February 3, 1998.

CBR has begun but not yet completed a survey of the Crow Butte site and its environs to identify properties of cultural significance to Native American tribes. This process, which may take six months to a year to complete, involves significant interactions between CBR and Native American tribes who once inhabited and/or still inhabit the Crow Butte site area. Depending on the results of this survey, additional consultations between NRC and the State Historic Preservation Officer for the State of Nebraska may be necessary (see Section 9.0 for a discussion of consultation to-date). While the survey is on-going, NRC will authorize CBR to continue operations within currently disturbed areas. However, prior to engaging in any construction activity not previously assessed by NRC, CBR will be required, by license condition, to complete the cultural resource survey. All disturbances associated with the proposed construction will be completed in compliance with the National Historic Preservation Act of 1966 (as amended) and its implementing regulations (36 CFR Part 800), and the

Archaeological Resources Protection Act of 1979 (as amended) and its implementing regulations (43 CFR Part 7).

In addition, in order to ensure that no unapproved disturbance of cultural resources occurs, CBR will be required to stop any work that results in the discovery of previously unknown cultural artifacts. Such artifacts shall be inventoried and evaluated in accordance with 36 CFR Part 800, and no disturbance shall occur until the licensee has received authorization from NRC to proceed. CBR agreed to these license conditions, by telephone, on February 3, 1998.

3.0 PROCESS DESCRIPTION

3.1 Introduction

The process of *in situ* uranium leach mining is relatively simple in theory. An oxidant- and carbonate-charged solution (called "lixiviant") is pumped into the production zone aquifer through injection wells. With slight pH adjustments, the reduced uranium is oxidized and dissolved by complexation with the carbonate. The uranium-rich solution ("pregnant" lixiviant) is drawn to the recovery wells where it is pumped to the surface and transferred to the processing circuit.

The uranium is removed from the solution by adsorption onto ion exchange (IX) resin. The now barren lixiviant is recharged with oxidant and carbonate and re-injected into the production zone for additional uranium recovery. When the resin bed becomes saturated with uranium, the resin is eluted, or stripped, by passing a strong chloride solution through the bed. The resulting concentrated uranium solution is transferred to tanks where the uranium is precipitated by the addition of hydrochloric acid, sodium hydroxide, and hydrogen peroxide. The resulting product is a uranium slurry that is approximately one-half water. This product can either be shipped as a slurry, processed into a wet cake, or dried. The production cycle is continued until the ore zone is depleted to a point at which economic recovery is no longer feasible. The extent to which *in situ* leaching can be conducted is limited by the suitability of the ore zone conditions for containing and controlling lixiviant during the leaching process.

During production, there is a constant movement of lixiviant through the aquifer from outlying injection wells to internal recovery wells. The injection and recovery wells can be arranged in any of a number of geometric patterns depending on the orebody's configuration, the aquifer permeability, and the operator's preference; however, most often, wells are placed in a five- or seven-spot pattern. Monitoring wells, which are screened in appropriate stratigraphic horizons, surround the wellfield pattern area to detect any lixiviant that may migrate out of the production zone, either vertically and horizontally. In a properly designed and operated system, these "excursions" of ISL solutions should be rare due to the confining layers above and below the ore zone and the continual movement of lixiviant toward centrally-located recovery wells.

Following the completion of uranium recovery in a particular mining area, the affected groundwater is restored through various methods to appropriate standards, which may include pre-operational baseline conditions or pre-mining class-of-use limits.

ISL extraction allows the recovery of deep, low-grade sandstone uranium deposits which currently are not economically recoverable by conventional mining methods. For the most part, previous operating experience has shown that uranium can be economically recovered and that groundwater quality can be restored to baseline or pre-mining class-of-use standards.

There are many environmental advantages to ISL recovery of uranium over conventional mining methods, such as open pit mining or underground mining. Conventional mining methods can produce a significant impact on the environment due to, among other things, the resultant open pits and spoil piles. The *in situ* method leaves underground aquifers physically intact, rather than mined out as in conventional operations. The greatest impact of the ISL extraction method is a temporary effect on the ore zone groundwater quality. This impact is termed temporary because, in most instances, the groundwater can be restored to appropriate standards.

3.2 The Orebody

The uranium deposit at the Crow Butte site is a roll-front deposit, similar to those in the Wyoming basins. The uranium was precipitated as mineral coatings on sand grains and within pore spaces in the host rock, in several long, sinuous roll fronts that are found within the lower subunits of the Basal Chadron Sandstone. Precipitation of the uranium resulted when the oxidized water containing the uranium encountered reducing conditions. These reducing conditions are probably the result of hydrogen sulfide, and to a lesser degree, organic material and pyrite, that were present in the aquifer.

The Basal Chadron Sandstone is locally divided into subunits by thin clay beds that confine the uranium-bearing waters into several distinct hydrologic subunits. These clay beds are laterally continuous for hundreds of feet, and they controlled the precipitation of the uranium over even greater distances. As a result, the mineralized zone of the Basal Chadron is essentially restricted to the lower 12 m (40 ft) of the Basal Chadron. The physical shape of the ore deposit is dependent on the local permeability of the sandstone matrix, its continuity and distribution in the geologic unit, and the former location of the oxidation/reduction front in the paleo aquifer. The recoverable ore is located in a portion of the Basal Chadron, which ranges from 300 to 450 m (1000 to 1500 ft) wide. The orebody ranges in grade from 0.05 to greater than 0.5 percent U_3O_8, with an average grade of 0.26 percent equivalent U_3O_8 and 0.31 percent chemical U_3O_8.

For ISL to be successful, the ore deposit must (1) be located in the hydrologically saturated zone, (2) be bounded above and below by suitable confining layers, (3) have adequate permeability, and (4) be amenable to chemical leaching. As described in the previous chapter, the production area in the Crow Butte Uranium Project has favorable hydrogeological and structural characteristics to allow the *in situ* leaching of uranium. The hydrogeology and aquifer characteristics indicate that ISL solutions will be contained within the production zone. The operational history from both the R&D and commercial projects supports this conclusion.

3.3 Wellfield Design and Operation

3.3.1 Wellfield Design

Currently, there are five mine units (MUs), designated as MUs 1–5, which have defined at the site (a sixth wellfield (MU-6) has been constructed but has yet to operate). Of these five, MUs 1 and 2 are in restoration, while MUs 3, 4, and 5 are in production. The locations of these wellfields are shown in Figure 3-1, and relevant characteristics of each MU is provided in Table 3-1. Each of the MUs is designed to have about the same quantity of reserves. Due to the possibility that the orebody boundaries will change as a result of future ore reserve information, CBR determines the actual configuration of the va-'ous wellfields, as well as the final boundaries of the MUs, when the production and injection wells are installed. The ore is typically extracted through the use of a series of five- or seven-spot patterns installed over the mineralized section of the formation. A single five-spot pattern is roughly rectangular in shape, consisting of four injection wells surrounding a single central recovery well. Spacing between the wells in any five-spot will range from 12 to 36 m (40 to 100 ft), depending on the topography and ore characteristics. Figure 3-2 shows a typical wellfield pattern for the project. Each MU contains a number of wellfield houses (two to seven) from which trunklines from the process circuit and injection and recovery solutions are distributed to the injection and production wells. Barren injection lixiviant is recharged with oxygen in the wellhouses for re-injection. All injection and manifold piping is either polyvinyl chloride (PVC), high density polyethylene (HDPE) with butt-welded joints, or equivalent piping, that is leak tested and buried prior to production operations. Injection and production solutions are monitored at the wellfield houses with totalizing flow meters to detect leaks in the injection/production circuit.

Table 3-1. Mine unit dimensions for the Crow Butte Uranium Project. (Values taken from CBR, 1997a)

Mine Unit	Thickness m (ft)	Number of Patterns	Pattern size m^2 (ft^2)	Porosity	Pore Volume liters (gallons)	Mine Unit Total Area ha (acres)
MU-1	6.0 (19.6)	38	987 (10,624)	0.29	64.6 (17.2) million	3.8 (9.3)
MU-2	5.0 (16.3)	52	910 (9800)	0.29	67.6 (18.0) million	4.7 (11.7)
MU-3	3.9 (12.8)	57	955 (10,284)	0.29	57.9 (15.4) million	5.4 (13.4)
MU-4	4.0 (13.0)	96	1000 (10,765)	0.29	109.4 (29.1) million	9.6 (23.7)
MU-5	4.6 (15.0)	183	702 (7557)	0.29	169.1 (45.0) million	12.9 (31.8)
MU-6	6.1 (20.0)	175	929 (10,000)	0.29	285.3 (75.9) million	16.3 (40.2)

3.3.2 Pre-operational Groundwater Sampling

CBR is required to establish pre-operational baseline groundwater quality in an MU prior to mining in that MU. Within the MU, pre-operational baseline groundwater quality data is required to be established at the following minimal density: (1) one production or injection well per 1.6 ha (4 acres), with a minimum of 10 restoration wells per MU, (2) one upper aquifer (Brule) monitor well per 2 ha (5 acres), and (3) all perimeter monitor wells. Perimeter monitor wells are completed in the production zone horizon (i.e., the Basal Chadron), and they surround the MU at a distance of 91 m (300 ft) or less from the mineralized zone and not more than 122 m (400 ft) from one another (CBR, 1995). Baseline groundwater quality data is not collected from the underlying Pierre Shale, because groundwater monitoring is not conducted in this formation, due to its thickness and hydraulic properties. The normal spacing of the ore zone wells, and the shallow zone and perimeter monitoring wells is shown schematically in Figure 3-2.

Three samples are collected from each well, with two-week intervals between sampling, and the samples are analyzed for a suite of 35 parameters (Table 3-2). Based on the data from the upper aquifer and perimeter monitor wells, upper control limits (UCLs) for each MU are established, while the production and injection well data are used to set restoration standards. The purposes of UCLs and restoration standards are discussed in Sections 3.7.1 and 4.1, respectively.

Table 3-2. Baseline water quality indicators (CBR, 1995)

Physical Indicators		
Specific Conductivity	Alkalinity	TDS
Temperature	pH	
Common Constituents		
Ammonia (NH_4 as N)	Chloride	Silica
Bicarbonate	Magnesium	Sodium
Calcium	Nitrate	Sulfate
Carbonate	Nitrite	Potassium
Trace and Minor Elements		
Arsenic	Fluoride	Nickel
Barium	Iron	Selenium
Boron	Lead	Vanadium
Cadmium	Manganese	Zinc
Chromium	Mercury	
Copper	Molybdenum	
Radionuclides		
Radium-226	Uranium	

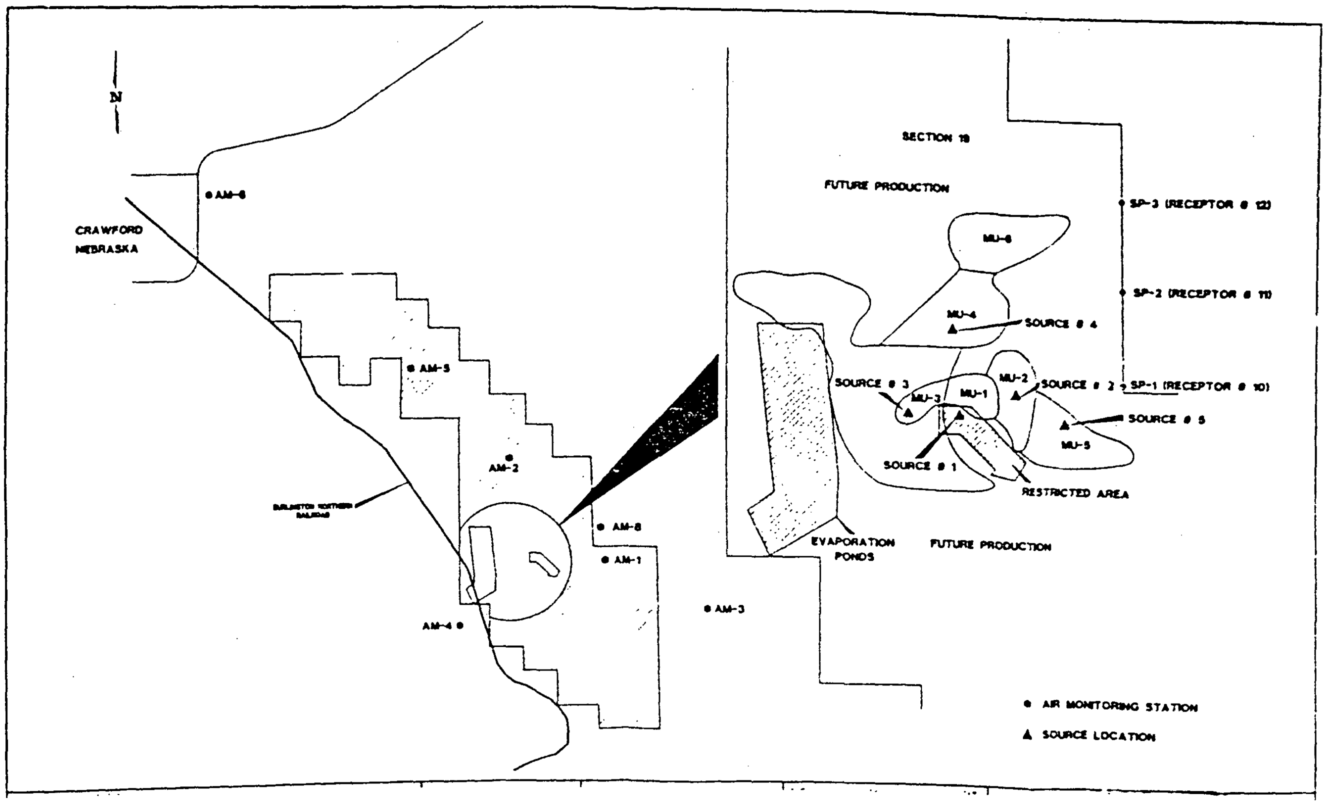


Figure 3-1. Locations of Mine Units 1 through 5 at the Crow Butte Uranium Project (from CBR, 1995)

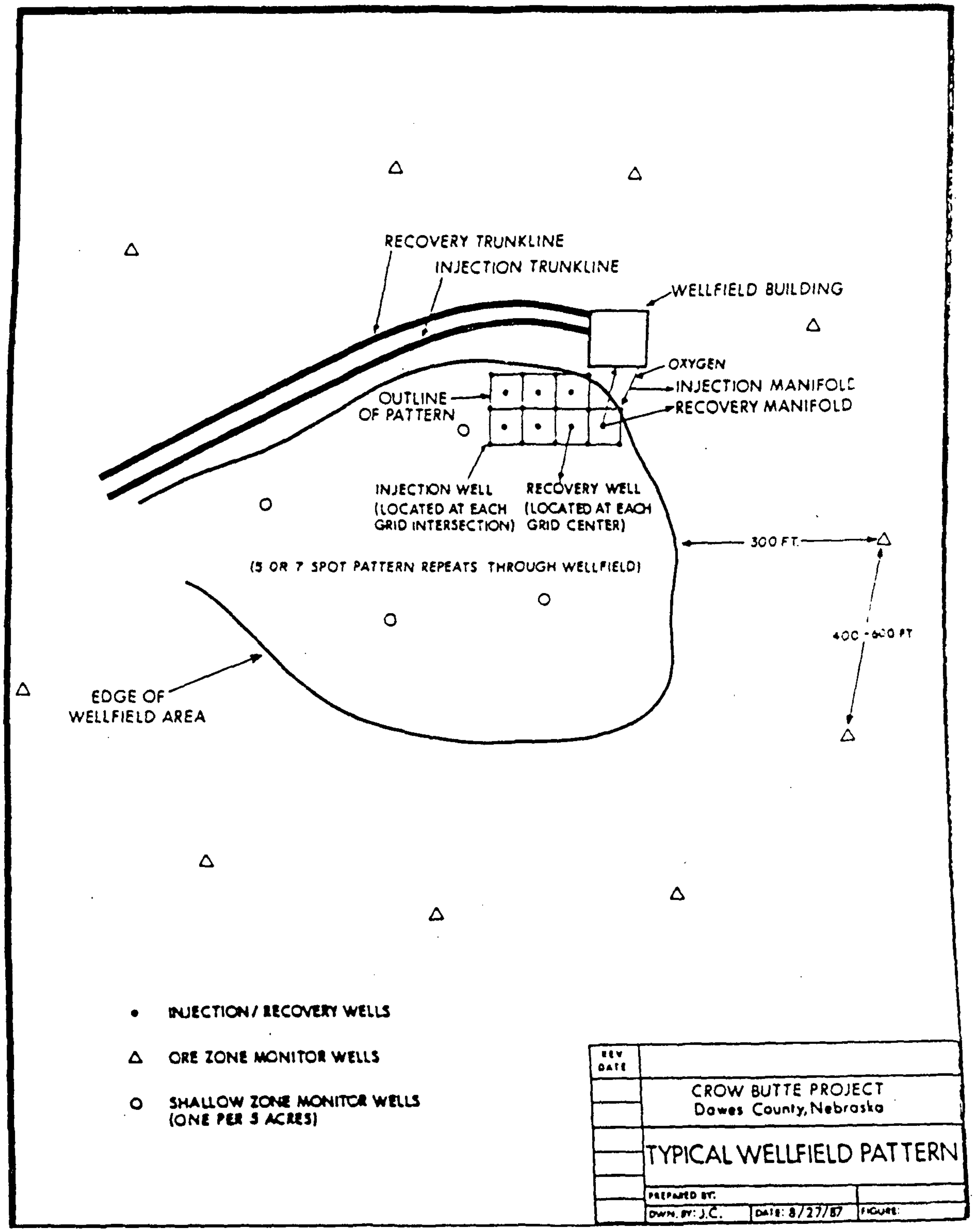


Figure 3-2. Typical wellfield pattern and monitoring well locations at the Crow Butte Uranium Project (from CBR, 1995)

Under CBR's current license, CBR is required to submit the baseline groundwater data to NRC at least two months prior to mining in an MU, in support of a license amendment request to establish UCLs and restoration standards for the MU. With the renewal of SUA-1534 under the performance-based format, the licensee's SERP will have the responsibility for evaluating the baseline data, establishing UCLs and restoration criteria, and evaluating the proposed monitoring program for compliance with existing license conditions, prior to mining in future MUs. NRC will review this information during its routine site inspections.

3.3.3 Well Construction and Testing

Typical construction methods for production, injection, and monitoring wells at the Crow Butte Uranium Project are described in detail in the LRA. These well completion methods are illustrated in Figures 3-3 through 3-5. The licensee will be required by license condition to construct all wells in accordance with the methods described in the LRA.

Following completion, well integrity is tested to ensure that the wells are appropriately completed and free of leaks that could cause lixiviant to enter casing intervals other than those in the ore zone. As described in the LRA, the integrity tests are performed using a pressure-packer test. This test requires placement of one or two packers within the well casing, with the bottom packer set just above the well screen and the upper packer (or a well cap) set at the wellhead. Thus, these packers segregate the non-perforated section of the well casing. Then, the bottom packer is inflated and the casing is pressurized to 125 percent of the maximum operating pressure. The well is then closed in and the pressure is maintained for a minimum of 20 minutes. If the well is unable to sustain at least 90 percent of the pressure for 20 minutes, the well is considered to have failed the integrity test. Wells not passing the integrity tests will be reworked and tested again. Repeated failure of the integrity testing will result in the well being plugged and abandoned by CBR in accordance with State requirements. The plugged well will prevent movement of fluids from the injection horizon into aquifers containing fresh and/or usable water. The integrity testing program also will ensure that fluids injected and recovered during mining will not be lost from the well due to failures of the casing. In accordance with its NDEQ UIC permit, CBR also conducts, in addition to initial integrity testing, mechanical integrity testing following well servicing and at least once every five years during the operational life of a well.

Currently under SUA-1534, CBR has been allowed to use a single point resistance test in place of the packer-pressure testing method. However, the staff states in NUREG-1569 (NRC, 1997) that it does not find sole reliance on single point resistance to be an acceptable method for determining mechanical well integrity. Therefore, NRC will modify this condition in the renewal license to allow the use of single point resistance only in conjunction with another approved method of well integrity testing. CBR agreed to this modification, by telephone, on November 12, 1997.

Under SUA-1534, CBR also is required to conduct initial mechanical integrity testing, as described above, on each injection and production well prior to their utilization and following any service. This condition will be clarified in the renewal license to require testing following service with equipment or procedures that could damage the well casing. In addition, to provide consistency with the provisions of the NDEQ UIC permit and the staff's recommendations in

NUREG-1569 (NRC, 1997), NRC also will require, by license condition, that repeat integrity testing be conducted at least once every five years for all operating wells. CBR agreed to this condition, by telephone call, on November 10, 1997.

3.4 Uranium Recovery Process

Uranium recovered during the extraction operation is processed as shown in Figure 3-6. The recovery process generally consists of six primary steps: (1) *in situ* uranium dissolution through injection and recovery of an oxidized, carbonate lixiviant; (2) stripping of the uranium from the pregnant lixiviant by sorption of uranium complexes onto IX resin; (3) reconstitution of the barren lixiviant by the addition of bicarbonate and oxygen and subsequent re-injection; (4) elution of the uranium complexes from the IX resin; (5) precipitation and settling of the uranium; and (6) filtering, de-watering, drying, and packaging of the uranium yellowcake for shipment. The general layout of the processing plant is shown in Figure 3-7.

The lixiviant used at the Crow Butte Uranium Project begins with local groundwater, to which CBR adds an oxidant (oxygen or hydrogen peroxide) and a complexant (sodium carbonate/bicarbonate). The typical composition of the injection lixiviant is given in Table 3-3. To ensure that the formation responds geochemically as previous experience indicates, the licensee will continue to be required, by license condition, to use a lixiviant composed of native groundwater, sodium carbonate/bicarbonate, and oxygen or hydrogen peroxide.

The lixiviant is gathered in the injection manifold at the wellhouse through buried pipelines and injected into the ore zone by the injection wells. Downhole injection pressures will be maintained below formation fracture pressures to avoid hydrofracturing the aquifer and promoting leakage into the overlying units. Ambient pressures at depth may exceed the strength rating of the PVC pipe, but the borehole cement is expected to protect the casing from adverse pressure effects. CBR estimates that the formation fracture pressure gradient at the site is 14.25 kilopascals per meter (kPa/m) (0.63 pounds per square inch per foot [psi/ft]) of well depth. For the typical operating depths at the Crow Butte site, this means that formation fracture pressures at the depth of the Basal Chadron aquifer range from about 1740 kPa at 122 m (250 psi at 400 ft) to 3475 kPa at 244 m (500 psi at 800 ft). These values provide a safety factor for limiting operating injection pressures. CBR limits injection pressures to the pressures at which well integrity was tested minus the safety factor, typically to injection pressures less than 690 kPa (100 psi). CBR also continuously monitors the injection pressure (CBR, 1995).

In the subsurface, the lixiviant oxidizes uranium from the 4+ to the 6+ oxidation state and dissolves the oxidized uranium as a uranyl-carbonate aqueous species. Other trace metals such as arsenic, selenium, vanadium, iron, and manganese also are mobilized during the leach process. The pregnant lixiviant is recovered through the production wells, piped to the wellfield house, and from there, sent by buried PVC trunklines to a surge tank in the processing plant, from where it is pumped into a series of IX columns. In the IX columns, the uranium, and to a lesser extent, other metals, are adsorbed onto the resin beads. Those metals which are not adsorbed on the resins will be recirculated into the wellfield. The solution exiting the IX columns is depleted in uranium and has low lixiviant strength. Therefore, additional oxidizing and complexing agents are added to the stream prior to reinjection.

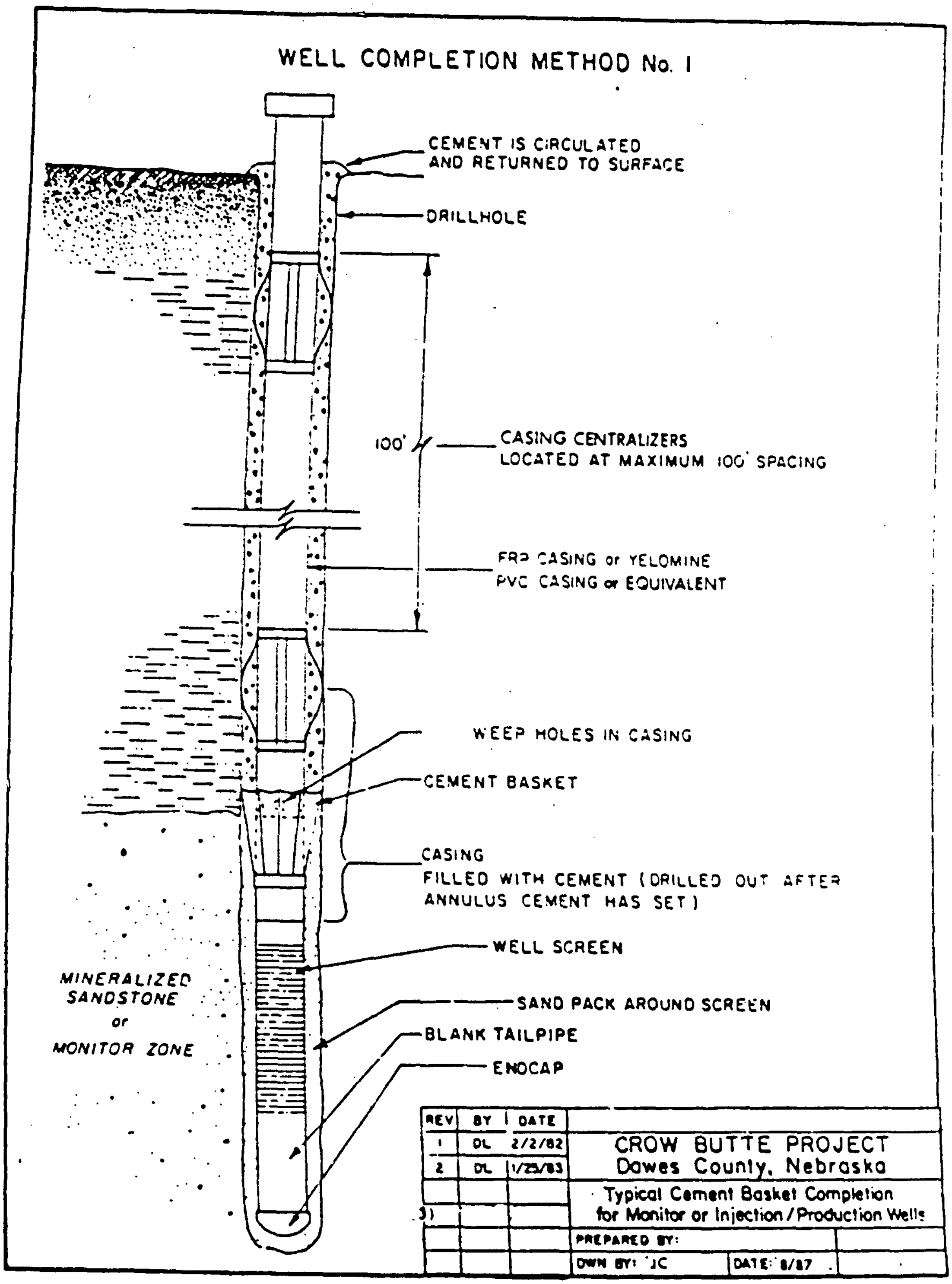


Figure 3-3. Well completion method one at the Crow Butte Uranium Project (from CBR, 1995)

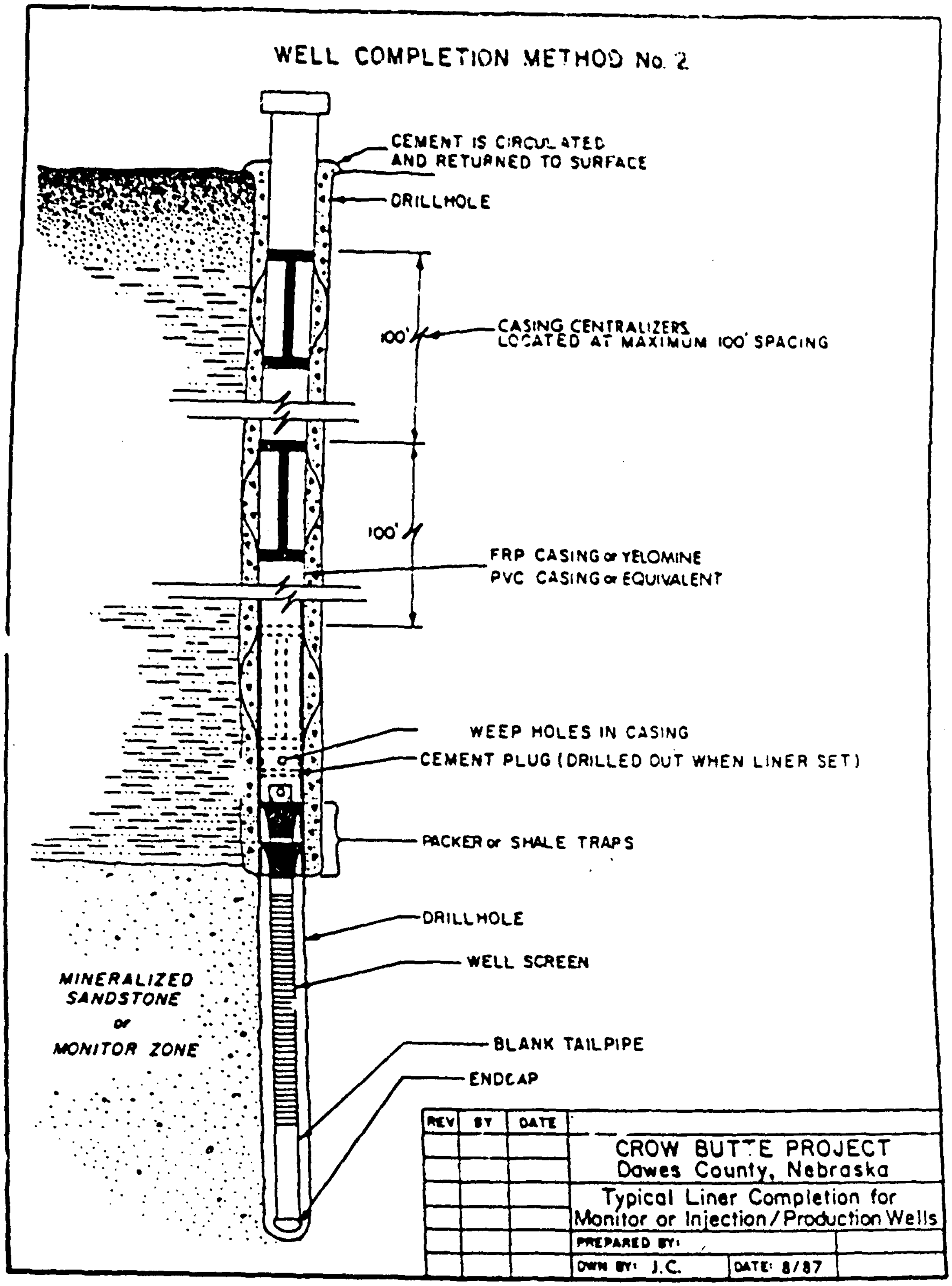


Figure 3-4. Well completion method two at the Crow Butte Uranium Project (from CBR, 1995)

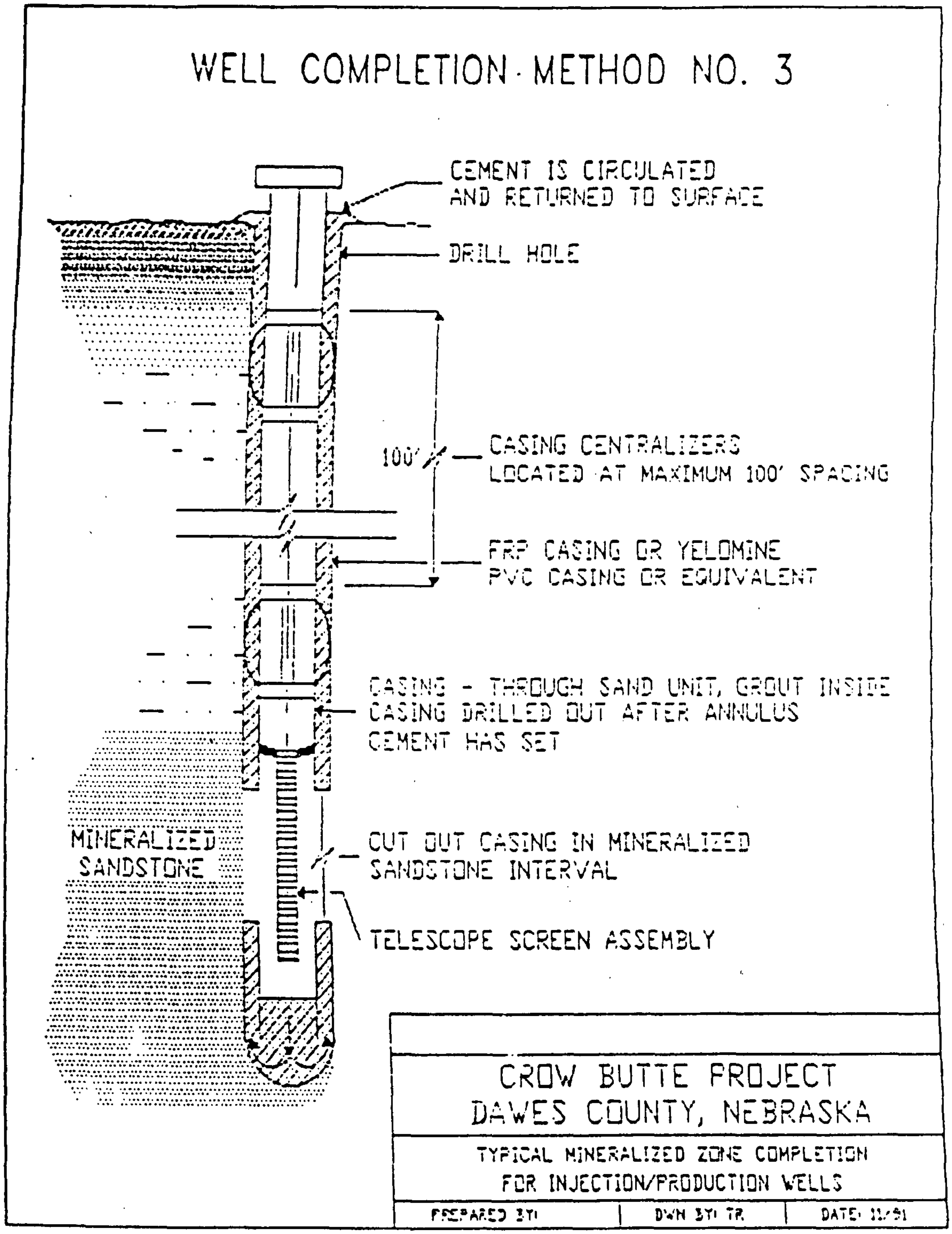


Figure 3-5. Well completion method three at the Crow Butte Uranium Project (from CBR, 1995)

Table 3-3. Typical lixiviant chemistry. All units in mg/L except pH, which is in standard units. (from NRC, 1989a)

Species	Range	
	Low	High
Na	≤ 400	6000
Ca	≤ 20	500
Mg	≤ 3	100
K	≤ 15	300
CO_3	≤ 0.5	2500
HCO_3	≤ 400	5000
Cl	≤ 200	5000
SO_4	≤ 400	5000
U_3O_8	≤ 0.01	500
V_2O_5	≤ 0.01	100
TDS	≤ 1650	12,000
pH	≤ 6.5	10.5

Once the majority of the ion exchange sites on the IX column resin are filled with uranium, the column is taken off stream. In the current process plant (CBR, 1995), there are eight IX columns that operate in sequence. After being taken off stream, the loaded column is eluted of uranium through a process in which the uranium-carbonate complex is stripped from the resin beads with a concentrated chloride solution. After the uranium has been stripped, the resin is rinsed with a sodium bicarbonate solution to convert the resin to a carbonate form and to control the chloride buildup in the circuit. The product of the elution process is a pregnant (i.e., uranium-rich) eluant that is discharged into a holding tank.

When a sufficient volume of pregnant eluant is held in storage, it is acidified to break down the uranyl carbonate complex ion. Next, the solution is agitated to remove the resulting carbon dioxide gas, and hydrogen peroxide is added to the solution to precipitate the uranium. The precipitated uranyl peroxide slurry (yellowcake) is pH-adjusted and allowed to settle, while the clear solution is decanted and either recirculated to the barren eluant storage tank, sent to fresh salt brine makeup for deep well injection, or sent to the solar evaporation ponds. The yellowcake is further de-watered and washed using a vacuum belt filter or equivalent. The resultant product is dried onsite in a vacuum dryer and then packaged in 208-L (55-gal.) drums for shipment.

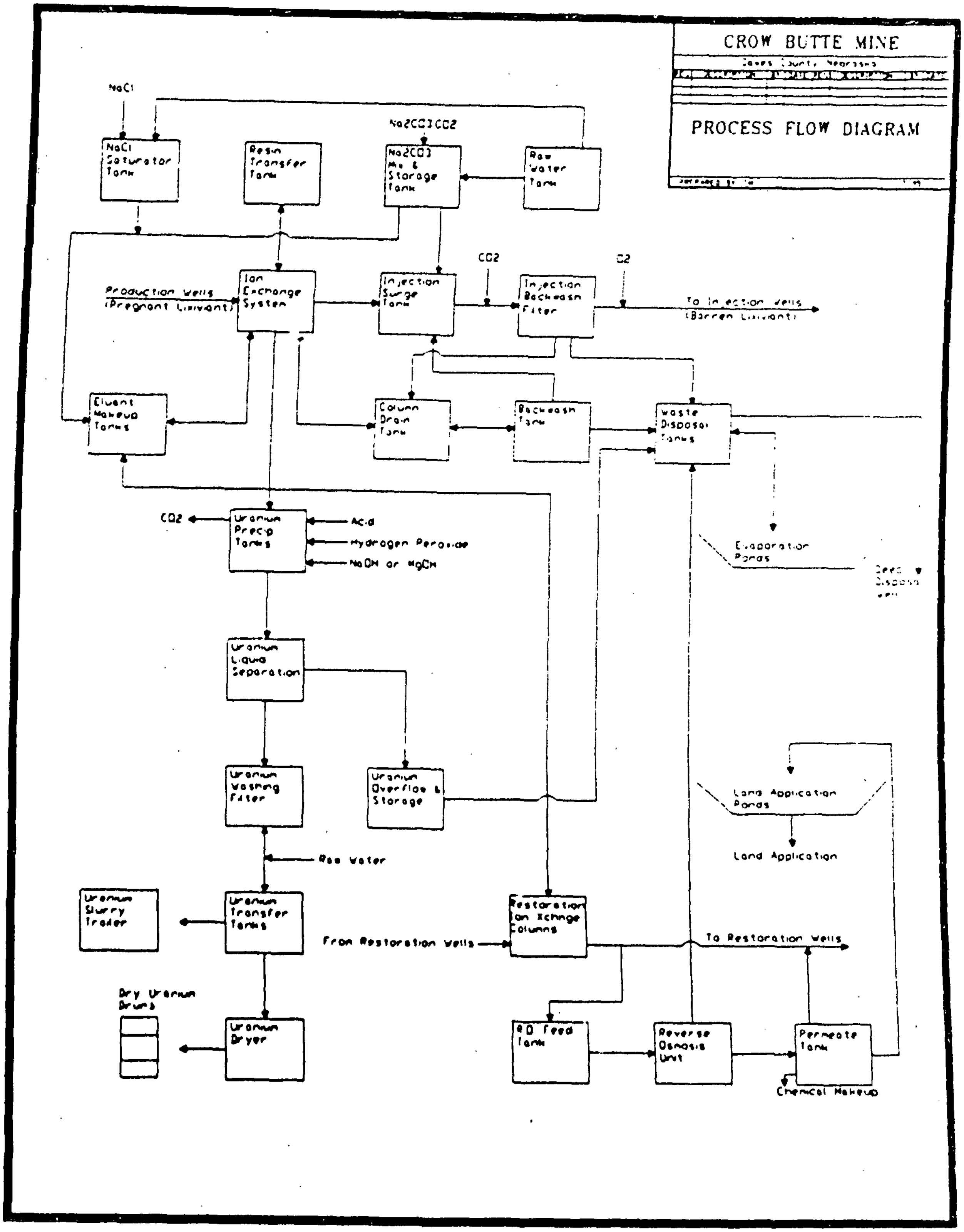


Figure 3-6. Flow sheet of the uranium recovery process at the Crow Butte Uranium Project (from CBR, 1995)

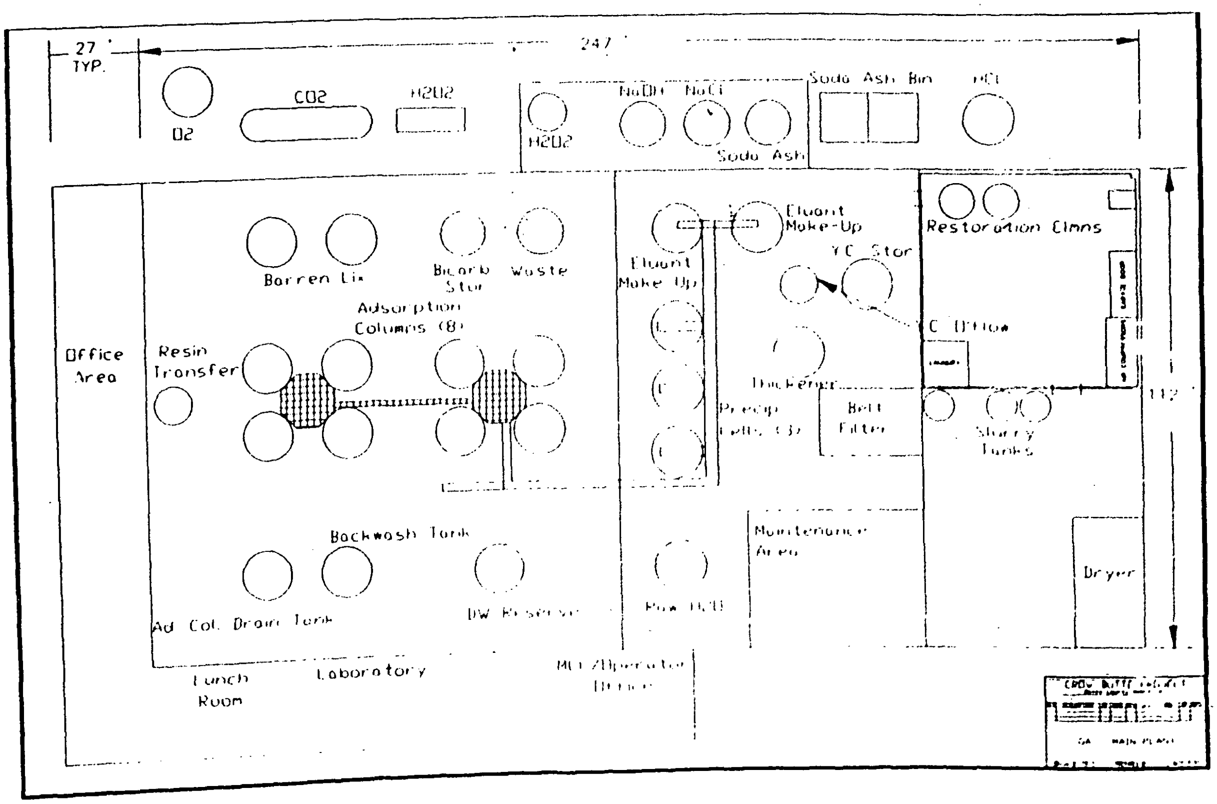


Figure 3-7. Generalized layout of the main processing facility at the Crow Butte Uranium Project (from CBR, 1995)

Currently, CBR is not authorized, by license condition, to exceed a maximum processing flowrate of 18,930 Lpm (5000 gpm). In addition, CBR currently is limited by license condition to a maximum production rate of 907,185 kg (2 million lbs) of yellowcake per year. These will continue to be license conditions in the renewal license.

3.5 Description of the Existing Main Process Plant

The processing circuit is housed in a building approximately 83 m long by 37 m wide (275 ft by 120 ft). In addition to processing tanks and equipment, the building contains a lunchroom, office, and laboratory space. A diagram of the plant is shown in Figure 3-7. The equipment in the main process plant can be assigned to one of the following process operations: lixiviant injection, filtration, IX, elution/precipitation, and dewatering/drying.

The lixiviant recovery system consists of two recovery surge tanks, which are used for temporary storage of the recovered lixiviant prior to its being pumped to the IX system. The IX system consists of two sets of four columns operated in a carousel configuration. The uranium loading process is continuous, but the elution process is operated on a batch basis. The depleted lixiviant is pumped through a system of filters to remove any formation particulates or pipe scale and is then pumped to the lixiviant injection system. The injection system consists of injection surge tanks and associated injection pumps. The tanks are made of fiberglass-reinforced polymer (FRP), and the injection is through a set of centrifugal pumps.

The elution/precipitation circuit consists of the barren eluant tanks and the acidizer/precipitator tanks. The eluant is pumped from the barren eluant tanks to the IX columns, and the pregnant eluant is transferred to the acidizer/precipitator where the uranium is precipitated. The precipitated uranium is de-watered and washed using a vacuum bed filter or equivalent. The yellowcake is dried on site using a vacuum dryer.

3.6 Generation and Management of Wastes

3.6.1 Gaseous Effluents

Air emissions from the commercial operations will be primarily in the form of radon-222. Radon-222 is present in the orebody and is formed by the decay of radium-226. The radon dissolves in the lixiviant as it travels through the orebody to production wells, and when the lixiviant is processed at the surface, radon is released from solution. Radon can potentially be released to the environment either from the wellfields or the processing plant. While injection wells are generally closed and pressurized, they are periodically vented and radon-222 is released. At the processing facility, radon-222 is vented from recovery surge tanks and the IX columns into a manifold and emitted to the atmosphere outside the plant via an induced draft fan.

The yellowcake drier is operated under negative pressure. There are no particulate emissions, because (1) particulates are controlled by bag filters and (2) moisture-laden air is recirculated through a closed-loop condenser where water condenses and entrains any remaining particulates.

Finally, there will be small quantities of gases, such as CO_2 and O_2, released from gas traps on the injection well pipelines.

As discussed in Section 3.7.3, CBR has been and will be sampling for specific radionuclides at seven locations surrounding the site. The results of this sampling, which are summarized in Section 5.7.2, are submitted to NRC on a semiannual basis.

3.6.2 **Liquid Wastes**

Liquid wastes from operations are generated from three sources: (1) wellfield development, (2) processing plant operations, and (3) aquifer restoration activities. During the first half of 1997, approximately 11.7 million L (3.1 million gal.) of plant-generated and wellfield development waste water was produced. In addition, during this same period, approximately 576 million L (152.2 million gal.) of restoration water was produced (CBR, 1997d).

CBR is required under its current license to return all liquid effluents from process buildings and other process waste streams, with the exception of sanitary wastes, to the process circuit, or to dispose of the effluents through any of the NRC-approved waste disposal options. Currently, CBR has three NRC-approved options for the disposal of liquid wastes: (1) solar evaporation ponds, (2) land application, or (3) deep well injection. To ensure that all liquid wastes will be accounted for, CBR will continue to be required by license condition to return all liquid effluents to the process circuit or to the appropriate disposal system.

3.6.2.1 Solar Evaporation Ponds

As of November 1997, five evaporation ponds were in use: R&D Cells 1 and 2, and Commercial Ponds 1, 3, and 4 (CBR, 1997c). These ponds are located as shown in Figure 2-2. The two R&D cells were constructed in 1985, with a 34 mil hypalon liner placed on top of 15.2 cm (6 in.) of sand and a 2:1 (horizontal to vertical) interior and exterior embankment slopes. The maximum depth of these ponds is 4.6 m (15 ft). The three commercial development ponds were completed in 1990 (Ponds 3 and 4) and 1992 (Pond 1). Ponds 3 and 4 have a 20 mil PVC bottom liner, an intermediate geonet, and a 60 mil HDPE top liner, with a maximum depth of 5.3 m (17.5 ft). In Pond 1, a 30 mil very low density polyethylene bottom liner was installed with an intermediate geonet and a 60 mil HDPE top liner. The overall depth of Pond 1 is 5.2 m (17 ft) from crest to pond bottom. The exterior slopes for all three commercial ponds are 2.5H:1V, and the interior slopes are 2H:1V.

At maximum capacity, the total allowed storage of the current five ponds is approximately 151 million L (39.9 million gal.). As of November 1, 1997, the pond system contained approximately 115.5 million L (30.5 million gal.) of waste water, a value representative of normal operating levels (CBR, 1997c). The total estimated evaporative capacity for the five ponds is 36.7 million L/yr (9.7 million gal./yr). Construction of two additional commercial ponds has been approved by NRC and, if installed, would increase capacity to 280 million L (74 million gal.). License conditions addressing the construction of these ponds will continue to be required in the renewal license.

CBR is required currently, by license condition, to maintain freeboards of 0.9 m (3 ft) in the R&D ponds and 1.5 m (5 ft) in the commercial ponds. These freeboard limits are designed to allow the evaporations ponds to accommodate a design precipitation event (63.5 cm [25 in.]) as well as a 97 km/hr (60 mi/hr) wind-generated wave with an engineering safety factor of 0.55 m (1.8 ft). Additionally, CBR is required to maintain sufficient reserve capacity in the evaporation pond system to allow the transfer of one pond's contents to the other ponds in the event of a leak. The renewal license will retain these conditions.

All ponds have a leak detection system consisting of underdrains which connect to leak detection standpipes. As discussed in Section 3.7.2, CBR must analyze water contained in the standpipes for leak indicator parameters any time 15.2 cm (6 in.) or more of fluid is present. In the event of leak verification, CBR is also required in SUA-1534 to take specific actions, including notification of NRC. These conditions will be retained in the renewal license.

3.6.2.2 Land Application of Treated Water

While land application of treated process water has been approved by NRC as a waste disposal option for the Crow Butte Uranium Project, CBR has not employed this option to date. If, however, CBR chooses to employ this disposal option in the future, such land application will be restricted by license condition to two areas described in previous CBR submittals. Area 1 is a 25 ha (60 acre) area located approximately 2.4 km (1.5 mi) northwest of the processing plant (NE¼, Sec. 13, T31N R52W), while Area 2 is a 16 ha (40 acre) plot located immediately adjacent to and south of the pilot processing plant (SE¼, Sec. 19, T31N R51W). Up to 145.7 million L (38.5 million gal.) of treated water per year could be disposed through land application. This quantity includes water purged during the construction and development of wells at the project and water treated by reverse osmosis. The release limits for various ionic species, metals, and some radionuclides are established by appropriate NRC, EPA, and State of Nebraska standards.

However, as stated, CBR has yet to implement land application of treated process water at the Crow Butte site.

3.6.2.3 Deep Well Injection

CBR disposes of some process fluids generated during operations via a Class I non-hazardous waste injection well installed to a total depth of about 1200 m (3925 ft). The fluids are injected into the Jurassic-aged Sundance and Morrison Formations at 75 to 375 Lpm (20 to 100 gpm) through perforations in the well casing at depths of 1075 to 1175 m (3528 to 3855 ft). The Sundance and Morrison Formations are located below the lowermost underground source of drinking water (USDW), and contain brines that make the water unsuitable for a USDW under either Federal or State of Nebraska regulations. Fluids disposed in this manner are derived from two sources: the production bleed and the eluant bleed. The injection stream typically consists of a sodium-chloride brine, high in TDS, with significant amounts of sulfate and the radionuclides uranium and radium-226. CBR may add scale and corrosion inhibitors to prevent fouling of the injection well.

NRC approved deep well injection of liquid process wastes on October 6, 1994, authorizing CBR to dispose of process fluids in the basal unit of the Sundance Formation beneath the site, provided that the State of Nebraska issued the necessary underground injection permit and found that the potential for contamination of other usable aquifers was minimal. In approving deep well injection as a waste disposal option, the NRC staff determined that the average concentration limits of the process fluids to be injected (10 mg/L for uranium and 1000 pCi/L for radium-226) were comparable to levels allowed by the staff at other sites approved for this method of waste disposal. On June 20, 1995, the State of Nebraska issued UIC Permit No. NE0206369 to CBR, authorizing the installation of a Class I non-hazardous waste injection well in S½, Section 19, T31N R51W.

On February 28, 1996, the staff approved injection of process fluids into the overlying Morrison Formation also; CBR's State permit was modified to authorize injection into the Morrison on April 17, 1996. Finally, on July 19, 1996, the staff approved revised concentration limits for uranium (25 mg/L), radium (5000 pCi/L), and sulfate (from 5000 mg/L to 10,000 mg/L) in the process fluids to be injected, finding that the new limits were still comparable with those approved for other licensed ISL operations.

Currently, CBR is required, by license condition, to operate its deep injection well in accordance with a Hydrogeologic Review and Engineering Design Report, submitted to NRC on August 24, 1993, and subsequently modified. This will continue to be a condition in the renewal license.

3.6.3 Solid Wastes

Sanitary wastes from the restrooms and lunchroom will be disposed in a septic system regulated by the State of Nebraska. Solid wastes generated at the site typically consist of spent resin, empty reagent containers, miscellaneous pipes and fittings, and domestic trash. These wastes will be classified as contaminated or non-contaminated waste, according to their radiological survey results.

Contaminated solid waste is separated into two categories. The first category is waste which has some salvage value or can be decontaminated to below unrestricted release limits. This type of waste may include piping, valves, instrumentation, equipment, and any other item that can be decontaminated. All decontaminated wastes will be inspected and surveyed by the CRSO or the health physics technician prior to release from the site to ensure that appropriate decontamination procedures have been observed. CBR stated that the release limits for decontaminated materials will be those specified in NRC Branch Technical Position "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct or Source Material," dated September 1984, will be released from the site. This guidance document was updated in May 1987 (NRC, 1987), and therefore, the licensee will be required to follow this more recent version, or a suitable alternative procedure approved by NRC prior to any such release. CBR agreed to this license condition, by telephone, on November 10, 1997.

The second category of waste includes items that have no salvage value and have been contaminated during uranium recovery operations. The most common example of this type of waste is radium-contaminated filters (CBR, 1995). These materials will be stored in a secure area until such time as they can be shipped to a site licensed to accept such waste for disposal.

Records of equipment and corresponding contamination levels will be maintained for all items released from the site. Any item having contamination levels that exceed regulatory limits will be disposed at a site approved to receive byproduct waste materials, as discussed below. Transportation of all material to the byproduct disposal facility will be handled in accordance with U.S. Department of Transportation and NRC regulations (49 CFR 173.389 and 10 CFR Part 71, respectively) .

Currently, CBR is authorized, by license condition, to dispose its contaminated wastes at IUSA's White Mesa uranium mill in Blanding, Utah. With this renewal, CBR will be allowed to dispose of byproduct waste materials at any site authorized by NRC or an NRC Agreement State to accept such material for disposal. CBR will be required to maintain onsite, for NRC inspection, a copy of its agreement with the disposal site. In the event CBR's agreement with IUSA expires or is terminated, CBR will be required to notify NRC within seven days of the expiration or termination date. A new agreement must be submitted to NRC for approval within 90 days of expiration or termination, or CBR will be prohibited from further lixiviant injection.

Non-contaminated solid wastes will be collected at the site on a regular basis and disposed in the nearest sanitary landfill. The waste is surveyed prior to disposal to ensure that no contaminated waste is released from the site.

3.7 Monitoring Programs

CBR conducts regular monitoring of groundwater, the evaporation ponds, and the surrounding environment to assess and mitigate impacts from commercial operations to individuals living near the facility and to the environment.

3.7.1 Hydrologic Monitoring

As discussed in Section 3.3.2, CBR has been and will continue to be collecting baseline groundwater quality data in each mine unit, from the Basal Chadron and Brule aquifers, prior to mining. With this data, upper control limits (UCLs) are calculated for each well for each of five excursion indicator parameters (chloride, sulfate, sodium, conductivity, and alkalinity). UCLs are calculated as 20 percent above the maximum baseline value measured for that parameter from the three samples taken from the well.

During uranium recovery operations, the baseline wells are sampled on a biweekly basis to determine whether lixiviant is migrating beyond the extraction zone. The samples are analyzed for the indicator parameters, with the results compared against the UCLs for the well. An excursion of lixiviant is assumed if two UCLs in any monitor well are exceeded, or if a single UCL for a monitor well is exceeded by 20 percent. If such an exceedance is observed in the initial sample, the well is placed on excursion status if either of two verification samples also indicates that a UCL(s) has been exceeded. If neither the second or third sample indicate exceedance of the UCLs, the first sample is considered in error.

Should a well be placed on excursion status, CBR is required to notify NRC within 24 hours, to institute corrective actions, and to increase the sampling frequency in the affected well(s) to once every seven days until the excursion is corrected. CBR also is required to submit a written status report to NRC within two months of excursion confirmation, providing a discussion of the excursion event, the corrective actions taken, and the results observed. An excursion is not considered concluded until the concentrations of the indicator parameters are below the appropriate UCLs for three consecutive weekly samples.

If corrective actions have not been effective by the time the 60-day excursion report has been submitted, CBR is required currently, by license condition, to terminate injection of lixiviant within the wellfield on excursion until such time as aquifer cleanup is complete. This condition will be retained in the renewal license.

Quality Assurance (QA) programs will be maintained by the CRSO. All QA programs will be conducted according to the Regulatory Guide 4.15, Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment (NRC, 1979). Standard QA procedures will be maintained throughout the project life.

The history of excursions during commercial operations at the Crow Butte Uranium Project is presented in Section 5.4.2.1. Additional aspects of CBR's groundwater sampling are identified in Table 3-4.

3.7.2 Evaporation Pond Monitoring

CBR has implemented an Evaporation Pond Onsite Inspection Program (CBR, 1996b) to conduct various inspections of the evaporation pond system on daily, weekly, monthly, quarterly, and annual bases during operations. These inspections include the following:

- Daily: visual inspection of pond embankments, and measurement and documentation of water depths in each pond;
- Weekly: visual inspection of perimeter fencing, inlet pipes, and the pond liner, and measurement and documentation of fluid levels in the underdrains and leak detection systems;
- Monthly: visual inspection of piping from the plant building to the ponds and the diversion channels;
- Quarterly: visual inspection of pond embankments for settlement, slope irregularities, vegetation growth, rill and gully formation, and documentation of any evidence of seepage or of any changes to upstream watershed areas which may affect runoff to the ponds; and
- Annually: technical evaluation of the pond system, surveys of the pond embankments, and reviews of inspection records conducted over the course of the year.

Currently, CBR is required, by license condition, to sample fluid from the leak detection system standpipes if more than 15.2 cm (6 in.) is detected and to analyze the fluid for leak indicators. If a leak is verified on the basis of analysis results, CBR is required to notify NRC within 48 hours and to begin to transfer the contents of the leaking pond to another pond(s) so that remedial actions can be taken. While these actions are on-going and for a two-week period following repairs, CBR also is required to analyze water quality in the affected standpipe(s) once every seven days for the leak indicators. Finally, CBR must submit a written report to NRC within 30 days of leak verification, reporting the analytical data collected, and describing the cause of the leak, the mitigative actions taken, and the results of those actions.

NRC will continue to retain these monitoring requirements in the renewal license. The results of evaporation pond leak detection monitoring during commercial operations is provided in Section 5.4.2.2.

3.7.3 Environmental and Effluent Monitoring

CBR has implemented a environmental and effluent monitoring program for the R&D site and for the commercial ISL operations. The program consists of a number of monitoring sites used to sample surface waters, groundwater, sediments, soils, and the air for various radionuclides, in an effort to determine the impacts on the environment from operations. The proposed site environmental and effluent monitoring program is outlined in Table 3-4.

In its submittal dated July 28, 1997, CBR proposed several modifications to its existing monitoring program. These modifications included: (1) changing the exchange frequency for the environmental radon detectors from quarterly to semiannually; (2) ending sampling for Th-230 in air particulate and stream sediment samples; and (3) discontinuing vegetation sampling. The staff finds these requests to be acceptable for the following reasons:

- In reducing the radon detector exchange frequency to semiannual, CBR will be able to achieve the lower level of detection (LLD) of 0.2 pCi/L recommended in Regulatory Guide 4.14 (NRC, 1980), while still allowing CBR to meet the semiannual reporting requirements under 10 CFR 40.65 and the requirements for annual dose calculations under 10 CFR Part 20.

- CBR uses a vacuum dryer, which theoretically reduces air particulate emissions from the dryer to zero. Measured airborne concentrations of Th-230 over the seven years of commercial operations at the Crow Butte site have been one percent or less of the 10 CFR Part 20 limit. Th-230 concentrations in annual stream sediment samples also have been consistently low (between 0.2 and 0.4 pCi/g) during the period of commercial operations.

- In Regulatory Guide 4.14 (NRC, 1983), the NRC staff recommends that vegetation sampling be conducted only if dose calculations indicate that the ingestion pathway from grazing animals is a potentially significant exposure pathway (i.e., if the predicted dose to an individual would exceed five percent of the applicable protection standards). CBR's MILDOS-AREA modeling results show that doses from the ingestion of affected meat and milk fall well below the five percent criterion.

Table 3-4. Radiological, Environmental, Operational, Effluent Monitoring Program (CBR, 1997e)

Sample Type	Location	Type	Number	Frequency	Analyses
Air (Radon)	Nearest residences and in the prevalent wind direction	Continuous	6	Semiannually	Rn-222
	Environmental control location near Crawford, NE		1		
Air (Particulates)	Same locations as radon monitoring	Continuous	7	2 weeks per month when dryer in use	U-nat, Ra-226, Pb-210
Surface Soil (top 5 cm)	Plant site before topsoil removal	Grab	2	Once	U-nat, Ra-226
	Plant site after topsoil removal	Grab	2	Once	U-nat, Ra-226
	Evaporation ponds before excavation	Grab	2	Once	U-nat, Ra-226
	Air sampling stations	Grab	7	Once	U-nat, Ra-226
Subsurface soil	Plant site	½ meter composites to one meter	1	Once	U-nat, Ra-226
Groundwater	Water supply wells within 1 km of area wellfield	Grab	1	Quarterly	U-nat Ra-226
	Each monitor well	Grab	1	Quarterly	U-nat Ra-226
Surface Water	Each stream passing through wellfield area (one up-stream and one down-stream)	Grab	2	Quarterly	U-nat Ra-226
	Each water impoundment in wellfield area	Grab	1	Quarterly	U-nat Ra-226
Direct Radiation	Air sampling stations	Continuous	7	Quarterly exchange of dosimeters	External gamma
Sediment	Each body of water	Grab up-and downstream of wellfields	1 or 2	Annually	U-nat, Ra-226 Pb-210

Should CBR decide in the future to begin land application of treated effluents, the staff recommends that it also should implement vegetation sampling within the land-applied areas so that assumptions in the MILDOS-AREA modeling concerning soil and plant uptake can be verified.

CBR is required, by license condition, to document the sampling and monitoring results, and to maintain such documentation for a period of at least five years. In addition, under 10 CFR 40.65, CBR is required to submit the results of the environmental and effluent monitoring program to NRC on a semiannual basis.

Finally, to ensure that a high quality sampling and analytical program is maintained, CBR is required, and will continue to be required, by license condition, to establish, review, and update standard operating procedures for all environmental monitoring required for the operation. These procedures are required to be reviewed by the CRSO on at least an annual basis, to determine that proper radiation protection principles are being applied.

4.0 GROUNDWATER RESTORATION, RECLAMATION, AND DECOMMISSIONING

4.1 Groundwater Restoration

After ore extraction is complete in a wellfield, groundwater restoration begins in the depleted ore zone, with the intent of reducing the concentration of mobilized constituents remaining in the groundwater. By license condition, the primary goal of restoration is to return the affected groundwater quality, on a MU average, to baseline conditions. This will continue to be so required in the renewal license.

If it is determined that a return to the pre-operational baseline is not reasonably achievable using best practicable technology, the secondary goal is to return the groundwater quality to a use consistent for which the water was suitable prior to the ISL operations, based on the class-of-use standards established by NDEQ.

4.1.1 Establishing Pre-operational Baseline Water Quality

As discussed in Section 3.3.2, CBR will collect baseline groundwater quality data prior to mining in each MU. This data is collected for the purposes of establishing both UCLs (see Section 3.7.1) and restoration standards for the MU. For the purposes of setting restoration standards, the data is required to be collected from the MU at a minimal density of one production or injection well per 1.6 ha (4 acres). As stated previously, the primary goal of restoration is to return the affected groundwater quality, on a MU average, to baseline conditions. Average pre-operational baseline water quality for MUs 1–5 is provided in Table 2-3.

With the issuance of a performance-based license, the SERP will have the responsibility of reviewing the baseline groundwater data and establishing restoration standards for subsequent MUs prior to mining in those MUs. CBR will continued to be required, by license condition, to collect the appropriate data at the required density.

4.1.2 Groundwater Restoration Methodology

A schematic of the groundwater restoration process is shown in Figure 4-1. Based on experience gathered during the R&D project and the on-going restoration of MUs 1 and 2, CBR has outlined in the LRA and in the NRC-approved groundwater restoration plan (CBR, 1996a), four basic methods for groundwater restoration that will be used at the Crow Butte Uranium Project:

a. Groundwater Transfer

In this method, pre-operational groundwater is recovered from an MU starting production and injected into the MU where restoration is commencing in order to dilute the higher TDS groundwater. In return, higher TDS groundwater from the MU in restoration is recovered and injected into the MU that will be starting production. The intent of this direct transfer is to lower the TDS in the MU being restored by displacing water affected by ISL operations with baseline quality water.

b. Groundwater Sweep

In this process, water is pumped without injection from the wellfield, causing an influx of baseline quality groundwater from the perimeter of the MU which sweeps the affected portion of the aquifer. This step is also intended to draw in the plume of affected water at the edges of the MU. This water is not returned to the wellfield, but instead is disposed through the waste water disposal system.

c. Groundwater Treatment

This process consists of extracting water from the ore zone, treating it to improve the water quality and either re-injecting the cleansed water (the permeate) into the ore zone or disposing it in a manner described in Section 3.6.2. IX and reverse osmosis (RO) will be the methods used to treat the water, with IX used to remove uranium. After IX, if the permeate is re-injected, a reductant is added periodically to the permeate to induce, in the ore zone, the precipitation and immobilization of uranium and other trace elements that were dissolved during the extraction process.

A portion of the recovery water can be sent to an RO unit. Prior to treatment by RO, the water is filtered, radium is settled out by treatment with barium chloride (BaCl), and the pH is lowered to prevent calcium carbonate from plugging the RO membranes. The permeate from the RO unit is either re-injected or, like the concentrated brine that is also produced, disposed in a manner described in Section 3.6.2. CBR demonstrated the effectiveness of RO during the R&D phase of operations.

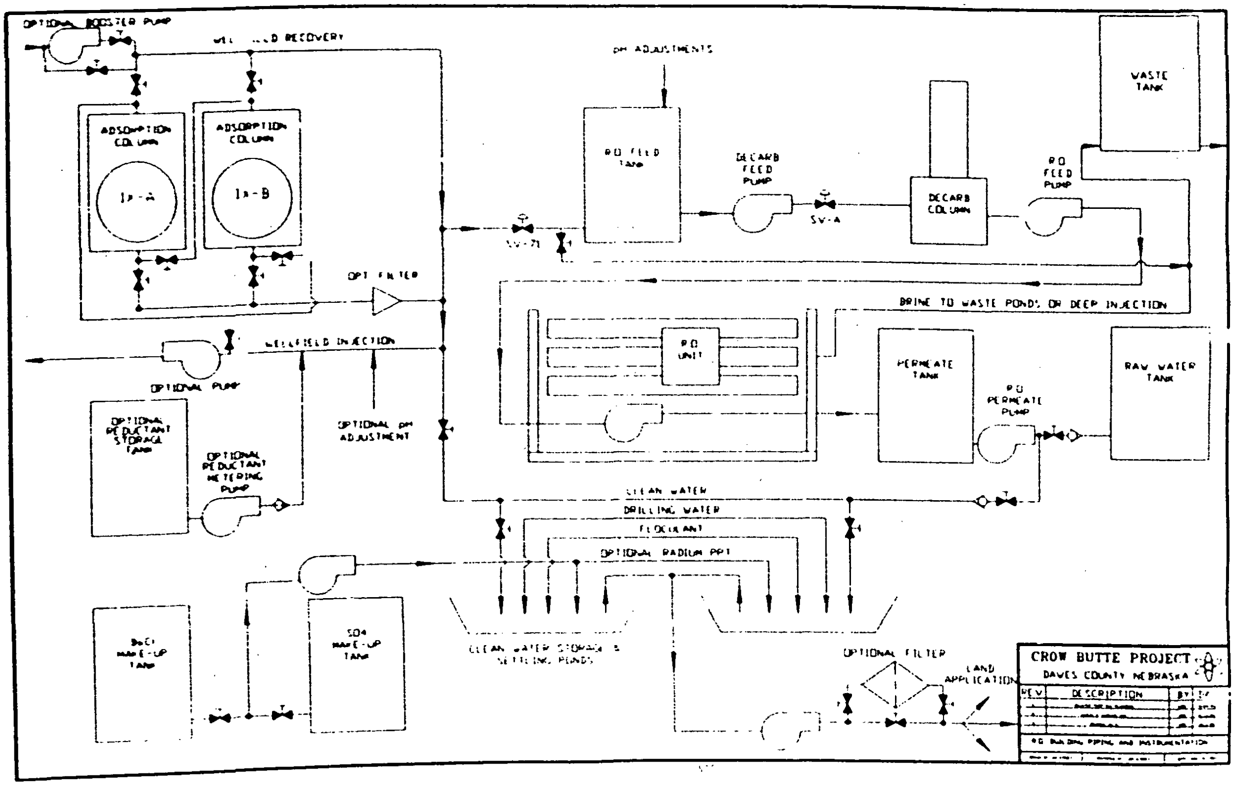


Figure 4-1. Schematic of the groundwater restoration process at the Crow Butte Uranium Project (from CBR, 1995)

d. Wellfield Recirculation

Following completion of all or some of the methods above, the treated groundwater is recirculated through the ore zone, by pumping from production wells and re-injecting the recovered solutions into the injection wells, to homogenize the groundwater.

Upon the completion of restoration in an MU, CBR will implement a groundwater stabilization monitoring program in which the restoration wells and any monitoring wells on excursion status will be sampled and assayed. Samples will be collected at a frequency of one sample per well per month for a period of six months. If all six samples show that restoration values for all wells are maintained during this period, CBR will consider restoration complete and will request of NRC and NDEQ that the MU be declared restored. If water quality is not stabilized, further restoration work may be required.

CBR will continue to be required, by license condition, to perform groundwater restoration in accordance with the currently approved groundwater restoration plan (CBR, 1996a).

4.1.3 Effectiveness of Groundwater Restoration

The typical rejection efficiency of the membranes used in the RO unit are provided in the LRA, with most of the analyzed constituents rejected at a 90 to 99 percent efficiency. The water is circulated through the unit several times to maximize efficiency. Data from the R&D operations indicate that the combination of IX, radium settling with BaCl, and RO reduces the concentration of most metals below detection limits, and common ions to below drinking water standards.

The success of R&D restoration efforts are discussed in detail in the staff's 1989 EA (NRC, 1989a), and are summarized here. The R&D restoration criterion was to return the affected groundwater to a class-of-use standard rather than to the average baseline value as currently required. Table 4-1 shows the groundwater quality data for 30 groundwater parameters monitored during restoration of the R&D wellfields. Of these parameters, 21 were restored to equal or less than their baseline minimum value, but 9 were not (ammonia, manganese, molybdenum, two forms of nitrogen, lead, radium-226, uranium, vanadium, and zinc). However, the staff determined that the overall change in water chemistry was very small, and that the water from the R&D operation was suitable for any pre-operational use. On April 12, 1988, the staff approved the completion of restoration in R&D Wellfield No. 2. The total number of pore volumes (PV) required during the R&D restoration was approximately 19, with approximately 16.4 PV being re-injected.

As part of its annual surety update, CBR provides estimates for the quantity of groundwater to be treated and groundwater restoration costs. CBR currently estimates (CBR, 1997a) that groundwater restoration for the commercial MUs will involve the circulation of a total of only 6 PV. This value differs considerably from the 19 PV used in the R&D restoration, in part because CBR was exploring different treatment techniques during the R&D program and because it has gained additional restoration experience with two of its commercial MUs.

Table 4-1. Baseline water quality and restoration quality for the Crow Butte R&D site (NRC, 1989a). All units in mg/L unless otherwise noted.

Parameter	Baseline Minimum	Baseline Maximum	Baseline Mean	Stabilization Mean
As	<0.001	0.003	0.001	0.001
B	0.87	0.95	0.93	0.84
Ba	<0.1	<0.1	0.1	0.1
Ca	10.4	16.4	14.1	10.5
Cd	<0.001	<0.001	0.001	0.001
Cl	176	301	202.6	169
Cr	<0.005	<0.005	0.005	0.005
Cu	<0.01	<0.01	0.01	0.01
F	0.62	0.74	0.68	0.55
Fe	<0.03	0.05	0.03	0.03
Hg	<0.0002	<0.0002	0.0002	0.0002
K	10.2	15.4	12.0	8.7
Mg	2.45	4.2	3.351	2.41
Mn	<0.005	0.013	0.0065	0.023
Mo	0.02	0.02	0.02	0.04
Na	387	470	404	333
NH_4 as N	0.17	0.40	0.29	0.62
Ni	<0.01	<0.01	0.01	0.01
NO_2 as N	<0.001	<0.001	0.001	0.014
NO_3 as N	<0.01	0.21	0.05	0.03
Pb	<0.005	<0.005	0.005	0.006
pH (standard units)	8.30	8.64	8.39	7.91
Ra-226 (pCi/L)	32.8	1451.0	858.7	236.7
Se	<0.001	<0.001	0.001	0.001
SO_4	316	356	343	275
TDS	1106	1270	1153	972
Total Carbonate	347.6	374.9	362.8	306.1
U	0.053	0.245	0.111	1.316
V	<0.01	<0.01	0.01	0.03
Zn	<0.01	0.02	0.01	0.02

MU-1 was placed into restoration on March 14, 1994. To date, the restoration program has involved (1) groundwater sweep to control mining solutions, (2) groundwater transfer (0.78 PV [51.1 million L (13.5 million gal.)]) from MU-4 into MU-1), (3) groundwater treatment with IX and RO (2.28 PV [148 million L (39.1 million gal.)]); and (4) the addition of sodium sulfate (Na_2S) to the RO permeate as a reductant. As of May 31, 1997, 20 of 39 well patterns in MU-1 have been returned to baseline conductivity. Treatment is anticipated to continue until April 30, 1998, at which point the restoration progress relative to other target parameters will be evaluated (CBR, 1997f).

MU-2 was placed in restoration on January 2, 1996. Restoration to date in MU-2 has involved treatment with IX to lower uranium concentrations. Treatment with RO will begin once restoration of MU-1 has been completed and is expected to take approximately two years (CBR, 1997f).

4.2 Reclamation and Decommissioning

4.2.1 Surface Reclamation

A certain level of reclamation activities will take place at the Crow Butte Uranium Project while new MUs are being developed. Reclamation activities in individual MUs will consist of returning disturbed lands to their pre-mining use.

All injection, production, and monitor wells will be plugged and abandoned prior to final closure of the site and after the groundwater restoration has been successfully completed. CBR uses an approved abandonment mud in well plugging. This mud is mixed in a cement unit and then pumped down a hose, which has been lowered to the bottom of the well casing using a reel.

When the hose is removed, the casing is topped off and a cement plug is placed on top. Then, a hole is dug around the well and, at a minimum, the top meter (3 ft) of casing is removed. Finally, the hole is backfilled and the surface is re-vegetated.

In decommissioning wellfields, CBR first removes surface equipment, such as injection and production feed lines, electrical conduits, well boxes, and wellhead equipment. Some wellhead equipment, such as valves, meters, or control fixtures, is salvaged. All buried wellfield piping is removed. Piping that is not reusable is considered contaminated and is disposed at a licensed byproduct waste material disposal site.

The plant site and solar evaporation pond areas will experience more disturbance than the wellfield areas. The plant and pond areas will be reclaimed in a fashion similar to the wellfield areas after groundwater restoration has been successfully completed. Treatment and disposal of pond water will depend on its chemical and radiological characteristics at the time of decommissioning. Pond sludges and sediments will be removed from the evaporation ponds and loaded into dump trucks or drums for disposal at the licensed byproduct disposal site. The pond liners will then be cleaned to the degree possible. If, after cleaning, they are below the surface contamination limits, the liners will be released to an unrestricted area. If contamination limits are exceeded, pond liners will be cut into strips and transported to the byproduct disposal site. Materials in the leak detection system will be excavated and surveyed for contamination. If the leak detection system is not contaminated, it will be released for unrestricted use; otherwise, it will be disposed at the byproduct disposal site.

Soil may be compacted in some areas from the drilling and maintenance traffic. Well closure will also involve some surface disturbance immediately surrounding each well. The non-vegetated or disturbed areas, including roads, will be either plowed or disced to aerate the soil. Soil from the wellfields and beneath the evaporation ponds will be surveyed for contamination, using an appropriately spaced grid with spot checks around likely areas of contamination. Any soils contaminated in excess of the limits defined in Appendix A to 10 CFR Part 40, will be removed and transported to a licensed byproduct disposal site. Excess soil from the built-up plant base and pond embankments will be returned to the ponds as fill. Following this, land surface contours will be re-established. A final soil background survey will be conducted on areas prepared for surface reclamation on a grid spacing adequate to confirm cleanup to applicable standards.

Following soil contouring and surface reclamation, topsoil will be replaced on all areas disturbed by the processing plant and the evaporation ponds. A grass seed mixture and fertilizer will then be spread. Assistance will be obtained from the U.S. Natural Resources Conservation Service to determine the proper seed mix and rate of application. A period of one to two years will be required to establish a suitable grass cover. During this time, fences will be maintained to keep livestock off the area and away from new vegetation. After that time, disturbed land may be returned to grazing use.

Reusable equipment will be segregated from worn-out or scrap items. Both categories of materials will be cleaned and temporarily stored onsite prior to final disposal. Cleaned refuse may be disposed in sanitary landfills, while contaminated materials will be disposed at a licensed byproduct disposal facility.

4.2.2 Plant Site Decommissioning

After the equipment, building, piping, and associated support facilities have been removed from the wellfield area, a gamma survey will be conducted over the same wellfield grid that was surveyed prior to operation. The gamma survey results will be compared with those determined prior to operations. Soil samples will then be obtained from locations that display elevated gamma readings, and the samples will be analyzed for their natural uranium and Ra-226 content. Based upon the results, contaminated soil will be removed and shipped to a byproduct disposal site. The gamma survey and soil sampling results will be used as a data base to assure that the site is radiologically safe for unrestricted use.

The plant area will be comprised of compacted earth, some surface covering material, a cement foundation, and the building. Once the building and cement pads have been removed, a gamma survey will be made of the compacted area. Any areas with elevated gamma readings will be sampled for radium and natural uranium to determine if contaminated soils must be removed. The compacted area will then be re-contoured, with excess soil placed in the pond pits, and the topsoil replaced. A final gamma survey will be performed and the results compared with the pre-operational survey results.

Reclamation and limited decommissioning will represent interim steps that are necessary prior to the final decommissioning of the site. To assure that final decommissioning is adequate to return the site to unrestricted use, CBR will continued to be required, by license condition, to submit a final detailed decommissioning plan for NRC review and approval at least 12 months prior to the planned final shutdown of mining operations.

5.0 EVALUATION OF ENVIRONMENTAL IMPACTS

5.1 Introduction

In situ leaching of uranium is an established technology. The major human health and environmental concerns associated with this technique of uranium recovery are the impacts of mining on groundwater quality, the impacts from potential evaporation pond leakage, the radiological impacts, and the disposal of wastes.

The ISL activities at the Crow Butte Uranium Project have involved or will involve (1) the temporary change in the land use of a permitted area of about 1130 ha (2800 acres), (2) disturbance of about 200 ha (500 acres), (3) net withdrawal of groundwater of about 95 Lpm (25 gpm) during ore extraction and 300 Lpm (80 gpm) during restoration (CBR, 1995), and (4) the temporary contamination of monitored groundwater aquifers. Facilities required for an ISL operation have already been constructed at the Crow Butte site.

The commercial operation was previously evaluated in an EA (NRC, 1989a) and an SER (NRC, 1989b) prepared by the NRC staff for the issuance of Source Material License SUA-1534 on December 29, 1989. The staff prepared and issued supplemental EAs for specific licensing actions on March 16, 1993; March 14, 1996; July 19, 1996; and June 13, 1997. With the renewal of SUA-1534 under the PBLC format, the licensee's SERP will be required to determine whether proposed changes in the facility, process circuit, or procedures (1) conflict with any license conditions or impair CBR's ability to meet all applicable NRC regulations; (2) degrade the essential safety and environmental commitments in the LRA; or (3) are not consistent with the conclusions of actions analyzed and selected in this EA. If any of these determinations are answered in the affirmative, then CBR will be required to request an amendment to SUA-1534 for the proposed change.

As discussed in Section 3.7.3, the licensee monitors all effluent streams and the various environmental pathways that could be affected (e.g., air, surface water, and groundwater). The results of this monitoring is submitted to NRC on a semiannual basis, in accordance with 10 CFR 40.65, along with injection rates, recovery rates, and injection manifold pressures. These conditions will continue to be required in the renewal license.

5.2 Air Quality Impacts

5.2.1 Construction-Related

Construction and development of the continued operations associated with this project could affect air quality by the release of diesel emissions from drilling and construction equipment and by releases of dust. Diesel emissions should be minor and of short duration, and will be readily dispersed in the atmosphere. Fugitive dust generated from construction and drilling activity, as well as vehicle traffic on unpaved roads, tends to be localized and of short duration.

5.2.2 Operations-Related

The main non-radiologic gaseous effluents that will be released from the operation of processing equipment in the uranium recovery plant include gases such as CO_2 and hydrogen chloride. These gases will be vented directly to the atmosphere where they will be readily dispersed. Impacts associated with the release of radioactive radon-222 are discussed in Section 5.7.

5.3 Land Use Impacts

The primary impact on land use is the fencing of the restricted areas within the permit area boundary to exclude livestock from approximately 61 ha (150 acres) until the completion of restoration and reclamation. CBR estimates in the LRA a loss of between 3.9 and 11.7 animal unit months (AUM) per year based on the then current (December 1995) stocking rates used in the area. These effects will be limited, temporary, and reversible through returning the land to its former grazing use following completion of post-mining surface reclamation. Wildlife is prevented from entering the evaporation pond area by a 2 m (6 ft) high fence.

5.4 Water Impacts

5.4.1 Surface Water Impacts

Potential impacts to surface water can result from lixiviant spills or waste water leaks reaching surface streams such as Squaw Creek and English Creek, or one of the eight surface impoundments that exist within or near the commercial restricted area boundaries.

Quarterly monitoring results during commercial operations (i.e., between 1990 and 1997) show that radionuclide concentrations have remained at or below pre-operational background levels. There have been a couple of events during this time period, however, which could have impacted surface waters in the vicinity of the project.

On March 25–26, 1991, a wellhead failure resulted in a spill of about 26,500 L (7000 gal.) of groundwater from the Basal Chadron aquifer. The licensee notified NRC and initiated a soil survey to determine the extent of contamination. One sample exceeded background for Ra-226 by more than 5 pCi/g. The licensee cleaned up the area around this sample by removing the contaminated soil and disposing of it in the facility's waste water evaporation pond. Confirmatory sampling was conducted to ensure compliance with Criterion 6(6) of 10 CFR Part 40, Appendix A.

On January 11, 1993, an injection trunkline in MU-3 leaked at a pipe joint at the site of a wellfield house that was under construction. Computer monitoring alarms indicated low flow, the plant was shut down about 20 minutes after the first alarm, and the cause of the alarm was investigated. The leaking section was isolated by an inline valve on the main trunkline, and the field was restarted about thirty minutes later. Approximately 87,000 L (23,000 gal.) of injection water spilled onto the ground, and an unknown amount flowed down a small drainage into Squaw Creek. The creek was frozen at the time, and the spill traveled approximately 0.4 km (0.25 mi) downstream. The licensee responded to the spill by collecting frozen lixiviant from the ground and disposing it in the waste water evaporation pond. Preliminary Ra-226 analysis of the spill indicated concentrations of about 0.2 pCi/L. The licensee notified NRC by telephone within 48 hours, and NRC performed a reactive inspection on January 14, 1993. As a result of this inspection, NRC issued two Severity Level IV violations to CBR for the pipeline failure and for the lack of an SOP addressing construction, testing, operation, or maintenance of pipelines used to transport injection fluids. The licensee responded to the inspection and violations by implementing a soil sampling program to characterize the potential radiological impact of the spill, constructing an earthen berm to protect Squaw Creek, and developing an impact analysis and incident response plan for wellfield releases to address construction, testing, operation, or maintenance of buried pipelines.

5.4.2 Groundwater Impacts

The native formation waters in the ore zones in the Basal Chadron aquifer are not recommended for human consumption because of naturally high levels of dissolved radioactive materials (uranium and Ra-226). In addition to uranium, other metals will also be mobilized by the mining process. As discussed in Section 4.1.2, groundwater restoration includes groundwater transfer, groundwater sweep, permeate reductant/injection, and aquifer recirculation. In 1988, the staff determined that the R&D operation was successful in restoring the groundwater quality to the pre-mining class-of-use goal set for that restoration program. As yet, CBR has not completed restoration of a commercial MU; however, based on the R&D demonstration and restoration efforts at *in situ* operations in other parts of the country, no long-term impacts on the aquifer are expected.

During operations, the potential exists for small portions of the surrounding groundwater occasionally to be affected by excursions. However, excursion monitoring and control will be implemented at all MUs. The degree of excursion monitoring and corrective action being implemented is sufficient that such occurrences will result in minimal environmental impacts.

CBR has conducted quarterly sampling of water supply wells near the facility. Radionuclide concentrations in these samples have remained at or below pre-operational background levels during commercial operations.

An additional concern with groundwater is the extent of drawdown in water supply wells near the project. CBR estimates (CBR, 1995) that the projected maximum drawdown, at a production rate of 18,930 Lpm (5000 gpm), ranges from approximately 6.7 m to 8.3 m (22 to 27 ft). In most cases, this is less than a 10 percent reduction of the available drawdown and in all cases less than 17 percent. The impact is limited because groundwater from the Chadron aquifer is not generally used and is not recommended for human consumption. Water levels are expected to recover after ISL operations are ended.

5.4.2.1 History of Excursions

While it is common to dramatically degrade the water quality within the mineralized zone during uranium recovery activities, migration of lixiviant-fortified groundwater beyond the expected confines (horizontal or vertical) of a wellfield may occur and be detected in a monitor well. These "excursions" may occur due to a variety of circumstances. Most excursions result from an improper balance between injection and recovery rates, undetected high permeability strata or geologic faults, improperly abandoned exploration drill holes, discontinuity and unsuitability of the confining units that allow movement of the lixiviant out of the ore zone, poor well integrity, or hydrofracturing of the ore zone or surrounding units. The potential for horizontal excursions will be primarily controlled through wellfield bleed (i.e., minor wellfield overproduction). Should overproduction fail, lixiviant-fortified groundwater could move to a monitor well. If such an event takes place, the excursion is reversed typically by increasing the overproduction rate, and thereby drawing the lixiviant back into the extraction zone.

During the commercial operation of the Crow Butte Uranium Project, no horizontal excursions have been reported. However, three vertical excursions have reported since 1989. During 1995, three MU-4 shallow monitoring wells in the overlying Brule formation were placed on excursion status, when UCL limits were exceeded for one or more excursion indicator parameters (chloride, sodium, sulfate, conductivity, and total alkalinity). In one case, it was determined that UCL exceedance was likely related to borehole cement contamination. CBR determined that the other two excursions were due to slight fluctuations in baseline groundwater quality, and so, after indicator parameters concentrations stabilized and re-established themselves, UCLs for the two wells were reset at slightly higher concentrations than before the excursions.

In addition to these three excursions, CBR has reported two other events in accordance with the reporting requirements for excursions. The first was reported in March 1996, after a routine five-year mechanical integrity test discovered the failure of a casing couple on an injection well in MU-2, at a depth of 12 m (40 ft), and an area of approximately 2320 square meters (25,000 square ft) was delineated with conductivity levels four to five times baseline. For this event, CBR is continuing groundwater remediation efforts. The second event occurred in November 1996, when a small leak was discovered in a plugged and abandoned injection well in MU-5, and minor amounts of mining solutions were determined to have leaked into a shallow aquifer approximately 30.5 m (100 ft) below the ground surface. After delineating the extent of the contamination, CBR commenced pumping to recover the leaked solution, and on April 28, 1997, CBR submitted sampling data collected from the injection well, which indicated that concentrations of the excursion indicator parameters were consistent with those observed in the shallow monitor wells located nearby.

In addressing excursions, CBR corrective actions have included:

- Notifying NRC as required by license condition;
- Discontinuing injection of ISL solutions into nearby injection wells;
- Drilling additional wells to delineate the extent of the excursion;
- Reviewing all well completion records and mechanical integrity test results for the wells surrounding the excursion well, reviewing of historic water levels, and increasing the sampling frequency; and
- Implementing groundwater remediation efforts, as needed.

The history of excursions at the Crow Butte Uranium Project is summarized in Table 5-1.

Table 5-1. History of wells that have exceeded UCL limits for one or more excursion parameters at the Crow Butte Uranium Project

Well	Mine Unit	Zone	Date Placed on Excursion	Parameters Exceeded	Current Status
SM 4-5	4	Overlying Brule Fm	1/25/95	Sulfate	Off excursion (5/5/95); No remediation necessary
SM 4-2	4	Overlying Brule Fm	4/13/95	Sodium, Alkalinity	Off excursion (2/20/97); No remediation necessary
SM 4-7	4	Overlying Brule Fm	12/29/95	Chloride	Off excursion (2/20/97); No remediation necessary
1196-5	2	Overlying Brule Fm	3/29/96	Conductivity, etc.	In remediation
1752-14	5	Overlying Brule Fm	11/8/96	Conductivity, etc.	Off excursion (10/97); Remediation completed

5.4.2.2 Evaporation Pond Spills and Seepage

Spills from the evaporation ponds resulting from dike failure could result in unacceptable contamination of surface waters and groundwater. However, the likelihood of dike failure is considered to be minimal, because the evaporation pond embankments have been designed in accordance with NRC staff recommendations in Regulatory Guide 3.11 (NRC, 1977). To ensure that the design specifications will not be exceeded, CBR will continue to be required by license condition to maintain minimum acceptable freeboard limits for each pond, as discussed in Section 3.6.2.1.

In addition, as discussed previously in Section 3.7.2, the licensee currently is required by license condition to conduct regular inspections of its evaporation ponds in accordance with the approved Evaporation Pond Onsite Inspection Program. Finally, the evaporation ponds are also inspected periodically by NRC or its contractors to ensure compliance with Federal guidelines for dam safety.

Accidental leaks from the evaporation ponds, if uncontrolled, potentially could contaminate shallow aquifers and locally degrade groundwater quality. Several minor leaks have been identified through monitoring of the leak detection system, as part of the environmental monitoring program. All reported leaks have involved only the upper, or primary, liner in a double-lined system; at no time have impounded solutions leaked into the ground beneath the ponds. These leaks are summarized in Table 5-2.

Table 5-2. History of evaporation pond leaks at the Crow Butte Uranium Project				
Pond	Date of Leak	Liner	Volume	Corrective Actions
Commercial 4	5/8/91	Upper	Not reported	Pond drained to expose holes in liner. Holes patched. Pond water pumped from underdrain system.
Commercial 4	1/15/92	Upper	1135 L (300 gals.)	Pond level lowered below leak location. Holes patched. Pond water pumped from underdrain system.
Commercial 3	3/13/92	Upper	757 L (200 gals.)	Same as above.
Commercial 4	1/4/93	Upper	Not reported	Same as above.
Commercial 4	2/22/93	Upper	Not reported	Same as above.
Commercial 4	5/19/93	Upper	Not reported	Same as above.
Commercial 1	8/13/97	Upper	257 L (68 gals.)	Same as above.

As previously discussed in Section 3.7.2, CBR will continue to be required, by license condition, to notify NRC in the event of an evaporation pond leak and to implement corrective actions to mitigate the potential consequences of the leak. In the past, corrective actions have included: (1) lowering the pond level in the leaking pond through liquid transfer to other ponds, (2) identifying and patching holes or tears in the liner, and (3) analyzing the water quality in the pond leak detection system for all leak indicators once a week during the leak period and once a week for the two weeks following repairs.

5.5 Impacts on Soils

Activities at the Crow Butte Uranium Project result in relatively minimal disturbance of soils. Soil horizons will be disrupted for the burial of pipelines and the construction of wellfield houses and plant facilities. In the wellfield, soil disturbance is limited to drilling and construction of access roads. The total area affected by facility operations is small relative to the size of the permit area, and disturbed areas will be remediated as part of site decommissioning (Section 4.2.1). Irrigation areas, if used, and spills will be monitored and controlled to maintain levels of radioactive and toxic constituents within allowable release standards.

If necessary, CBR will use its environmental monitoring program to identify impacts on soil resulting from land application. These efforts will include water analysis prior to release for land application to assure compliance with release limits. Soil sampling would be used to establish background for uranium, radium, and other metals (barium, boron, molybdenum, and vanadium). Soil sampling for Ra-226 would be conducted following each irrigation season. Groundwater sampling includes three monitoring wells in the Brule Formation near both irrigation areas, and surface water sampling includes impoundments and stream sampling near the irrigation areas.

CBR is required currently to maintain a log of all significant solution spills and to notify NRC of any such spills that may have a radiological impact on the environment. During 1996, the licensee logged 27 spill incidents, which ranged in volume from 45 to 65,500 L (12 to 17,305 gal.) of fluid unrecovered. Of these, only one was determined to be reportable to NRC. To remove any confusion as to what may constitute a "significant" spill, with this renewal, NRC will modify this license condition to require that CBR maintain documentation of all spills involving source or byproduct materials or process chemicals. CBR still will be required to notify NRC of any spills that may have a radiological impact on the environment. The required spill documentation will include the date and volume of the spill, radiological survey results, corrective actions taken, and maps showing the spill location and any impacted areas. The purpose of this documentation is to aid in the final site decommissioning activities. CBR agreed to this modified condition, by telephone, on February 3, 1998.

CBR also is responsible for radium cleanup of soils during final site decontamination and decommissioning. CBR will meet NRC criteria for release to unrestricted use such that radium soil concentrations, averaged over an area of 100 m^2 (1075 ft^2) does not exceed background levels by more than (1) 5 pCi/g of Ra-226 averaged over the first 15 cm (6 in.) below the surface, and (2) 15 pCi/g of Ra-226 averaged over 15-cm (6-in.) thick layers more than 15 cm (6 in.) below the surface. In approving CBR's land application plan (Amendment 21 to SUA-1534; November 16, 1993), conservative NRC calculations indicated that, after 20 years of restoration and land application, Ra-226 concentrations in the top 15 cm (6 in.) would be less than 0.3 pCi/g.

5.6 Impacts on Ecological Systems

The principal effect on the ecology will be disturbance of the soil as a result of drilling activities and construction of wellfield houses, plant facilities, access roads, and pipelines. These disturbances will be confined for the most part to the uranium recovery facility and the wellfields, and will consist of cleared land parcels surrounded by undisturbed land. Reclamation and reseeding of the property will occur after cessation of ore extraction (see Section 4.2.1) or sooner when possible, as in the case of buried pipelines. Alteration of fewer than about 200 ha (500 acres) is not considered to constitute a significant adverse impact.

5.6.1 Endangered Species

The black-footed ferret (*Mustela nigripes*) is the only Federally-listed threatened or endangered mammal that may occur in the region; however, the last black-footed ferret sighting in the region occurred in 1959. The ferret's principal prey, the prairie dog, is not common in the site environs, and therefore, black-footed ferrets are not expected in the area.

Whooping cranes (*Grus americana*), bald eagles (*Haliaeetus leucocephalus*), and peregrine falcons (*Falco peregrinus anatum*) are Federally-listed threatened or endangered bird species that may occur in the region. Whooping cranes migrate through Nebraska between March and May and again from October to December each year, using shallow, sparsely-vegetated streams and wetlands for roosting and feeding. These birds were not observed in the site area during a 1982 survey, although sightings have been confirmed on wetlands near Whitney, Nebraska, approximately 12 miles northeast of the site (CBR, 1995).

Bald eagles were observed during the 1982 survey, and they are sparsely scattered across Dawes County, Nebraska during migration (November 1 to April 1). However, these birds do not nest in the survey area, and neither critical habitat nor regular roosting sites can be found in the site area. Peregrine falcons, on the other hand, generally are associated with wetland and open areas, such as grassland and cropland. These birds were not observed during the 1982 survey.

Finally, CBR has stated that no identified Federally-listed endangered plant or amphibian/reptile species occur on the Crow Butte Uranium Project (CBR, 1995).

The staff considers it unlikely that there will be significant impacts to raptors (including bald eagles and peregrine falcons), because there will be little to no reduction in suitable prey and minimal destruction (if any) of potential nesting sites. Impacts to whooping cranes are not expected, because there will be no reduction of critical habitat for these birds as a result of operations at the Crow Butte Uranium Project. The U.S. Fish and Wildlife Service indicated its agreement with the staff's conclusion, by letter dated January 5, 1998 (see Appendix A).

5.6.2 Aquatic Biota

Squaw Creek and English Creek run through the permit area, and there are eight impoundments in or near the permit area. With the exception of the spill described in Section 5.4.1, aquatic resources have not been impacted by commercial operations. Following the January 11, 1993, spill, CBR constructed berms and containment dams to prevent further spills into Squaw Creek, and implemented an incident response plan to reduce the chance of another release to the aquatic system.

In addition, CBR is conducting, and will continue to conduct, regular monitoring of surface waters flowing through the project, as part of its environmental monitoring program.

5.7 Radiological Impacts

5.7.1 Introduction

The primary source of radiological impact to the environment from site operations is radon-222 released from the processing plant and the wellfields. This section describes project-contributed incremental radiological effects on the environment in the vicinity of the project. Among the items discussed are: (1) exposure pathways, (2) impacts to nearby individuals, and (3) impacts to biota other than man.

Because the operations at the CBR facility do not involve conventional blasting and removal of ore from the orebody, there will be no radionuclide particulate emissions associated with such activities, nor from the grinding of ore, as is done at a conventional uranium mill. In addition, CBR employs a vacuum dryer for final yellowcake processing, with dust and gas generated from drying collected in a liquid condenser. As a result, no particulates will be released to the environment.

5.7.2 Offsite Impacts

Radioactive emissions of radon-222 are vented to the atmosphere from injection wells, and through a manifold system connected to IX columns and production surge tanks. Processing plant emissions are released to the atmosphere through an exhaust stack. Releases of Ra-222 may result in three exposure pathways: inhalation, ingestion, and external exposure.

In approving CBR's request to increase its processing flowrate from 13,250 Lpm (3500 gpm) to 18,930 Lpm (5000 gpm) (Amendment 34 to SUA-1534; March 14, 1996), the staff reviewed MILDOS-Area calculations submitted by CBR. Based on its review, the staff determined that the modeling satisfactorily showed that the potential radiological impacts to offsite individuals would remain well below the 1 millisievert per year (mSv/yr) (100 millirem per year [mrem/yr]) public dose limit of 10 CFR 20.1301. The largest dose estimate was 0.203 mSv/yr (20.3 mrem/yr) for an individual located approximately 1.0 km (0.62 mi) from the processing plant exhaust stack.

To ensure that offsite concentrations will be maintained below permissible limits, the licensee will continue to be required to monitor radon concentrations at and near the site boundary. Results of this monitoring is submitted to NRC on a semiannual basis, in accordance with 10 CFR 40.65.

5.7.3 Radiological Impact on Biota Other Than Humans

Although no guidelines concerning acceptable limits of radiation exposure have been established for the protection of species other than humans, it is generally agreed that the limits for humans are conservative for other species. Doses from gaseous effluents to terrestrial biota such as birds and mammals will be similar to those calculated for humans and use the same exposure pathways. Because the effluents of the facility will be monitored to protect human health and safety, no adverse radiological impact is expected for resident animals. Fencing prevents most large domestic and wild animals from entering the evaporation ponds and the plant facilities. It is possible that migratory birds may land on the ponds, but the visits should be infrequent.

The licensee is required to conduct an environmental monitoring program that evaluates the concentration of radionuclides in the environment that could lead to offsite exposures. The staff considers that CBR's environmental monitoring program has proven sufficient to evaluate the radiological impacts of the operations at the Crow Butte Uranium Project.

5.8 <u>In-Plant Safety</u>

The NRC, through 10 CFR Part 20 and license conditions, requires a radiological safety program that contains the basic elements needed to assure that exposures are kept low or, in any event, as low as is reasonably achievable (ALARA). Therefore, an in-plant radiation safety program which includes the following is required:

- Qualified management of the radiation safety program and appropriate training of personnel,
- Written radiation procedures,
- Airborne and surface contamination sampling and monitoring,
- Internal and external radiation monitoring programs,
- An approved respiratory protection program, and
- An annual ALARA audit and frequent in-house inspections.

In addition, during routine radiation safety inspections, the NRC staff observes in-plant industrial safety for deficiencies and brings any deficiencies found to the attention of facility management.

The NRC considers the program of in-plant safety, as required by Federal regulations, and the radiation safety program, as defined by 10 CFR Part 20, to be sufficient to protect the worker during normal operations. The NRC evaluation of the licensee's radiation safety program is discussed more fully in the SER.

5.9 Waste Disposal Impacts

Under NRC regulations (10 CFR Part 40, Appendix A, Criterion 2), to avoid the proliferation of waste disposal sites, byproduct material from uranium ISL operations must be disposed at existing uranium mill tailings disposal sites, unless such offsite disposal is shown to be impracticable or the benefits of onsite disposal clearly outweigh those of reducing the number of waste disposal sites. Therefore, NRC will continue to require, by license condition, that waste byproduct materials generated by project operations be disposed at a licensed byproduct waste disposal site. CBR's current arrangement for doing so and additional NRC requirements are discussed in Section 3.6.3.

To ensure that CBR retains control of all contaminated wastes while they are onsite, the licensee will continue to be required, by license condition, to maintain an area within the restricted area boundary for the storage of contaminated materials prior to their disposal. CBR will survey all equipment, buildings, and other items for radioactive contamination, prior to their release from the site for unrestricted use. CBR will continue to be required to dispose of all contaminated wastes and evaporation pond residues at a licensed radioactive waste disposal site. Finally, transportation of all material to the byproduct disposal facility will be handled in accordance with U.S. Department of Transportation and NRC regulations (49 CFR 173.389 and 10 CFR Part 71, respectively).

6.0 ENVIRONMENTAL EFFECTS OF ACCIDENTS

6.1 Potential Failure of Chemical Storage Tanks

Process fluids will be contained in vessels and piping circuits within the recovery plant or within outside storage tanks placed on concrete berms. Tanks are typically constructed of fiberglass or steel. Tank accidents may involve complete rupture of one of the tanks or the development of small leaks. The plant building structure and a concrete curb are designed to limit and contain any liquid spills that occur within the building and direct the spill to a floor sump. The environmental consequences of such a leak are considered to be minor, since all fluids from the floor sump will be pumped back into the process circuit or to the waste disposal system. The licensee has SOPs in place for managing spills should they occur. The contingency plans for the plant also include alarms and automatic shutdown actions for critical parameters and equipment to further reduce the likely impact of a potential tank failure.

6.2 Potential Pipeline Failures

The rupture of a pipeline between the main recovery plant and an MU or within a wellfield can result in a loss of either barren or pregnant lixiviant and the contamination of the ground in the area of the break. CBR buries all piping from the plant, as well as that to and within the wellfields, to avoid freezing. All pipeline welds are tested at operating pressures prior to burial and the start of production flow (CBR, 1995). Each wellfield has a number of wellfield houses where injection and recovery lines are monitored continuously. Individual lines have high and low flow alarms, and all set points and alarms are monitored by computer in the control room. In addition, each wellfield house has an alarm system to detect spills within the house. In this way, small, occasional leaks at joints and fittings for pipes in the wellfield houses can be detected and repaired as needed.

The trunkline leak in MU-3 on January 11, 1993 (discussed in Section 5.4.1) resulted in low flow alarms and a shutdown of the wellfield to isolate the leak. As a result of the 1993 leak and the subsequent analysis of its causes, CBR developed and implemented an impact analysis and incident response plan for wellfield releases addressing construction, testing, operation, and maintenance of buried pipelines.

6.3 Potential Failure of Evaporation Pond Liner or Berms

Leaks in the evaporation ponds can be detected either by the regular visual inspections or by the leak detection system installed in each pond. As described in Section 5.4.2.2, CBR has taken, and will continue to be required to take, appropriate corrective actions in the event of leaks.

Although catastrophic failure of the berms is considered unlikely, due to their design and pond freeboard requirements, CBR has contingency plans in place in the event of such an occurrence.

6.4 Potential Failure of Injection or Production Well Casing

A casing failure would be most significant in injection wells where the solution is injected under pressure. Depending on where the casing leak is located, a failure potentially could be undetected for several days. Failure of a production well is likely to cause a less significant excursion due to the lower operating pressures involved. To minimize the likelihood of such leaks, CBR pressure-tests wells for integrity following initial completion, after testing and certain types of maintenance, and at least once every five years during a well's operational lifetime. With the casing cementing and integrity testing procedures implemented at the Crow Butte Uranium Project, the probability of casing failure should be low.

6.5 Potential for Hydraulic Fracturing

If the injection pressures should exceed the fracturing pressure of the confining formation, fractures could be induced that result in excursions into the overlying aquifers. Such an event is unlikely, because the wellfields are operated at pressures well below the formation fracturing pressure.

6.6 Potential Impacts from Transportation Accidents

Transportation of materials to and from the Crow Butte site includes: (1) the shipment of process chemicals and fuel to the site, (2) the shipment of packaged yellowcake offsite, and (3) the shipment of contaminated wastes from the site to a licensed disposal facility.

The Crow Butte Uranium Project receives approximately 272 bulk chemical deliveries per year (CBR, 1995). Based on published accident statistics, the likelihood of a truck shipment involving chemicals or yellowcake shipment being involved in an accident of any type in the area of the facility, during a one-year period, is approximately one percent. CBR has an emergency response plan in place to deal with transportation accidents.

Dried yellowcake is generally packaged in 208 L (55 gal.) 18 gauge drums holding an average of about 364 kg (800 pounds). A typical shipment, made three to four times per month, consists of about 55 drums. CBR transports the yellowcake in accordance with appropriate U.S. Department of Transportation and NRC regulations for Type A packaging (49 CFR Parts 171–189 and 10 CFR Part 71). All vehicles and shipments will be surveyed for contamination prior to leaving the site. A shipping packet is provided with copies of all documents related to the shipment, including an exclusive use statement, bills of lading, Form 741, contamination survey results, emergency telephone numbers, emergency procedures, a list of materials in the spill control kit, and the driver responsibility statement.

In the LRA, CBR provides the results of an analysis of a hypothetical yellowcake shipment accident, estimating that the 50-year dose commitment to the lungs in the general population was less than one percent of the 50-year integrated dose from natural background.

Transportation of contaminated material to a license byproduct disposal facility occurs as needed. Because the number of trips is much less than that for other types of shipments, and because of the low levels of radiation typically involved with these materials, the impact from transportation accidents involving these shipments is considered to be low. Emergency procedures will be the same as for the yellowcake and chemical shipments.

7.0 ALTERNATIVES

The action under consideration is the renewal of Source Material License SUA-1534, for continued commercial operation of the Crow Butte Uranium Project, as requested by CBR. The alternatives available to NRC are to:

(1) Renew the license with such conditions as are considered necessary or appropriate to protect public health and safety and the environment;

(2) Renew the license, with such conditions as are considered necessary or appropriate to protect public health and safety and the environment, but not allow CBR to expand its operations beyond those previously approved; or

(3) Deny renewal of the license.

Based on its review of the information identified in Section 1.3.2, the NRC staff has concluded that the environmental impacts associated with the proposed action do not warrant either the limiting of CBR's future operations or the denial of the license renewal. Additionally, in the SER prepared for this action, the staff has reviewed the licensee's proposed action with respect to the criteria for license issuance specified in 10 CFR Part 40, Section 40.32, and has no basis for denial of the proposed action. Therefore, the staff considers that Alternative 1 is the appropriate alternative for selection.

8.0 FINANCIAL SURETY

Under 10 CFR Part 40, Appendix A, Criterion 9, NRC licensees are required to establish a financial surety arrangement adequate to cover the estimated costs, if accomplished by a third party, for completion of the NRC-approved site closure plan including: decommissioning and decontamination of the facility, the cost of offsite disposal of radioactive solid process or evaporation pond residues, soil and water analyses, and groundwater restoration as warranted. For ISL facilities, these costs include decommissioning and decontaminating aboveground facilities, disposing of radioactive process solids or evaporation pond residues, and restoring groundwater in the mined areas to restoration targets. The surety is based on an estimate which must account for the total costs that would be incurred if an independent contractor were contracted to perform the work. The surety estimate must be approved by NRC and based on an NRC-approved decommissioning and reclamation plan. The licensee also must provide the surety arrangement through a financial instrument acceptable to NRC. The licensee's surety mechanism will be reviewed annually by NRC to ensure that sufficient funds are available to complete reclamation. Additionally, the amount of the surety should be adjusted to recognize any increases or decreases in liability resulting from inflation changes, engineering plan changes, or other conditions affecting costs.

CBR has maintained an acceptable surety mechanism throughout the course of commercial operations at the Crow Butte Uranium Project. The current surety level to cover aboveground decommissioning and decontamination, offsite disposal of radioactive solid process wastes or evaporation pond residues, and groundwater restoration is $8,950,827, held as an Irrevocable Standby Letter of Credit issued by Colorado National Bank, in favor of the State of Nebraska. This surety amount was reviewed and approved by NRC on January 7, 1998. CBR will continue to be required, by license condition, to maintain a financial surety arrangement in accordance with the requirements of 10 CFR Part 40, Appendix A, Criterion 9. The surety requirements will continue to be reviewed at least annually by NRC to ensure that the funds and surety arrangements are acceptable.

9.0 CONSULTATIONS WITH OTHER FEDERAL AGENCIES AND THE STATE OF NEBRASKA

On October 21, 1997, a draft copy of this EA was sent to the NDEQ for review and comment. By telephone on October 28, 1997, a representative of the NDEQ provided editorial and clarification comments to the staff. In response, the staff made minor revisions to Sections 3.3.3, 5.4.2.1, and 6.0.

By letter dated December 8, 1997, the staff requested comments from the U.S. Fish and Wildlife Service (USFWS) on the effects that the continued operations at the Crow Butte site may have on endangered or threatened species. With this letter, the staff stated its belief that it had no reason to expect that any such plant or animal species would be affected adversely on or near the site. In response, by letter dated January 5, 1998 (see Appendix), the USFWS concurred with the staff's conclusion.

The staff also consulted with the State Historic Preservation Officer (SHPO) for the State of Nebraska, in accordance with the provisions of the National Historic Preservation Act of 1966, as amended. This consultation culminated in a telephone conference call between the staff, the Deputy SHPO, a State archaeologist, the licensee, and two consultants to the licensee; the results of this call are documented in a December 31, 1997, letter from the staff to the SHPO (see Appendix A). In that conference call, the Deputy SHPO stated that CBR's continued policy of avoidance for the six potentially eligible sites identified in a 1987 survey (Section 2.7) remained acceptable. The Deputy SHPO did recommend that an additional survey be conducted to identify traditional cultural properties in the region including and surrounding the Crow Butte site. The staff committed to including a condition in the renewed SUA-1534 to require CBR to conduct a cultural resources survey prior to engaging in any construction activity not previously assessed by NRC (Section 2.7). By letter dated January 30, 1998, the Deputy SHPO indicated his agreement with the staff's summary of the consultation to date, but indicated that additional consultation may be necessary depending on the outcome of the traditional cultural properties survey (see Appendix A). The staff recognizes this possibility.

10.0 FINDING OF NO SIGNIFICANT IMPACT

CBR has applied to NRC to renew Source Material License SUA-1534 and authorize continued commercial uranium production at the Crow Butte Uranium Project in Dawes County, Nebraska. NRC has re-examined actual and potential environmental impacts associated with the project and has determined that the renewal of the source material license will (1) be consistent with the applicable requirements of 10 CFR Part 40, (2) not be inimical to public health and safety, and (3) not have long-term detrimental effects on the environment.

Therefore, based on an evaluation of CBR's renewal request, the NRC staff has determined that the proper action is to issue a final Finding of No Significant Impact in the *Federal Register*. The following statements support the FONSI and summarize the conclusions resulting from the staff's environmental assessment:

A. The proposed groundwater monitoring program is sufficient to detect excursions (vertical or horizontal) of mining solutions. Furthermore, aquifer testing and the previous history of operations indicate that the production zone is adequately confined, thereby assuring hydrologic control of mining solutions;

B. Liquid process wastes will be disposed in accordance with approved waste disposal options. Monitoring programs are in place to ensure appropriate operation of the deep disposal well and to detect potential leakage from the solar evaporation ponds;

C. An acceptable environmental and effluent monitoring program is in place to monitor effluent releases and to detect if applicable regulatory limits are exceeded. Radiological effluents from facility operations have been and are expected to continue to remain below the regulatory limits;

D. All radioactive wastes generated by facility operations will be disposed offsite at a licensed byproduct waste disposal site;

E. Groundwater impacted by mining operations will be restored to baseline conditions on a mine unit average, as a primary goal. If baseline conditions cannot be reasonably achieved, the R&D operations have demonstrated that the groundwater can be restored to applicable class-of-use standards; and

F. Because the staff has determined that there will be no significant impacts associated with approval of the license renewal, there can be no disproportionally high and adverse effects or impacts on minority and low-income populations. Consequently, further evaluation of Environmental Justice concerns, as outlined in Executive Order 12898 and NRC's Office of Nuclear Material Safety and Safeguards Policy and Procedures Letter 1-50, Revision 1, is not warranted.

Based on these findings, the NRC staff recommends that CBR's source material license be renewed for the continued commercial scale operation of the Crow Butte Uranium Project. The source material license shall be based upon the licensee's LRA, this EA, the SER, and the license conditions that address environmental issues (see Section 11). License conditions addressing radiation safety concerns can be found in the SER.

11.0 CONCLUSIONS INCLUDING ENVIRONMENTAL LICENSE CONDITIONS

Upon completion of the environmental review of CBR's application for the renewal of Source Material License SUA-1534, the staff has concluded that the continued commercial operation of the Crow Butte Uranium Project, in accordance with the following conditions to be included in the renewed SUA-1534, is protective of public health and safety and the environment, and fulfills the requirements of 10 CFR Part 51. Therefore, the staff recommends renewal of SUA-1534, subject, in part, to the following conditions:

1. A. The licensee may, without prior NRC approval, and subject to the conditions specified in Part B of this condition:

   (i) Make changes in the facility or process, as presented in the application.

   (ii) Make changes in the procedures presented in the application.

   (iii) Conduct tests or experiments not presented in the application.

   B. The licensee shall file an application for an amendment to the license, unless the following conditions are satisfied:

   (i) The change, test, or experiment does not conflict with any requirement specifically stated in this license (excluding information referenced in the approved license application), or impair the licensee's ability to meet all applicable NRC regulations.

   (ii) There is no degradation in the essential safety or environmental commitments in the license application, or provided by the approved reclamation plan.

   (iii) The change, test, or experiment is consistent with the conclusions of actions analyzed and selected in this EA.

   C. The licensee's determinations concerning Part B of this condition shall be made by a "Safety and Environmental Review Panel" (SERP). The SERP shall consist of a minimum of three individuals employed by the licensee, and one of these shall be designated as the SERP chairman. One member of the SERP shall have expertise in management and shall be responsible for approval of managerial and financial 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 CRSO or equivalent, with the responsibility for 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 health physics, groundwater hydrology, 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.

D. 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 that changes are in compliance with the requirements referred to in Part B of this condition. The licensee shall furnish, in an annual report to 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 NRC change pages to the operations plan and reclamation plan of the approved license application to reflect changes made under this condition.

2. Written standard operating procedures (SOPs) shall be established and followed for all operational process activities involving radioactive materials that are handled, processed, or stored. SOPs for operational activities shall enumerate pertinent radiation safety practices to be followed. Additionally, written procedures shall be established for non-operational activities to include in-plant and environmental monitoring, bioassay analyses, and instrument calibrations. An approved, up-to-date copy of each written procedure shall be kept in the process area to which it applies.

   All written procedures for both operational and non-operational activities shall be reviewed and approved in writing by the CRSO before implementation and whenever a change in procedure is proposed to ensure that proper radiation protection principles are being applied. In addition, the CRSO shall perform a documented review of all existing SOPs at least annually.

3. Before engaging in any developmental activity not previously assessed by NRC, the licensee shall conduct a cultural resource inventory. All disturbances associated with the proposed development will be completed in compliance with the National Historic Preservation Act of 1966 (as amended) and its implementing regulations (36 CFR Part 800), and the Archaeological Resources Protection Act of 1979 (as amended) and its implementing regulations (43 CFR Part 7).

   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 shall occur until the licensee has received authorization from NRC to proceed.

   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.

4. The licensee shall conduct operations within the permit area boundaries shown in Figure 1.3-1 of the approved license application, as amended by the submittal dated July 28, 1997.

5. Plant throughput shall not exceed a maximum flow rate of 18,930 Lpm (5000 gpm), excluding restoration flow. Annual yellowcake production shall not exceed 908,000 kg (2 million lbs).

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

7. 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 years it is in use. The integrity test shall pressurize the well to 125 percent of the maximum operating pressure 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.

   Additionally, flow rates on each injection and recovery well, and manifold pressures on the entire system, shall be measured and recorded daily. During well-field operations, injection pressures shall not exceed the integrity test pressure at the injection well heads.

8. The licensee shall establish pre-operational baseline groundwater quality data for all mine units. Baseline water quality sampling shall provide representative pre-mining groundwater quality data and restoration criteria as described in the approved license application.

   The data shall consist, at a minimum, of the following sampling and analyses:

   A. Three samples shall be collected from production and injection wells at a minimum density of one production or injection well per 4 acres. These samples shall be collected at least 14 days apart.

   B. The samples shall be analyzed for alkalinity, ammonia, arsenic, barium, bicarbonate, boron, cadmium, calcium, carbonate, chloride, chromium, copper, fluoride, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, nitrate, nitrite, pH, potassium, radium-226, selenium, silica, sodium, specific conductivity, sulfate, temperature, total dissolved solids, uranium, vanadium, and zinc.

   C. Groundwater restoration goals shall be established on a parameter-by-parameter basis, and the primary goal of restoration shall be to return the groundwater quality, on a mine unit average, to baseline conditions. The licensee shall conduct ground-water restoration activities in accordance with the groundwater restoration plan submitted by letter dated November 26, 1996.

9. Prior to mining in each mine unit, the licensee shall collect groundwater samples from and establish Upper Control Limits (UCLs) for designated upper aquifer and perimeter monitor wells. The data shall consist, at a minimum, of the following sampling and analyses:

A. Three samples shall be collected from the monitor wells at a minimum density of (1) one upper aquifer monitor well per 5 acres, and (2) all perimeter monitor wells. These samples shall be collected at least 14 days apart.

B. The samples shall be analyzed for the following indicator parameters: chloride, sodium, sulfate, conductivity, and total alkalinity.

C. For each monitor well, UCLs shall be calculated for each indicator parameter as equal to 20 percent above the maximum concentration measured for that parameter among the three samples.

10. All liquid effluents from process buildings and other process waste streams, with the exception of sanitary wastes, shall be returned to the process circuit; discharged to the solar evaporation ponds; disposed by land irrigation in accordance with the licensee's proposal submitted on August 3, 1988, as modified by its submittal on June 7, 1993; or deep well injected in accordance with the licensee's report submitted on August 24, 1993, as modified by submittals on December 7, 1995, and April 3, 1996.

11. Prior to mining in each mine unit, the licensee shall establish Upper Control Limits (UCLs) for each monitor well, equal to 20 percent above the maximum baseline concentration measured for each of the indicator parameters. The indicator parameters shall be chloride, sodium, sulfate, conductivity, and total alkalinity.

All designated monitor wells shall be sampled and tested no more than 14 days apart. If two UCLs are exceeded in a well or if a single UCL in a well 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 set of samples was acquired. If neither the second or third sample indicates exceedance, the first sample shall be considered in error.

If either the second or third sample confirms that UCL(s) are exceeded, the well in question will be place on excursion status. Upon confirmation of an excursion, the licensee shall notify NRC, implement corrective action, and increase the sampling frequency for the 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 5.7.8.1 of the approved license application. An excursion is considered concluded when the concentrations of the indicators parameters are below the concentration levels defining an excursion for three (3) consecutive weekly samples.

12. In the event a lixiviant excursion is confirmed by groundwater monitoring, NRC shall be notified by telephone within 24 hours and in writing within 7 days from the time the excursion is confirmed. In addition, a written report shall be submitted to NRC within 60 days of excursion confirmation. The report shall describe the excursion event, corrective actions taken, and results obtained. If the well(s) are still on excursion when the report is

submitted, the report also must contain a schedule for the submittal of future reports to NRC which will provide an update of corrective actions taken and the results obtained. In addition, if the well(s) are still on excursion at the time the 60-day report is submitted, the licensee shall terminate injection of lixiviant into the wellfield on excursion until such time that aquifer cleanup is complete.

13. Each of the R&D evaporation ponds shall have at least 0.9 m (3 ft) of freeboard. Each of the commercial evaporation ponds shall have at least 1.5 m (5 ft) of freeboard.

    Additionally, the licensee shall maintain, at all times, sufficient reserve capacity in the evaporation pond system to enable transferring the contents of a pond to the other ponds. In the event of a leak and subsequent transfer of liquid, freeboard requirements shall be suspended during the repair period.

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

    Any time 15.2 cm (6 in.) 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 15.2 cm (6 in.) 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, lower the fluid level by transferring the pond's contents to an alternate cell, and undertake repairs, as needed. Water quality in the affected standpipes shall be analyzed for the five parameters listed above once every seven days during the leak period and once every seven days for at least 14 days following repairs.

15. In the event evaporation pond standpipe water analyses indicate that a pond is leaking, NRC shall be notified by telephone within 48 hours of leak verification. In addition, a written report shall be submitted to NRC within 30 days of first notifying NRC that a leak exists. This report shall include analytical data, describe the mitigative action, and discuss the results of that action.

16. The licensee shall establish and conduct an effluent and environmental monitoring program in accordance with the program submitted by letter dated July 28, 1997.

17. Effluent and environmental monitoring program results submitted in accordance with 10 CFR 40.65 shall be reported in the format shown in Table 3 of Regulatory Guide 4.14, (Rev. 1) entitled, "Sample Format for Reporting Monitoring Data." These reports also shall include injection rates, recovery rates, and injection manifold pressures.

18. Until license termination, the licensee shall maintain documentation on all spills of source or 11e.(2) byproduct materials, and all spills of process chemicals. Documented information shall include: date, spill volume, total activity of each radionuclide released,

radiological survey results, corrective actions, results of remediation surveys, and a map showing the spill location and impacted area.

19. The licensee shall notify NRC by telephone within 48 hours of any spill of source or 11e.(2) byproduct materials and all spills of process chemicals, that may have a radiological impact on the environment. This notification shall be followed, within seven days, by submittal of a written report detailing the conditions leading to the spill, corrective actions taken, and results achieved. This requirement is in addition to the reporting requirements of 10 CFR Part 20 and 10 CFR 40.60.

20. The licensee shall maintain an NRC-approved financial surety arrangement, consistent with 10 CFR 40, Appendix A, Criterion 9, adequate to cover the estimated reclamation and closure costs, if accomplished by a third party, for all existing operations and any planned expansions or operational changes for the upcoming year. Reclamation includes all cited activities and groundwater restoration, as well as off-site disposal of all 11e.(2) byproduct material.

    Within three months of NRC approval of a revised closure plan and cost estimate, the licensee shall submit for NRC review and approval, a proposed revision to the financial surety arrangement if estimated costs in the newly approved site closure plan exceed the amount covered in the existing financial surety. The revised surety shall then be in effect within three months of written NRC approval.

    Annual updates to the surety amount, required by 10 CFR 40, Appendix A, Criterion 9, shall be provided to NRC by October 1 of each year. If NRC has not approved a proposed revision 30 days prior to the expiration date of the existing surety arrangement, the licensee shall extend the existing arrangement, prior to expiration, for one year. Along with each proposed revision or annual update of the surety, 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 estimated costs for site closure.

    At least 90 days prior to beginning construction associated with any planned expansion or operational change which was not included in the annual surety update, the licensee shall provide for NRC approval an updated surety to cover the expansion or change.

    The licensee shall also provide NRC with copies of surety-related correspondence submitted to the State of Nebraska, a copy of the State's surety review, and the final approved surety arrangement. The licensee also must ensure that the surety, where authorized to be held by the State, identifies the NRC-related portion of the surety and covers the above-ground decommissioning and decontamination, the cost of offsite disposal, soil and water sample analyses, and groundwater 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/decommissioning plan, cost estimates, and annual updates should follow the outline in Appendix E to NUREG-1569 (NRC, 1997).

entitled "Recommended Outline for Site-Specific *In Situ* Leach Facility Reclamation and Stabilization Cost Estimates."

Crow Butte Resources, Inc.'s currently approved surety instrument, an Irrevocable Standby Letter of Credit issued by Colorado National Bank, in favor of the State of Nebraska, shall be continuously maintained in the sum total amount of no less than $8,950,827 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.

21. The licensee shall maintain an area within the restricted area boundary for the temporary storage of contaminated materials. All contaminated wastes and evaporation pond residues shall be disposed at a radioactive waste disposal site licensed to accept 11e.(2) byproduct material.

22. Release of equipment or packages from the restricted area shall be in accordance with the NRC guidance document entitled, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Materials," dated May 1987, or suitable alternative procedures approved by NRC prior to any such release.

23. The licensee shall dispose of 11e.(2) byproduct material from the Crow Butte facility at a site licensed by NRC or an NRC Agreement State to receive 11e.(2) byproduct material. The licensee shall identify the disposal facility to NRC in writing. The licensee's approved waste disposal agreement must be maintained on-site. In the event the agreement expires or is terminated, the licensee shall notify NRC in writing, within 7 days after the date of expiration or termination. A new agreement shall be submitted for NRC approval within 90 days after expiration or termination, or the licensee will be prohibited from further lixiviant injection.

24. 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 mining operations.

25. The licensee shall conduct groundwater restoration activities and post-restoration monitoring in each MU in accordance with the groundwater restoration plan submitted by letter dated November 26, 1996. The goal of restoration shall be to return groundwater quality, on an MU average, to baseline conditions.

26. The licensee shall construct evaporation ponds 2 and 5 in accordance with the submittal dated May 23, 1988, as modified by the submittal dated July 16, 1992. In addition, the ponds shall be constructed as follows:

    A. Fill material shall be classified as a silty sand material in accordance with the Unified Soil Classification System.

    B. Quality control of the fill shall be performed in accordance with the guidance provided for radon barrier materials in the NRC Staff Technical Position on testing and inspection plans (January 1989).

C. As-built drawings shall be submitted to NRC within 3 months of the completion of construction of each pond.

27. The results of the following activities, operations, or actions shall be documented: sampling, analyses, surveys and monitoring, survey/monitoring equipment calibration results, reports on audits and inspections, all meetings and training courses required by this license and any subsequent reviews, investigations and corrective actions. Unless otherwise specified in the NRC regulations, all such documentation shall be maintained for a period of at least five (5) years.

12.0 REFERENCES

Crow Butte Resources, Inc. (CBR), 1997a, "1998 Surety Estimate - Revision 3," transmitted by letter from Stephen P. Collings (CBR) to Joseph J. Holonich (NRC), dated November 10, 1997.

CBR, 1997b, "Standard Operating Procedures for Safety and Environmental Review Panel; Revised Section 5 Operations of the Renewal Application," transmitted by letter from Stephen Collings (CBR) to Joseph J. Holonich (NRC), dated October 31, 1997.

CBR, 1997c, 1997 Pond Inspection Report, transmitted by letter from Steven Magnuson (CBR) to Joseph J. Holonich (NRC), dated October 31, 1997.

CBR, 1997d, "Semiannual Radiological Effluent and Environmental Monitoring Report for First and Second Quarters 1997," transmitted by letter from Rhonda Grantham (CBR) to Ross Scarano (NRC), dated August 29, 1997.

CBR, 1997e, Request to amend Source Material License SUA-1534, transmitted by letter from Stephen P. Collings (CBR) to Joseph J. Holonich (NRC), dated July 28, 1997.

CBR, 1997f, "Response to Request for Additional Information - License Renewal," transmitted by letter from Steve Collings (CBR) to Joseph J. Holonich (NRC), dated June 25, 1997.

CBR, 1997g, "Response to Acceptance Review Comments for the Renewal of Source Material License No. SUA-1534," transmitted by letter from Steve Collings (CBR) to Joseph J. Holonich (NRC), dated April 1, 1997.

CBR, 1996a, "Crow Butte ISL Mine, Crow Butte Resources, Inc., Groundwater Restoration Plan," transmitted by letter from Stephen P. Collings (CBR) to Joseph J. Holonich (NRC), dated November 26, 1996.

CBR, 1996b, "Crow Butte Resources, Inc., Crow Butte Mine, Dawes County, Nebraska. Evaporation Pond Onsite Inspection Program," Revised February 5, 1996, submitted by letter from Stephen P. Collings (CBR) to Joseph J. Holonich (NRC), dated February 5, 1996.

CBR, 1995, "Crow Butte Uranium Project, Dawes County, Nebraska: Application for Renewal of USNRC Radioactive Source Materials License SUA-1534," dated December 1995 and submitted by letter from Stephen P. Collings (CBR) to Joseph J. Holonich (NRC), dated December 20, 1995.

CBR, 1987, "Crow Butte Uranium Project, Dawes County, Nebraska: Application and Supporting Environmental Report for USNRC Commerical Source Material License," September 1987.

State of Nebraska, 1997, Nebraska State Handbook, Nebraska Department of Economic Development Internet site address *<http://www.ded.state.ne.us/economy/stathand>*.

State of Nebraska Department of Environmental Quality, 1996, letter from Randolph Wood (NDEQ) to Steve Collings (CBR), dated November 27, 1996.

U.S. Nuclear Regulatory Commission (NRC), 1997, "Draft Standard Review Plan for *In Situ* Leach Uranium Extraction License Applications," NUREG-1569, Office of Nuclear Material Safety and Safeguards, October 1997.

NRC, 1996, "Supplemental Environmental Assessment for Crow Butte Resource, Inc.'s Crow Butte In-Situ Leach Mining Project Dawes County, Nebraska, in Consideration of an Amendment (Increase in Deep Well Injection Constituent Concentration Limits) to NRC Source Material License SUA-1534," NRC Docket No. 40-8943, issued June 20, 1996.

NRC, 1993, "SUA-1534, Amendment No. 21 - Land application of restoration waste water - Ferret's Crow Butte ISL facility," Memorandum for the Docket File from J. Grimm, NRC Project Manager, NRC Docket No. 40-8943, dated November 16, 1993.

NRC, 1989a, "Environmental Assessment by the Uranium Recovery Field Office in Consideration of an Application for a Source Material License for Ferret Exploration Company of Nebraska Crow Butte Commercial In Situ Leach Operation, Dawes County, Nebraska," Docket No. 40-8943, issued December 12, 1989.

NRC, 1989b, "Safety Evaluation Report for Issuance of Source Material License, Ferret Exploration Company of Nebraska, Inc., Crow Butte Project, Dawes County, Nebraska," Docket No. 40-8943, issued December 12, 1989.

NRC, 1989c, "Staff Technical Position on Testing and Inspection Plans during Construction of DOE's Remedial Action at Inactive Uranium Mill Tailing Sites," Rev. 2, Division of Low-Level Waste Management and Decommissioning, January 1989.

NRC, 1987, "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material," Division of Fuel Cycle, Medical, Academic, and Commercial Use Safety, May 1987.

NRC, 1984, "United States Nuclear Regulatory Commission Environmental Assessment by the Uranium Recovery Field Office in Consideration of Source Material License for Wyoming Fuel Company, Crow Butte ISL Project, Dawes County, Nebraska," Docket No. 40-8829, issued September 28, 1984.

NRC, 1980, "Radiological Effluent and Environmental Monitoring at Uranium Mills," NRC Regulatory Guide 4.14, Rev. 1, April 1980.

NRC. 1979. "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment," NRC Regulatory Guide 4.15, Rev. 1, February 1979.

NRC, 1977, "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills," NRC Regulatory Guide 3.11, Rev. 2, December 1977.

APPENDIX

DOCUMENTATION OF
CONSULTATION WITH OTHER FEDERAL AGENCIES
AND
THE STATE OF NEBRASKA

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 08, 1997

U.S. Fish and Wildlife Service
ATTN: Field Supervisor
208 W. Second Street
Federal Building, 2nd Floor
Grand Island, Nebraska 68801

SUBJECT: INFORMATION REQUEST ON PROTECTED PLANT AND ANIMAL SPECIES

Dear Sir or Madam:

The U.S. Nuclear Regulatory Commission currently is reviewing a license renewal application from Crow Butte Resources, Inc. (CBR) for its Crow Butte *in-situ* leach uranium solution mine in Dawes County, Nebraska. The facility is located approximately eight kilometers (five miles) southeast of Crawford, Nebraska, and solution mining operations are currently permitted within an approximately 1130-hectare (2800-acre) area that encompasses all or portions of Sections 11, 12, and 13 of Township 31N, Range 52W and Sections 18, 19, 20, 29, and 30 of Township 31N, Range 51W, Dawes County, Nebraska. The NRC staff is preparing an Environmental Assessment to document its review of CBR's renewal application, and the staff is proposing to renew CBR's license for a period of ten years.

Enclosed are the results of the NRC staff's review of the results of plant and animal surveys conducted by the licensee. Based on this review, the staff currently has no reason to expect any such plant or animal species to be adversely affected on or near the site. However, NRC would appreciate any information or concerns you might have regarding the effects of the continued operations at the Crow Butte site on listed, proposed, or candidate endangered and threatened species, as well as any other sensitive-species concerns.

If you have any questions concerning this letter, please contact Mr. James Park of my staff. Mr. Park can be reached at (301) 415-6699. Thank you for your prompt assistance on this matter.

Sincerely,

Joseph J. Holonich, Chief
Uranium Recovery Branch
Division of Waste Management
Office of Nuclear Material
Safety and Safeguards

Docket No. 40-8943
License No. SUA-1534

Enclosure: As stated

Enclosure

Endangered Species

The black-footed ferret (*Mustela nigripes*) is the only Federally-listed threatened or endangered mammal that may occur in the region; however, the last black-footed ferret sighting in the region occurred in 1959. The ferret's principal prey, the prairie dog, is not common in the site environs, and therefore, black-footed ferrets are not expected in the area.

Whooping cranes (*Grus americana*), bald eagles (*Haliaeetus leucocephalus*), and peregrine falcons (*Falco peregrinus anatum*) are Federally-listed threatened or endangered bird species that may occur in the region. Whooping cranes migrate through Nebraska between March and May and again from October to December each year, using shallow, sparsely-vegetated streams and wetlands for roosting and feeding. These birds were not observed in the site area during a 1982 survey, although sightings have been confirmed on wetlands near Whitney, Nebraska, approximately 12 miles northeast of the site (CBR, 1995).

Bald eagles were observed during the 1982 survey, and they are sparsely scattered across Dawes County, Nebraska, during migration (November 1 to April 1). However, these birds do not nest in the survey area, and neither critical habitat nor regular roosting sites can be found in the site area. Peregrine falcons, on the other hand, generally are associated with wetland and open areas, such as grassland and cropland. These birds were not observed during the 1982 survey.

Finally, CBR has stated that no identified Federally-listed endangered plant or amphibian/reptile species occur on the Crow Butte Uranium Project (CBR, 1995).

The staff considers it unlikely that there will be significant impacts to raptors (including bald eagles and peregrine falcons), because there will be little to no reduction in suitable prey and minimal destruction (if any) of potential nesting sites. Impacts to whooping cranes are not expected, because there will be no reduction of critical habitat for these birds as a result of operations at the Crow Butte Uranium Project.

(excerpt from NRC draft "Environmental Assessment for Renewal of NRC Source Material License SUA-1534, Crow Butte Resources, Incorporated, Crow Butte Uranium Project, Dawes County, Nebraska")

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
Nebraska Field Office
203 West Second Street
Grand Island, Nebraska 68801

January 5, 1998

Mr. Joseph J. Holonich
Chief, Uranium Recovery Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Mr. Holonich:

This responds to your December 8, 1997, letter requesting comments from the U.S. Fish and Wildlife Service (Service) regarding a license renewal application from Crow Butte Resources, Inc. for its Crow Butte *in-situ* leach uranium solution mine in Dawes County, Nebraska. We concur with the conclusion that the project as currently operated does not adversely affect federally listed threatened and endangered species or their critical habitat. Therefore, no further section 7 consultation under the Endangered Species Act of 1973 is required with the Service.

Long-term inpacts of radiation exposure to birds utilizing the evaporation ponds may potentially be a cause for concern (namely radium, because of its propensity to bioaccumulate). Further, selenium levels in the evaporation ponds may result in selenium toxicosis in birds using the ponds. Because of the potential chronic effects of radiation and selenium exposure, bird usage of the evaporation ponds should continually be monitored.

If you have any further questions, please contact Mr. Wally Jobman within our office at (308)382-6468, extension 16.

Sincerely,

Acting [signature]
Nebraska Field Supervisor

cc: NGPC; Lincoln, NE (Attn: Martha Tacha)

(6)NRC.ltr

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 31, 1997

Mr. Lawrence J. Sommer, Director
Nebraska State Historical Society
1500 R Street
P.O. Box 82254
Lincoln, Nebraska 68501

SUBJECT: RESULTS OF CONSULTATION UNDER SECTION 106 OF THE NATIONAL HISTORIC PRESERVATION ACT OF 1966, AS AMENDED

Dear Mr. Sommer:

The U.S. Nuclear Regulatory Commission staff is in the process of reviewing an application by Crow Butte Resources, Inc. (CBR) to renew its NRC source material license for the commercial production of uranium at CBR's Crow Butte *in-situ* leach uranium solution mine in Dawes County, Nebraska. Under Section 106 of the National Historic Preservation Act of 1966, as amended (NHPA) and its implementing regulations at 36 CFR Part 800, the NRC is required to consult with the appropriate State Historical Preservation Officer (SHPO) so that the effects of a federally-licensed undertaking on sites eligible or potentially eligible for listing on the National Register of Historic Places may be taken into account. It is in your role as the SHPO for the State of Nebraska that I am contacting you.

On December 9, 1997, Mr. James Park of my staff coordinated a telephone conference call with the Deputy SHPO for the State of Nebraska (Mr. Robert Puschendorf), a State of Nebraska employee at Fort Robinson State Park (Mr. Terry Steinacher), the CBR President (Mr. Stephen Collings), and two consultants to CBR. The purpose of this call was to discuss issues raised by Mr. Puschendorf in a December 3, 1997, telephone call with Mr. Park regarding the extent of historical, archaeological, and cultural resource surveys performed to date for the region including and surrounding the Crow Butte site.

Associated with its commercial operations at the Crow Butte site, CBR has had two historical and archaeological surveys performed. The first was conducted in 1987 by a member of the Nebraska State Historical Society (NSHS), in which six potentially eligible historical and archaeological sites were identified. Rather than make a final determination of eligibility for any of these sites at that time, CBR chose to pursue a policy of avoidance and to commit to coordinate with the NSHS prior to development in the immediate vicinity of a potentially eligible site. The second survey was conducted in 1995 by CBR consultants and confirmed that operations to date had not impacted any of the six sites identified in the 1987 survey.

In the December 9, 1997, conference call, Mr. Puschendorf stated that he considered the results of the 1987 survey still to be adequate and CBR's continued policy of avoidance to be acceptable. He recommended that CBR and the NSHS re-formalize their agreement regarding pre-development coordination to bring it up to date.

Mr. Puschendorf also recommended that a survey of traditional cultural properties be performed in the region including and surrounding the Crow Butte site. This survey would be designed to identify properties of cultural significance to Native American tribes who once inhabited or still inhabit the area. Mr. Puschendorf stated his belief that the surveys performed to date for the Crow Butte site have not addressed fully the issue of traditional cultural properties as required under the NHPA and its current implementing regulations. As an outcome of this conference call, CBR did commit to initiating contact with the appropriate Native American tribes.

Finally, NRC, for its part, proposed that it include in the renewal license issued to CBR, a condition requiring CBR to conduct a cultural resource inventory prior to engaging in any developmental activity not previously assessed by NRC. In addition, NRC would require that all disturbances associated with the proposed development be completed in compliance with the NHPA and its implementing regulations, and the Archaeological Resources Protection Act of 1979, as amended, and its implementing regulations (43 CFR Part 7). Mr. Puschendorf stated his belief that this would be acceptable to the State.

Based on the results of the December 9, 1997, conference call (i.e., the proposed license conditions to require a cultural resource survey and CBR's initiation of the survey process), the NRC staff considers that it can proceed with the re-licensing of the commercial operations at the Crow Butte site. The staff welcomed the opportunity to consult with the State of Nebraska Deputy SHPO and appreciated his comments and input. The NRC staff considers that no further consultation is necessary and no response to this letter is required.

If you have any questions regarding this letter, please contact Mr. Park at (301) 415-6699.

Sincerely,

Charlotte Abrams for

Joseph J. Holonich, Chief
Uranium Recovery Branch
Division of Waste Management
Office of Nuclear Material
Safety and Safeguards

Docket No. 40-8943
License No. SUA-1534

cc: R. Puschendorf, NSHS
T. Steinacher, NE/Fort Robinson
S. Collings, CBR

NEBRASKA STATE HISTORICAL SOCIETY
1500 R STREET, P.O.BOX 82554, LINCOLN, NE 68501-2554
(402) 471-3270 Fax: (402) 471-3100 Museum Fax: (402) 471-3314 NSHS@inetnebr.com
Historic Preservation Office: Telephone (402) 471-4787; FAX (402) 471-3316;
Internet address: hpnshs@nebraskahistory.org

January 30, 1998

Mr. Joseph J. Holonich
Chief
Uranium Recovery Branch
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Re: Crow Butte Resources, Inc.
License #SUA-1534
HP #9702-003-01

Dear Mr. Holonich:

We have appreciated the opportunity to consult on cultural resources within the purview of the referenced licensing. Your letter of December 31, 1997 summarized discussions recently held in consultation concerning this licensing.

Your letter, however, did not fully summarize the circumstance by which comments relative to the identification of traditional cultural properties would be addressed. Reference is made to 36 CFR Part 800 4(a). The indication was given that concurrent to the six month public comment period, notice would be made to appropriate Native American tribes regarding traditional cultural properties. The Nebraska SHPO would be apprised of this process and any comments received. Further consultation may be indicated as a result of this process.

We hope this adequately addresses our understanding and that adequate opportunity will be available to address SHPO concurrence to this licensing.

Sincerely,

L. ROBERT PUSCHENDORF
Deputy State Historic
Preservation Officer

LRP/pft
cc: James Park, NRC