construction, the exclusion of agricultural activities from this area over the course of the Three Crow project should not have a significant impact on local agricultural production.

H.1.3 Surface Water Impacts of Construction

When stormwater drains off a construction site, it can carry sediment and other pollutants that can potentially harm lakes, streams and wetlands. The U.S. Environmental Protection Agency (EPA) estimates that 20 to 150 tons of soil per acre is lost every year to stormwater runoff from construction sites. For this reason, stormwater runoff is controlled by the Nebraska Department of Environmental Quality's (NDEQ) National Pollutant Discharge Elimination System (NPDES) regulations.

Construction activities at the Crow Butte project to date have had a minimal impact on the local hydrological system. CBR conducts construction activities under NDEQ permitting regulations for control of construction stormwater discharges contained in Title 119 (NDEQ 2005). CBR is required by NDEQ General Construction Stormwater NPDES Permit NER 100000 to implement procedures that control runoff and the deposition of sediment in surface water features during construction activities. These procedures are contained in EHSM'S Volume VI, *Environmental Manual* and require active engineering measures, such as berms, and administrative measures, such as work activity sequencing to control runoff and sedimentation of surface water features. CBR must annually submit a construction plan for the coming year and obtain authorization from the NDEQ under the general permit.

Administrative and engineering controls implemented by CBR during initial site preparation and construction of the Three Crow Satellite Facility and related facilities are expected to ensure that surface water impacts are minimal.

H.1.4 Population Impacts of Construction

The effects of construction of the proposed Three Crow Satellite Facility on the immediate population will be an unavoidable impact, although a temporary one. Construction activities will require additional temporary construction workers. Many of these positions will likely be filled by local labor. Any additional workers that may not be from the immediate area will cause a short-term increase in housing demand. The population impacts of construction are discussed in more detail in Section H.6.

H.1.5 Social and Economic Impacts of Construction

The social and economic impacts to the City of Crawford and surrounding areas during the construction of the original facility were slight given the relatively small scale of activities. The future construction activities for the Three Crow Satellite Facility will be even smaller in scope. CBR estimates that four to seven temporary construction workers will be involved in constructing the Three Crow Satellite facilities. The social and economic impacts of construction are discussed in more detail in Section H.6.

H.1.6 Noise Impacts of Construction

Increased vehicle travel and the operation of construction equipment within the TCEA during the construction phase of the project would result in a slight increase in noise impacts to residents. Noise from construction equipment could raise noise levels as much as 9 dBA during the construction phase of the project. Noise from construction would not be generated during nighttime hours. Construction activities would typically occur over an 8-hour work day, 5 days per week. Increased noise levels would be intermittent and temporary. The resulting increase in vehicle noise from construction and construction traffic, (including movement of heavy equipment, which would be much less dense and slower than typical highway traffic) would be barely perceptible over the existing ambient noise that is intermittently dominated by vehicle noise from Four Mile Road and the BNSF railroad.. Noise from construction and construction traffic would be temporary and would briefly add to existing highway noise.

H.2 Environmental Effects of Operations

The major environmental concerns during the operation of the Three Crow Satellite Facility will be air quality effects, land use and water quality impacts, ecological impacts, and radiological impacts.

H.2.1 Air Quality Impacts of Operations

The primary new emission source of nonradiological pollutants will be tailpipe emissions of nitrogen oxides (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2), non-methane-ethane volatile organic compounds (VOC), and particulate matter with a diameter less than ten micrometers (PM_{10}) resulting from vehicle traffic within the TCEA. Approximately 6-8 vehicle trips per day (VTPD) are anticipated as part of regular operations. These vehicles are expected to be light duty pick-up style trucks. Heavy equipment in the form of drill rigs, equipment haulers, or water trucks will be used as necessary and are anticipated to average less than one VTPD. These emissions are expected to be minor and should not affect the local ambient air quality.

The operations of the TCEA Satellite Facility will not result in major emissions of these nonradiological emissions and would therefore not be considered a major source of emissions under state permitting regulations, especially since the TCEA project will be located in an National Ambient Air Quality Standards (NAAQS) attainment area for all criteria pollutants and there are no Prevention of Significant of Deterioration (PSD) issues (see discussions below). This statement also would apply to the construction activities, which pose higher impact risks than the operations phase (see discussions in Section H.1.1). Other nonradiological emissions occurring during operations would be fugitive dust emissions generated by activities such as onsite traffic related to operations and maintenance, employee traffic to and from the site, resin transfers from the satellite facility to the main CPF, and heavy truck traffic delivering supplies to the site and product from the site. Dust emissions associated with the operational phase will be less than the construction phase.

H.2.1.1 Particulate Emissions During Operations

The amount of dust generated during operations can be estimated from the following equation taken from "Supplement No. 8 for Compilation of Air Pollutant Emission Factors" (EPA 1978).

$$E = (0.81s) \times \frac{S}{30} \times \frac{365-w}{365}$$

Where:

E	=	emission factor, lb TSP per vehicle-mile
s	=	silt content of road surface material, 40%
S	=	average vehicle speed, 30 miles per hour
w	=	mean number of days with 0.01 inches or more of rainfall, 85

Using the values stated above, the emission factor is equal to 0.25 lb TSP per vehicle-mile. The distance from the City of Crawford to the Three Crow Satellite Facility is approximately 8.0 miles. Approximately 3.6 miles of this distance is on improved roads and 4.4 miles is on dirt or trail roads. CBR expects that most employees at the Three Crow Satellite Facility will travel from the City of Crawford. Assuming ten employees and a 7 day workweek, there would be 70 round trips per week and the weekly mileage on dirt or trail roads would be 616 miles. Deliveries and other travel may require up to 50 round trips per week which would be an additional 440 miles per week on dirt or trail roads.

The distance from the Three Crow Satellite Facility to the Crow Butte Main Facility is 9.1 miles (via Saw Log Road) of which 8.1 miles are on dirt or trail roads. Assuming 2 round trips per day for resin transfer and an additional 10 round trips per day for facility personnel traveling between the sites, the total mileage on dirt or trail roads will be approximately 1,360 miles per week. This estimate is based on a 7 day work week.

The total travel on dirt and trail roads for personnel, resin transfer, deliveries and incidental travel will be approximately 2,420 miles per week. With an emission factor of 0.25 lb TSP per vehicle-mile, there will be a total dust emission of approximately 15.7 tons per year as a result of increased traffic on dirt and trail roads.

Any increase in fugitive dust emissions resulting from operational activities within the TCEA would be minimal. Mitigation measures such as the application of water or dust control chemicals to unpaved roads will be implemented as necessary.

H.2.1.2 Criteria Pollutant Regulatory Compliance Issues

The statements in this section apply to both construction and operations phase of the proposed TCEA Satellite Facility.

The National Ambient Air Quality Standards (NAAQS) for PM_{10} are 150 micrograms per cubic meter (24-hour average), and 50 micrograms per cubic meter (annual average). All counties within the 80 km radius of the project are in attainment of NAAQS. Concentrations of the criteria pollutants from the TCEA operations will not be expected to exceed the regulated or "threshold" level for one or more of the NAAQS pollutants within the 80 km radius.

In addition to the NAAQS ambient air quality standards, there are national standards for the Prevention of Significant Deterioration (PSD) of air quality. The PSD program is administered by the State of Nebraska and South Dakota, with their programs designed to protect the air quality in area that are in attainment with the NAAQS and to prevent degradation of air quality in areas below the standard (designed as clean air areas). The PSD requirements establish allowable pollution "increments" that may be added to the air in each area while still protecting air quality. The increment is the maximum allowable deterioration of air quality.

The allowable increments vary by location across the states. Those areas characterized as Class I (i.e., National Parks and Wilderness Areas) and allow less incremental pollution increase. Class III areas are planning areas set aside for industrial growth. The areas classified as Class II are essentially all other areas of the state not designated as Class I or Class III. There are no Class I National Park and Wilderness Areas in Nebraska. The State of South Dakota has two Class I Areas: Badlands and Wind Cave National Parks. The Wind Caves National Park is the closer of the two to the TCEA, being a distance of approximately 63 miles. Therefore, no impacts associated with PSD requirements would be expected based on the estimated amount of emissions from the TCEA operations.

H.2.2 Land Use Impacts of Operations

The principal land uses for the TCEA and the 2.25-mile review area is grazing livestock. Rangeland accounted for 42.8 percent of the land use in the TCEA and surrounding 2.25-mile area of review (AOR) as discussed in Section G.1.2. The secondary land use within the TCEA license boundary is cropland. This cropland is primarily wheat, although a small proportion is used for alfalfa hay. Cropland accounted for 18.7 percent of the land use in the TCEA and the AOR. Land use was discussed in detail in Section G.1.2.

For the proposed disturbance of 671 acres for the proposed satellite facilities, wellfields, evaporation pond areas and roadways, cropland accounts for 384.0 acres or 57.2 percent of the total area. Rangeland accounts for 265.9 acres or 39.6 percent of the total area. Rangeland rehabilitation (4.53 acres) and structural biotope (16.63 acres) are the only other impacted land uses. **Figure H.2-1** depicts the proposed wellfield areas and the current types of land use.

As a result of site preparation and construction, cattle production will be excluded from the areas that are under development. The total estimated area that will be impacted during the course of the project is the 671 acres associated with the satellite facility, wellfields, evaporation ponds, and roads. As discussed in Section G.12, livestock and livestock products had a value of $28.61 per acre, indicating that livestock production on impacted rangeland within the TCEA has a potential value of approximately $7,610

As a result of site preparation and construction, crop production will be excluded from the areas that are under development. The total estimated cropland area that will be impacted during the course of the project is the 384.1 acres associated with the satellite facility, wellfields, evaporation ponds, and roads. In 2007 Dawes County had 44,100 acres harvested for 70,170 tons of alfalfa hay and 43,445 acres harvested for 1,337,320 bushels of winter wheat (NASS 2009). These harvests resulted in yields of 1.6 tons of alfalfa hay and 30.8 bushels of wheat per acre harvested. Based on these yields, the lost annual crop production in the TCEA would be as much as 615 tons of hay and up to 11,833 bushels of wheat.

Considering the relatively small size of the area impacted by operations, the exclusion of agricultural activities from this area over the course of the Three Crow project will not significantly impact local or regional agricultural production. The limited impacts are considered temporary and reversible by returning the land to its former grazing use through post-mining surface reclamation.

The current operations in the previously licensed area have shown that CBR can successfully restore the land surface following mining operations. Surface reclamation activities including contouring and revegetation have been performed routinely following initial mine unit construction. Additionally, CBR recently completed surface and subsurface reclamation of a significant portion of Mine Unit 1 following approval of groundwater restoration. These areas have been successfully recontoured and revegetation has been completed in accordance with NDEQ requirements.

H.2.3 Geologic and Soil Impacts of Operations

H.2.3.1 Geologic Impacts of Operations

Geologic impacts are expected to be minimal, if any. No significant matrix compression or ground subsidence is expected, as the net withdrawal of fluid from the Basal Chadron Sandstone will be on the order of 1% or less, and the anticipated drawdown over the life of the project is expected to be on the order of 10% of the available head, or less. Further, once mining and restoration operations are completed and restoration approved, groundwater levels will return to near original conditions under a natural gradient.

If the Pine Ridge structural feature is in fact a fault, changes in aquifer pressure potentially could impact activity related to the fault and the transmissive characteristics of the fault (e.g., resistance to flow). There are numerous documented cases where injection in the immediate vicinity of a fault has caused an increase in seismic activity. However, such response typically occurs when injection operations have increased the pressure in the aquifer by a significant amount (e.g., 40 to 200 percent pressure increase over initial conditions). The pressure in the Basal Chadron will be increased by localized scale by injection operations during mining and restoration operations, and will be more than offset by production within each wellfield pattern.

H.2.3.2 Soil Impacts of Operations

Construction of the facilities at the TCEA will affect soils. With proper implementation of Best Management Practices, effects to soils are not expected to be significant within the TCEA.

The severity of soil impacts would depend on the number of acres disturbed and the type of disturbance. Potential impacts include soil loss, sedimentation, compaction, salinity, loss of soil productivity, and soil contamination. Effects to soils at the TCEA would result from the clearing of vegetation, excavating, leveling, stockpiling, compacting, and redistributing soils during construction and reclamation. Disturbance related to the construction and operation of the TCEA would continue until the area is revegetated.

Wind erosion is possible at the TCEA, particularly in the eastern half of the project area. Various soils meet the criteria for high wind erosion hazard (USDA 1977). These soils have one or more major constituents that are fine sand or sandy loam that can easily be picked up and spread by wind. Construction presents the greatest threat to soils with potential for wind erosion. Wind erosion will be controlled by removing vegetation only where it is necessary, avoiding clearing and grading on erosive areas, surfacing roads with locally obtained gravel, and timely reclamation.

Water erosion is also possible at the TCEA, especially in areas disturbed by road and wellfield construction. Various soils meet the criteria for severe water erosion hazard (USDA 1977). These soils have low permeability and high K-factors, making them susceptible to water erosion. The K-factor is used to describe a soil's erodibility; it represents both susceptibility of soil to erosion and the rate of runoff. It is calculated from soil texture, organic matter, and soil structure. Construction and operation would increase soil loss through water erosion. Removal of vegetation for any activity exposes soils to increased erosion. Excavation could break down soil aggregates, increasing runoff and gully formation. Soil loss will be reduced substantially by avoiding highly erosive areas such as badlands and steep drainages. Locating roads in areas where cuts and fills would not be required, surfacing roads with gravel, installing drainage controls, and reseeding and installing water bars across reclaimed areas will also aid in reducing soil loss.

Sedimentation in streams and rivers at the TCEA could result from soil loss. Sedimentation could alter water quality and the fluvial characteristics of area drainages. Installation of appropriate erosion control measures as required by CBR's Construction Stormwater NPDES authorization (see Section H.1.3) and avoidance of erosive soils will aid in reducing sedimentation.

Activity on the site has potential to compact soils. Soils sensitive to compaction do exist on the site. Compaction of the soils could decrease infiltration and promoting higher runoff. Construction and traffic will be minimized where possible, and soils will be loosened prior to reseeding to control the effects of soil compaction.

Any soil on the site can be saline depending on site-specific conditions, such as permeability, clay content, quality of nearby surface waters, plant species, and drainage characteristics. Saline soils are extremely susceptible to soil loss caused by development. Soil erosion in areas with high salt content would contribute to salinity in the White River Basin. Reclamation of saline soils can be difficult, and no method that works in all situations has yet been found.

Facility development would displace topsoil, which would adversely affect the structure and microbial activity of the soil. Loss of vegetation would expose soils and could result in a loss of organic matter in the soil. Excavation could cause mixing of soil layers and breakdown of the soil structure. Removal and stockpiling of soils for reclamation could result in mixing of soil profiles and loss of soil structure. Compaction of the soil could decrease pore space and cause a loss of soil structure as well. This would result in a reduction of natural soil productivity.

A number of erosion and productivity problems resulting from the TCEA may cause a long-term declining trend in soil resources. Long-term impacts to soil productivity and stability would occur as a result of large scale surface grading and leveling, until successful reclamation would be accomplished. Reduction in soil fertility levels and reduced productivity would affect diversity of reestablished vegetative communities. Moisture infiltration would be reduced, creating soil drought conditions. Vegetation would undergo physiological drought reactions.

Surface spillage of hazardous materials could occur at the TCEA. If not remediated quickly, these materials have the potential to adversely impact soil resources. In order to minimize potential impacts from spills, a Spill Prevention, Control, and Countermeasure (SPCC) Plan will be implemented. The SPCC plan will include accidental discharge reporting procedures, spill response, and cleanup measures.

Soil Impact Mitigation Measures

Best Management Practices (BMPs) have been included in the project description and will be followed to control erosion, minimize disturbance, and facilitate reclamation. The following mitigation measures will be valuable in reducing the effects to soil resources at the TCEA. BMPs and mitigation measures relevant to soil resources are also discussed in the water quality and reclamation sections of this document. Fundamentally, efforts will be made to preserve existing vegetation where practical.

Sediment Control

Divert surface runoff from undisturbed area around the disturbed area.

Retain sediment within the disturbed area.

Surface drainage shall not be directed over the unprotected face of the fill.

Operations and disturbance on slopes greater than 40 percent need special sediment controls and should be designed and implemented appropriately.

Avoid continuous disturbance that provides continuous conduit for routing sediment to streams.

Inspect and maintain all erosion control structures.

Repair significant erosion features, clogged culverts, and other hydrological controls in a timely manner.

If best management practices do not result in compliance with applicable standards, modify or improve such best management practices to meet the controlling standard of surface water quality.

Topsoil

Topsoil to be removed should be removed prior to any development activity to prevent loss or contamination.

When necessary to substitute for or supplement available topsoil, use overburden that is equally conducive to plant growth as topsoil.

To the extent possible, directly haul (live handle) topsoil from site of salvage to concurrent reclamation sites.

Avoid excessive compaction of topsoil and overburden used as plant growth medium by limiting the number of vehicle passes, and handling soil while saturated and scarifying compacted soils.

Time topsoil redistribution so seeding, or other protective measures, can be readily applied to prevent compaction and erosion.

Roads

Construct and maintain roads to minimize soil erosion by:

Restricting the length and grade of roadbeds;

Surfacing roads with durable material (i.e., locally obtained native gravel);

Creating cut and fill slopes that are stable;

Revegetating the entire road prism including cut and fill slopes; and,

Creating and maintaining vegetative buffer strips, and constructing sediment barriers (e.g. straw bales, wire-backed silt fences, check dams) during the useful life of roads.

Regraded Material

Design regraded material to control erosion using activities that may include slope reduction, terracing, silt fences, chemical binders, seeding, mulching etc.

Divert all surface water above regarded material away from the area and into protected channels.

Shape and compact regraded material to allow surface drainage and ensure long-term stability.

Concurrently reclaim regarded material to minimize surface runoff.

Implementation of the above BMPs, SPCCs, and SWPPPs will minimize effects to soils associated with the construction of the Three Crow Satellite Facility.

H.2.4 Archeological Resources Impacts of Operations

Field investigations were conducted in January 2006 on a 2,100-acre area of anticipated potential development encompassing the TCEA. The proposed 1,643 acres that makes up the TCEA are totally included within this acreage. Three historic sites and three isolated prehistoric artifacts were located and identified. As noted in Section G.3, these resources are not likely to yield important prehistorical or historical information and are not considered eligible for the National Register of Historic Places.

H.2.5 Groundwater Impacts of Operations

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

H.2.5.1 Groundwater Consumption

Groundwater impacts and consumption related to the Three Crow operation will be fully assessed in an Industrial Groundwater Permit application that is required by NDEQ. Information from the existing Groundwater Permit for the current license area indicates that the drawdown from mining operations in the basal Chadron Formation is minimal (e.g., less than 10 percent of the available head). Based on drawdown data from years of operation in the current license area, and on the formation characteristics from the Three Crow Pump Test, the drawdown effect on the Chadron aquifer as a result of operations has been and is expected to remain minimal.

Groundwater consumption from the Three Crow operation is expected to be on the order of 0.5% to 1.5% of the total mining flow (6,000 gpm). Additional consumptive volume (1,500 gpm) will be used during aquifer restoration, especially the groundwater sweep phase. However, it is expected that the net consumption for the entire operation will be on the order of 50 to 100 gpm.

H.2.5.2 Potential Declines in Groundwater Quality

Excursions represent a potential effect on the adjacent groundwater as a result of operations. During production, injection of the lixiviant into the wellfield results in a temporary degradation of water quality in the exempted aquifer compared to pre-mining conditions. Movement of this water out of the wellfield to the monitor well ring results in an excursion. Excursions of contaminated groundwater in a wellfield can result from an improper balance between injection and recovery rates, undetected high permeability strata or geologic faults, improperly abandoned exploration drill holes, discontinuity and unsuitability of the confining units which allow movement of the lixiviant out of the ore zone, poor well integrity, and hydrofracturing of the ore zone or surrounding units.

To date, there have been several confirmed horizontal excursions in the Chadron sandstone in the current license area. These excursions were quickly detected and recovered through overproduction in the immediate vicinity of the excursion. In all but one case, the reported vertical excursions were actually due to natural seasonal fluctuations in Brule groundwater quality and very stringent upper control limits (UCLs). In no case did the excursions threaten the water quality of an underground source of drinking water since the monitor wells are located well within the aquifer exemption area approved by the EPA and the NDEQ. **Table H.2-1** provides a summary of excursions reported for the current license area.

H.2.5.3 Potential Groundwater Impacts from Accidents

Groundwater quality could potentially be impacted during operations due to an accident such as evaporation pond leakage or failure, or an uncontrolled release of process liquids due to a wellfield accident. If there should be an uncontrolled evaporation pond leak or wellfield accident, potential contamination of the shallow aquifer (Brule), as well as surrounding soil, could occur. This could occur as a result of a slow leak or a catastrophic failure, a shallow excursion, an overflow due to excess production or restoration flow, or due to the addition of excessive rainwater or runoff.

To mitigate the likelihood of pond failure, all evaporation ponds at Three Crow will be designed and built to NRC standards using impermeable synthetic liners. A leak detection system will also be installed, and all evaporation ponds will be inspected on a regular basis. In the event that a problem is detected, the contents of any given evaporation pond can be transferred to another evaporation pond while repairs are made. The proposed evaporation pond design and operation was discussed in greater detail in Sections N.2.6 and N.2.7.

Over the course of the current licensed operation, CBR has experienced several leaks associated with the inner evaporation pond liner on the commercial evaporation ponds. These small leaks are virtually unavoidable since the liners are exposed to the elements. In each case these leaks were quickly discovered during routine inspections, primarily due to a response in the underdrain system. Corrective actions included lowering the evaporation pond level and locating the leak to allow repairs. In none of these situations was the shallow groundwater affected since the outer pond liner functioned as designed and prevented a release of the evaporation pond contents. All pond leaks, causes, and corrective actions are reported to the NRC and the NDEQ (NDEQ 2002).

With respect to potential overflow of an evaporation pond, current standard operating procedures require that evaporation pond levels be closely monitored as part of the daily inspection. Process flow to the evaporation ponds will be minimal in comparison to the pond capacity, thus it can easily be diverted to another evaporation pond if necessary. In addition, sufficient freeboard will be maintained on all evaporation ponds to allow for a significant addition of rainwater with no threat of overflow. Finally, the dikes and berms around the evaporation ponds will channel runoff away from the ponds.

Another potential cause of groundwater impacts from accidents could be releases as a result of a spill of injection or production solutions from a wellfield building or associated piping. In order to control these types of releases, all piping is either PVC, high density polyethylene with butt welded joints, or equivalent. All piping is leak tested prior to production flow and following repairs or maintenance.

H.2.6 Surface Water Impacts of Operations

H.2.6.1 Surface Water Impacts from Sedimentation

Protection of surface water from stormwater runoff during on-going wellfield construction related to operations is regulated by the NDEQ as discussed in Section H.1.3.

H.2.6.2 Potential Surface Water Impacts from Accidents

Surface water quality could potentially be impacted by accidents such as an evaporation pond leakage or failure or an uncontrolled release of process liquids due to a wellfield accident. Section H.2.5.3 discussed the operation of the ponds and measures to prevent and control wellfield spills. An additional measure to protect surface water is that wellfield areas are installed with dikes or berms to prevent spilled process solutions from entering surface water features. Process buildings are constructed with secondary containment, and a regular program of inspections and preventive maintenance is in place.

H.2.7 Ecological Impacts of Operations

H.2.7.1 Impact Significance Criteria

The following criteria were used to determine the significance of construction and operation of the proposed project on wildlife and vegetation resources within the project area. These criteria were developed based on professional judgment, involvement in other National Environmental Policy Act (NEPA) projects throughout the West, and state and federal regulations.

Removal of vegetation such that following reclamation, the disturbed area(s) would not have adequate cover (density) and species composition (diversity) to support pre-existing land uses, including wildlife habitat;

Unauthorized discharge of dredged or fill materials into, or excavation of, waters of the U.S., including special aquatic sites, wetlands, and other areas subject to the Section 404 of the Clean Water Act, Executive Order 11988 - flood plains, and Executive Order 11990 - wetlands and riparian zones;

Reclamation is not accomplished in compliance with Executive Order 13112 (Invasive Species);

Introduction and establishment of noxious or other undesirable invasive, non-native plant species to the degree that such establishment results in listed invasive, non-native species occupying any undisturbed rangeland outside of established disturbance areas or hampers successful revegetation of desirable species in disturbed areas;

Whether or not a substantial increase in direct mortality of wildlife caused by road kills, harassment, or other causes would occur;

Incidental take of a special-status species to the extent that such impact would threaten the viability of the local population;

Whether or not an officially-designated critical wildlife habitat was eliminated, sustained a permanent reduction in size, or was otherwise rendered unsuitable;

Whether or not any effect, direct or indirect, results in a long-term decline in recruitment and/or survival of a wildlife population; and

Construction disturbance during the breeding season or impacts to reproductive success which could result in the incidental loss of fertile eggs or nestlings, or otherwise lead to nest abandonment in accordance with regulations prescribed by the Migratory Bird Treaty Act.

H.2.7.2 Vegetation

As described in detail in Chapter N, a total of nine well fields, satellite facility, evaporation ponds and access roads will be constructed in 2014 with an expected mine life of operation of approximately five years. As shown in **Figure H.2-1**, wellfield development will be constructed in areas dominated by cultivated areas and mixed grass prairie vegetation, TCEA, Areas within Sections 28, 29, 30 and 33 T31N 52W will be developed and contain wellfields and a significant amount of project-related infrastructure.

Vegetation removal and soil handling associated with the construction and installation of well fields, pipelines, access roads, and satellite facilities would affect vegetation resources both directly and indirectly. However, since most project-related infrastructure will be constructed within cultivated agricultural fields, vegetation impacts will be negligible. If the mixed-grass prairie vegetation community were to be developed, the impacts would include those described below.

Direct impacts would include the short-term loss of vegetation (modification of structure, species composition, and areal extent of cover types) due to soil disturbance and grading activities. Indirect impacts would include the short-term and long-term increased potential for non-native species invasion, establishment, and expansion; exposure of soils to accelerated erosion; shifts in species composition and/or changes in vegetative density; reduction of wildlife habitat; and changes in visual aesthetics.

The total number of acres currently identified as having the potential for disturbance within the 1,643-acre permit area over the long-term operation of the project will be approximately 671 acres (**Table H.2-2**). Initially, the construction of the satellite building(s)/associated facilities, evaporation ponds, Mine Unit No. 1 and needed roadways would have short-term surface disturbances of approximately 100 acres (approximately 6 percent of the total permit boundary acreage). The production building and associated facilities would disturb an area of 1.8 acres (area within fence-line of production facilities) and the evaporation ponds an area of 11.6 acres (area within fence-line of ponds). These structures, except for approximately 2.23 acres of the evaporation ponds, are located within Mine Units 1, 2 and 3. **Table H.2-2** provides a breakdown of the area of disturbance by the type of habitat cover acreage.

Over the life of the project (10 years), it is currently estimated that 41 percent of total permit area acreage would be disturbed due to site development and operation. The likelihood of impact is greatest for the primary vegetation cover types of cultivated fields (384 acres) and mixed grass prairie (266 aces), which occupy approximately 97 percent of the total acreage with the potential for disturbance (671 acres). Cultivated and mixed grass prairie habitat cover (946 and 579 acres, respectively) account for 58 percent and 35 percent, respectively, of the total permit acreage of 1643 acres. There are no plans to disturb riverine and deciduous streambank forest habitat cover types within the permit boundary.

The majority of new roads are located within proposed wellfields. An existing road will serve as the entrance roadway to the production facility and offices. This road will be upgraded. Estimated acreage disturbances was based on a 40-foot wide entrance road and 20-foot wide mine unit roads. Road locations and distances can be seen in **Figure A.2-3.**

The proposed deep disposal well will be located to the east of the fenced-in area of the satellite facilities (**Figure N.2-2),** located within mixed grass prairie habitat consisting of an area of approximately 50 x 50 feet. Potential impacts are considered minimal based on the operating history of the deep disposal well located at the current CBR operating facility.

Construction activities, increased soil disturbance, and higher traffic volumes could stimulate the introduction and spread of invasive, non-native species within the TCEA. Non-native species invasion and establishment as a result of previous and current disturbance has become an increasingly concern in western States. These species often out-compete desirable species, including special-status species, rendering an area less productive as a source of forage for livestock and wildlife. Additionally, sites dominated by invasive, non-native species often have a different visual character that may negatively contrast with surrounding undisturbed vegetation. Currently, the TCEA has a relatively high level of noxious weeds and other unwanted invasive, non-native species in the areas adjacent to roads, particularly Four Mile Road (**Figure G.4-1**), but to a lesser degree in areas located farther from roads.

In general, the duration of effects on cultivated agricultural land and mixed-grass prairie vegetation are significantly different. Cropland areas can be readily returned to production through fertilizer treatments and compaction relief. However, disturbed native prairie tracts require reclamation treatments and natural succession to return to pre-disturbance conditions of diversity (both species and structural). Reestablishment of mixed-grass prairie to pre-disturbance conditions would be influenced by factors that are both climatic (growing season, temperature, and precipitation patterns) and edaphic (physical, chemical, and biological) conditions in the soil.

Previously planted agricultural fields would be recontoured to approximate pre-contours and ripped to depths of 12 to 18 inches to relieve compaction. If mixed-grass prairie tracts are disturbed by surface activities, these areas would be completely reclaimed. Reclamation of mixed-grass prairie would generally include: (1) complete cleanup of the disturbed areas (well fields and access roads), (2) restoring the disturbed areas to the approximate ground contour that existed before construction, (3) replacing topsoil, if removed, over all disturbed areas, (4) ripping disturbed areas to a depth of 12 to 18 inches, and (5) seeding recontoured areas with a locally adapted, certified weed-free seed mixture.

H.2.7.3 Surface Waters and Wetlands

Surface disturbances associated with the proposed facilities would not affect surface waters in the TCEA. Cherry Creek, an ephemeral stream, is the only potential available surface waters within the TCEA, with the creek being desiccated by man-made activities (i.e., mixed grass prairie surrounded by croplands) and without defined banks and streambed. In addition, no wetlands have been identified within the project area. Therefore, impacts to wetlands and surface waters are not anticipated.

H.2.7.4 Wildlife and Fisheries

The effects on wildlife would be associated with construction and operation of project facilities, which include displacement of members of some wildlife species, loss of wildlife habitats, and an increase in the potential for collisions between wildlife and motor vehicles. Other potential effects include a rise in the potential for illegal kill, harassment, and disturbance of wildlife because of increased human presence primarily associated with increased vehicle traffic. The magnitude of impacts to wildlife resources would depend on a number of factors, including the time of year, type and duration of disturbance, and species of wildlife present.

H.2.7.5 Small Mammals and Birds

The direct disturbance of wildlife habitat in the TCEA likely would reduce the availability and effectiveness of habitat for a variety of common small mammals, birds, and their predators. The initial phases of surface disturbance and increased noise would result in some direct mortality to small mammals, and would displace some bird species from disturbed areas. In addition, a slight increase in mortality from increased vehicle use of roads in the area would be expected.

The temporary disturbances that occur during the construction period would tend to favor generalist wildlife species such as ground squirrels and horned larks, and would have more impact on specialist species such as western meadowlarks, lark buntings, and grasshopper sparrows. Overall, the long-term disturbance of the 1,643 acre project area would have a low effect on common wildlife species. The primary songbirds that may be affected by the reduction in cultivated fields would be horned larks, sage sparrows, sage thrashers, and vesper sparrows. Although there is no way to accurately quantify these changes, the impact is likely to be low in the short term and be reduced over time as reclaimed areas begin to provide suitable habitats.

Because of the high reproductive potential of these species, they would rapidly repopulate reclaimed areas as habitats become suitable. Birds are highly mobile and would disperse into surrounding areas and use suitable habitats to the extent that they are available. The primary small mammals in the TCEA include, but are not limited to, eastern cottontail, deer mouse, thirteen-lined ground squirrel, white-footed mouse, meadow jumping mouse, and northern pocket mouse. The initial phases of surface disturbance would result in some direct mortality and displacement of small mammals from construction sites. Quantifying these changes is not possible because population data are lacking. However, the impact is likely to be low, and the high reproductive potential of these small mammals would enable populations to quickly repopulate the area once reclamation efforts are initiated.

H.2.7.6 Big Game Mammals

The principal wildlife impacts likely to be associated within the proposed project include: (1) a direct loss of certain big game habitat, most likely deer and pronghorn; (2) the displacement of these big game species; (3) an increase in the potential for collisions between wildlife and motor vehicles; and (4) an increase in the potential for the illegal kill and harassment of wildlife.

In general, direct habitat removal used by big game mammals is expected to be minimal, as the project area is predominantly used for agricultural production. Since a substantial proportion of the project area is used for seasonal crop production, only a small proportion of the available wildlife habitat in the project area would be affected. The capacity of the project area to support various big game populations should remain essentially unchanged from current conditions.

In addition to the direct removal of habitat due to the development of wells and associated satellite facilities, disturbances from drilling activities and traffic would affect wildlife use of the habitat immediately adjacent to these areas. However, big game mammals are adaptable and may adjust to non-threatening, predictable human activity. It is envisioned that most big game mammal responses will consist of avoidance of areas proximal to the operational facilities, with most individuals carrying out normal activities of feeding and bedding within adjacent suitable habitats. In addition, the magnitude of displacement would decrease over time as: (1) the animals have more time to adjust to the operational circumstances; and (2) the extent of the most intensive activities such as drilling and road building diminishes and the well fields are put into production. By the time the well fields are under full production, construction activities will have ceased, and traffic and human activities in general would be greatly reduced. As a result, this impact would be minimal and it is unlikely that big game mammals would be significantly displaced under full field development. The level of big game mammal use of the project area is more likely to be determined by the quantity and quality of forage available.

The potential for vehicle collisions with big game mammals would increase as a result of increased vehicular traffic associated with the presence of construction crews and would continue (although at a reduced rate) throughout all phases of the well field operations. Development of new roads would allow greater access to more areas and may lead to an increased potential for poaching of big game animals. However, due to the proximity to the City of Crawford and locations of farm residences in the project area, the incidence of vehicle collision impacts to big game mammals is anticipated to occur infrequently and no long-term adverse effects are expected.

Based on the foregoing, long-term adverse effects are not expected on any local big game mammal populations.

H.2.7.7 Upland Game Birds

The potential effects of the operation and maintenance of project facilities on upland game birds may include nest abandonment and reproductive failure caused by project-related disturbance and increased noise. Other potential effects involve increased public access and subsequent human disturbance that could result from new construction and production activities.

H.2.7.8 Sharp-tailed Grouse

No sharp-tailed grouse leks are known to occur within the project area. If leks were identified, reduction of noise levels in areas near leks would minimize potential impacts.

H.2.7.9 Raptors

As noted in Section G.4.6.5.3, few raptors and not nests were observed during the 2008 field survey. The potential impacts to raptors within the TCEA include: (1) temporary reductions in prey populations; and (2) mortality associated with roads.

The development of proposed well fields pads, evaporation ponds and satellite facilities would disturb an estimated 266 acres of mixed grass prairie, a potential habitat for several species of small mammals that serve as prey items for raptors. This impact would affect approximately 16 percent of the total project area, although this is not likely to be a limiting factor of raptor use within this area. The small amount of short-term change in prey base populations created by the construction activities is minimal in comparison to the overall status of the rodent and lagomorph populations. While prey populations would likely sustain some impact during the initial phase of the project, prey numbers would be expected to soon rebound to pre-disturbance levels following reclamation or active agricultural uses. Once reclaimed or in active agricultural uses, these areas would likely promote an increased density and biomass of small mammals that is comparable to those of undisturbed areas. For these reasons, implementation of the project is not expected to produce any appreciable long-term negative changes to the raptor prey base within the TCEA.

There will be no new public roads constructed. However, there will be increased traffic due to site operations on current county roads such as Four Mile Road. As use of the project area increases, the potential for encounters between raptors and humans would increase and could result in increased disturbance to nests and foraging areas. Closure to public vehicle use for roads located near active raptor nests would offset this potential impact. Some raptor species feed on road-killed carrion on and along the roads, while others (owls) may attempt to capture small rodents and insects that are illuminated in headlights. These raptor behaviors put them in the path of oncoming vehicles where they are in danger of being struck and killed. The potential for such collisions can be reduced by requiring drivers to follow all posted speed limits.

H.2.7.10 Fish and Macroinvertebrates

Suitable habitat for fish and macroinvertebrates exists within the White River and its tributaries. However, the construction, operation, and maintenance of the project are not expected to affect these habitats. There are no surface impoundments located within the permit boundary.

H.2.7.11 Threatened and Endangered Species

Eskimo Curlew

The Eskimo Curlew (*Numenius borealis*) is a relatively short, slender curlew with a slightly down curved bill. The bird's northward migrations route encompasses the eastern portion of Nebraska, but it has been reported that the curlew has migrated through all regions of the state during the months of March, April, May and June. Newly plowed fields, burned prairies and marshes are particularly attractive to migrating curlews. It feeds in the plowed fields by 8 or 9 am, and can be observed consuming grasshopper egg pods, earthworms and locusts.

In the project area, there is potential feeding habitat for the bird. Yet, there haven't been any possible or confirmed sightings within the area (AGC Nebraska Chapter 2007). It is unlikely that the bird uses the area for anything but a migratory access way. Upon review of the bird's absence in the area, it is concluded that the negotiated alternative would have no effect on the Eskimo Curlew.

Mountain Plover

The Mountain Plover is currently being considered for listing under its federal status, and it is listed as threatened in the state of Nebraska. Nebraska law provides additional protection by requiring state agencies to ensure that their actions, or actions authorized or funded by them, do not jeopardize the mountain plover (NPGC 2008d). The plover prefers nesting in arid flats in very short grass with a lot of bare ground, often times near prairie dog colonies.

There is potential habitat for the plover in southern Dawes and Sioux counties, and there been recent scattered observations in the neighboring Box Butte County (NPGC 2008d). It is possible that they may occur in isolated instances in the project area, but because prairie dogs are likely controlled and there isn't a lot of bare ground space in the area, strong plover nesting habitats are limited. Further, no nests were observed during field studies.

Because there is plover potential in the project area, measures can be taken to reduce effects to the bird. (1) Disallow construction activities during the critical nesting season: the last two weeks of April through the second week of July. (2) If construction activities cannot be avoided during these periods, a presence–absence survey of suitable Mountain Plover habitat in which ground disturbing activities are proposed would be conducted.

After review of the bird's status and potential occurrence within the TCEA, it is concluded that the proposed project with the above-referenced mitigation measures will not have adverse effects on the Mountain Plover.

Swift Fox

The swift fox is widely distributed throughout the Great Plains, and small, disjunct populations exist in the western third of Nebraska and Kansas (USFWS 1995b). High-quality swift fox habitat is present within the Oglala National Grassland, immediately northwest of the TCEA. The TCEA contains mixed-grass prairie, which is considered suitable habitat for the swift fox; however, the this area is a mosaic of grassland and cropland, which does not favor swift fox use, though this species can use areas with mixed land uses (USFWS 2001). Mixed grass prairie makes up approximately 35 percent (579 acres) of the project permit area.

Since swift fox are known to occur within the region, and suitable mixed-grass prairie habitat occurs throughout the TCEA, potential impacts may result from project implementation. Construction activities within these mixed-grass prairie habitats could affect potential swift fox denning and foraging habitats. If swift fox are denning in the immediate vicinity of a planned project facility, it is likely that construction activities would displace adults away from the den, at least during daytime periods of construction. Displacement could prevent the adults from securing adequate food for pups or prevent adults for adequately caring for their young. In addition, vehicular traffic associated with the construction and operation of project facilities could result in vehicle collisions resulting in direct mortality.

Because the potential for the displacement of swift fox from construction and operational activities exists within mixed-grass prairie, mitigation measures will be made to avoid and/or reduce such incidents.

CBR will avoid impacting the swift fox species by selecting planned areas of disturbance (including wellfields and drills sites) that are not in suitable habitat and by avoiding certain locations during specific times of the year. Surveys shall be conducted that are consistent with the Nebraska Game and Parks Commission (NG&PC) standard protocol included in CBR's Mineral Exploration Permit Number NE0210824 as Attachment 1, issued by the Nebraska Department of Environmental Quality (NDEQ) on August 19, 2009. The procedures in Attachment 1 are specific to drilling of boreholes, therefore these procedures have been expanded to include Three Crow project development activities, including construction, operational activities (e.g., wellfield development, satellite facility facilities, and access roadways) and decommissioning. The modified survey protocol to be used for the swift fox at the TCEA is presented in **Appendix 11** of Volume II of this application.

Based upon the analysis of the effects of project implementation, the current and potential status of this species in the TCEA, and more suitable habitats in the region, it is concluded that the proposed project and planned mitigation measures will result in no adverse effect on the swift fox.

Reptiles, Amphibians, and Fish

No threatened or endangered reptiles, amphibians, or fish species have been recorded in the TCEA, and none are expected to occur.

H.2.7.12 Cumulative Impacts

Cumulative impacts to ecological resources are not anticipated to occur as no substantive impairment of ecological stability or diminishment of biological diversity within the TCEA. Of the total 1,643 acres within the permit boundary, 384 acres (approximately 23 percent of the total acreage) consist of cultivated habitat (**Table H.2-2**). The mine units are comprised of approximately 380 acres of this cultivated habitat. Mixed grass prairie comprises 266 acres of the

TCEA, which is 16 percent of the total permit area acreage. The majority of this acreage (approximately 254 acres) is located with the proposed mine unit boundaries.

H.2.8 Noise Impacts of Operations

Noise sources during operation are expected to increase due to increased vehicle travel and increased numbers of employees traveling to and from the City of Crawford for work and from resin transfer to the current CPF. Train usage would not increase as a result of operation. Processing equipment at the satellite site would be minimal and is not expected to add to existing noise sources. Increases in noise levels due to operation are expected to be less than noise levels generated during construction. Therefore, it is expected that noise levels during operation would be barely perceptible over the existing ambient noise that is dominated by vehicle noise from SH 2/71 and the BSNF railroad.

H.3 Radiological Effects

An assessment of the radiological effects of the TCEA must consider the types of emissions, the potential pathways present, and an evaluation of potential consequences of radiological emissions.

The TCEA will have a production flow capacity of approximately 6000 gpm and will use fixed bed downflow ion exchange columns to separate uranium from the pregnant production fluid. The facility will also have a capacity to treat 1500 gpm of restoration solution. The restoration process will use fixed bed downflow ion exchange columns to remove the uranium and reverse osmosis to remove the dissolved solids. Waste disposal at the satellite will be via a deep injection well with a two cell evaporation pond to provide surge capacity. The loaded ion exchange resin will be transferred from the columns to a resin trailer for transport to the current CPF, for regeneration and stripping. The reclaimed resin will be transported back to the TCEA satellite and reused in ion exchange columns.

The uranium bearing regenerant in the current CPF is treated in the uranium precipitation circuit. The precipitated uranium is vacuum dried.

The only airborne radiological emission from the facility will be radon-222 (radon) gas. Radon is present in the ore body and is formed from the decay of radium-226. Radon is dissolved in the lixiviant as it travels through the ore body to a production well, where the solution is brought to the surface. The concentration of radon in the production solution is calculated using methods found in NRC Regulatory Guide 3.59, "Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations" (March 1987).

MILDOS-AREA (December 1998) was used to model radiological impacts on human and environmental receptors (e.g. air and soil) using site specific radon release estimates, meteorological and population data, and other parameters.

In the following sections, the assumptions and methods used to arrive at an estimate of the potential radiological impacts of the TCEA coupled with the current C. A detailed presentation of the source term and other MILDOS-AREA parameters is included in **Appendix 13**. The anticipated effects are compared to the naturally occurring background levels. This background radiation, arising from cosmic and terrestrial sources, as well as naturally occurring radon gas, comprises the primary radiological impact to the environment in the region surrounding the proposed project.

H.3.1 Exposure Pathways

The TCEA is an in-situ uranium facility. The only source of planned radioactive emissions from the facility is radon gas, which is dissolved in the leaching solution. Radon gas may be released as the solution is brought to the surface and processed in the satellite facility. Unplanned emissions from the site are possible as a result of accidents and engineered structure failure but are not addressed in the MILDOS-AREA modeling. A human exposure pathway diagram addressing planned and unplanned radiological emissions is presented in **Figure H.3-1.**

The facility will have pressurized downflow ion exchange columns capable of processing 6000 gpm of production solution. The satellite facility will also have ion exchange and reverse osmosis equipment with a capacity of 1500 gpm to process restoration solutions.

Within the pressurized columns, the radon will remain in solution and be returned to the formation. It will not be released to the atmosphere. There will be minor releases of radon during the air blow down prior to resin transfer to the resin trailer. The air blow down and the gas released from the vent during column filling will be vented into the exhaust manifold and discharged via the main radon exhaust stack. It is estimated that less than 10 percent of the radon contained in the process solutions will be vented to atmosphere.

In the source term calculation, Cameco estimates that 10 percent of the contained radon found in the 6000 gpm flow processed by pressurized downflow IX columns will be released to the environment.

After the IX resin is loaded it will be transferred to a resin trailer. The trailer will transfer the resin to the main process facility for additional processing. The stripped and regenerated resin will be transferred to the trailer and returned to the satellite facility and transferred into a process column. It is anticipated that two round trips will occur per day.

The injection wells will generally be closed and pressurized, but periodically vented. It is estimated that 25 percent of the radon produced in the production fluids will be released in the wellfield.

Atmospheric emissions of radon will lend its presence to all quadrants of the area surrounding the TCEA and the current CPF. Radon itself impacts human health or the environment marginally, because it is an inert noble gas. Radon has a relatively short half-life (3.8 days) and its decay products are short lived, alpha emitting, non-gaseous radionuclides. These decay products have the potential for radiological impacts to human health and the environment. **Figure H.3-1** shows all exposure pathways, with the possible exception of absorption, can be important depending on the environmental media impacted. All of the pathways related to air emissions of radon were evaluated using MILDOS-AREA.

H.3.2 Exposures from Water Pathways

The solutions in the zone to be mined will be controlled and adequately monitored to ensure that migration does not occur. The overlying aquifers will also be monitored.

The Three Crow Satellite Facility will have a two-cell surge pond used to store waste solutions, prior to deep well injection. The surge ponds will be double-lined with impermeable synthetic liners. There is a leak detection system installed to provide a warning if the liner develops a leak. The ponds, therefore, are not considered a source of liquid radioactive effluents.

The primary method of waste disposal at the TCEA will be by deep well injection. The deep well will be completed at a depth of 3500 to 4000 ft, isolated from any underground source of drinking water by approximately 1800 ft of Pierre Shale. The well will be constructed under a permit from the NDEQ and meet all requirements of the Underground Injection Control program.

The Three Crow Satellite Facility processing building will be located on a curbed concrete pad to prevent any liquids from entering the environment. Solutions used to wash down equipment will drain to a sump and be pumped to the ponds. The pad will be of sufficient size to contain the contents of the largest tank if it ruptures.

Since no routine liquid discharges of process water are expected, there are no definable water-related pathways.

H.3.3 Exposures from Air Pathways

The only source of radionuclide emissions is radon released into the atmosphere through a vent system or from the wellfields. As shown in **Figure H.3-1**, atmospheric releases of radon can result in radiation exposure via three pathways; inhalation, ingestion, and external exposure.

Based on the site specific data and the method of estimation of the source term presented in **Appendix 13**, the modeled emission rate of radon from the facility is 5446 Ci/yr which includes releases from ion exchange, production and restoration activities.

The Total Effective Dose Equivalent (TEDE) to nearby residents in the region around the TCEA, NTEA and current CPF was also estimated using MILDOS-AREA. To show compliance with the annual dose limit found in 10 CFR § 20.1301, CBR has demonstrated by calculation that the TEDE to the individual most likely to receive the highest dose from the collective site operations of the Three Crow Satellite Facility, North Trend Satellite Facility and the current CPF is less than 100 mrem per year. The results of the MILDOS-AREA simulation are presented in **Table H.3-1**. The coordinates of all receptors are listed in **Appendix 13** along with the source values and the locations of the sources. Receptor locations and appropriate identifiers are shown on **Figure H.3-2**. **Table H.3-1** shows the estimated TEDE from operation of the TCEA, current CPF and the NTEA.

No TEDE limits were exceeded. An evaluation of the TEDE follows:

1) The maximum TEDE is 32.3 mrem/yr.

2) Receptor Three Crow 1 is the closest resident in the downwind direction for the Three Crow Satellite Facility. The estimated TEDE at this location is 32.3 mrem/yr.

3) Since radon-222 is the only radionuclide emitted, public dose limits in 40 CFR §§ 190 and the 10 mrem/yr constraint rule in 10 CFR § 20.1101 are not applicable to the CBR facility.

H.3.4 Population Dose

The annual population dose commitment to the population in the region within 80 km of the Crow Butte Project (TCEA, NTEA and current CPF) is also predicted by the MILDOS-AREA code. The results are listed in **Table H.3-2**, where the dose to the bronchial epithelium is expressed in person-rem. For comparison, the dose to the population within 80 km of the facility due to natural background radiation is included in the table. These figures are based on the 1980 population and average radiation doses reported for the Western Great Plains.

The atmospheric release of radon also results in a dose to the population on the North American continent. This continental dose is calculated by comparison with a previous calculation based on a 1 kilocurie release near Casper, Wyoming, during the year 1978. The results of these calculations are included in **Table H.3-2** and also combined with dose to the region within 80 km of the facility to arrive at the total radiological effects of one year of operation at the Crow Butte Project.

For comparison of the values listed in **Table H.3-2**, the dose to the continental population as a result of natural background radiation has been estimated. This estimate is based on a North American population of 346 million and a dose to each person of 500 mrem/yr to the bronchial epithelium. The maximum radiological effect of the combined operation of the TCEA, NTEA and the current CPF would be to increase the dose to the bronchial epithelium of the continental population by 0.00057 percent.

H.3.5 Exposure to Flora and Fauna

There are two primary potential pathways for radiological exposures to flora and fauna: radon emissions and accidental spills of radiological containing fluids (e.g., lixiviant).

H.3.5.1 Radon Releases

Radon emissions at satellite uranium in situ facilities such as the proposed Three Crow Satellite Facility (i.e., no yellowcake dryer and associated facilities) are considered the primary air contaminant during operations. Radon emissions during normal operations are considered the most important pathway for exposure to flora and fauna due to deposition of Ra-222 decay products on surface water, surface soils and vegetation. The MILDOS-AREA model provides an estimate of surface deposition rate as a function of distance from the source for the Ra-222 decay products and calculates surface concentrations.

The exposure to flora and fauna was evaluated in the Environmental Report submitted in September of 1987 (Ferret Exploration Company of Nebraska, 1987) and the doses were found to be negligible. The proposed Three Crow Satellite Facility and North Trend Satellite Facility will have no measurable impact on dose to flora and fauna.

The potential exists for individual fauna (e.g., small mammals and birds) that are mobile to have contact with higher, but short-term, contact with concentrations of Ra-222 than the public due to the potential proximity to releases. However, due to the typical mobility of such animals, it is likely that individuals would receive an intermittent exposure, as opposed to a constant concentration for the entire year.

There are currently no regulatory dosimetric standards for the protection of flora and fauna, with radiological protection frameworks being traditionally focused on the protection of man. Historically, the International Commission on Radiological Protection (ICRP) has maintained a position towards human health versus non-human species with the position that protection of humans from radiation exposure implicitly ensures an adequate protection of other living organisms, therefore the environment (Brechignac, F. 2009 [ICRP 1977 and 1991]). However, the development of a system capable of ensuring adequate protection of the environment against the harmful effects of ionizing radiation is currently being debated (Brechignac, F. 2002).

H.3.5.2 Fluid Discharges

There are currently no planned discharges from the Three Crow operations, with waste waters being discharged to evaporation ponds or a Class I deep disposal well. Therefore, any fluid discharges would be associated with spills, e.g., pipeline break or leak. Spills of this type would be expected to occur within the restricted wellfield areas and between the wellfields and satellite process facility. Since the satellite processing building, fuel tanks, and chemical tanks are constructed on pads that are engineered to contain any spill from a pipe rupture, leaking vessel or inadvertent spill. Therefore, it is unlikely that any spills in the processing area would reach soils and vegetation. CBR operating procedures provide for ongoing monitoring of operational activities and for a rapid corrective action response to any spill, which would result in cleanup of the spilled material and, if applicable, removal of any contaminated soil and vegetation.

Long-term experience at CBR has shown that single-event spills typically do not cause significant contamination of soil and vegetation.

There is limited potential for wildlife or domestic animals to consume contaminated vegetation or seeds. Other than the potential for accidental spills discussed above which would be immediately assessed and cleaned up, Three Crow operations would not be expected to significantly impact food source such as vegetation and seeds that local animals depend upon.

H.4 Non-Radiological Effects

Nonradiological effects of site preparation and construction activities are discussed in Section H.1, including impacts on air quality, land use, surface water, population, social and economic, and noise impacts. Impacts on operational activities are discussed in Section H.2, including air quality, land use, soil, groundwater, surface water, ecology and noise impacts.

As discussed in Sections H.1 and H.2, overall emissions associated with equipment and facility operations during site preparation, construction and operations would be expected to be minimal and should not affect the local ambient air quality. Nonradiological emissions include NO_x, CO, SO_2, VOC and particulate matter (operating equipment and fugitive dust due to traffic on unpaved areas). During operations, a gaseous and airborne effluent will consist of air ventilated from the process building ventilation system and vented from process vessels and tanks. This gaseous effluent would primarily contain radon gas as previously discussed in Section H.3. The gaseous and airborne effluent will not contain any significant non-radiological emissions.

In addition to gaseous and airborne effluents, there would be three types of wastes generated at the proposed TCEA Satellite Facility: liquid, solid and sanitary. The operational-generated liquid wastes would be disposed of through a deep disposal well and evaporation ponds. Such liquid wastes would consist of: wellfield bleed streams; facility washdown water; groundwater restoration water; laboratory wastewaters; liquids resulting from rainwater/snow fall and spills within the curbed process areas. Accumulations of rainfall/snowmelt and any spills within the curbed bulk chemical, lubricant storage facility and the fuel diked area will be removed and disposed in accordance with the site's Spill Prevention, Containment and Countermeasure Plan. Well development water in the wellfields will be collected in dedicated tanker trucks and transported to the main satellite processing facility for disposal in the deep disposal well or evaporation ponds.

There would be no discharge from the evaporation ponds. The deep disposal well will permanently dispose of liquid wastes and will be permitted under a Class I UIC Permit issued by the NDEQ. The current Class I UIC Permit for the deep disposal well located at the current CPF implements injection limits and requires monthly monitoring for RCRA Metals to ensure that hazardous waste is not injected. Based on the monitoring for the current deep disposal well, there is no non-radiological impact expected due to the liquid effluents from the Three Crow Satellite Facility.

Solid wastes generated would consist of waste such as spent resin, resin fines, filters, miscellaneous pipe and fittings, and domestic waste. These wastes are classified as contaminated or noncontaminated waste according to radiological survey results. Contaminated byproduct waste that cannot be decontaminated is packaged and stored until it can be shipped to a licensed waste disposal site or licensed mill tailings facility. Non-contaminated solid waste is collected on the site on a regular basis and disposed of in a sanitary landfill permitted by the NDEQ. No significant non-radiological impacts associated with management of relative small quantities of solid wastes would be expected.

The TCEA is expected to only generate a small amount of hazardous waste and is expected to be classified as a Conditionally Exempt Small Quantity Generator. The potential for any adverse impacts due to the handling and disposal of hazardous waste would be minimal due to the small quantities handled and operational procedures in CBR's *EHSMS Program Volume VI, Environmental Manual.* The EHSMS document is reviewed annually and the sections updated as required.

Sanitary liquid waste will be disposed of in an on-site wastewater treatment system (i.e., septic) permitted by the NDEQ under the Class V Underground Injection Control (UIC) Regulations. Periodic removal of septic tank solids will be performed by companies or individuals licensed for such activities by the State of Nebraska. There have been no problems associated with operating a similar sanitary system at the current commercial operating facility, and no problems would be expected for the Three Crow operations.

For any spill, the free liquids would be recovered and any contaminated soils would be removed and placed in an offsite disposal site approved for the type of waste generated. Spills are also discussed in Section H.5.

In summary, the design and construction of the Three Crow Satellite Facility will concentrate on minimizing the potential for releases of nonradiological waste materials. For example, CBR will use diking or flow cut-off and flow isolation procedures and equipment for radiological and nonradiological spill control. A quality assurance and quality control system will be used, which would involve pre-operational testing of equipment, periodic testing and regular inspection of equipment (e.g., pipelines, manifolds), and associated monitoring on line flows and pressures with automatic shutdowns in response to flow or pressure changes. Consequently, any spills should be small with little impacts on the environment. For any spill, the free liquids would be recovered and disposed of in the deep disposal well or evaporation ponds and any contaminated soils would be removed and placed in an offsite disposal site approved for the type of waste generated.

H.5 Effects of Accidents

Accidents involving human safety associated with the in-situ uranium mining technology typically have far less severe consequences than accidents associated with underground and open pit mining methods. In-situ mining provides a higher level of safety for personnel and neighboring communities when compared to conventional mining methods or other energy-related industries. Accidents that may occur would generally be quite minor when compared to other industries, such as an explosion at an oil refinery or chemical plant. Radiological accidents that might occur are easily detected and mitigated. The remote location of the facility and the low level of radioactivity associated with the process both decrease the potential hazard of an accident to the general public.

NRC has previously evaluated the effects of accidents at uranium milling facilities in NUREG–0706 and specifically at in situ leach facilities in NUREG/CR-6733 (NRC 1980a, CNWRA 2001). These analyses demonstrate that, for most credible potential accidents, consequences are minor so long as effective emergency procedures and properly trained personnel are used. The CBR emergency management procedures contained in CBR's Environmental, Health, Safety and Management System (EHSMS) Program Volume VIII, *Emergency Manual,* have been developed to implement the recommendations contained in the NRC analyses. Training programs contained in CBR's EHSMS Volume VII, *Training Manual,* have been developed to ensure that CBR personnel have been adequately trained to respond to all potential emergencies. CBR's EHSMS Program Volume II, *Management Procedures,* requires periodic testing of emergency procedures and training by conducting drills.

NUREG-0706 considered the environmental effects of accidents at single and multiple uranium milling facilities. Analyses were performed on incidents involving radioactivity and classified these incidents as trivial, small, and large. NUREG-0706 also considered transportation accidents. Some of the analyses in NUREG-0706 are applicable to ISL facilities, such as transportation accidents; however, much of the analyses do not apply due to the significantly different mining and processing methods. ISL facilities do not handle large quantities of radioactive materials such as crushed ore and tailings, so the quantity of material that could be affected by an incident is significantly less than at a mill site.

NUREG/CR-6733 specifically addressed risks at ISL facilities and identified the following "risk insights".

H.5.1 Chemical Risk

Of the highly hazardous chemicals, toxics, and reactives listed in Appendix A to 29 CFR §1910.119, none will be used at the Three Crow Satellite Facility. As a satellite facility, Three Crow will use oxygen, carbon dioxide, and sodium bicarbonate for addition to the injection solution. Sodium sulfide may be used as a reductant during groundwater restoration activities. All other operations requiring process chemicals described in NUREG/CR-6733 will be performed at the Central Processing Facility.

Crow Butte construction, operating, and emergency procedures have been developed to implement the codes and standards that regulate hazardous chemical use.

H.5.1.1 Oxygen

Oxygen presents a substantial fire and explosion hazard. The design and installation of the oxygen storage facility is typically performed by the oxygen supplier and meets applicable industry standards. As currently practiced at the Central Processing Facility, CBR will install wellfield oxygen distribution systems at the Three Crow site. Combustibles such as oil and grease will burn in oxygen if ignited. CBR ensures that all oxygen service components are cleaned to remove all oil, grease, and other combustible material before putting them into service. Acceptable cleaning methods are described in CGA G-4.1 (CGA 1996). Construction of oxygen systems in the wellfield are covered by procedures contained in CBR's EHSMS Program Volume III, *Operations Manual*. Emergency response instructions for a spill or fire involving oxygen systems are contained in CBR's EHSMS Program Volume VIII, *Emergency Manual*.

H.5.1.2 Carbon Dioxide

The primary hazard associated with the use of carbon dioxide is concentration in confined spaces, presenting an asphyxiation hazard. Bulk carbon dioxide facilities are typically located outdoors and are subject to industry design standards. Floor level ventilation and carbon dioxide monitoring at low points is currently performed at the current CPF to protect workers from undetected leaks of carbon dioxide. Operation of carbon dioxide systems is currently covered by procedures contained in CBR's EHSMS Program Volume III, *Operations Manual*. Emergency response instructions for a leak involving carbon dioxide are contained in CBR's EHSMS Program Volume VIII, *Emergency Manual*.

H.5.1.3 Sodium Bicarbonate

Sodium carbonate is primarily an inhalation hazard. CBR typically uses soda ash and carbon dioxide to prepare sodium carbonate for injection in the wellfield. Soda ash storage and handling systems are designed to industry standards to control the discharge of dry material. Operation of sodium carbonate systems is currently covered by procedures contained in CBR's EHSMS Program Volume III, *Operations Manual*. Emergency response instructions for a spill involving sodium carbonate or soda ash are contained in CBR's EHSMS Program Volume VIII, *Emergency Manual*.

H.5.2 Radiological Risk

H.5.2.1 Tank Failure

A spill of the materials contained in the process tanks at the Three Crow Satellite Facility will present a minimal radiological risk. Process fluids will be contained in vessels and piping circuits within the processing building. Oxygen, hydrogen peroxide, carbon dioxide propane and fuel will be stored in outside storage tanks. The tanks at the Three Crow Satellite Facility will contain injection and production solutions and ion exchange resin. Elution, precipitation, and drying will be performed at the central processing facility. The satellite facility will be designed to control and confine liquid spills from tanks should they occur. The facility building structure and concrete curb will contain the liquid spills from the leakage or rupture of a process vessel and will direct any spilled solution to a floor sump. The floor sump system will direct any spilled solutions back into the facility process circuit or to the waste disposal system. Bermed areas, tank containments, or double-walled tanks will perform a similar function for process vessels located outside the satellite building.

All tanks will be constructed of fiberglass or steel. Instantaneous failure of a tank is unlikely. Tank failure would more likely occur as a small leak in the tank. In this case, the tank would be emptied to at least a level below the leaking area and repairs or replacement made as necessary.

H.5.2.2 Facility Pipe Failure

The rupture of a pipeline within the satellite processing area is easily visible and can be repaired quickly. Spilled solution will be contained and removed in the same fashion as for a tank failure.

Response procedures for the radiological risk from releases are currently contained in CBR's EHSMS Volume VIII, *Emergency Manual*. These procedures also provide instructions for emergency notification including notification to NRC in compliance with the requirements of 10 CFR 20.2202 and 20.2203.

H.5.3 Groundwater Contamination Risk

H.5.3.1 Lixiviant Excursion

Excursions of lixiviant at ISL facilities have the potential to contaminate adjacent aquifers with radioactive and trace elements that have been mobilized by the mining process. These excursions are typically classified as horizontal or vertical. A horizontal excursion is a lateral movement of mining solutions outside the exempted portion of the ore-body aquifer. A vertical excursion is a movement of ISL fluids into overlying or underlying aquifers.

CBR controls lateral movement of lixiviant by maintaining wellfield production flow at a rate slightly greater than the injection flow. This difference between production and injection flow is referred to as process bleed. The bleed solution is either recycled in the processing facility or is sent to the liquid waste disposal system. When process bleed is properly distributed among the many mining patterns within the Mine Unit, the wellfield is said to be balanced.

CBR monitors for lateral movement of lixiviant using a horizontal excursion monitoring system. This system consists of a ring of monitor wells completed in the same aquifer and zone as the injection and production wells. The current NRC License and NDEQ Class III UIC Permit require that Chadron aquifer monitor wells be located no more than 300 feet from the nearest mineral production wells and no more than 400 feet from each other. These spacing requirements have proven effective for monitoring horizontal excursions at Crow Butte and will be employed at the Three Crow Satellite Facility. Monitor wells are sampled biweekly for approved excursion indicators. CBR proposes to implement the current approved excursion monitoring program at the Three Crow Satellite Facility. The program is discussed in detail in Chapter Q.

Section H.2.5 provided a discussion of horizontal excursions reported at the current Crow Butte operation. The historical experience indicates that the selected indicator parameters and UCLs allow detection of horizontal excursions early enough that corrective action can be taken before water quality outside the exempted aquifer boundary is significantly degraded. As noted in NUREG/CR-6733, significant risk from a horizontal excursion would occur only if it persisted for a long period without being detected (NRC 2000).

Vertical excursions can be caused by improperly cemented well casings, well casing failures, improperly abandoned exploration wells, or leaky or discontinuous confining layers. CBR controls vertical excursions through aquifer testing programs and rigorous well construction, abandonment, and testing requirements. Aquifer testing is conducted before mining wells are installed to detect any leaks in the confining layers. Aquifer test reports are submitted to the NDEQ for review and approval before well construction activities may proceed. Well construction and integrity testing is conducted in accordance with NDEQ regulations contained in Title 122 and methods approved by NRC and NDEQ. Construction and integrity testing methods are discussed in detail in Chapter N. Well abandonment is conducted in accordance with methods approved and monitored by the NDEQ and discussed in detail in Chapter T. Procedures for these activities are contained in CBR's EHSMS Program Volume III, *Operating Manual.*

CBR monitors for vertical excursions in the overlying aquifers using shallow monitor wells. These wells are located within the wellfield boundary at a density of one well per four acres. Shallow monitor wells are sampled biweekly for approved excursion indicators. CBR proposes to implement the current approved excursion monitoring program at the Three Crow Satellite Facility. The program is discussed in detail in Chapter Q.

H.5.3.2 Pond Failure

An accident involving a leak in a pond is detectable either from the regular visual inspections or through monitoring the leak detection system. The current pond operation and inspection program is contained in CBR's EHSMS Program Volume VI, *Environmental Manual,* and consists of daily, weekly, monthly and quarterly inspections in conjunction with an annual technical evaluation of the pond system. The CBR monitoring program was developed to meet the guidance contained in NRC Regulatory Guides 3.11 and 3.11.1 (NRC 1977 and 1980b). Any time six inches or more of fluid is detected in the standpipes, it is analyzed for specific conductance. If the water quality is degraded beyond the action level, it is sampled again and analyzed for chloride, alkalinity, sodium, and sulfate. In addition, monitor wells are installed downgradient of the pond in the first water bearing zone. These monitor wells are sampled and analyzed for the excursion parameters on a quarterly basis. The pond operation and monitoring program was discussed in detail in Section Q.6.

In the event of a leak, the contents of any one pond can be transferred to another pond cell while repairs are made. Freeboard requirements may be waived during this period. Catastrophic failure of a pond embankment is unlikely given the design and inspection requirements of the pond and the freeboard limitations.

H.5.4 Wellfield Spill Risk

The rupture of an injection or recovery line in a wellfield, or a trunkline between a wellfield and the Three Crow Satellite Facility would result in either a release of barren or pregnant lixiviant solution, which would contaminate the ground in the area of the break. All piping from the satellite facility, to and within the wellfield will be buried for frost protection. Pipelines are constructed of PVC, high density polyethylene (HDPE) with butt welded joints, or equivalent. All pipelines are pressure tested at operating pressures prior to final burial and production flow and following maintenance activities that may affect the integrity of the system.

Each mine unit will have a number of wellhouses where injection and production wells will be continuously monitored for pressure and flow. With the control system currently employed at current CPF, individual wells may have high and low flow alarm limits set. All monitored parameters and alarms will be observed in the satellite control room via the computer system. In addition, each wellfield building will have a “wet building” alarm to detect the presence of any liquids in the building sump. High and low flow alarms have been proven effective at the current operation in detection of significant piping failures (e.g., failed fusion weld).

Occasionally, small leaks at pipe joints and fittings in the wellhouses or at the wellheads may occur. Until remedied, these leaks may drip process solutions onto the underlying soil. CBR currently implements a program of continuous wellfield monitoring by roving wellfield operators and required periodic inspections of each well that is in service. Based on experience from the current operation, small leaks in wellfield piping typically occur in the injection system due to the higher system pressures. These leaks seldom result in soil contamination based on monitoring using field survey instruments and soil samples for radium-226 and uranium. Following repair of a leak, CBR procedures require that the affected soil be surveyed for contamination and the area of the spill documented. If contamination is detected, the soil is sampled and analyzed for the appropriate radionuclides. Contamination may be removed as appropriate.

H.5.5 Transportation Accident Risk

Transportation of materials to and from the Three Crow Satellite Facility can be classified as follows:

Shipments of process chemicals or fuel from suppliers to the site.

Shipment of radioactive waste from the site to a licensed disposal facility.

Shipments of uranium-laden resin from the satellite facility to the central processing facility and return shipments of barren, eluted resin from the current CPF back to the Three Crow Satellite Facility.

The first two types of transportation risks do not present an increase over the risks associated with operation of the current Crow Butte facility since production from Three Crow is planned to replace declining production at the current facility. The shipment of loaded ion exchange resin from Three Crow and the return of barren, eluted resin represent an additional transportation risk that was not considered for the current operation.

NUREG-0706 concluded that the probability of a truck accident in any year is 11 percent for each uranium extraction facility or mill. This calculation used average accident probabilities (4.0×10^{-7}/km for rural interstate, 1.4×10^{-6}/km for rural two-lane road, and 1.4×10^{-6}/km for urban interstate) that NUREG/CR-6733 determined were conservative with respect to probability distributions used in a later NRC transportation risk assessment (CNWRA 2001). For Three Crow, uranium-loaded and barren resin will be routinely transported by tank truck from the satellite facility to the central processing facility. For the Crown Point site, NRC determined that the probability of an accident involving such a truck was 0.009 in any year (NRC 1997).

Accident risks involving potential transportation occurrences and mitigating measures are discussed below:

H.5.5.1 Accidents Involving Shipments of Process Chemicals

Based on the current production schedule and material balance, it is estimated that approximately 150 bulk chemical deliveries per year will be made to the Three Crow Satellite Facility. This averages about one truck per working day for delivery of chemicals throughout the operational life of the project. Types of deliveries include carbon dioxide, oxygen, bicarbonate, hydrogen peroxide and soda ash.

H.5.5.2 Accidents Involving Radioactive Wastes

Low level radioactive 11(e)2 by-product material or unusable contaminated equipment generated during operations will be transported to an approved licensed disposal site. Because of the low levels of radioactive concentration involved, these infrequent shipments are considered to have minimal potential impact in the event of an accident.

H.5.5.3 Accidents Involving Resin Transfers

One of the potential additional risks associated with operation of a satellite facility is the transfer of the ion exchange resin to and from the satellite facility.

Resin will be transported to and from the Three Crow Satellite Facility in a 4,000 gallon capacity tanker trailer. It is currently anticipated that one load of uranium-laden resin will be transported to the Crow Butte central processing facility for elution and one load of barren eluted resin will be returned to the Three Crow Satellite Facility on a daily basis.

The transfer of resin between the two sites will occur on county and private roads. The planned transport route has been designed to avoid travel on U.S. Highway 20 and Nebraska State Highway 2/71. The planned transport route will cross these two highways. The route that will be used for resin transfer from the Three Crow Satellite Facility to the current CPF (9.1 miles) is discussed in Section H.2.1.

Resin or eluate shipments will be treated similarly to yellowcake shipments in regards to Department of Transportation (DOT) and NRC regulations. Shipments will be handled as Low Specific Activity (LSA) material for both uranium-laden and barren eluted resin. Pertinent procedures include:

The resin, either loaded or eluted, will be shipped as "Exclusive Use Only". This will require the outside of each container or tank to be marked "Radioactive LSA" and placarded on four sides of the transport vehicle with "Radioactive" diamond signs.

A bill of lading will be included for each shipment (including eluted resin). The bill of lading will indicate that a hazardous cargo is present. Other items identified shall be the shipping name, ID number of the shipped material, quantity of material, the estimated activity of the cargo, the transport index and the package identification number.

Before each shipment of loaded or barren eluted resin, the exterior surfaces of the tanker will be surveyed for alpha contamination. In addition, gamma exposure rates will be obtained from the surface of the tanker and inside the cab of the tractor. All of the survey results will appear on the bill of lading.

Licensed and trained CBR drivers will transport the resin between the Three Crow Satellite Facility and the central processing facility.

Crow Butte's current emergency response plan for yellowcake and other transportation accidents to or from the Crow Butte site is contained in CBR's EHSMS Program Volume VIII, *Emergency Manual*. This plan will be expanded to include an emergency resin transfer accident procedure. Personnel at both the Three Crow Satellite Facility and the current CPF will receive training for responding to a resin transfer transportation accident.

Currently, Crow Butte Resources intends to treat the eluted resin the same as the uranium loaded resin. It is possible that the eluted resin may be clean enough to be transported as non-radioactive material, as defined by DOT regulations. Operating experience will aid in the determination of the most practical and efficient way of dealing with the shipment of barren resin. Regardless, compliance with all applicable DOT and NRC regulations will be the primary determining factor.

The worst case accident scenario involving resin transfer transportation would be an accident involving the transport truck and tanker trailer when carrying uranium laden resin where all of the tanker contents were spilled. Because the uranium is ionically-bonded to the resin and the resin is in a wet condition during shipment, the radiological and environmental impacts of such a spill are minimal. The radiological or environmental impact of a similar accident with barren, eluted resin would be very minor. The primary environmental impact associated with either accident would be the salvage of soils impacted by the spill area and the subsequent damage to the topsoil and vegetation structure. Areas impacted by the removal of soil would be revegetated.

In the event of a transportation accident involving the resin transfer operation, CBR will institute its emergency response plan for transportation accidents. To minimize the impacts from such an accident, the following procedures will be followed:

Each resin hauling truck will be equipped with a radio which can communicate with either the Crow Butte central processing facility or the Three Crow Satellite Facility. In the event of an accident and spill, the driver can radio to both sites to obtain help.

A check-in and check-out procedure will be instituted where the driver will call the receiving facility prior to departure from his location. If the resin shipment fails to appear within a set time, a crew would respond and search for this vehicle. This system will assure reasonably quick response time in the case that the driver is incapacitated in the accident.

Each resin transport vehicle will be equipped with an emergency spill kit which the driver can use to begin containment of any spilled material.

Both the satellite and central process facilities will be equipped with emergency response packages to quickly respond to a transportation accident.

Personnel at the satellite and central process facilities as well as the designated truck drivers will have specialized training to handle an emergency response to a transportation accident.

H.5.6 Natural Disaster Risk

NUREG/CR-6733 considered the potential risks to an ISL facility from natural disasters. Specifically, the risk from an earthquake and a tornado strike were analyzed. NRC determined that the primary hazard from these natural events was from dispersal of yellowcake from a tornado strike and failure of chemical storage facilities and the possible reaction of process chemicals during either event. NUREG/CR-6733 recommended that licensees follow industry best practices during design and construction of chemical facilities. CBR is committed to following these standards.

The project area along with most of Nebraska is in seismic risk Zone 1. Most of the central United States is within seismic risk Zone 1 and only minor damage is expected from earthquakes that occur within this area. Seismology was discussed in detail in Section E.4.

The Crow Butte operation is located in an area that is subject to tornadoes. CBR emergency procedures currently contained in CBR's EHSMS Program Volume VIII, *Emergency Manual,* provide instructions for response and mitigation of natural disasters and spills or radioactive materials.

H.6 Economic and Social Effects of Construction and Operation

The preliminary evaluation of socioeconomic impacts of the commercial facility was completed in 1987 as reported in the original commercial license application. The preliminary evaluation was divided into two phases – construction and operation. The evaluation concluded that the construction phase would cause a moderate, positive impact to the local economy, resulting from the purchases of goods and services directly related to construction activities. Impacts to community services such as roads, housing, schools, and energy costs would be minor or non-existent and temporary.

Since the inception of the operational phase, the overall effect of the current commercial facility operations on the local and regional economy has been beneficial. Purchases of goods and services by the mine and mine employees contribute directly to the economy. Local, state, and the federal governments benefit from taxes paid by the mine and its employees. Indirect impacts, resulting from the circulation and recirculation of direct payments through the economy, are also beneficial. These economic effects further stimulate the economy, resulting in the creation of additional jobs. Beneficial impacts to the local and regional economy provided by the current operation would continue for the life of the mine, estimated to be an additional nine years as of January 2010. However, the positive impacts from the current operation will begin to decline as reserves are depleted in the next five years.

The current mine operation has not resulted in any significant impact to the community infrastructure (including schools, roads, water and sewage facilities, law enforcement, medical facilities, and any other public facility) in the City of Crawford or in Dawes County. As discussed in further detail below, the mine currently employs a workforce of approximately 67 employees and 14 contractors. The majority of these employees are hired from the surrounding communities.

In summary, monetary benefits accrue to the community from the presence of the Crow Butte Project. Against these monetary benefits are the monetary costs to the communities involved, such as those for new or expanded schools and other community services. While it is not possible to arrive at an exact numerical balance between these benefits and costs for any one community, or for the project, because of the ability of the community and possibly the project to alter the benefits and costs, this section summarizes the economic impact of the project to date and projects the incremental impacts from operation of the proposed Three Crow Satellite Facility.

H.6.1 Tax Revenues

Table H.6-1 summarizes the recent tax revenues from the Crow Butte project in U.S. Dollars.

Future tax revenues are dependent on uranium prices which cannot be forecast with any accuracy; however, these taxes are also somewhat dependent on the number of pounds of uranium produced by CBR. Spot market values for U_3O_8 peaked at about $125 per pound in 2007 have since fallen to around $40.75 per pound as of June 21, 2010 (UxC 2010). It is likely that market values will not return to the 2007 high in the near future and that future tax revenues will more likely be representative of 2008 and 2009 levels.

The present taxes are based on a relatively consistent production rate of 800,000 pounds per year. The additional production from the Three Crow Satellite Facility should be about 600,000 pounds per year. This additional production will eventually be offset by declining production from the current CPF; however, the incremental contribution to taxes would be on the order of $1.0 million to $1.2 million per year in combined taxes.

It is anticipated that the transition from operations at the current permitted CBR facilities to the proposed Three Crow and North Trend Satellite operations would allow the uninterrupted continuation of these contributions towards the funding of Dawes County government subdivisions. Beneficiaries of CBR contributions to the General Fund, and therefore to Dawes County government subdivisions, include school districts, fire districts, county and municipal government agencies, and the White River Natural Resource District. Assuming uranium prices remain consistent with recent 2008-2009 prices, CBR tax revenue contributions from the proposed project are likely to account for a proportion of annual contributions of tax revenues to state funds similar to the levels from current operations.

H.6.2 Temporary and Permanent Jobs

H.6.2.1 Current Staffing Levels

CBR currently employs approximately 67 employees and 2 contractors employing 14 people on a full-time basis. Short-term contractors and part time employees are also used for specific projects and/or during the summer months and may add up to 10 percent to the total staffing. This level of employment is significant to the local economies. Total employment in Dawes County in November 2008 was 4,747 out of a total labor force of 4,833 (BLS 2010). Based on these statistics, CBR currently provides approximately 1.5 percent of all employment in Dawes County. In 2008, CBR's total payroll was over $3,941,000. Of the total Dawes County wage and salary payments of $86,633,000 in 2008, the CBR payroll represented about 5 percent.

Total CBR payroll for the past five years was:

2005	$2,382,000
2006:	$2,543,000
2007	$3,822,000
2008	$3,941,000
2009	$4,216,870*

*Estimate

The average annual wage for all workers in Dawes County was $49,167 for 2008. By way of comparison, the average wage for CBR was about $58,821. Entry-level workers for CBR earn a minimum of $16.15 per hour or $33,600 per year, not including overtime, bonus or benefits.

H.6.2.2 Projected Short-Term and Long-Term Staffing Levels

CBR expects to supplement the existing workforce for the proposed Three Crow operation with an additional 10 to 12 full time employees, 4 to 7 full time contractor employees, and 10 to 15 part time employees and short-term contractors for construction activities. The full- and part-time employees will be needed for the satellite facility and wellfield operator and maintenance positions. Contractor employees (i.e., drilling rigs) may also increase by four to seven employees depending on the desired production rate. It is anticipated that the majority of the proposed Three Crow full time and part time workforce and contractors would be available from the current labor force in Dawes County. As of January, 2009, total unemployment in Dawes County was 216 individuals or 4.5 percent of the total work force of 4,799 (BLS 2010). CBR expects that any new positions will be filled from this pool of available labor. These additional positions should increase payroll by about $40,000 per month, or $400,000 to $480,000 per year.

CBR actively pursues a policy of hiring and training local residents to fill all possible positions. Due to the technical skills required for some positions, a small percentage of the current mine staff (less than five percent) have been hired elsewhere and relocated to the area. Because of the small number of people who have needed to move into the area to support this project, the impact on the community in terms of expanded services has been minimal.

Because skills and services required for the proposed Three Crow project would be available in the existing local labor force, it is not anticipated that the proposed project would require the migration of additional workers into nearby communities of the City of Crawford and City of Chadron, or unincorporated Dawes County. In the event that proposed project requirements for specialized skills could not be met with the current workforce or local labor force, a small number of workers could be hired from outside of Dawes County. However, any such labor needs would be a negligible change in the population of Dawes County. It is not anticipated that there would be any change in the local population from implementation of the proposed project.

Because no changes in employment or population are anticipated as a direct result of implementation of the Proposed Action, no impacts to housing availability, including public housing, are expected. There would be no short- or long-term employees that would require temporary housing; therefore the proposed project would not affect the lodging capacities of nearby communities.

There would be no noticeable increase in the local population from the construction, operation, and maintenance of the proposed project; consequently, there would be no increase in the need for law enforcement and fire safety, medical facilities, public schools, grocery stores, or other community resources in Dawes County.

No increases in existing levels of domestic water usage in Dawes County are expected, nor are effects to existing domestic water facilities anticipated from an increase in population. In addition, the water requirements of the Three Crow construction and operations would not affect municipal water systems.

Electricity, water, propane and other fuel, sanitary water, wastewater treatment required for construction and operations will be provided by the utilities that currently provide these services to existing CBR operations. The proposed project may increase the quantities of electricity, water, propane and other fuel consumed by CBR activities for a limited period of time during because operations at Three Crow, would commence as production from the current CPF is winding down. However, the scope of production at Three Crow would be similar to current operations in the Crow Butte Permit Area. It is anticipated that fuel and utility requirements would also be similar. No substantial increases are likely for new operations at the Three Crow project over existing operational uses.

It is not anticipated that construction activities would increase costs to other customers supplied by the affected utilities, or increase the requirement for utility services beyond the capacities of the providers. There would be no substantial uses of electricity for construction activities. Fuel would continue to be provided by local suppliers. There would be no interruption of fuel deliveries to other customers from increased propane, diesel and gasoline usage at Three Crow construction sites.

The Solid Waste Agency of North West Nebraska currently has the capacity for approximately 99 years of service, and would not be affected by the receipt of construction waste or trash from Three Crow site. Other wastes are managed on site by CBR. Provision of waste services by local waste disposal providers would not be affected, as wastes are managed on-site by CBR.

H.6.3 Impact on the Local Economy

It is anticipated than the monetary benefits and costs from the Three Crow operations would be similar to current CPF operations. In addition to providing a significant number of well-paid jobs in the local communities of the Cities of Crawford, Harrison, and Chadron, Nebraska, CBR actively supports the local economies through purchasing procedures that emphasize obtaining all possible supplies and services that are available in the local area.

Total CBR payments made to Nebraska businesses for the past five years were:

2005	$4,570,000
2006	$4,396,000
2007	$5,167,000
2008	$7,685,000
2009	$7,838,700

The vast majority of these purchases were made in the City of Crawford and Dawes County. This level of business is expected to continue and should increase somewhat with the addition of expanded production from the Three Crow Satellite Facility, although not in strict proportion to production. While there are some savings due to some fixed costs (current CPF utilities for instance), there are additional expenses that are expected to be higher (i.e., wellfield development for the proposed satellite facilities). Therefore, it can be estimated that the overall effect on local purchases will be proportional to the number of pounds produced. Local purchases that will be made annually for Three Crow operations are estimated to be $3.7 to $4.4 million. Most of these purchases will continue to be made in the City of Crawford and Dawes County. In addition, mineral royalty payments accrue to local landowners. Production royalties of $325,000 were paid to land owners in 2009. Additional royalty payments would be made to TCEA land owners. Most of the landowners are residents of the Dawes County; therefore beneficial impacts to county revenues and local businesses were accrued through the spending and circulation of these dollars in the local economy.

H.6.4 Economic Impact Summary

As discussed in this section, the Crow Butte Project currently provides a significant economic impact to the local Dawes County economy. Approval of this license amendment request would have a positive impact on the local economy as summarized in **Table H.6-2**. Approval of the proposed TCEA License Amendment would continue the current economic impact through the anticipated end of production (2020). The Proposed Action requires no in-migrating workforce from outside of the local area that currently provides the CBR labor force (primarily communities in Dawes County). Consequently, no increases in housing or community service demands would occur, and existing and planned facilities would not be adversely affected.

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NRC. 2009. Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities. NUREG – 1910. Washington, D.C. May 2009.

Table H.2-1 Crow Butte Resources Excursion Summary

Monitor Well ID	Date On Excursion	Date Off Excursion	Causal Factor(s)
SM4-5	January 25, 1995	March 9, 1995	Poor Well Development
SM4-2	April 2, 1995	March 13, 1996	Poor Well Development
SM4-7	December 27, 1995	March 13, 1996	Poor Well Development
I-196	March 29, 1996	August 19, 1999	Casing Leak
I-752	November 8, 1996	May 7, 1997	Casing Leak
SM6-26	March 19, 1998	No record available	High Water Table
CM6-6	July 1, 1999	September 23, 1999	Excursion of mining solutions
I-567	September 20, 1999	October 12, 1999	Casing Leak
PR-15	January 13, 2000	March 23, 2000	Mine Unit 1 interior monitor well affected by adjacent groundwater restoration (unrelated to mining activities)
SM6-18	March 6, 2000	April 11, 2001	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
IJ-13	April 20, 2000	July 20, 2000	Mine Unit 1 interior monitor well affected by adjacent groundwater restoration (unrelated to mining activities)
SM7-23	April 27, 2000	January 13, 2004	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-28	May 25, 2000	June 22, 2000	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-13	May 25, 2000	July 20, 2000	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-12	September 8, 2000	November 2, 2000	Surface leak
SM6-13	March 1, 2001	April 12, 2001	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM7-23	December 4, 2001	January 9, 2004	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
CM5-11	September 10, 2002	June 3, 2003	Excursion of mining solutions
CM6-7	April 4, 2002	April 25, 2002	Excursion of mining solutions

Table H.2-1 Crow Butte Resources Excursion Summary

Monitor Well ID	Date On Excursion	Date Off Excursion	Causal Factor(s)
PR-8	December 23, 2003	Ongoing	Mine Unit 1 interior monitor well affected by adjacent groundwater restoration (unrelated to mining activities)
CM5-19	May 2, 2005	July 26, 2005	Excursion of mining solutions
SM6-28	June 16, 2005	July 5, 2005	High water table due to heavy spring rains (unrelated to mining activities)
SM6-12	June 27, 2005	July 26, 2005	High water table due to heavy spring rains (unrelated to mining activities)
CM9-16	August 4, 2005	November 8, 2005	Excursion of mining solutions
CM8-21	January 18, 2006	April 4, 2006	Excursion of mining solutions
PR-15	September 26, 2006	Ongoing	See IJ-13 and PR-8
CM9-5	May 15, 2008	June 24, 2008	Excursion of mining solutions
CM9-3	May 30, 2008	July 15, 2008	Excursion of mining solutions
SM6-20	April 27, 2009	August 25, 2009	Excursion of mining solutions
CM9-4	June 11, 2009	July 21, 2009	Excursion of mining solutions
SM6-20	March 16, 2010	Ongoing	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM8-6	April 13, 2010	Ongoing	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)

Table H.2-2 Acres Disturbed by Three Crow Satellite Facility, Evaporation Ponds, Wellfields and Roads

Disturbed Area	Type of Habitat Cover				Total
	Cultivated	Mixed Grass Prairie	Range Rehabilitation	Structure Biotype	
	Acres				
Mine Units (9)	379.87	253.94	3.52	8.86	646.12
Satellite Facilities (Inside Mine Unit (MU) boundary)	--	1.8	--	--	1.8
Evaporation Ponds (Inside MU Boundary)	0.03	5.52	--	6.0	11.6
Evaporation Ponds (Outside MU boundary)	--	0.46	--	1.77	2.23
Roadways (inside MU boundary)	4.14	3.10	--	--	7.24
Roadways (outside MU boundary)	0.1	1.17	1.01	--	2.28
Total Disturbed Acres	384.14	265.99	4.53	16.63	671.3

Note: The Satellite Facilities, roadways and a major part of the evaporation ponds are located within mine units. Therefore, the disturbance acreages associated with these assets are subtracted from the mine unit acreages and listed separately. Disturbances outside of the mine units are listed separately.

Table H.3-1 Estimated Total Effective Dose Equivalent (TEDE) to Receptors Near the Crow Butte Uranium Processing Facility

Receptor #	Description	Distance from Main Facility (km)	TEDE* (mrem/y)
1	R1	1.3	5.6
2	R2	2.8	4.1
3	R3	3.3	5.2
4	R4	4.4	2.7
5	R5	5.4	2.8
6	Crawford	6.3	2.6
7	R7	4.4	4.6
8	R8	4.1	4.7
9	R9	3.6	6.5
10	R10	3.0	11.2
11	R11	3.3	6.0
12	R12	2.4	13.6
13	R13	1.5	22.1
14	R14	1.1	23.0
15	R15	0.6	26.3
16	R16	1.3	7.6
17	R17	1.4	4.8
18	Ehlers	0.7	11.1
19	Gibbons	1.0	21.3
20	Stetson	1.3	15.6
21	Knode	3.3	5.2
22	Brott	1.9	10.6
23	SP1	0.8	13.9
24	SP2	0.9	22.2
25	SP3	1.1	20.8
26	McDowell	4.9	4.2
27	Taggart	4.8	4.6
28	Franey	4.9	5.8
29	Bunch	4.4	6.5
30	Dyer	2.5	2.9
31	NT-1	12.0	6.3
32	NT-2	9.8	3.9
33	NT-3	9.2	3.7
34	NT-4	8.9	3.0
35	NT-5	8.2	3.1
36	NT-6	13.7	2.0
37	NT-7	12.9	1.67

Table H.3-1 Estimated Total Effective Dose Equivalent (TEDE) to Receptors Near the Crow Butte Uranium Processing Facility

Receptor #	Description	Distance from Main Facility (km)	TEDE* (mrem/y)
38	NT-8	2.8	12.0
1	Three Crow-1	8.3	32.3
2	Three Crow-2	11.3	1.1
3	Three Crow-3	6.8	2.3
4	Three Crow-4	5.3	3.2
5	Three Crow-5	12.4	1.4
6	Three Crow-6	9.9	2.3
7	Three Crow-7	3.5	2.4
8	Three Crow-8	9.6	2.1

*No differences in TEDE between age classes were observed.

Table H.3-2 Dose to the Population Bronchial Epithelium and Increased Continental Dose from One Year's Operation at the Crow Butte Facility

Criteria	Dose (person rem/yr)
Dose received by population within 80 km of the facility	201
Natural background by population within 80 km of the facility	21439
Dose received by population beyond 80 km of the facility	783
Total continental dose	985
Natural background for the continental population	1.73×10^{8}
Fraction increase in continental dose	5.7×10^{-6}

Table H.6-1 Tax Revenues from the Current Crow Butte Project

Type of Taxes	2009	2008	2007	2006	2005
Property Taxes	914,000	1,120,000	1,102,000	627,000	351,000
Sales and Use Taxes	136,000	140,000	90,000	238,000	185,000
Severance Taxes	403,000	512,000	1,066,000	545,000	338,000
Total	1,453,000	1,772,000	2,258,000	1,410,000	874,000

Table H.6-2 Current Economic Impact of Crow Butte Uranium Project and Projected Impact from TCEA

Activity	Current Crow Butte Operation	Estimated Economic Impact due to Three Crow Expansion Area
Employment		
Full Time Employees	67	+ 10 to 12
Full Time Contractor employees	14	+ 4 to 7
Part Time Employees and Short Term Contractors	3	+ 4 to 7**
CBR Payroll, 2009	$4,216,870*	+ $400,000 to $480,000
Taxes		
Property Taxes	$914,000	-
Sales and Use Taxes	$136,000	-
Severance Taxes	$403,000	-
Total Taxes	$1,453,000	+ $1,000,000 to $1,200,000
Production Royalties		
Royalty Payments, 2009	462,000	+ 325,000
Local Purchases		
Local Purchases, 2009	$7,838,700	+ $3,650,000 to $4,350,000
Total Direct Economic Impacts	$13,970,570	+ $5,375,000 to $6,355,000

*Estimated **All construction workers

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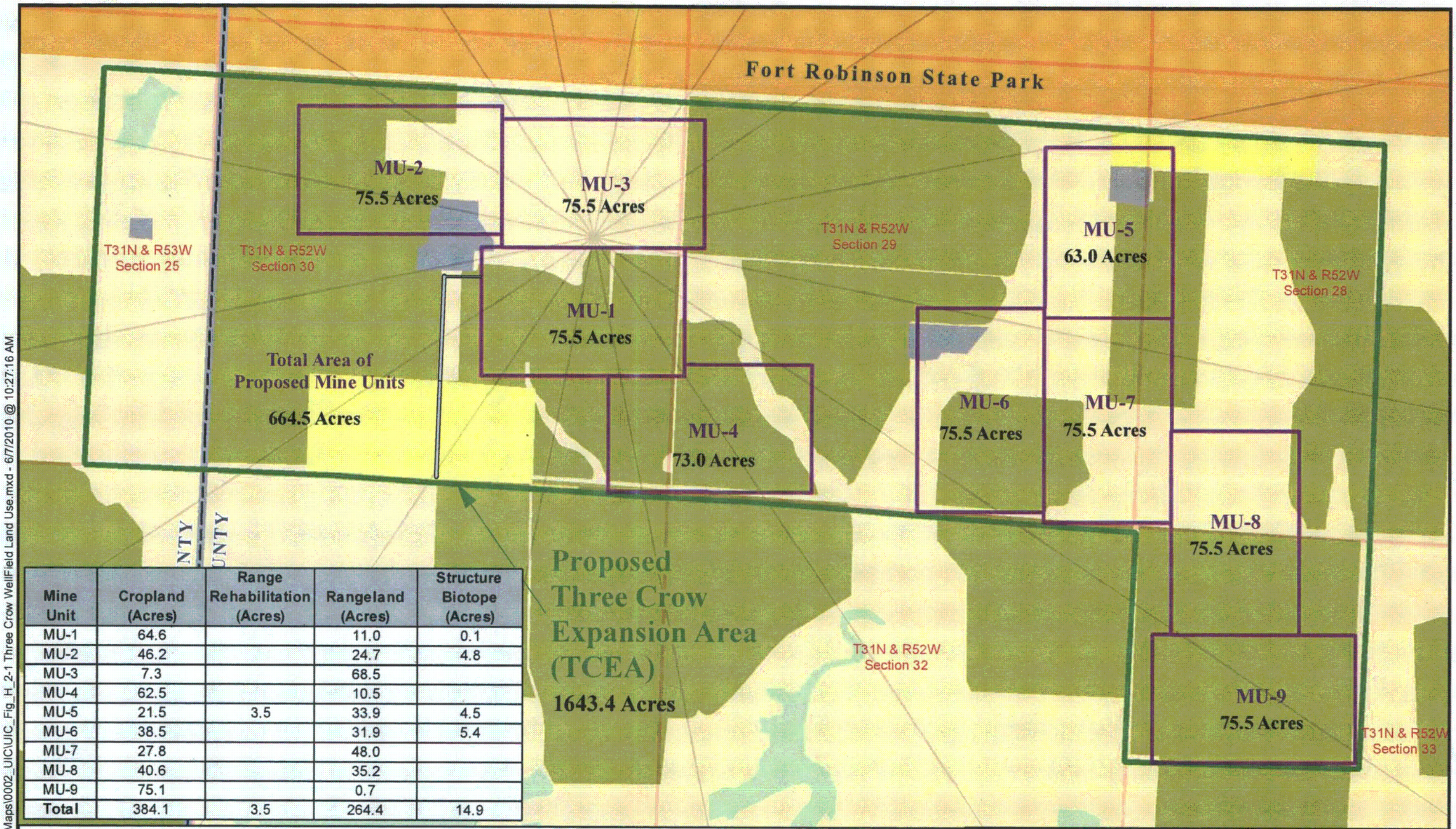

Mine Unit	Cropland (Acres)	Range Rehabilitation (Acres)	Rangeland (Acres)	Structure Biotope (Acres)
MU-1	64.6		11.0	0.1
MU-2	46.2		24.7	4.8
MU-3	7.3		68.5	
MU-4	62.5		10.5	
MU-5	21.5	3.5	33.9	4.5
MU-6	38.5		31.9	5.4
MU-7	27.8		48.0	
MU-8	40.6		35.2	
MU-9	75.1		0.7	
Total	384.1	3.5	264.4	14.9

Legend

Land Use

- Cropland
- Forested Land
- Rangeland
- Range Rehabilitation
- Structure Biotope
- Recreational Land

- Mine Unit Boundary
- Proposed Three Crow Expansion Area
- Grid Sector
- Fence

Acres of Disturbance
Outside of Mine Units--
4.51 Total
0.10 Cropland
1.63 Rangeland
1.01 Range Rehabilitation
1.77 Structure Biotope

0 1,000 2,000
Scale in Feet
PROJECTION:
NAD_1927_STATEPLANE_
NEBRASKA_NORTH_FIPS_2601

N W E

CROW BUTTE RESOURCES, INC.

FIGURE H.2-1
THREE CROW
WELLFIELD LAND USE

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

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

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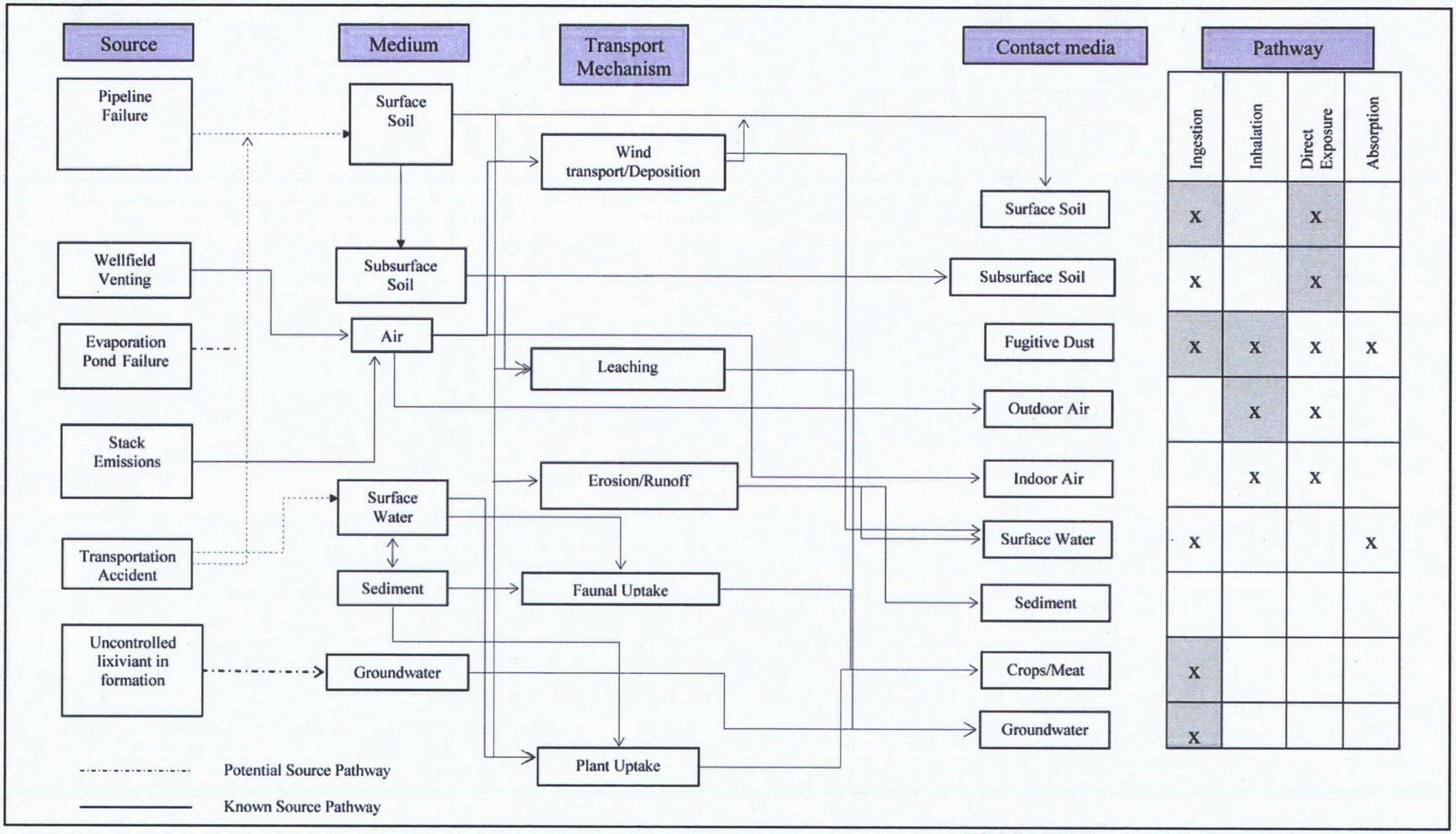

Contact media	Ingestion	Inhalation	Direct Exposure	Absorption
Surface Soil	X		X	
Subsurface Soil	X		X	
Fugitive Dust	X	X	X	X
Outdoor Air		X	X	
Indoor Air		X	X	
Surface Water	X			X
Sediment				
Crops/Meat	X			
Groundwater	X			

Note: X depicts the pathway that outlines the route which radiological emissions may follow to reach the public.
Gray shading depicts predominant pathway.

CROW BUTTE RESOURCES, INC.

FIGURE H.3-1
THREE CROW
HUMAN EXPOSURE PATHWAYS FOR KNOWN AND POTENTIAL SOURCES OF RADIOLOGICAL EMISSIONS

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

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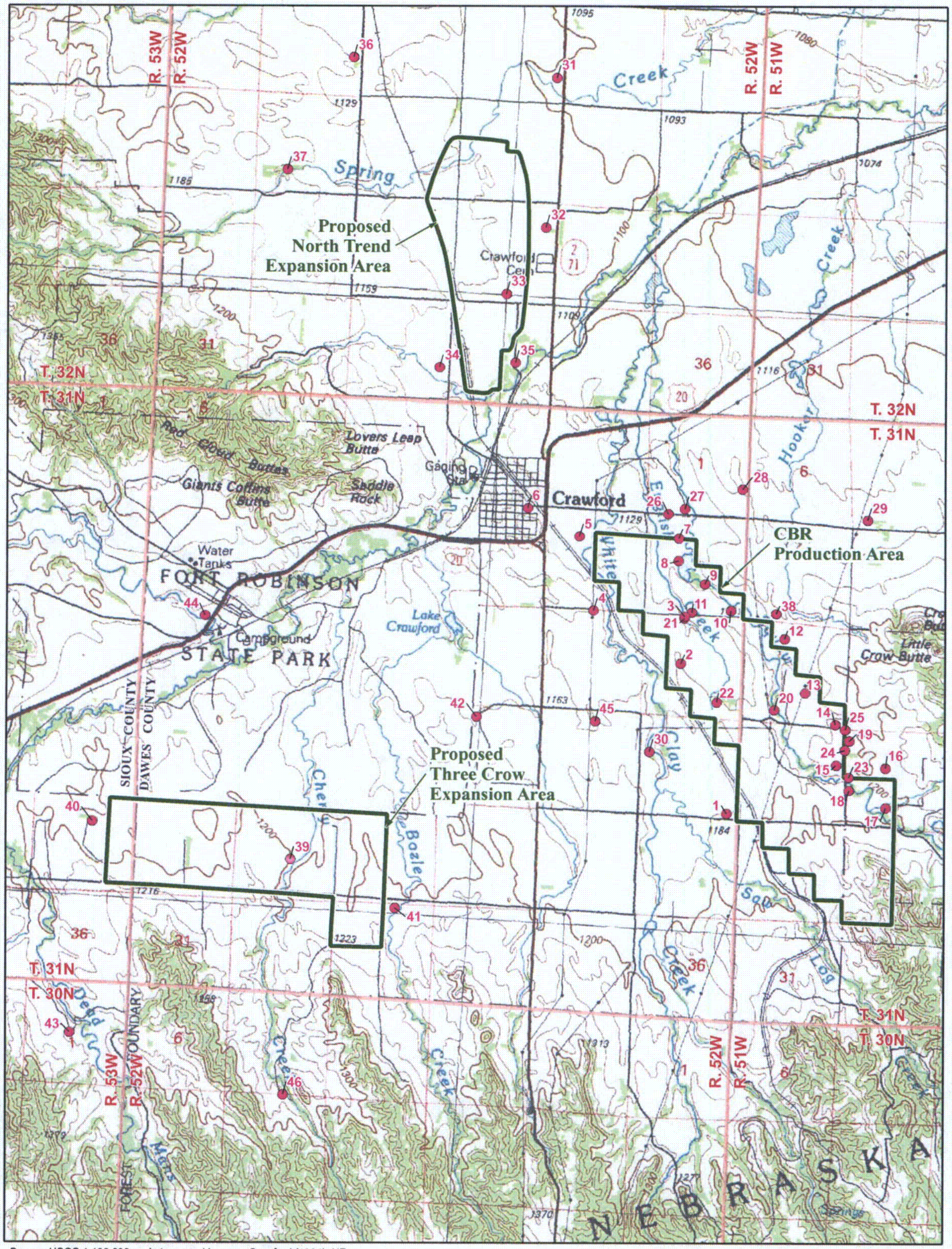

Source: USGS 1:100,000 scale topographic map - Crawford (1984), NE

LEGEND

● Receptors

N W E

0 4,000 8,000
Scale in Feet

CROW BUTTE RESOURCES, INC.

FIGURE H.3-2
MILDOS RECEPTORS

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

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CHAPTER I. COST-BENEFIT ANALYSIS

I.1 General

The general need for production of uranium is assumed to be an integral part in the nuclear fuel cycle with the ultimate objective being the operation of nuclear power reactors. In reactor licensing evaluations, the benefits of the energy produced are weighed against environmental costs including a prorated share of the environmental costs of the uranium fuel cycle. The incremental impacts of typical mining and milling operation required for the fuel cycle are justified in terms of the benefits of energy generation to the society in general. However, the specific site-related benefits and costs of an individual fuel-cycle facility such as the current CPF and the proposed Three Crow Satellite Facility must be reasonable as compared to that typical operation.

I.2 Economic Impacts

Monetary benefits have accrued to the community from the presence of the current CPF, such as local expenditures of operating funds and the federal, state and local taxes paid by the project. Against these monetary benefits are the monetary costs to the communities involved, such as those for new or expanded schools and other community services. While it is not possible to arrive at an exact numerical balance between these benefits and costs for any one community, or for the project, because of the ability of the community and possibly the project to alter the benefits and costs, this section summarizes the economic impact of the project to date and projects the incremental impacts from operation of the proposed TCEA Satellite Facility.

I.2.1 Tax Revenues

Table I.1-1 summarizes the tax revenues from the current CPF.

Future tax revenues are dependent on uranium prices which cannot be forecast with any accuracy; however, these taxes are also somewhat dependent on the number of pounds of uranium produced by CBR. To the extent that uranium prices remain at current levels (spot market of around $40.75 per pound U_3O_8 on June 21, 2010 [UxC 2010]), the increased production from the Three Crow Satellite Facility should contribute to higher tax revenues as well.

The present taxes are based on a relatively consistent production rate of 800,000 pounds per year. The additional production from the Three Crow Satellite Facility should be about 600,000 pounds per year. This additional production will eventually be offset by declining production from the original Crow Butte Project; however, the incremental contribution to taxes would be on the order of $1.0 million to $1.2 million per year in combined taxes.

I.2.2 Temporary and Permanent Jobs

I.2.2.1 Current Staffing Levels

CBR currently employs approximately 67 employees and 2 contractors employing 14 people on a full-time basis. Short-term contractors and part time employees are also used for specific projects and/or during the summer months and may add up to 5 percent to the total staffing. This level of employment is significant to the local economies. The private employment in Dawes County in 2008 was 2,491 out of a total labor force of 3,065. Based on these statistics, CBR currently provides approximately 3.0 percent of the private employment in Dawes County. In 2006, CBR's total payroll was over $3,941,000. Of the total Dawes County wage and salary payments of $86,633,000 in 2008, the CBR payroll represented about 5 percent.

Total CBR payroll for the past four years was:

2005	$2,382,000
2006	$2,543,000
2007	$3,822,000
2008	$3,941,000
2009	$4,216,870 (estimated)

The average annual wage for all workers in Dawes County was $49,167 for 2008. By way of comparison, the average wage for CBR was about $58,821. Entry-level workers for CBR earn a minimum of $16.15 per hour or $33,600 per year, not including bonus or benefits.

I.2.2.2 Projected Short-Term and Long-Term Staffing Levels

CBR expects that construction of future satellite faciliites will provide approximately ten to fifteen temporary construction jobs for a period of up to one year for each satellite facility. It is likely that the majority of these jobs will be filled by skilled construction labor brought into the area by a construction contractor, although some positions could be filled by local hires. Permanent CBR employees will perform all other facility construction (e.g., wells and wellfields).

CBR actively pursues a policy of hiring and training local residents to fill all possible positions. Due to the technical skills required for some positions, a small percentage of the current mine staff (less than five percent) have been hired elsewhere and relocated to the area. Because of the small number of people who have needed to move into the area to support this project, the impact on the community in terms of expanded services has been minimal. CBR expects that the types of positions required at the current facility and those that will be created by any future expansion will be filled with individuals from the local workforce and that there will be no significant impact on services and resources such as housing, schools, hospitals, recreational facilities, or other public facilities. In 2008, total unemployment in Dawes County was 933 individuals, or 4.3 percent of the total work force of 4,936. CBR expects that any new positions will be filled from this pool of available labor.

CBR projects that the current staffing level will increase by ten to twelve full-time CBR employees for each active satellite facility. These new employees will be needed for satellite facility operators and wellfield operator and maintenance positions. Contractor employees (i.e., drilling rigs) may also increase by four to seven employees depending on the desired production rate. The majority if not all of these new positions will be filled with local hires.

These additional positions should increase payroll by about $40,000 per month, or $400,000 to $480,000 per year.

I.2.3 Impact on the Local Economy

In addition to providing a significant number of well-paid jobs in the local communities of the Cities of Crawford, Harrison, and Chadron, Nebraska, CBR actively supports the local economies through purchasing procedures that emphasize obtaining all possible supplies and services that are available in the local area.

Total CBR payments made to Nebraska businesses for the past four years were:

2005	$4,570,000
2006	$4,396,000
2007	$5,167,000
2008	$7,685,000
2009	$7,838,700

The vast majority of these purchases were made in Crawford and Dawes county.

This level of business is expected to continue and should increase somewhat with the addition of expanded production from proposed satellite facilities and from restoration activities, although not in strict proportion to production. While there are some savings due to some fixed costs (current CPF utilities for instance), there are additional expenses that are expected to be higher (well-field development for the satellites is expected to be more expensive). Therefore, it can be assumed that the overall effect on local purchases will be relatively proportional to the number of pounds produced. In addition, mineral royalty payments accrue to local landowners. This should translate to additional purchases of $3.65 to $4.35 million per year.

I.2.4 Economic Impact Summary

As discussed in this section, the Crow Butte Project currently provides a significant economic impact to the local Dawes County economy. Approval of this license amendment request would have a positive impact on the local economy as summarized in **Table I.1-2**.

I.2.5 Estimated Value of Three Crow Resource

CBR is currently continuing to develop the reserve estimates for the TCEA. Based on the current recoverable resource estimate of 3,750,481 pounds U_3O_8 and the market price of uranium ($40.75 per pound on June 21, 2010 [UxC 2010]), the total estimated value of the energy resources at Three Crow is approximately $150,000,000. This value will fluctuate as the market price and realized price varies.

I.2.6 Short-Term External Costs

I.2.6.1 Housing Impacts

The available housing resources should be adequate to support the short term needs during facility construction. According to the Nebraska Department of Economic Development (NDED), in 2000 (last US census) a total of 492 housing units were vacant in Dawes County out of a total housing base of 4,004 units (NDED 2010). Of the vacant units, 176 were available for rent. In addition to this availability of rental housing units, there are two small hotels in Crawford that generally have vacancies and routinely provide units for itinerant workers such as railroad crews. Temporary housing resources have experienced little change in the past two decades.

I.2.6.2 Noise and Congestion

CBR projects an increase in the noise and congestion in the immediate area of the Three Crow Satellite Facility during initial construction of the facility. This will include heavy truck and equipment traffic and access to the jobsite by construction workers. These impacts will be most noticeable to residents in the immediate vicinity of the facility and will be temporary in nature. The increase in noise should be considered in light of the project location, which is bounded on the south by Four Mile Road.

A Burlington Northern Santa Fe (BNSF) rail line is located east of SH 2/71 and is approximately 2.9 miles from the TCEA boundary at the closest point. Noise from the trains on the BNSF rail line would be intermittently audible to receptors within and in close proximity to the TCEA. The rail line is used for combining local "pusher" engines with south bound trains to assist them in climbing the Pine Ridge south of the City of Crawford. As a result, there is a significant amount of noise generated by this activity including trains parked for extended periods. Dust from construction activities will be controlled using standard dust suppression techniques used in the construction industry.

I.2.6.3 Local Services

As previously noted, CBR actively recruits and trains local residents for positions at the mine. CBR expects that the majority of permanent positions at the new Three Crow Satellite Facility will be filled with local hires. As a result of using the local workforce, the impact on local services should be minimal. In many cases these services (e.g., schools) are under-utilized due to population trends in the area.

I.2.7 Long-Term External Costs

I.2.7.1 Housing and Services

Because of the small number of people who have needed to move into the area to support this project, the impact on the community in terms of expanded services has been minimal. CBR expects that the types of long term positions that will be created by the expansion to the proposed Three Crow area will be filled with individuals from the local workforce and that there will be no significant impact on services and resources such as housing, schools, hospitals, recreational facilities, or other public facilities. In 2008, total unemployment in Dawes County was 933 individuals, or 4.3 percent of the total work force of 4,936. CBR expects that the new positions at the Three Crow Satellite Facility will be filled from this pool of available labor.

I.2.7.2 Noise and Congestion

CBR projects a minor increase in the long term noise and congestion in the immediate area of the Three Crow Satellite Facility. Most of this will consist of increased traffic from employees commuting to and from the work site and performing work in the wellfields. Some increase in heavy truck traffic will occur due to deliveries of process chemicals such as oxygen and the shipment of ion exchange resin from the Three Crow Satellite Facility to the current CPF.

Delivery and ion exchange shipments should average two per day. These impacts will be most noticeable to residents in the immediate vicinity of the facility.

In the area around Crawford, the increased traffic will be unnoticeable due to the presence of U.S. Highway 20 and Nebraska Highway 2/71, which are both significant transport routes. The annual average 24 hour total and heavy vehicle count for U.S. Highway 20 at the eastern approach to Crawford for 2008 was 1,650 and 215, respectively (NDOR 2010). The limited additional traffic related to the TCEA operation will not significantly affect these main routes.

Aesthetic Impacts

The visible surface structures proposed for the TCEA include wellhead covers, wellhouses, electrical distribution lines, and one satellite processing building and evaporation ponds. The project will use existing and new roads to access each wellhouse, the deep disposal well building, evaporations ponds and the satellite procesing building. Project development would alter the physical setting and visual quality of portions of the landscape, which would affect the overall landscape to some degree, as viewed from sensitive viewing areas. The proposed facilities would introduce new elements into the landscape and would alter the existing form, line, color, and texture, which characterize the existing landscape. The project would primarily affect agricultural land.

In foreground-middleground views, the satellite processing building, evaporation ponds, wellhouses, and associated access road clearings would be the most obvious features of development. Clearings and access roads would be visible as light-tan exposed soils in geometrically-shaped areas with straight, linear edges that provide some textural and color contrasts with the surrounding cropland. The satellite processing building, wellhouses, and wellhead covers would be painted to harmonize with the surrounding soil and vegetation cover. These facilities would be visible from Four Mile Road and residences within the Expansion Area, but would be subordinate in scale to the rural landscape.

The electric distribution line poles would be an estimated 20 feet tall, and would be located throughout the project area to connect wellhouses with existing lines. The distribution lines are similar in appearance to those typical of the rural landscape, but would occur at a higher density than on adjacent lands. The lines would be obvious to viewers at the viewing areas, but would not change the rural character of the existing landscape.

Wellhead covers would be difficult to discern in the landscape from any sensitive viewing area. The form and textural contrast would be very weak because the relatively low profile (3 feet high) and small size of these would disappear into the surrounding textures of soil and vegetation. Generally, color contrasts are most likely to be visible in foreground-middleground distance zone. However, the wellhead covers would be painted a tan color that would harmonize with the surrounding vegetation and soil colors. Therefore, contrast of line, form, texture, and color would be low. The facilities would not be noticeable to the casual observer. Wellhead covers would be visually subordinate to the landscape in foreground-middleground distance zone.

I.2.7.3 Land Access Restrictions

Property owners of land located within the immediate wellfield(s) and other facility boundaries will lose access and free use of these areas during mining and reclamation. The areas impacted are all used for agricultural purposes and the owners will lose the ability to use the areas for production purposes. Offsetting these land use restrictions are the surface lease and mineral royalty payments to the landowners.

I.2.8 Most Affected Population

The expected impacts from the proposed Three Crow Satellite Facility can be characterized as an incremental increase in the impacts from operation of the current facility. For the most part, the impact from operation of the current Crow Butte Uranium Project has been positive for the City of Crawford and the surrounding communities. CBR has provided much-needed well compensated employment opportunities for the local population. Additionally, the policy of purchasing goods and services locally to the extent possible has had a positive economic impact on an area facing economic challenges. Tax expenditures and particularly the recent increases in local property taxes paid due to the increase in the price of uranium have had a significant economic impact on local government-provided services.

Offsetting these positive impacts to the local population are increases in noise, congestion, and aesthetic impacts for residents in and adjacent to the proposed Three Crow Satellite Facility. Most residents located in the proposed license area are land owners that have mineral and/or surface leases with CBR and will benefit economically from the presence of the facility.

I.2.9 Satellite Facility Decommissioning Costs

Approval of the proposed Three Crow Satellite Facility will result in CBR incurring additional decommissioning liabilities for the installed facilities. The actual estimated decommissioning costs will be included in the annual surety update required by SUA-1534 submitted to the NDEQ and the NRC for approval prior to construction activities.

I.3 The Benefit Cost Summary

The benefit-cost summary for a fuel-cycle facility such as the Crow Butte Project (i.e., CPF and proposed NTEA and TCEA) involves comparing the societal benefit of a constant U_3O_8 supply (ultimately providing energy) against possible local environmental costs for which there is no directly related compensation. For this project, there are basically three of these potentially uncompensated environmental costs:

- Groundwater impact
- Radiological impact
- Disturbance of the land

The groundwater impact is considered to be temporary in nature, as restoration activities will restore the groundwater to a pre-mining quality. The successful restoration of groundwater during the R&D project and the commercial restoration of Mine Unit 1 have demonstrated that the restoration process can meet this criterion successfully.

The radiological impacts of the current and proposed project are small, with all radioactive wastes being transported and disposed of off-site. Radiological impacts to air and water are also minimal.

Extensive on-going environmental monitoring of air, water, and vegetation has shown no appreciable impact to the environment from the Crow Butte Project.

The disturbance of the land for an ISL facility is quite small, especially when compared with conventional surface mining techniques. All of the disturbed land will be reclaimed after the project is decommissioned and will become available for previous uses.

I.4 Summary

In considering the energy value of the U_3O_8 produced to U.S energy needs, the economic benefit to the local communities, the minimal radiological impacts, minimal disturbance of land, and mitigable nature of all other impacts, it is believed that the overall benefit-cost balance for the proposed TCEA is favorable, and that issuing a Class III UIC Permit is the appropriate regulatory action.

I.5 References

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The Ux Consulting Company. (UxC). 2010. *Ux Weekly.* [Web page]. Located at: http://www.uxc.com/review/uxc_Prices.aspx. Accessed on: June 28, 2010.

Table I.1-1 Tax Revenues from the Current Crow Butte Project

Type of Taxes	2009	2008	2007	2006	2005
Property Taxes	914,000	1,120,000	1,102,000	627,000	351,000
Sales and Use Taxes	136,000	140,000	90,000	238,000	185,000
Severance Taxes	403,000	512,000	1,066,000	545,000	338,000
Total	**1,453,000**	**1,772,000**	**2,258,000**	**1,410,000**	**874,000**

Table I.1-2 Current Economic Impact of Crow Butte Uranium Project and Projected Impact from TCEA

Activity	Current Crow Butte Operation	Estimated Economic Impact due to Three Crow Expansion Area
Employment		
Full Time Employees	67	+ 10 to 12
Full Time Contractor employees	14	+ 4 to 7
Part Time Employees and Short Term Contractors	3	+ 4 to 7**
CBR Payroll, 2009	$4,216,870*	+ $400,000 to $480,000
Taxes		
Property Taxes	$914,000	-
Sales and Use Taxes	$136,000	-
Severance Taxes	$403,000	-
Total Taxes	$1,453,000	+ $1,000,000 to $1,200,000
Production Royalties		
Royalty Payments, 2009	462,000	+ 325,000
Local Purchases		
Local Purchases, 2009	$7,838,700	+ $3,650,000 to $4,350,000
Total Direct Economic Impacts	**$13,970,570**	**+ $5,375,000 to $6,355,000**

*Estimated **All construction workers

CHAPTER J. INJECTION FLUID PROPERTIES

J.1 Proposed Lixiviant

Crow Butte proposes to use an alkaline lixiviant at the Three Crow Expansion Area (TCEA) that is based on sodium- bicarbonate as the complexing agent and gaseous oxygen or hydrogen peroxide as the oxidizing agents. This alkaline lixiviant results in two principal geochemical reactions – oxidation and subsequent dissolution of uranium and other metals from the ore body (Davis and Curtis 2007).

Crow Butte has used this technology successfully at its current CPF operation for approximately 18 years. Currently, all active and proposed In Situ Leach (ISL) facilities in Wyoming, Nebraska and New Mexico use alkaline-based lixiviants (NRC and WDEQ 2009). The alkaline-based in situ leach operations are considered to be easier to restore than when using acid-based lixiviants.

With the startup of operations, a leach solution (injection fluid) is injected into the formation via the injection wells for recovery of uranium. Hydrogen peroxide (H_2O_2) or gaseous oxygen (O_2) is typically used as the oxidant because both revert to naturally occurring substances. Carbonate species are also added to the lixiviant solution in the injection stream to promote the dissolution of uranium as a uranyl carbonate complex. Once the injected fluids are returned from the wellfield (via the production wells) to the ion exchange columns in the TCEA Satellite Facility, treatment of the uranium-bearing leach solution results in removal of the uranium, resulting in the displacement of chloride, bicarbonate, and sulfate ions. The now barren leach solution is then reinjected into the formation. A more detailed description of the injection procedures and reactions associated with the lixiviant can be found in Chapter M.

Typical lixiviant (injection fluid) concentrations of major constituents are shown in **Table J.1-1**. The basis for these values is a review of lixiviant fluid composition and concentration observed during operations at the existing CPF. These values are considered to be typical of current leaching operations as well as what is expected during operations at the TCEA.

Routine sampling and analysis for biological constituents (e.g., coliforms) of the lixiviant is not conducted by current operations and is not planned for the TCEA. Such monitoring is not required by the Nebraska Department of Environmental Quality (NDEQ) or the Nuclear Regulatory Commission (NRC). The main concern with biological organisms during leaching operations is the potential for well screens becoming partially or totally plugged with bacterial encrustations. Although rarely needed, CBR does occasionally use well chlorination and well acidification for treating wells that do not respond physically to stimulation techniques in order to kill bacteria slimes and encrustations. The treatment methods are discussed in Chapter L – Stimulation Program.

J.2 References

U.S. Nuclear Regulatory Commission (NRC) and Wyoming Department of Environmental Quality (WDEQ). 2009. *Generic Environmental Impact Statement for In Situ Leach Uranium Milling Facilities - Final Report.* NUREG-1910. May 2009.

Davis, J.A. and Curtis, J.P. 2007. *Consideration of Geochemical Issues in Groundwater Restoration at Uranium In-Situ Leaching Mining Facilities*. NUREG/CR-6870. Washington, D.C.: NRC. January 2007.

Table J.1-1 Typical Lixiviant Concentrations

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

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

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CHAPTER K. FORMATION TESTING PROGRAM

Because of the extensive historical operations at the current CPF, and recent work in support of the Class III UIC permit application for the NTEA, Crow Butte was able to utilize that data when preparing this application. **Figure B.2-1** shows the proximity of the TCEA to the current operations and proposed NTEA. Where the current CPF is referenced, distinctions between the two areas are noted, and site-specific data have been collected at the TCEA when needed.

K.1 Borehole Geophysical Logs

Detailed analysis of a suite of borehole geophysics provides a method for interpreting lithology, stratigraphy and depositional environment, and for deriving porosity values, permeability index, and water salinity. The log curves used for interpretation and parameter derivation measure: resistivity, electron density, interval travel time, spontaneous potential, natural radioactivity, and hydrogen content. As of February 2010, there have been approximately 730 exploration holes drilled within the TCEA boundary. Of these 730 boreholes, a subset was used for the development of each of the cross sections A-A', B-B', C-C', D-D' and E-E' (**Figure E.1-2**).

Common hydrogeologic objectives of borehole geophysical logging include: (1) definition and correlation of aquifer or other lithologic units; (2) estimation of aquifer properties such as porosity and permeability; and (3) assessment of physical properties of formation water including conductivity, total dissolved solids, and total hardness. These objectives must be considered in the design, selection, and implementation of an effective logging program.

There are three basic parameters derived or interpreted from borehole geophysical logs: lithology, resistivity and porosity. From these basic parameters, there are numerous variations that can provide information regarding lithologic identification, correlation, facies evaluation, delineation of permeable and porous zones, and identification of pore fluids. The type of measurements used to determine this information is discussed in Chapter E.

Approximately 170 geophysical logs were reviewed for interpretation and correlation in the TCEA (**Appendix 4**). Approximately 75 logs were correlated and utilized to generate five cross sections. An additional 20 logs were correlated near the six cross section lines. Logs from four oil and gas wells outside the TCEA were reviewed. Detailed discussions of the results of the logging activities are presented in Chapter E.

K.2 Coring and Drill Cutting Testing

CBR has historically used core samples and drill cuttings in support of efforts to better define hydrogeologic and geochemical properties of the subsurface of areas being considered for in-situ leach (ISL) mining. Core samples may be collected, but coring is typically not needed during the drilling and construction of Class III wells. The types of tests that are conducted on core samples are based on the intended need (e.g., porosity, relative permeability, and lithology).

Core samples were collected from the upper, middle and lower Basal Chadron Sandstone by CBR at Three Crow and analyzed for mineralogy by x-ray diffraction analyses and for grain size distribution. See further discussions in Section K.2.2 and Section E.3.2.2.

K.2.1 Ore Amenability

Amenability of the uranium deposits in the Basal Chadron Sandstone in the Crow Butte Project to ISL mining was demonstrated initially through core studies at the original CBR production facility where mining is currently being conducted. Results of core studies were confirmed in the Research and Development (R&D) phase of the project at the Crow Butte site using bicarbonate/carbonate leaching solutions with oxygen. Reports concerning the results of the R&D activities, including restoration of affected groundwater, have been submitted to the Nuclear Regulatory Commission (NRC) and the Nebraska Department of Environmental Quality (NDEQ).

Ore amenability is discussed in Section A.1.2.

K.2.2 Sedimentologic and Petrographic Analysis

In order to obtain an aquifer exemption, sedimentologic and petrographic studies of cores specific to the TCEA were conducted. Of particular importance was the proper hydraulic characterization of the upper and lower confining units for the Basal Chadron sandstone. In 2008, two exploration boreholes (T-1050c and T-1051c) were advanced in the northeastern quarter of Section 30 T31N R52W of the TCEA. Core samples were collected from target intervals within the confining units above and below the Basal Chadron Sandstone:

- clay unit within Upper Chadron above Middle Chadron sandstone
- clay unit within Middle Chadron between Middle Chadron sandstone and Basal Chadron Sandstone
- Pierre Shale

Core samples were analyzed for mineralogy; petrology; and textural, mineralogical, porosity and permeability parameters (e.g., sieve data, thin-sections, x-ray diffraction, and microprobe analysis). The results of the core samples sampling and analyses are discussed in Chapters E and F.

K.3 Hydrological Testing

The NDEQ requires the following hydrological testing as part of a formation testing program:

- Install monitor wells and perform pumping test(s) to assess site conditions.
- Analyze pumping test data.
- Submit a Hydrological Test Report for NDEQ review and approval.

In general, the aquifer tests employed the following methodology:

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

- Analysis of data from aquifer test, and
- Interpretation of results of test.

Pumping tests on the Basal Chadron Sandstone aquifer were conducted in the TCEA in April, 2008. The final report on pumping test activities in the TCEA (Three Crow Regional Hydrologic Testing Report - Test #7 [Petrotek 2008]) is attached as **Appendix 5** to this application. A brief summary of the testing activities from pumping test activities in the TCEA is provided below. The findings are discussed in more detail in Chapter F.

The pumping test (Test #7) was performed by pumping a well completed in the Lower Basal Chadron Sandstone and monitoring groundwater levels in the pumping well, five monitor wells in the Lower Basal Chadron Sandstone, two wells in the Upper Basal Chadron, and in three wells in the overlying Brule Formation.

The 2008 pumping test was designed to assess the following:

- The degree of hydrologic communication between the Basal Chadron Sandstone pumping well and the surrounding Basal Chadron Sandstone monitor wells;
- The presence or absence of hydrologic boundaries within the Basal Chadron Sandstone aquifer over the test area;
- The hydrologic characteristic of the Basal Chadron Sandstone aquifer within the test area; and
- The degree of hydrologic isolation between the Basal Chadron Sandstone aquifer and the overlying aquifers.

The pumping test results demonstrated the following conclusions:

- All Basal Chadron Sandstone monitoring wells and the pumping well are in communication throughout the TCEA pumping test area;
- The upper and lower Basal Chadron Sandstone wells are in communication;
- The Basal Chadron Sandstone has been adequately characterized with respect to hydrogeologic conditions within the majority of the proposed TCEA test area;
- Adequate confinement exists between the Basal Chadron Sandstone and the overlying Brule Formation throughout the proposed TCEA test area; and
- The 2008 pumping testing was sufficient to proceed with UIC Class III permitting and a NRC license amendment application for the TCEA.

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

More detailed discussions as to the summary and conclusions of Pumping Test #7 can be found in Section F.2.3.

K.4 Baseline Groundwater Levels and Quality

A monitoring program was conducted to establish baseline groundwater quality conditions in the TCEA. Water-level measurements and groundwater quality samples (i.e., for non-radiological and radiological parameters) were collected in 2007, 2008, 2009 and 2010 to establish background conditions in the vicinity of the TCEA. Data were developed for the two water-bearing zones at the TCEA: the Brule Formation and the Basal Chadron Sandstone Formation. Monitoring was performed on TCEA monitor wells and private water supply wells located in close proximity to the TCEA Area of Review (AOR). A description of the sampling program is discussed below.

K.4.1 CBR Monitor Wells

Seven active monitoring wells were screened in the Brule Formation (BOW 2006-1, BOW 2006-2, BOW 2006-3, BOW 2006-4, BOW 2006-5, BOW 2006-6, and BOW 2006-7). A private well (W-273), which is a private well (Miller) completed with the TCEA permit boundary, is also being used as an onsite monitor well. Ten active monitoring wells are screened in the Basal Chadron Sandstone (CPW 2006-1, COW 2006-1, COW 2006-2, COW 2006-3, COW 2006-4, COW 2006-5, COW 2006-6, COW 2006-7, UBCOW 2006-1, and UBCOW 2006-2). Well completion reports for these monitoring wells are included in **Appendix 1,** with the exception of W-273 where completion records are not available.

K.4.1.1 Water-Level Measurements

Water-level measurement events for the Brule Formation were conducted at four monitoring wells (BOW 2006-1, BOW 2006-2, BOW 2006-3, BOW 2006-4) during two water level measurement events in January 2009 and at seven CBR monitoring wells ((BOW 2006-1, BOW 2006-2, BOW 2006-3, BOW 2006-4, BOW 2006-5, BOW 2006-6, BOW 2006-7) and W-273 in January and February 2010.

Water-level measurement events for the Basal Chadron Sandstone were conducted at all ten monitoring wells (CPW 2006-2, COW 2006-1, COW 2006-2, COW 2006-3, COW 2006-4, COW 2006-5, COW 2006-6, COW 2006-7, UBCOW 2006-1, and UBCOW 2006-2) during three water level measurement events during the months of January 2009, January 2010 and February 2010.

The purpose of these measurements was to allow evaluation of the hydraulic gradient with the TCEA. The results of these measurements are discussed in Section F.2.1

K.4.1.2 Water Quality

Three bi-weekly sampling events were conducted at eight Brule Formation monitoring wells (BOW 2006-1, BOW 2006-2, BOW 2006-3, BOW 2006-4, Bow 2006-5, BOW 2006-6, BOW 2006-7 and Miller Well (W-273) in November 2008 through February 2009 and at ten Basal Chadron Sandstone monitoring wells (CPW 2006-2, COW 2006-1, COW 2006-2, COW 2006-3, COW 2006-4, COW 2006-5, COW 2006-6, COW 2006-7, UBCOW 2006-1, and UBCOW 2006-2) between December 2008 and February 2009.

Groundwater samples collected from all designated sampling locations were analyzed for the following parameters:

- Radionuclides (U-nat, Ra-226, Th-230, Pb-210, Po-210) [Dissolved and suspended fractions reported]
- Major ions (Ca, Mg, Na, K, CO_3, HCO_3, SO_4, Cl, NH_4 as N, NO_2 as N, NO_3 as N, F, SiO_2) Field parameters (TDS, conductivity, alkalinity, pH)
- Trace metals (Al, As, Ba, B, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Mo, Ni, Se, V, Zn) [Dissolved fractions reported]
- Quality assurance data (anion, cation, WYDEQ A/C Balance, Calc TDS, TDS A/C Balance)

This 2008/2009 sampling program allowed for a more accurate characterization of the water quality and hydraulic gradient within the Basal Chadron sandstone in the TCEA. Results from the analyses listed above will be used to evaluate water quality baseline values for future restoration to groundwater standards. The results of this sampling are discussed in Section F.2.2 of Chapter F.

K.4.2 Private Wells

CBR conducted an extensive water user survey to identify private water supply wells within a 2.25-mile radius of the proposed TCEA. The water user survey and sampling results are discussed in Section F.2.6.2. Based on the results of the water users survey, all water wells within the TCEA and AOR are completed in the relatively shallow Brule Formation, with no wells completed in the Basal Chadron Sandstone.

K.5 Formation Gradient Pressures

NDEQ Title 122, Chapter 19, Section 002.02 requires that the injection pressure at the wellhead of Class III UIC injection wells shall not exceed a maximum, which shall be calculated so as to assure that the pressure in the injection zone during injection does not initiate new fractures or propagate existing fractures in the injection zone, initiate fractures in the confining zone, or cause migration of injection or formulation fluids into an underground source of drinking water. CBR will operate the TCEA using maximum wellhead injection pressures that will result in "pressure at well depth" that will be significantly lower than typical default maximum formation gradient pressures allowed by the U.S. Environmental Protection Agency (USEPA). Based on the CBR's maximum injection wellhead pressure of 100 pounds per square inch (psi), and the calculated formation gradient pressure of 0.62 psi/ft, adverse impacts listed should not occur. This position is supported by historical experience of the current CBR facility operating successfully since 1991 at similar pressures. Formation gradient pressure calculations are discussed in Chapter P.

K.6 References

Petrotek Engineering Corporation. (Petrotek). 2008. *Three Crow Regional Hydrologic Testing Report- Test #7*. Prepared for Crow Butte Resources, Inc. August 2008.

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CHAPTER L. STIMULATION PROGRAM

There are several processes used to clean the well bore, enlarge channels, and increase pore space in the interval to be injected, thus making it possible for fluids to move more readily into the formation including, but not limited to swabbing, surging, jetting, blasting, acidizing, and hydraulic fracturing. Crow Butte Resources, Inc. (CBR) uses stimulation techniques for cleaning the well bore, but does not use blasting or fracturing for the aquifer/formation itself. CBR frequently uses the swabbing technique for cleaning well bores, and as necessary, may periodically use other physical techniques such as surging, jetting, and pumping.

Although rarely, CBR does occasionally use well chlorination and well acidification for treating wells which do not respond to physical stimulation techniques. During the course of production, well screens may become totally or partially plugged with precipitated materials such as carbonates or bacterial encrustations. Treating a well with chlorine will kill most bacteria, and treating a well with hydrochloric acid (HCl) will kill most bacteria and remove encrustations. CBR has written procedures that describe the proper methods for treating wells with HCl or chlorine. Specific topics covered include chemical strength, holding times, physical processes, well purging, and safety. These procedures are in agreement with those described in Groundwater and Wells, Second Edition by Fletcher G. Driscoll (Driscoll 1986) and those published by the Nebraska Department of Health and Human Services (NDHHS 2008).

L.1 Well Chlorination

Treating a well with chlorine will kill most varieties of bacteria. However, chlorine cannot penetrate thick bacteria slimes and encrustations; consequently, only those bacteria on the surface are killed. For severe cases, it is better to treat the well with HCl because it can more easily penetrate the slimes and encrustations. CBR's procedure is written for using sodium hypochlorite at 5.25 percent strength.

The procedures are as follows:

- Because bacteria will likely exist from surface to total depth, it is necessary to treat the entire well. A 5.25 percent liquid chlorine solution or 65 percent dry chlorine is poured down the well bore from the surface. The total volume poured down the well bore should raise the concentration of chlorine in the water in the well bore to 1,000 parts per million (ppm). To achieve this concentration, 2.5 ounces of 6 percent liquid sodium hypochlorite or 0.175 ounces of 65 percent dry sodium hypochlorite would be added for each foot of water in the well bore.
- For best results, the water in the well bore is agitated to mix the chlorine solution. One agitation method is to turn on the pump for a few seconds and then turn it off. Repeat this process several times. Allow the water to flow back through the pump before restarting it so the impellers are not turning in the wrong direction.
- Allow the solution to sit in the well for 4 to 8 hours.
- Pour clean water down the well bore to wash residual chlorine from the casing wall. Use at least three times the volume of the sodium hypochlorite. Purge the solution out of the well and into a water truck or trailer or other appropriate container. Purge at least three casing volumes. After pumping the initial three casing volumes, continue purging until

the conductivity and pH are stable. Dispose of the solution in the commercial evaporation ponds.

L.2 Well Acidification Using HCl

Acidification of a well using HCl is effective for killing bacteria, removing bacterial encrustations and slimes, and dissolving carbonate scales.

If the goal is to dissolve carbonate scales, the first step is to log the well from the total depth to surface using gamma, resistivity, and self-potential tools. Because radium co-precipitates with calcium, this oftentimes is an effective way to determine the location of scale.

- The acid is introduced to the top of the screened interval through tubing in order to prevent dilution. The pump and motor may be left downhole if they are composed of materials that are compatible with HCl for short periods of time. If the check valve is drilled out, the acid can be introduced through pumps that are compatible with the acid. When using 38 percent HCl in a 4.5-inch diameter well, a total of 1 gallon of acid solution per foot of screened interval should be introduced. For example, if the screened interval is 20 feet, then introduce 20 gallons of 38 percent HCl.
- The acid may react violently with the carbonate in the well. Always provide a safe pathway for escaping gas and/or water. HCl fumes are toxic.
- Chase the acid with a sufficient amount of water to force the acid out of the tubing and into the screen and surrounding host formation.
- If possible, agitate the solution by swabbing or other means. Allow the acid to sit for 2 to 4 hours in order to kill bacteria. The pH must be maintained below 2.
- Using the same tubing, purge the well for at least three casing volumes and until the pH and conductivity are stable. Dispose of the purged water in the commercial evaporation ponds.
- Re-log the hole to determine if any scale remains. Test the well to see if the flow rate has improved. If significant improvement is achieved, additional acid treatment may provide additional benefit. If no significant improvement is achieved after the first treatment, it is not likely that additional treatment will help.

L.3 References

Driscoll, Fletcher G. 1986. Groundwater and Wells, 2nd. Edition, Johnson Division, St. Paul, MN.

Nebraska Department of Health and Human Services (NDHHS). 2007. *Water Well Disinfection.* 2007. [Web page]. Located at: http://www.hhs.state.ne.us/puh/enh/brochures.htm. Accessed on December 02, 2009.

CHAPTER M. INJECTION PROCEDURES

Production of uranium by in-situ leach (ISL) mining techniques involves a mining step and a uranium recovery step. Mining is accomplished by installing a series of injection wells through which the leach solution is pumped into the ore body. Corresponding production wells and pumps promote flow through the ore body and allow for the collection of uranium-rich leach solution. Uranium is removed from the leach solution by ion exchange, and then from the ion exchange resin by elution. The leach solution can then be reused for mining purposes. The elution liquid containing the uranium (the "pregnant" eluant) is then processed by precipitation, dewatering, and drying to produce a transportable form of uranium.

The Three Crow Expansion Area (TCEA) is being developed by Crow Butte Resources, Inc. (CBR) in conjunction with their current CPF, which is currently permitted under Class III UIC Permit number NE0122611 issued by the Nebraska Department of Environmental Quality (NDEQ). The TCEA will be developed by constructing independent wellfields and mining support facilities while utilizing existing processing equipment at the current CPF to the greatest extent possible for uranium recovery. Transfer of recovered leach solutions from the area is prohibitive because of the distance that a relatively large stream would have to be pumped. Therefore, a satellite facility will be constructed in the TCEA to provide chemical makeup of leach solutions, recovery of uranium by ion exchange, and restoration capabilities. The ion exchange processes at the satellite facility serve to recover the uranium from the production solution in a form (loaded ion exchange resin) that is relatively safe and simple to transport by tanker truck to the CPF for elution and further processing of recovered uranium. Regenerated resin is then transported back to the satellite facility for reuse in the ion exchange circuit.

M.1 Solution Mining Process and Equipment

M.1.1 Ore Body

In the current CPF boundary, uranium is recovered by ISL from the Basal Chadron Sandstone at a depth that varies from 400 feet to 900 feet. The overall width of the mineralized area varies from 1,000 feet to 5,000 feet. The ore body ranges in grade from less than 0.05 up to 0.5 percent U_3O_8, with the average grade estimated at 0.27 percent U_3O_8. The current CPF is licensed for a flow rate of 11,000 gallons per minute (excluding restoration flow) and a maximum production flow of 9,660 gallons per minute (gpm) under Class III UIC Permit NE012261. Total annual production is limited to 2 million pounds of yellowcake.

The depth to the ore body within the Basal Chadron Sandstone in the TCEA ranges from approximately 580 to 940 feet below ground surface (bgs). The width of the ore body varies from approximately 2,100 to 4,000 feet. Indicated ore resources as U_3O_8 for the TCEA are 3,750,481 pounds (lbs) with an additional inferred estimate of 1,135,452 lbs. Total reserves are estimated at 4,900,000 lbs. The ore grade as U_3O_8 ranges from 0.05 to 5 percent with an average ore grade of 0.22 percent. The expected annual production rate is approximately 600,000 pounds per year. The average flow rate throughput is approximately 4,500 gpm excluding 1,500 gpm for restoration.

Typical stratigraphic intervals to be mined by the in-situ mining method were shown in the geologic cross-sections contained in Chapter E. For ISL wellfields, the production zone is the geological sandstone unit where the leaching solutions are injected and recovered.

M.1.2 Wellfield Design and Operation

The proposed Three Crow Mine Unit map and mine schedule are shown in **Figure A.2-3** and **Figure A.2-4** of Chapter A. The preliminary map and mine schedule are based on CBR's current knowledge of the area. As the TCEA is developed, the mine schedule and a mine unit map will be developed further. The TCEA will be subdivided into an appropriate number of mine units. Each mine unit will contain a number of wellhouses where injection and recovery solutions from the satellite plant building are distributed to the individual wells. The injection and production manifold piping from the satellite process facility to the wellfield houses will be either polyvinyl chloride (PVC), high-density polyethylene (HDPE) with butt-welded joints, or an equivalent. In the wellfield house, injection pressure will be monitored on the injection trunk lines. Oxidizer will be added to the injection stream and all injection lines off of the injection manifold will be equipped with totalizing flowmeters, which will be monitored in the Satellite Facility control room. The TCEA wellfields will be designed in a manner consistent with the existing CBR wellfields.

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

The cell dimensions vary depending on the formation and the characteristics of the ore body. The injection wells in a normal pattern are expected to be between 65 feet and 150 feet apart. A typical wellfield layout is shown in **Figure M.1-1**. The wellfield is a repeated seven-spot design, with the spacing between injection wells ranging from 65 to 150 feet.

Other well designs include alternating single-line drives. All wells are completed so they can be used as either injection or recovery wells, so that wellfield flow patterns can be changed as needed to improve uranium recovery and restore the groundwater in the most efficient manner. During operations, leaching solution enters the formations through the injection wells and flows to the recovery wells. Within each wellfield, more water is produced than injected to create an overall hydraulic cone of depression in the production zone. Under this pressure gradient, the natural groundwater movement from the surrounding area is toward the wellfield, providing additional control of the leaching solution movement. The difference between the amount of water produced and that injected is the wellfield "bleed." The minimum over-production or bleed rates will be a nominal 0.5 percent of the total wellfield production rate, and the maximum bleed rate typically approaches 1.5 percent. Over-production is adjusted as necessary to ensure that the perimeter ore zone monitor wells are influenced by the cone of depression resulting from the wellfield production bleed. The wellfield bleed is typically disposed in the waste disposal system.

Monitor wells will be placed in the Chadron Formation and in the first significant water-bearing sand above the Chadron Formation. All monitor wells will be completed by one of the three methods discussed in Chapter **N**, developed prior to leach solution injection. The development process for monitor wells includes establishing baseline water quality before the initiation of mining operations. The locations of monitor wells for the proposed TCEA are shown in **Figure M.1-2**.

Injection of solutions for mining will be at a rate of 4,500 gpm with a 0.5 to 1.5 percent production bleed stream. Production solutions returning from the wells to the production manifold will be monitored with a totalizing flowmeter. All pipelines and trunklines will be leak tested and buried prior to production operations.

A water balance for the proposed Three Crow Satellite Facility is shown on **Figure M.1-3.** The liquid waste generated at the Satellite Facility will be primarily the production bleed which, at a maximum scenario, is estimated at 1.5 percent of the production flow. At 4,500 gpm, the volume of liquid waste would be 35,478,000 gallons per year. CBR proposes to adequately handle the liquid waste through the combination of deep disposal well injection and evaporation ponds.

Prior to the injection of leaching chemicals, CBR will recirculate the natural groundwater for a time that may range from 1 day to 1 week. CBR will achieve the following during the groundwater recirculation phase:

- Calibration of the injection/recovery operational systems including surface equipment and final selection of injected procedures,
- Establishment of the circulation pathways between the injection and recovery wells,
- Development of the hydraulic gradients toward the production cells(s) to prevent outward movement of the lixiviant from the very beginning of the production phase, and
- Observation of the Basal Chadron aquifer response to the injection/pumping operations and final adjustment of the rate of overpumping.

After the initial recirculation, injection of lixiviant will be initiated in the injection wells and solution production will be initiated in the recovery wells. The recovered solutions will then be transferred to the Satellite Facility. Regional information, previous CBR permit submittals, and historical operational practices indicate that the minimum pressure that could initiate hydraulic fracture is 0.63 pounds per square inch per foot (psi/ft) of well depth. This value has historically and successfully been applied to CBR operations. In comparison, the injection pressure for the TCEA will be limited to less than 0.62 psi/ft of well depth. This later value of 0.62 psi/ft of well depth was calculated by the use of a U.S. Environmental Protection Agency (USEPA) formula where the maximum injection pressure at the wellhead is used to calculate the fracture gradient formation value (see detailed discussions in Chapter P – Injection Operating Pressures). Injection pressures also will be limited to the pressure at which the well was integrity tested. The injection pressure monitoring system will have a high pressure alarm, and if the pressure exceeds the set point, corrective action will be taken. This corrective action may include shutting down the injection pump.

Monitoring of production (extraction) and injection rates and volumes will enable an accurate assessment of water balance for the wellfields. A bleed system will be employed that will result in less leach solution being injected than the total volume of fluids (leach solution and native groundwater) being extracted. A bleed of 0.5 to 1.5 percent will be maintained during production, resulting in more groundwater being extracted than injected. Maintenance of a negative water balance through use of this bleed will help to ensure that there is a net inflow of groundwater into the wellfield, thereby minimizing the potential movement of lixiviant and its associated contaminants out of the wellfield.

Wellhead pressure will be monitored at the injection manifold. Pressure gauges will be installed at each injection wellhead or on the injection manifold and monitored at least daily. Wellhead pressure will be restricted to less than 0.62 psi/ft of well depth. Injection rates will be adjusted to maintain wellhead pressure below that level.

Each new production well casing (extraction and injection) will be pressure tested to confirm the integrity of the casing prior to being used for mining operations. Wells that fail pressure testing will be repaired or cemented and replaced as necessary. Wells that are abandoned will be properly plugged (i.e., cemented) and abandoned as described in Chapter T. Wells will be abandoned in accordance with approved NDEQ plugging procedures.

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

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

M.1.3 Process Description

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

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

Oxidation:

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

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

Dissolution:

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

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

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

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

1. Loading of uranium complexes onto an ion exchange resin,
2. Reconstitution of the leach solution by addition of carbon dioxide and/or sodium bicarbonate and oxygen,
3. Elution of uranium complexes from the resin, and
4. Precipitation of uranium.

The process flow sheet for the above steps is shown in **Figure M.1-4**. The left side of this figure depicts the uranium extraction process that is completed at the Satellite Facility. The right side of the figure shows the uranium recovery steps that will be performed at the CPF. Once the ion exchange (IX) resin at the Three Crow Satellite Facility is loaded to capacity with uranium complexes, the resin will be transferred to the Central Plant for the completion of uranium recovery.

M.1.3.1 Three Crow Satellite Facility

Uranium Extraction

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

$$2\,R\,HCO_3 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2HCO_3^{-1}$$
$$2\,RCl + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2Cl^{-}$$
$$R_2SO_4 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + SO_4^{-2}$$

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

The now barren leach solution passes from the IX columns to a barren lixiviant trunk line. At this point, the solution is refortified with carbon dioxide, sodium or carbonate chemicals as required and pumped to the wellfield for reinjection into the formation. The expected lixiviant concentration and composition is shown in **Table J-1** of Chapter J.

Resin Transport

Once the majority of the ion exchange sites on the resin in an IX column are filled with uranium, the column will be taken out of service. The loaded resin with uranium will be transferred to a tanker truck for transport to the Central Plant for elution and final processing.

M.1.3.2 Central Plant

Elution

At the Central Plant, the loaded resin that has been transported from the satellite facility will be stripped of uranium by an elution process based on the following chemical reaction:

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

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

Precipitation

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

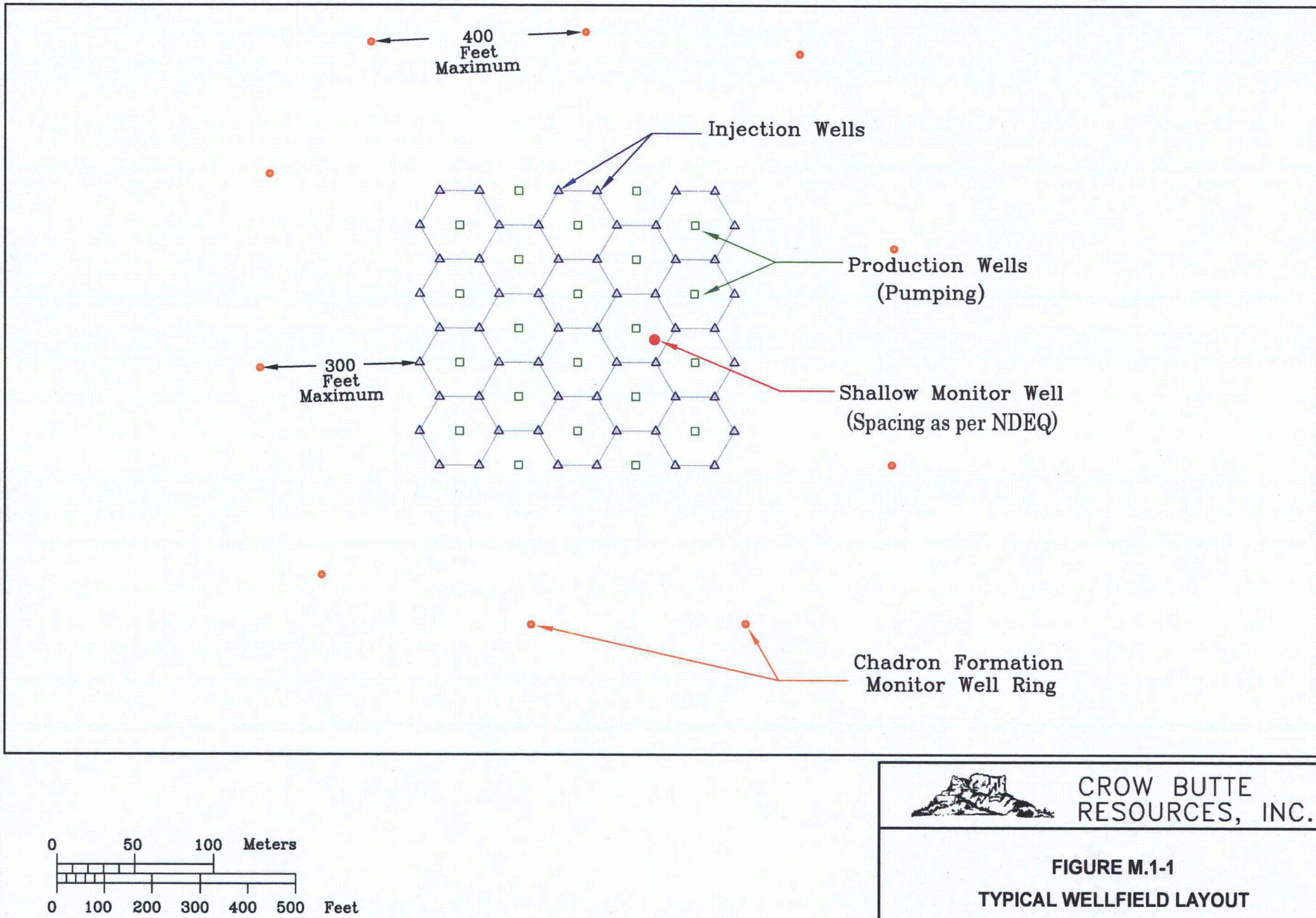
$$UO_2(CO_3)_3^{-4} + 6H^+ \longrightarrow UO_2^{++} + 3\ CO_2\uparrow + 3H_2O$$

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

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

Once the resin has been stripped of the uranium by the process of elution, the resin will be returned to the Three Crow Satellite Facility for reuse in the ion exchange circuit.

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



CROW BUTTE RESOURCES, INC.

FIGURE M.1-1

TYPICAL WELLFIELD LAYOUT

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

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Highlands Ranch, CO 80129
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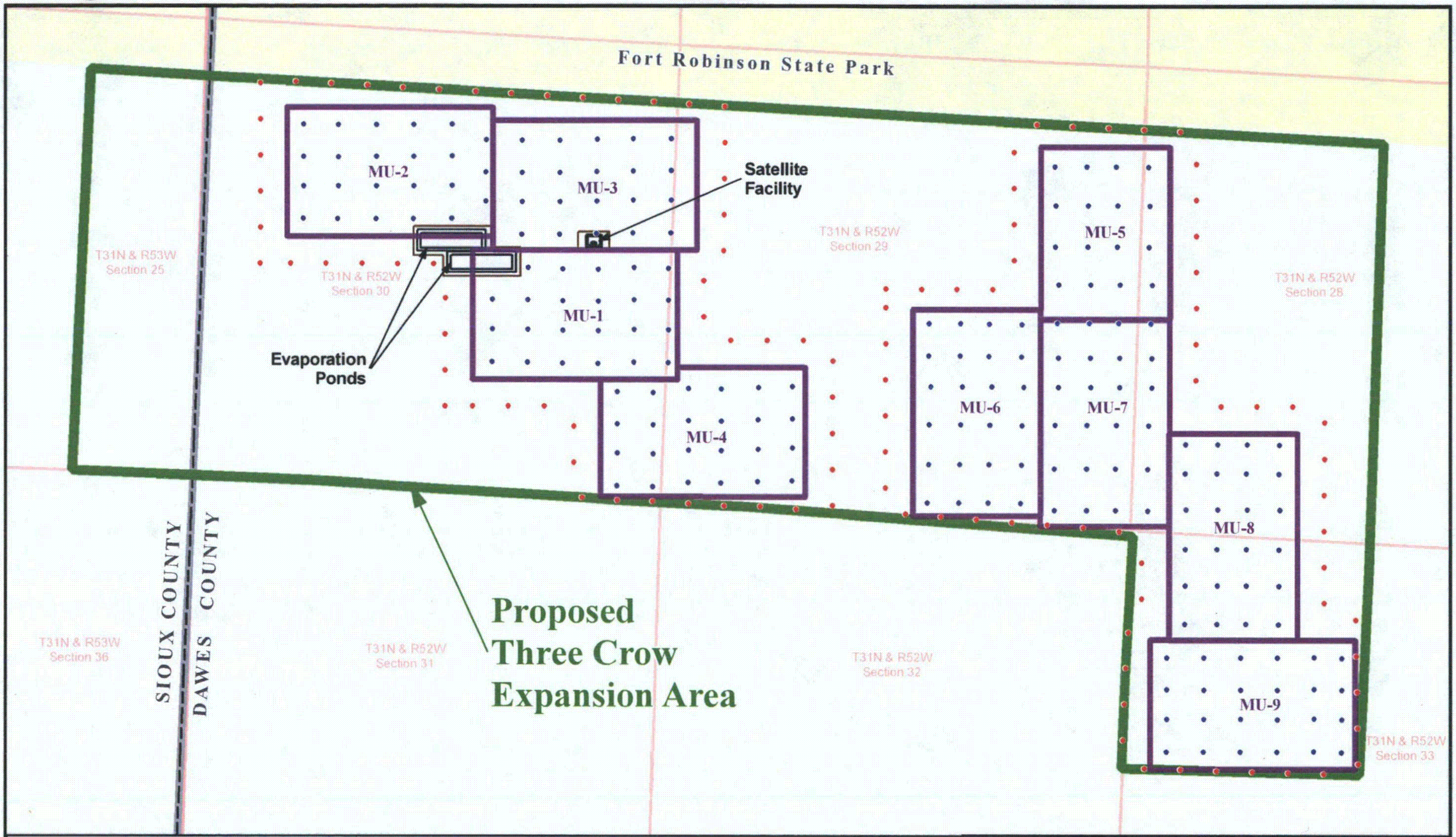

LEGEND

- Commercial Monitor Well
- Shallow Monitor Well
- Security Fence
- Satellite Facility
- Evaporation Ponds
- Proposed Three Crow Expansion Area
- Mine Unit Boundary
- Fort Robinson State Park

0 1,000 2,000
Scale in Feet

N W E

PROJECTION: NAD_1927_STATEPLANE_NEBRASKA_NORTH_FIPS_2601

CROW BUTTE RESOURCES, INC.

FIGURE M.1-2
THREE CROW MONITOR WELL LAYOUT

PROJECT: CO001396.00002 MAPPED BY: JC CHECKED BY: JEC

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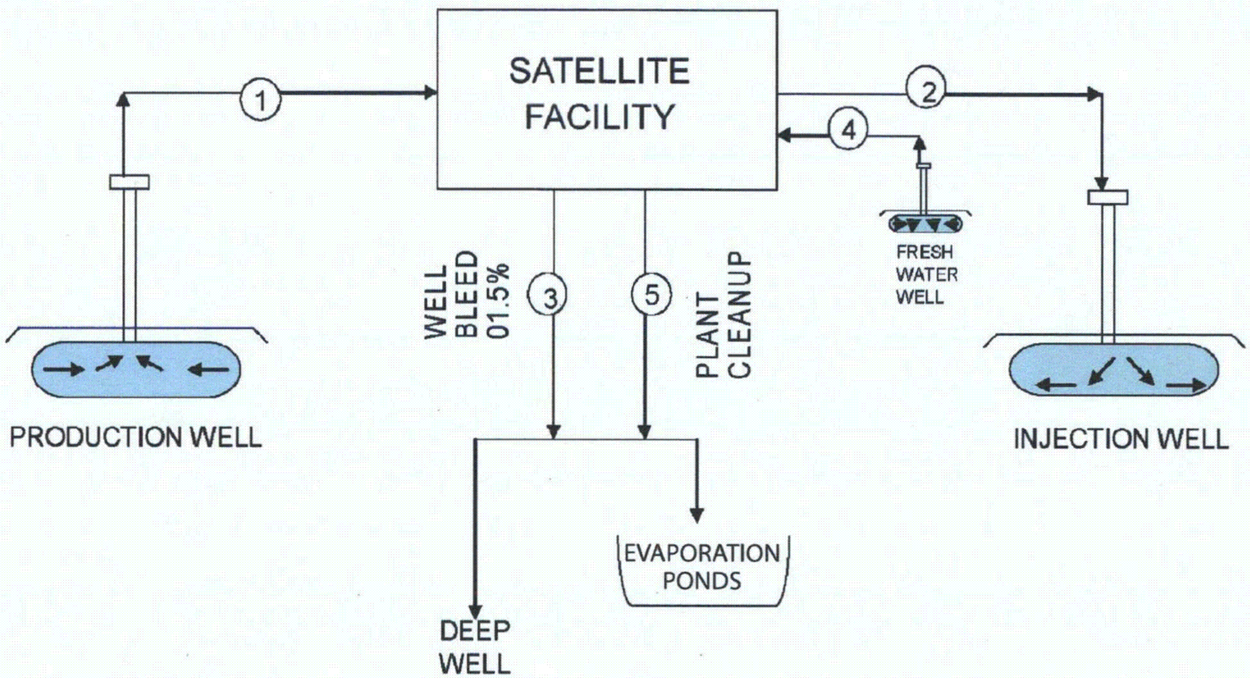

STREAM #	1	2	3	4	5
SOLUTION GPM*	4,500	4,432.5	67.5	2	2

*BALANCE IS NOMINAL FOR A 1.5% BLEED. ACTUAL BALANCE MAY VARY ACCORDINGLY.

CROW BUTTE RESOURCES, INC.

FIGURE M.1-3
THREE CROW WATER BALANCES

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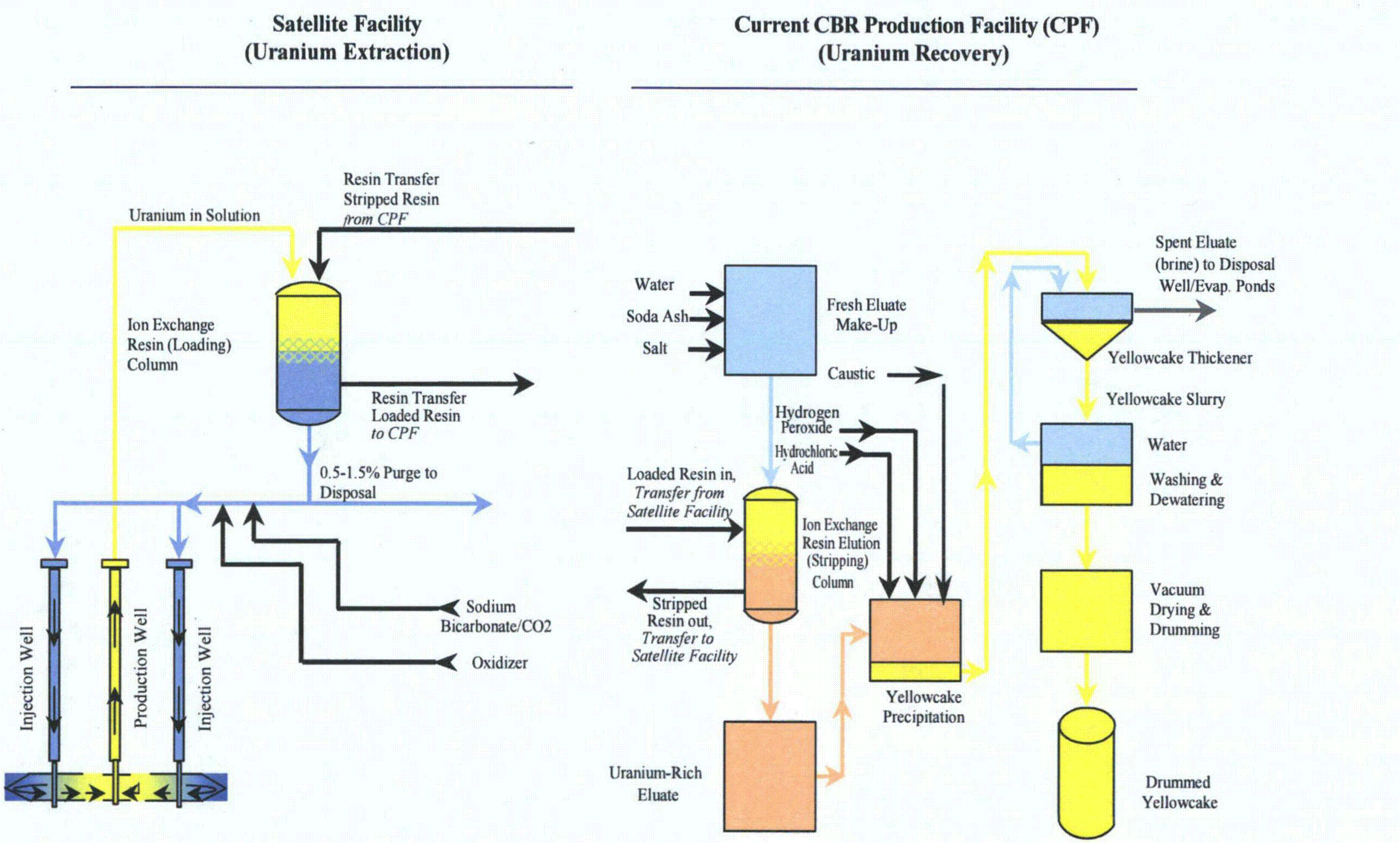

CROW BUTTE RESOURCES, INC.

FIGURE M.1-4
THREE CROW SATELLITE FACILITY AND CURRENT CBR PRODUCTION FACILITY PROCESS FLOW DIAGRAM

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CHAPTER N. WELL CONSTRUCTION/DESIGN AND ASSOCIATED FACILITIES

N.1 Well Construction and Integrity Testing

The following information concerning the injection zone (water bearing) within the Three Crow Expansion Area (TCEA) is determined or calculated for newly constructed Class III wells:

- Fluid pressure,
- Temperature,
- Fracture pressure,
- Other physical and chemical characteristics of the injection zone,
- Physical and chemical characteristics of the formation fluids, and
- Compatibility of injected fluids with formation fluids.

These requirements are discussed in different chapters of this application.

In order to meet NDEQ requirements, the following criteria will be considered in developing a proposed monitoring program, including the number, location, construction and frequency of monitor wells:

- The population relying on the underground source of drinking water (USDW) affected or potentially affected by the injection operation,
- The proximity of the injection operation to points of withdrawal of drinking water,
- The local geology and hydrology,
- The operating pressures and whether a negative pressure gradient is being maintained, and
- The injection well density.

These criteria will be used in preparing and submitting a proposed monitor well program to NDEQ. The NDEQ will make the final determination of the number, location, construction, placement and frequency of monitor wells

All new Class III wells will be cased and cemented to prevent the migration of fluids into or between underground sources of water. The casing and cementing used in construction will be designed for the life expectancy of the well. All Class III well designs will be submitted to the Nebraska Department of Environmental Quality (NDEQ) by a professional engineer.

The following factors are considered when determining and specifying casing and cementing requirements:

- Depth to the injection zone;
- Injection pressure, external pressure, internal pressure, axial loading, etc.
- Hole size;

- Size and grade of all casing strings (wall thickness, diameter, nominal weight, length, joint specification, and construction material);
- Corrosiveness of injected fluids and formation fluids;
- Lithology of injection and confining zones; and
- Type and grade of cement.

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

N.1.1 Well Materials of Construction

The well casing material will be polyvinyl chloride (PVC). PVC well casing is 4.5 inch SDR-17 (or equivalent). The PVC casing joints are normally approximately 20 feet long each. With SDR-17 PVC casing, each joint is connected by a watertight o-ring seal which is located with a high-strength nylon spline.

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

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

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

N.1.2 Well Construction Methods

Pilot holes for monitor, production, and injection wells are drilled to the top of the target completion interval with a small rotary drilling unit using native mud and a small amount of commercial drilling fluid additive for viscosity control. The hole is logged, reamed, casing set, and cemented to isolate the completion interval from all other aquifers. Three well construction methods are described (not necessarily in the order of their preferred use). Any of the methods is appropriate for monitor wells and has been approved by the NDEQ under the UIC Permit. **Final, detailed engineering drawings depicting the construction details of the Class III wells will be submitted to the NDEQ for approval prior to commencement of construction.**

Three well construction methods are described in this section. Of the three methods, CBR primarily uses Method 1 shown in **Figure N.1-1** on a routine basis. Method 2 shown in **Figure N.1-2** may be used by the CBR Geology staff when there is a need to study the geology of an area and to determine the best placement of the screens without having to attach screens to the casing string. Method 3 shown in **Figure N.1-3** is not routinely used, but this method is maintained as an option so that the method (including minor modifications) can be used if warranted for specific geological formations.

- Method No. 1

  For this method, the well is drilled to depth in the Pierre Shale, and then logged. Based upon the e-log, geological staff will pick a casing depth, and will then begin to review the local area wells for the best location (depth) to pick the screened interval. The well is cased through the mining zone and cemented in place. Cement flows down the inside of the casing, exits out the bottom, and flows back up the annulus to the surface. Cement may be pushed out of the bottom of the casing by use of a rubber cement plug that is pushed to the bottom and stays in the bottom of the well, or cement may be displaced using fresh water. If the cement is displaced with water, a rig will need to drill the excess cement out of the casing prior to under-reaming and setting screens. If the cement is displaced using a cement plug, then nothing further is required prior to under-reaming. The under-reaming process begins with a rig tripping (inserting in borehole) a specialized drill bit into the depths to be screened. Blades on the bit open outward and cut away and remove the casing and cement grout from the area to be screened. When the interval to be screened has been cut away, the drill rig removes the drill pipe, and the hole is logged to make certain that the cut is accurate. If the cut-check depths are determined to be satisfactory, the rig is used to place the screen assembly at the selected depth and then develop of the well.

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

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

- Method No. 2

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

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

- Method No. 3

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

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

<u>Screening</u>

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

For injection and production wells, the screen interval is determined by the Geologic staff based on the location of sands and ore grade material. Correlating and selecting the zones to be mined and making certain that the screened intervals between wels are hydrologically connected is completed by reviewing geophysical logs. Typically, an interval of approximately 18 feet is screened; however, individual intervals may range from 6 feet to 35 feet in length.

For monitor wells, a slightly different process is followed for placement of the screens. When the monitor well is drilled, the total thickness of the production zone is calculated. The amount of screens to be placed in the well must cover the production zone and the screen to blank ratio must exceed 50%. Care should be taken to ensure that those zones impacted by nearby wells are covered by screens, not blank. The monitor wells will be installed to ensure requirements of Chapter 17 of NDEQ Title 122 are met.

A well completion report is completed for each well and submitted to the NDEQ. These data are kept available on site for review. All wells are constructed by a licensed/certified water well contractor, as defined by Nebraska Health and Human Services System, Water Well Standards and Licensing Act, Article 46.

N.1.2.1 Cement Grout Specifications

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

- A density of no less than 11.5 lbs/gal.
- A bentonite grout shall be mixed as close as possible to a concentration of 1.5 lb. bentonite per gallon of water (1 quart polymer per 100 gallons of water may be premixed to prevent the clays from hydrating prematurely) and shall have a density of 9.2 lbs./gal or higher.

N.1.2.2 Logging Procedures and Other Tests

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

<u>Logging Equipment</u>

CBR currently owns three operational logging units. All were built by Century Geophysical Corporation in Tulsa, Oklahoma. They are a 2000 model, a 2006 model, and the newest is a 2008 model. These units are capable of logging drill holes to a depth of approximately 2,000 feet.

These trucks are capable of using a wide variety of tools. All of these tools, or probes, as used by CBR, measure Single Point Resistance (RES), spontaneous Potential (SP), Natural Gamma (GAM[NAT]), and Deviation. Some of the probes used by CBR also are capable of measuring temperature, 16-inch normal resistance, and 64-inch normal resistance. All probes used at CBR are of a Century Geophysical design, and include the 9060, 9055, 9144, and 9057 types (**Table N.1-1**). Deviation with these units is measured using a slant angle and azimuth technique. Standardized procedures are used by trained personnel to carry out the logging tasks.

Borehole Geophysical Logs

As of January 21, 2010, there have been 698 exploration/development holes and 18 monitor and observation wells drilled within the TCEA boundary. A sample portion of a borehole geophysical log (boring SO-9) is shown in **Figure E.1-4 of Chapter E**. Detailed analysis of a carefully chosen suite of borehole geophysics provides a method for interpreting lithology, stratigraphy, depositional environment, and for deriving porosity values, permeability index, and water salinity. The log curves used for interpretation and parameter derivation measure resistivity, spontaneous potential, natural radioactivity, and deviation.

Log interpretation and parameter evaluation involves analysis of the measured log curve values and responses. The measured curve and resultant analysis are affected by drilling processes, properties of the formation, and limitations of the logging tools themselves. Common hydrogeologic objectives of borehole geophysical logging include: (1) definition and correlation of aquifer or other lithologic units; (2) estimation of aquifer properties such as porosity and permeability; and (3) assessment of physical properties of formation water including conductivity, total dissolved solids, and total hardness. These objectives must be considered in the design, selection, and implementation of an effective logging program.

There are three basic parameters derived or interpreted from borehole geophysical logs: lithology, resistivity, and porosity. From these basic parameters, there are numerous variations that can provide information regarding lithologic identification, correlation, facies evaluation, delineation of permeable and porous zones, and identification of pore fluids. The type of measurements used to determine this information are:

- spontaneous potential
- natural gamma radiation (Ray)
- resistivity/induction

The following represent the general log suite at each borehole location.

Gamma ray (GR) tools measure naturally occurring gamma ray radiation emitted spontaneously from the formation by uranium, thorium, and the potassium 40 isotope. Natural gamma logs are powerful tools in lithologic identification and correlation, identification of potential migration pathways, and evaluation of water quality with respect to radionuclides, such as uranium salts. GR logs usually show the clay content in sedimentary rocks, because heavy radioactive elements (potassium, thorium, and uranium-radium) tend to concentrate in clays. While clays and clayey sands are higher in radioactivity, clean sands (no clay content) and carbonates usually exhibit low levels of radioactivity. The GR curve can differentiate among sands, clays, and the gradation between the two. As radioactive elements tend to concentrate in shales and clays, high gamma ray readings reflect high shale or clay content in sedimentary units. Very low levels of radioactive elements or isotopes are present in clean formations (sands, gypsum, and anhydrite) unless contaminants are present such as dissolved potassium or uranium salts, volcanic ash, or granite wash. The tool records counts per second, which should be converted to American Petroleum Institute (API) units. Natural gamma logs should always be calibrated in API units. The API unit is a unit of counting rate used for scaling gamma-ray logs and neutron logs (Schlumberger 2010). The API unit of radioactivity is used for natural gamma ray logs and is based on an artificially radioactive concrete block located at the University of Houston, Texas. This unit was chosen because it was considered to be twice the radioactivity of typical shale. The primary standard for calibrating gamma ray logs is the formation.

The Spontaneous Potential (SP) log is a measurement of the electrical potential (voltage) that occurs in a boring when fluids of different salinities are in contact. The electrical potential is produced by the interaction of formation water, conductive drilling fluids, and certain ion-selective sediments (clay). Because clays have a very low permeability, and sands a high permeability, the SP can be a valuable lithology indicator. In general, clay-free permeable beds of moderate to low resistivity are sharply defined by the SP curve. High resistivity beds distort the SP currents, flattening the slope of the SP curve at bed boundaries. This causes poor bed boundary definition. In addition, the SP curve is also distorted (depressed or elevated) by permeable zones that contain clay, hydrocarbons, gas, or contaminants.

Single point resistance tools measure the resistance to current flow between a tool electrode and a ground electrode (conventional single point resistance), or between an electrode in the tool and the shell of the tool (differential single point resistance). Response of the log curve is attributed to lithologic units of varying resistance. Resistance increases in freshwater-filled sands or gravels and decreases in shales, clays, silts, and brine-filled sands. Curve values are recorded in ohms. Point resistance tools have a relatively small radius of investigation and poor thin bed resolution in comparison to resistivity tools. These logs are mainly used for correlation of beds.

The Neutron-Neutron (N-N) tool is a direct measurement of variations in the hydrogen content of the formation. A Neutron-Neutron probe takes a direct measurement of the variations in the hydrogen content profile. The neutron probe contains a source of high-energy neutrons (commonly americium-beryllium) with thermal neutron detectors at a fixed distance away from the source. The tool records counts per second, which should be converted to API units. A high count indicates a low porosity, while a low count indicates a high porosity. Neutron logs are influenced by changes in the hole diameter.

Borehole Deviation Logging

Deviation of boreholes is measured using a slant angle and azimuth technique. CBR uses a Century Geophysical Corporation Tool Borehole deviation log tool 9057 or equivalent to record the attitude (dip angle and dip direction) of rock layers in the borehole. Borehole deviation and pad 1 azimuth are recorded in real time, via a deviation package contained within the tool, which contains the X-Y inclinometers and the X-Y-Z magnetometers. From these sensors, the Compu-Log computes and records slant angle, (angle of the tool), and slant angle bearing (tool direction) as the tool proceeds along the borehole path. This device is aligned to correct for spatial indications with pad 1 azimuth. The deviation calibration is performed by recording two CPS rotating logs, and then using the dipmeter calibration to produce a special deviation calibration file.

Other Testing

Field Observations and Core Samples Analysis

At CBR, subsurface formation lithology mapping and interpretation for boreholes during the drilling and construction of Class III wells are primarily based on field observations and geophysical logging. Field observations during drilling include depth, drilling rate, size of cuttings, and changes in lithology. Drill cuttings or core samples may be analyzed for physical and chemical parameters as needed in support of geophysical measurements. For example, core samples were recently collected in the TCEA for four lithostratigraphic units. Sample analyses included x-ray diffraction (XRD) and sieve analysis (i.e., grain size distribution). Of particular importance for this sampling program was a better understanding of the hydraulic characterization of the upper and lower confining units for the Basal Chadron sandstone. This information was required for the Aquifer Exemption Petition.

Core samples may be collected as needed, but coring is typically not needed during the drilling and construction of Class III wells. The types of tests that are conducted on core samples are based on the intended need (e.g., porosity, relative permeability, and lithology).

Groundwater Measurements

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

N.1.3 Well Development

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

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

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

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

Following well installation, all well development water will be captured in water trucks specifically labeled and dedicated for such purpose, and equipped with signage indicating that these trucks may only discharge their contents to the lined evaporation ponds. As the signage requires, all well development water will be disposed of in the evaporation ponds.

N.1.4 Well Integrity Testing

Field-testing of all injection, production, and monitor wells is performed to demonstrate the mechanical integrity of the well casing. This mechanical integrity test (MIT) is performed using pressure-packer tests. Every well will be tested after well construction is completed and before it can be placed in service, after any workover with a drill rig or servicing with equipment or procedures that could damage the well casing, at least once every 5 years, and whenever there is any question of casing integrity. To assure the accuracy of the integrity tests, the field pressure gages and a calibrated test gage are periodically compared. The MIT procedures have been approved by the NDEQ and are currently contained in EHSMS Program Volume III, *Operating Manual*. These same procedures will be used at the TCEA.

The following general MIT procedure is used:

- The well is tested after well development and prior to the well being placed into service. The test consists of placement of two packers within the casing. The bottom packer is set just above the well screen, and the upper packer is set at the wellhead. The packers are inflated with nitrogen, and the casing is pressurized with water to 125 percent of the maximum operating pressure (i.e., 125 psi).
- The well is then "closed in" and the pressure is monitored for a minimum of 20 minutes, maintaining 90 percent of the original pressure to pass the test.
- If more than 10 percent of the pressure is lost during this period, the well has failed the integrity test. When possible, a well that fails the integrity testing will be repaired and the testing repeated. If the casing leakage cannot be repaired or corrected, the well is plugged and reclaimed as described in Chapter T.

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

N.2 Three Crow Satellite Facility, Wellfields, and Chemical Storage Facilities

N.2.1 Three Crow Satellite Facility Equipment

The process flow sheet for the Three Crow Satellite Facility and associated Central Recovery Facility is shown in **Figure M.1-4** of Chapter M.

A general arrangement for the Satellite Facility is shown on **Figure N.2-1**. The Three Crow Satellite Facilities will be housed in a building approximately 130 feet long by 100 feet wide. The Satellite Facility equipment includes the following systems:

- Ion exchange,
- Filtration,

- Resin transfer, and
- Chemical addition.

The Three Crow Satellite Facility will be located within a 1.8-acre fenced area in the east ½ of the NW¼, Section 27, T32N, R52W. This area will also contain the evaporation ponds, deep disposal well, and chemical storage areas. **Figure N.2-2** shows the plan view of these facilities.

The Satellite Facility will house the ion exchange (IX) columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, a small laboratory, and an employee break room. Bulk soda ash, carbon dioxide, oxygen in compressed form, and/or hydrogen peroxide will be stored adjacent to the Satellite Facility or in the wellfield. Sodium bicarbonate and/or gaseous carbon dioxide are added to the lixiviant as the fluid leaves the Satellite Facility for the wellfields. Gaseous oxygen is added to the injection line for each injection well at the wellhouses.

The IX system consists of eight fixed-bed ion exchange columns. The IX columns will be operated as three sets of two columns in series with two columns available for restoration. The IX system is designed to process recovered leach solution at a rate of 4,500 gpm with each column sized at 11.5-foot diameter by 21-foot overall height with 500 cubic feet of resin operated downflow. Once a set of columns is loaded with uranium, the resin is transferred to a truck for transport to the central processing building at the existing Crow Butte Project.

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

N.2.2 Wellfield Equipment

The TCEA will be subdivided into a number of mine units (**Figure A.2-3** of Chapter A). The typical locations of injection and production wells are shown in **Figure M.1-1** of Chapter M and are discussed in Chapters A and M. Each mine unit will contain a number of wellhouses, where injection and recovery solutions from the Satellite Facility building are distributed to the individual wells. The injection and production manifold piping from the satellite process facility to the wellfield houses will be either PVC or high-density polyethylene (HDPE) with butt-welded joints or an equivalent. In the wellhouse, injection pressure will be monitored on the injection trunk lines. Oxidizer will be added to the injection stream, and all injection lines off of the injection manifold will be equipped with totalizing flowmeters, which will be monitored in the satellite control room. The TCEA wellfields will be designed in a manner consistent with the existing CBR wellfields.

N.2.3 Chemical Storage

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

N.2.4 Process Related Chemicals

Process-related chemicals stored in bulk at the Three Crow Satellite Facility will include soda ash, carbon dioxide, oxygen, and/or hydrogen peroxide. Sodium sulfide may also be stored for use as a reductant during groundwater restoration.

N.2.5 Non-Process Related Chemicals

Non-process related chemicals that will be stored at the Three Crow Satellite Facility include petroleum (gasoline, diesel) and propane. Due to the flammable and/or combustible properties of these materials, all bulk quantities will be stored outside of process areas at the Satellite Facility. All gasoline and diesel storage tanks are located above ground and within secondary containment structures to meet U.S. Environmental Protection Agency (USEPA) requirements.

N.2.6 Evaporation Ponds

The evaporation pond configuration at the Three Crow Satellite Facility will be similar to the existing ponds at the current CBR license area. The exact number and capacity of the ponds will depend upon the results of the performance of the deep disposal well test as far as determining the waste water disposal rate. In addition, the pond design cannot be finalized until completion of the site geotechnical assessment. This information is currently not available due to the stage of project development.

The evaporation ponds will be designed to comply with the requirements of the NDEQ, as specified in Title 123. Prior to construction, CBR will submit a construction permit application for review and approval by the NDEQ. In addition, an NRC license amendment application with pond design and specifications, which meet the requirements of the most recent NRC pond design and construction NRC Regulatory Guide 3.11 (NRC 2008), will be submitted to the NRC prior to pond construction.

N.2.7 Engineering Drawings

The final and detailed engineering drawings for the surface and associated subsurface facilities shall be submitted to the NDEQ for approval prior to commencement of construction.

N.3 Notice of Intent to Operate

Prior to the operation of each mine unit, or any part thereof, CBR shall submit a notice of completion of construction to the NDEQ with the following information:

1. A scaled map indicating the location of all monitoring, production, and injection wells and known archaeological sites.
2. A well completion report for all injection/production well(s).
3. A statement that each Class III well or group of wells utilizing a positive displacement pump shall be equipped with both high- and low-pressure safety switches, which will shut down the pump in case of pressure increase over the authorized pressure or sudden pressure loss.
4. A well completion report for all monitor well(s).

5. The baseline sampling data used to determine the Upper Control Limits (UCLs) and the designation of these limits.
6. The baseline sampling data used to determine the restoration values and CBR's recommendation for wells to be designated as restoration wells in the mine unit.
7. The results of testing that demonstrates the mechanical integrity for all wells by:

   Setting a packer immediately above the completion interval and a packer or wellhead at ground surface. The space between the two will then be pressurized to at least 125 percent of the maximum operating pressure specified in Section Q4. The pressure will be held for a period of 20 minutes maintaining 90 percent of the original pressure to pass the test.

In addition to item 7, the following information shall be provided:

a) A precalculated amount of cement/bentonite grout or benonite grout to fill the annular space of the well along with well records demonstrating the presence of adequate grouting material to prevent material fluid migration.

AND

b) Any other data gathered for the injection and production wells.

8. In addition, CBR shall have available on site for review upon request any other pertinent information which has been compiled, such as:
   a) All available geological and geophysical logging and testing on the well(s).
   b) The results of the formation testing program.
   c) Compatibility of injected materials with fluids in the injection zone and the minerals in both the injection zone and the confining zone.

The Notice of Intent to Operate for each mine unit or partial mine unit will be submitted at least 30 days prior to any injection..

N.4 References

Schlumberger. 2010. *API Unit.* [Webpage]. Located at: http://www.glossary.oilfield.slb.com/Display.cfm?Term=API%20unit. Accessed on: March 21, 2010.

U.S. Nuclear Regulatory Commission (NRC). 2008. Regulatory Guide 3.11. Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities. Revision 3. November 2008.

Table N.1-1 Background Information for Logging Probes Used at the Three Crow Expansion Area

Logging Tool	Tool Specifications
9060	Natural gamma, Spontaneous Potential, Single Point Resistance
9055	Vertical Deviation, Natural Gamma, Neutron Detector, Neutron Porosity, Spontaneous Potential, Single Point Resistance, Radioactive Source (1 Curie Am241Be)
9144	Natural Gamma, 64 in. Normal Resistivity, 16 in. Resistivity, Fluid Resistivity, Lateral Resistivity 48 in., Spontaneous Potential, Single Point Resistance, Temperature and Delta Temperature, Slant Angle and Aximuth.
9057	Natural Gamma, 64 in. Normal Resistivity, 16 in. Normal Resistivity, Neutron-Neutron, Lateral Resisitivity 48 in., Spontaneous Potential, Single Point Resistance, Temperature and Delta Temperature, Slant Angle and Azimuth

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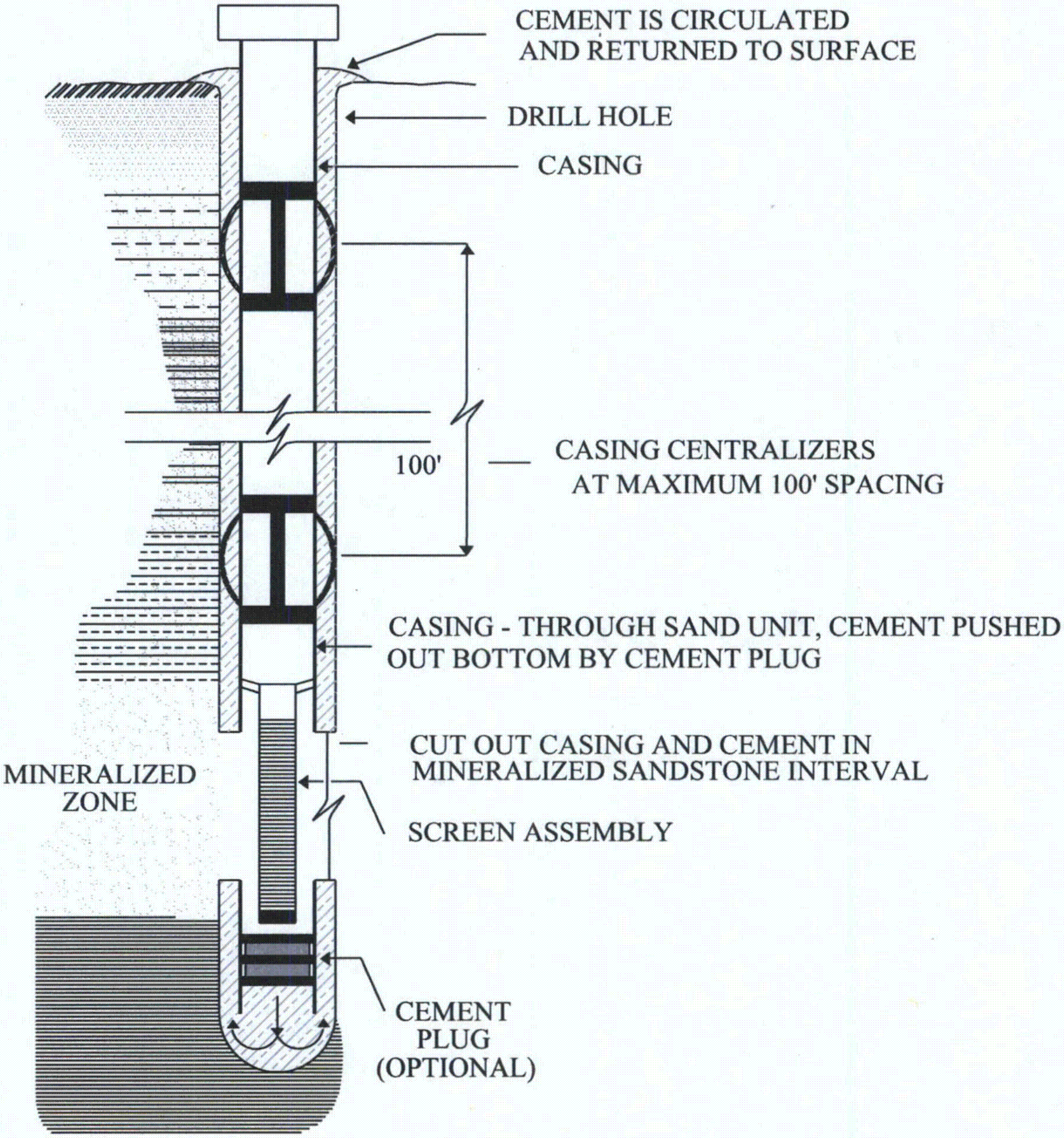


CROW BUTTE RESOURCES, INC.

FIGURE N.1-1

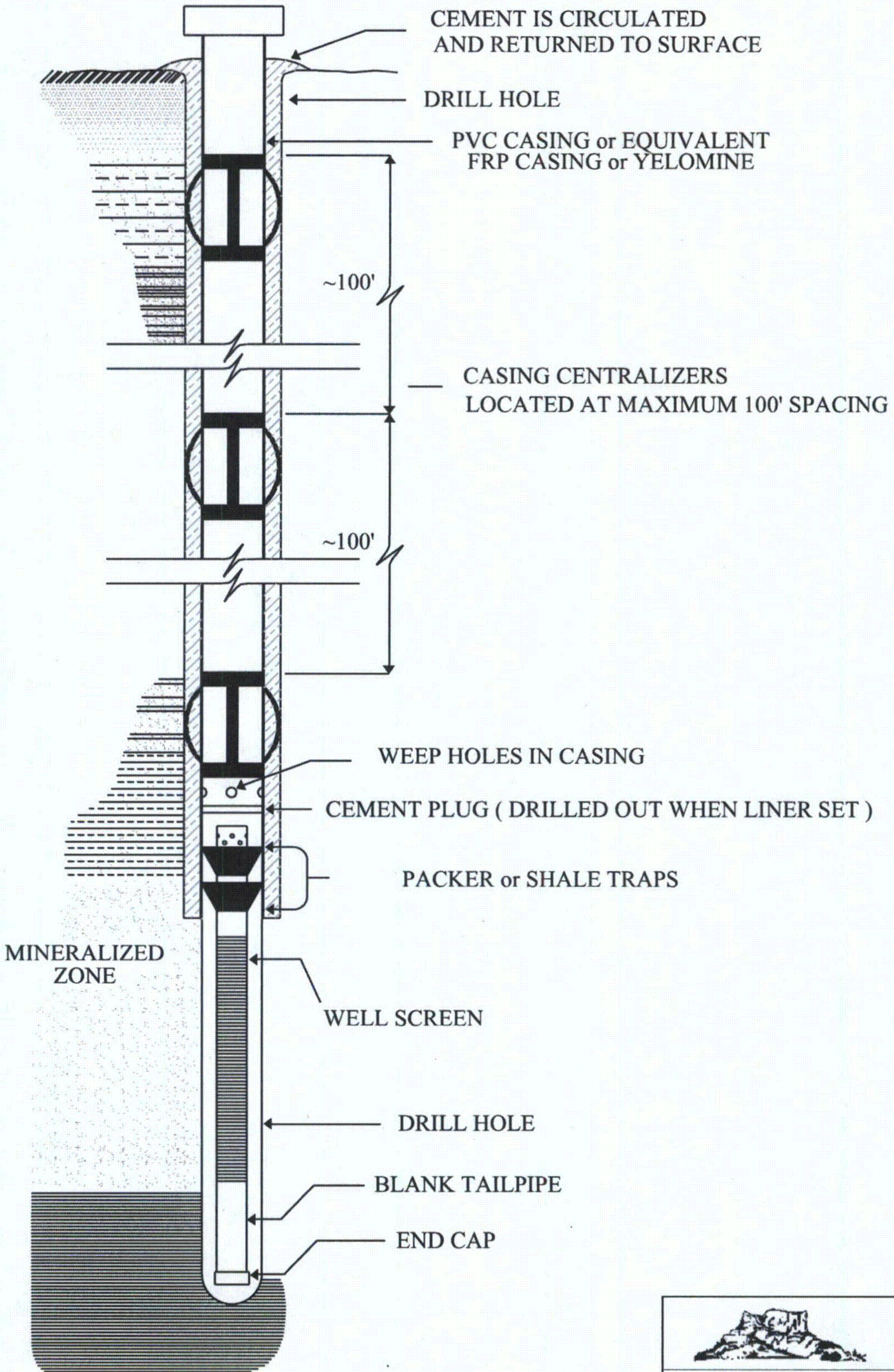
TYPICAL MINERALIZED ZONE COMPLETION FOR INJECTION/PRODUCTION WELLS

METHOD NO.1

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

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

PATH: K:\CBR[…]\CO001396_ThreeCrow1_ACAD\ARCADIS_NewDrawings\WellCompletionMethods.dwg LAYOUT: UIC_No1 DA[…]E: 2/2/2010 3:41 PM



CROW BUTTE RESOURCES, INC.

FIGURE N.1-2

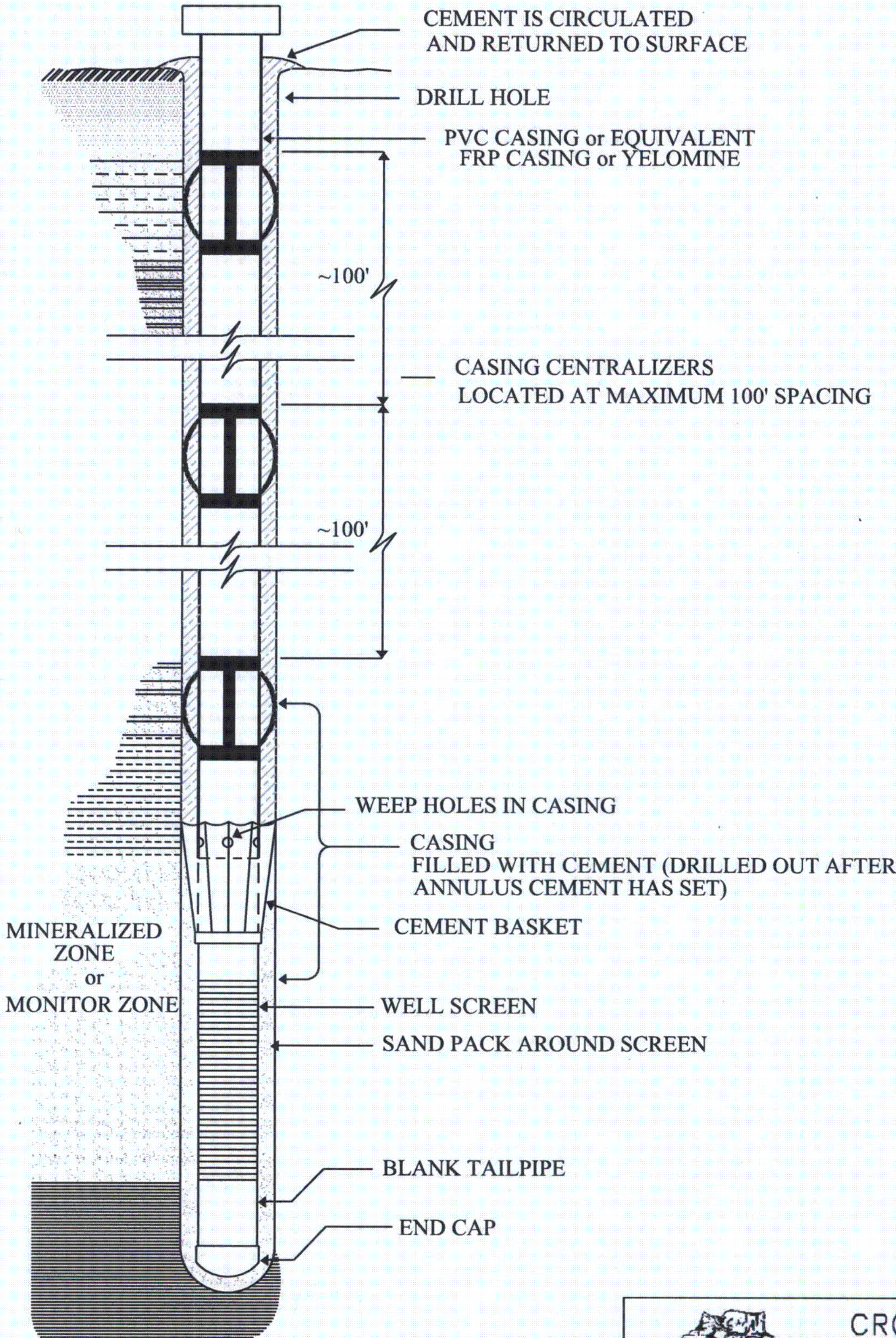
TYPICAL LINER COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS

METHOD NO.2

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

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

PATH: K:\CBR \CO001396_ThreeCrow\1_ACAD\ARCADIS_NewDrawings\WellCompletionMethods.dwg LAYOUT: UIC_No2 DA E: 2/2/2010 2:24 PM



CROW BUTTE RESOURCES, INC.

FIGURE N.1-3

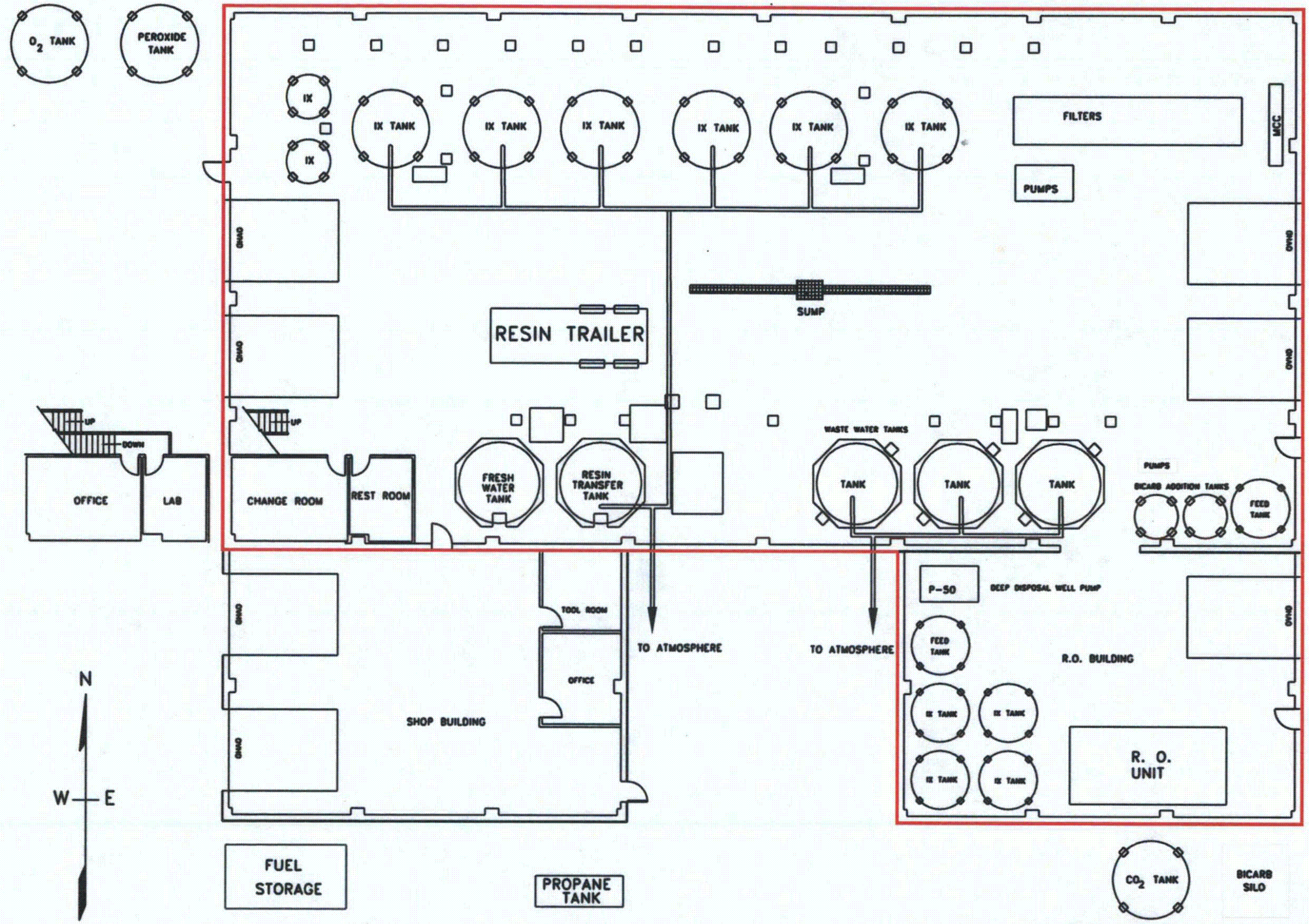
TYPICAL CEMENT BASKET COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS

METHOD NO.3

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

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

PATH: K:\CBR_ CO001396_ThreeCrow1_ACAD\ARCADIS_NewDrawings\WellCompletionMethods.dwg LAYOUT: UIC_3 DATE 2/2/2010 3:41 PM



RESTRICTED AREA BOUNDARY

10 0 10 20 30
Feet

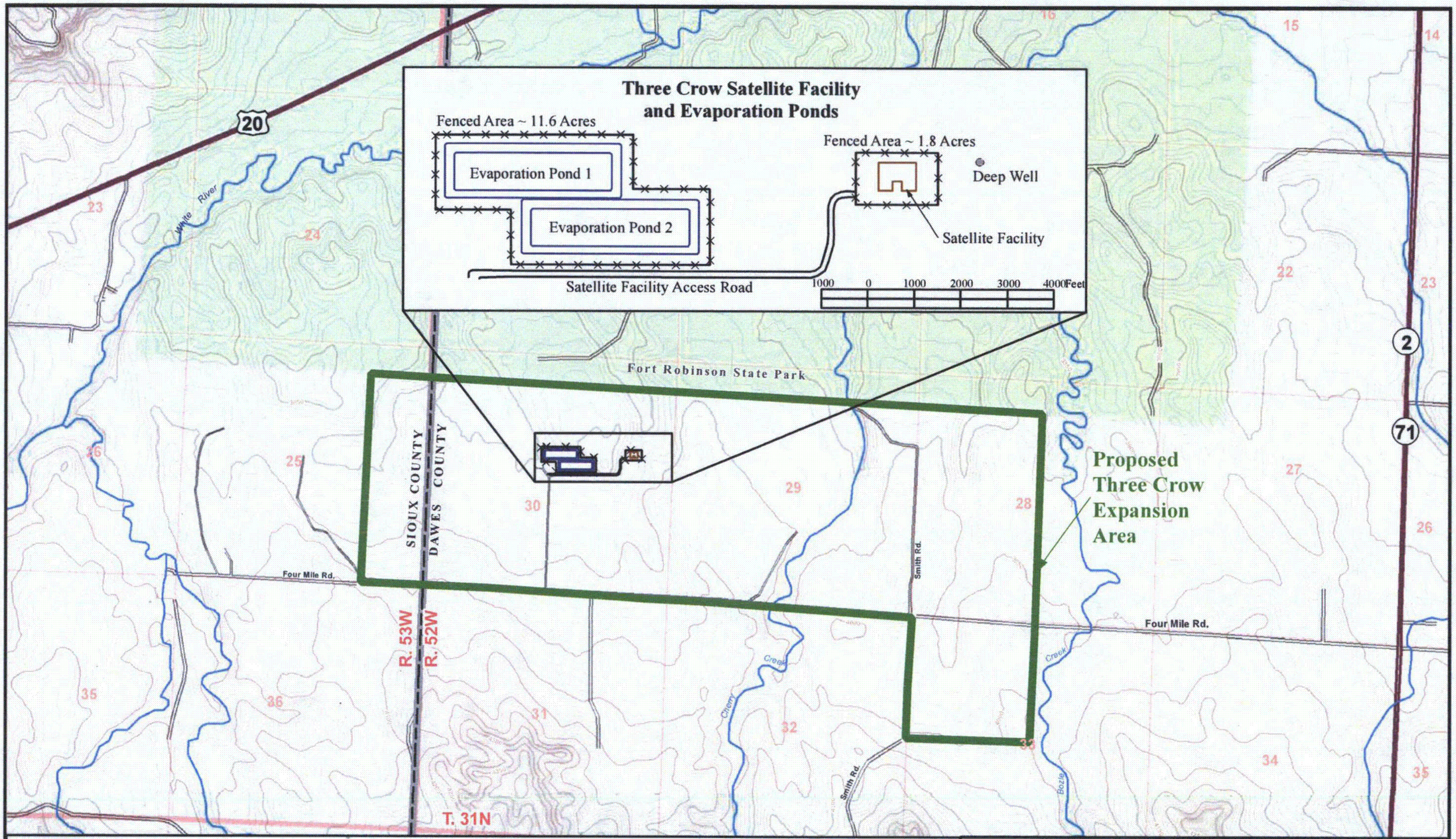
CROW BUTTE RESOURCES, INC.

FIGURE N.2-1
THREE CROW
SATELLITE FACILITY LAYOUT

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

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

PATH: C:\Documents and Settings\MHoefer\My Documents\3CrowSatelliteLayout.dwg LAYOUT: UICRpt_N2-1 DATE/TIME: 2/2/2010 3:35 PM



LEGEND

- Proposed Three Crow Expansion Area
- Fort Robinson State Park
- River/Creek
- Security Fence
- Highway
- County Boundary
- Elevation Contour (10-Ft Interval)
- Road

0 1,000 2,000
Scale in Feet

PROJECTION:
NAD 1927 STATE PLANE
NEBRASKA NORTH, FIPS 2601

CROW BUTTE RESOURCES, INC.

FIGURE N.2-2
GENERAL ARRANGEMENT
SATELLITE FACILITY VIEW

PROJECT: CO001396.00003 MAPPED BY: JC CHECKED BY: JEC

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

CHAPTER O. CONTINGENCY PLANS FOR WELL SHUT-INS AND FAILURES

O.1 Contingency Plans

The Nebraska Department of Environmental Quality (NDEQ) has authority for groundwater protection including the proper plugging and abandonment of wells. Improperly plugged and abandoned wells can allow contamination of groundwater resources through the influence of surface contamination or mixing between formations with different groundwater quality. Proper plugging and abandonment of mining and monitor wells located at the Three Crow Expansion Area (TCEA) will be regulated under NDEQ Rules and Regulations, Title 122, *Rules and Regulations for Underground Injection and Mineral Production Wells* and the Class III Underground Injection Control (UIC) Permit.

Vertical excursions can be caused by improperly cemented well casings, well casing failures, and improperly abandoned exploration wells. Crow Butte Resources, Inc. (CBR) controls such potential vertical excursions through rigorous well construction, abandonment, and testing requirements. Construction and integrity testing methods are discussed in detail in Section N – Well Construction & Associated Facilities. Wells are abandoned in accordance with methods approved and monitored by the NDEQ and discussed in detail in Section T.1 – *Well Plugging and Abandonment*. Procedures for wellfield reclamation are also contained in CBR's Environmental Health and Safety Management System (EHSMS) Program Volume VI, Section 12 – *Crow Butte Wellfield Reclamation* (CBR 2008). Applicable actions addressed in these documents pertaining to shut-ins and well failures are addressed in this section.

Several controls are in place to prevent the migration of fluids to overlying aquifers. CBR will plug all exploration holes to prevent commingling of the Brule and Chadron aquifers and to isolate the mineralized zone. In addition, prior to placing a well in service, a well mechanical integrity test (MIT) will be performed. This requirement of the NDEQ UIC Program ensures that all wells are constructed properly and capable of maintaining pressure without leakage. Finally, monitor wells completed in the overlying aquifer will be sampled regularly for the presence of leach solution.

Should upward fluid migration be detected, injection will be stopped, i.e., "shut in", until proper plugging can be accomplished. The NDEQ will be notified as required in Title 122, Chapter 21 – *Reporting Requirements*. Should any problems be detected in the casing of an injection well, the well will be repaired and must pass an MIT before it can be placed in service.

Typically, the reasons for shutting in and abandoning a well fall into the following categories:

- The well is damaged or well performance cannot be restored. Fracturing of a well casing and casing damage due to maintenance operations (e.g., workover with a drill rig or servicing with equipment) are two potential examples of situations requiring well replacement.

  The second category of well failures may be typified by a well which, due to formation damage or other reasons, will not respond to treatment allowing adequate injections or production.

Should a well failure be detected, the well will be integrity tested per Section Q.4 – *Well Integrity Testing*, to try and determine the nature of the failure. If repair is feasible, the well will be repaired and integrity tested again. If the well passes the integrity testing, it will be put back into service and monitored closely. Should the well fail integrity testing, or should it be beyond repair, it will be plugged and abandoned in accordance with Section T –*Plugging and Abandonment Plan.*

- Newly constructed wells may occasionally be unusable for two reasons:
    - The well will not pass an integrity test and cannot be successfully repaired; or
    - The casing string is too crooked to allow drilling out the cement grout or under-reaming of the casing at the proper depth.

If the well to be plugged does not pass an integrity test, it will be plugged using the following procedure:

- A mechanical plug may be placed above the screened interval at the discretion of the Site Senior Geologist or his designee.
- Thirty to 50 feet of coarse bentonite chips will be added to provide a grout seal.
- An approved bentonite-based hole-plugging product or cement grout will be placed by tremie pipe from the chips to the top of the casing. The weight of the gel or grout plus the weight of the bentonite chips will be enough to exceed the local Chadron Formation pressure plus the maximum injection pressure allowed (100 pounds per square inch [psi]).
- The tremie pipe will be removed (when possible), and the casing will be filled to the surface.
- The well casing will be capped but will not be cut off below ground level at this time in order to monitor the casing for any problems which may arise.
- If the well to be plugged is too crooked to be completed, it is still effectively sealed to prevent groundwater migration. Therefore, cement grout or bentonite plugging product will be placed with a tremie pipe as deep as possible into the open portion of the well casing and filled to the surface. These wells will not be cut off below the ground level for monitoring purposes.

The type of plugging fluid, volume, and density shall be measured and recorded for all plugged and abandoned wells. Per the requirements of Title 122, Chapter 35, CBR will submit a notarized affidavit to the NDEQ detailing the significant data and the procedure used in connection with each well plugged. The affidavit will be signed by a qualified witness to the plugging procedure. For an individual well, the affidavit will be submitted within 15 days after the plugging is complete.

The Nebraska Department of Natural Resources (DNR) also requires filing of a well abandonment notice for registered wells. The DNR report is to be filed within 60 days of the decommissioning of the well.

O.2 References

Crow Butte Resources, Inc. (CBR). 2008. *Environmental Health and Safety Management System, Volume VI, Environmental Manual.*

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CHAPTER P. INJECTION OPERATING PRESSURES

P.1 Regulatory Requirements

Nebraska Department of Environmental Quality (NDEQ) Title 122, Chapter 19, Section 002.02 requires that the injection pressure at the wellhead of Class III underground injection control (UIC) injection wells shall not exceed a maximum, which shall be calculated to assure that the pressure in the injection zone during injection does not initiate new fractures or propagate existing fractures in the injection zone, initiate fractures in the confining zone, or cause migration of injection or formulation fluids into an underground source of drinking water. Injection pressures will also be limited to the pressure at which the well was integrity tested. U.S. Environmental Protection Agency (USEPA) Regions 3, 4, 6, 8, 9, and 10 allow for use of a default value of 0.733 pounds per square inch per foot (psi/ft) for formation gradient pressure in a number of states, whereas USEPA Region 5 allows use of a default value of 0.80 psi/ft (**Table P.1-1**). The NDEQ has previously approved a fracture pressure gradient of 0.63 psi/ft at depth for the nearby operating Crow Butte facility.

P.2 Three Crow Injection Pressure Requirements

The maximum injection pressure to be used for the Three Crow Expansion Area (TCEA) wellfield operations will be limited to 100 psi at the wellhead, with an average of 96.4 psi. These pressures are required in order to keep the oxidant (oxygen) in solution. This maximum value has historically and successfully been applied to the nearby CPF operations, which is below the pressures passing the mechanical integrity testing for injection wells. Based on these wellhead injection pressures, the maximum injection pressure shall not exceed 0.62 psi/ft of well depth or the maximum operating pressure of the injection piping. Operating with an average injection pressure of 100 psi at the wellhead, and the maximum 0.62 psi/ft of well depth, provides a factor of safety to avoid fracturing the formation at the depths and piezometric surfaces encountered in the vicinity of the wellfield or cause migration of injection or formation fluids into another underground source of drinking water (requirements of NDEQ Title 122, Chapter 19, Section 002.02). This maximum wellhead injection pressure and resulting pressure at well depth will be lower than pressures allowed by the USEPA that are based on default formation gradient pressure values (**Table P.1-1**).

With a maximum injection pressure of 100 psi at the injection wellhead, and the fluid pressure increasing at a rate of 0.62 psi/ft with depth, the pressure at 670 feet bgs (average upper screening interval depth at top of production zone) will be 415 psi. At the top and bottom of the formation (approximately 580 and 940 feet) the formation pressures would be approximately 360 and 583 psi, respectively. Injection rates will be adjusted to maintain wellhead injection and formation gradient pressures below the maximum allowable levels.

The injection pressure monitoring system will have a high-pressure alarm and, if the pressure exceeds the set point, corrective action will be taken. This corrective action may include shutting down the injection pump.

In summary, operating at a maximum wellhead injection pressure of 100 psi, with a maximum formation gradient of 0.62 psi/ft at depth, will result in the TCEA operations meeting the requirements of NDEQ Title 122, Chapter 19, Section 002.02. In addition, the calculated fracture pressure gradient is well below default levels allowed by the USEPA for a number of other states. The nearby CBR facility is a similar operating facility that has operated successfully using similar pressures within a comparable geologic setting since 1991.

Table P.1-1 Maximum Injection Pressure and Formation Gradient Comparisons

Regulatory Agency	Allowable Maximum Injection Pressure at Wellhead (psi)	Formation Gradient Pressure (psi/ft)	Formation Depth (Feet) [top of production zone]
USEPA[a]	160	0.733 [491 psi at 670 feet]	670[d]
USEPA[b]	196	0.80 [536 psi at 670 feet]	
CBR[c]	**100**	**0.62** **[415 psi at 670 feet]**	

[a] USEPA formula used to calculate maximum injection pressure using fracture gradient formation default value of 0.733 psi/ft [40 CFR 147 (the same formula is used for a number of states, including Colorado, Montana, Oklahoma, California, Nevada, Oregon, Pennsylvania, Kentucky, and Florida)].

$Pm = (0.733-0.433Sg)d$

Where :

Pm = injection pressure at the well head

0.733 = default value for the fracture gradient in units of pounds per square inch (psi) per foot (ft)

0.433 = normal hydrostatic pressure gradient of a column of fresh formation water of depth.

Sg = specific gravity of the injection fluid (i.e., lixiviant); CBR value is 1.005

d = injection well depth in feet (average depth of 668 feet bgs for top of production zone in the TCEA)

[b] Using USEPA Region 5's fracture pressure gradient formation default value of 0.80 psi/ft in the above-referenced USEPA formula. States allowed to use this default value include Michigan, Indiana, and Ohio.

[c] The NDEQ has previously approved a maximum wellhead injection pressure of 100 psi and a resulting 0.63 psi/ft formation pressure gradient for the current nearby CBR facility. These pressures have proven to be compatible for a geologic setting similar to the TCEA.

[d] Refers to an average depth of 670 feet bgs for screened interval at top of production zone in the TCEA; based on all geophysical and Basal Chadron Sandstone monitor wells completed in or nearby the TCEA.

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CHAPTER Q. MONITORING PROGRAM

Q.1 Characteristics of the Injected Fluid

For the injection of sodium carbonate/bicarbonate and an oxidant, or a restoration reductant to the wells designated as injection wells, CBR proposes to utilize the injection well limitations shown in **Tables Q.1-1** and **Q.1-2**.

Sample(s) taken in compliance with the injection requirements specified in **Tables Q.1-1** and **Q.1-2** would be collected at the following locations:

a. Injection pressure from a gauge on the manifold.
b. Injection totalizer from flow meter downstream of any filters after chemicals are added but before oxidant addition.
c. Injection fluid (physical and chemical characteristics) downstream from filter after chemicals are added but before oxidant addition.

The injection filters may be located in the main Satellite Facility, downstream of the injection pumps. Samples of lixiviant would be collected from the injection pipeline downstream of the injection filters, immediately before the pipeline leaves the main Satellite Facility building. Samples collected here would be analyzed daily for chloride, sulfate, sodium, total alkalinity and pH. For clarification, sodium and sulfate are not included in biweekly excursion monitoring parameters since these parameters do not indicate movement. However, the injection stream leaving the Satellite Facility will be monitored for sodium and sulfate, as well as chloride, total alkalinity and pH. The current CBR Class III UIC permit imposes limits on the concentrations of these parameters in the injection stream.

Injection fluid properties are discussed in Chapter J, and injection operating pressures are discussed in Chapter P.

Q.2 Monitoring Devices

Q.2.1 Instrumentation and Control

The wellfield houses will be located remotely from the Satellite Facility building. A distribution system will be used to control the flow to and from each well in the wellfield. Wellfield instrumentation will be provided to measure total production and injection flow and to indicate the pressure that is being applied to the injection trunklines. Wellfield houses will be equipped with wet alarms to monitor the presence of liquids in the wellfield house sumps.

Instrumentation will be provided to monitor the total flow into the Satellite Facility, the total injection flow leaving the plant, and the total waste flow leaving the plant. Instrumentation will be provided on the plant injection manifold to record an alarm in the event of any pressure loss that might indicate a leak or rupture in the injection system. The instruments used for flow measurement will include, but are not limited to, turbine meters, ultrasonic meters, variable area meters, electromagnetic flow meters, differential pressure meters, positive displacement meters, piezoelectric and vortex flow meters. The injection pumps will be sized or equipped so that they are incapable of producing pressures high enough to exceed design pressure of the injection lines or the maximum pressure to be applied to the injection wells. Pressure gauges, pressure shutdown switches and pressure transducers will be used to monitor and control the trunkline pressures.

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

The SCDA system will be interconnected throughout the facility via a Local Area Network (LAN) to many computer display screens. The software used to display plant processes and collect data incorporates a series of menus which allows the plant operators to monitor and control a variety of systems and parameters. Critical processes, pressures, and wellfield flows will have alarmed set-points that alert operators when any parameters are out of tolerance. In addition, each wellfield house will contain its own processor, which will allow it to operate independent of the main computer. Pressure switches will be fitted to each injection manifold in the Header House to alert the plant and wellfield operators of increasing manifold pressures. All critical equipment will be equipped with uninterruptible power supply (UPS) systems in the event of a power failure.

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

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

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

Q.3 Annulus Pressure Monitoring

Due to the construction and testing methods required for Class III wells and described in Chapter N, the annular space around the well casing is filled with cement during construction. Therefore, there will be no need to continually monitor the pressure on the annulus between the tubing and the long string of casing.

Q.4 Well Integrity Testing

Field-testing of all injection, production, and monitor wells will be performed to demonstrate the mechanical integrity of the well casing. This mechanical integrity test (MITs) will be performed using pressure-packer tests. Every well will be tested after well construction is completed and before it can be placed in service, after any workover with a drill rig or servicing with equipment or procedures that could damage the well casing, at least once every 5 years, and whenever there is any question of casing integrity. To assure the accuracy of the integrity tests, the field pressure gages and a calibrated test gage will be periodically compared. The MIT procedures have been approved by the Nebraska Department of Environmental Quality (NDEQ) for the current CPF operations and are currently contained in CBR's Environmental Health and Safety Management System (EHSMS) Program Volume III, *Operating Manual* (CBR 2003a). These same procedures will be used at the Three Crow Expansion Area (TCEA).

The following general MIT procedure is used:

- The well is tested after well development and prior to the well being placed into service. The test consists of placement of one or two packers within the casing. The bottom packer is set just above the well screen, and the upper packer is set at the wellhead. The packers are inflated with nitrogen, and the casing is pressurized with water to 125 percent of the maximum operating pressure (125 psi).
- The well is then "closed in", and the pressure is monitored for a minimum of 20 minutes.
- If more than 10 percent of the pressure is lost during this period, the well has failed the integrity test. When possible, a well that fails the integrity testing will be repaired and the testing repeated. If the casing leakage cannot be repaired or corrected, the well is plugged and reclaimed as described in Chapter T. CBR submits all integrity testing records to the NDEQ for review after the initial construction of a mine unit or wellfield. Test results are also maintained on site for regulatory review.

Q.5 Monitor Wells

Q.5.1 Monitoring Program Description

The environmental water monitoring program includes the routine monitoring and analysis of water samples within the permitted areas and surrounding environs to ensure compliance with federal and state rules and regulations and company policies. The water monitoring programs are designed to provide maximum surveillance for environmental control and are based on many years of monitoring experience in conjunction with guidance and suggested practices from numerous regulatory agencies.

During operations at the Three Crow Satellite Facility, a detailed water sampling program will be conducted to identify any potential impacts to water resources of the area. CBR's operational water monitoring program includes the evaluation of groundwater within the permit area.

Q.5.1.1 Groundwater Monitoring for Operations

The groundwater excursion monitoring program will be designed to detect any excursions of lixiviant into the ore zone aquifer outside of the perimeter of the wellfield as well as any lixiviant that may be leached into the overlying water bearing strata. The Pierre Shale below the ore zone is more than 1,200 feet thick and contains no water-bearing strata. Therefore, it is not necessary to monitor any water-bearing strata below the ore zone

Monitor Well Baseline Water Quality

After delineation of the production unit boundaries, monitor wells will be installed no farther than 300 feet from the wellfield boundary and no farther than 400 feet apart, or as directed by the NDEQ. The spacings referenced here are requirements of the current Crow Butte Project's Class III UIC permit. After completion, wells will be washed out and developed (by air lifting or pumping) until water quality in terms of pH and specific conductivity appears stable and consistent with the anticipated quality of the area. After development, wells will be sampled to obtain baseline water quality. For baseline sampling, wells will be purged before sample collection to ensure that representative water is obtained. All monitor wells, including ore zone and overlying monitor wells, will be sampled three times at least 14 days apart. Samples will be analyzed for chloride, conductivity, and total alkalinity as specified in **Table Q.5-1**. Results from the samples will be averaged arithmetically to obtain a baseline value as well as a maximum value for determination of upper control limits (UCLs) for excursion detection. Well development and sampling will be performed in accordance with the instructions contained in CBR's EHSMS Program Volume VI, *Environmental Manual* (CBR 2003b).

A typical wellfield layout is shown in **Figure M.1-1** of Chapter M. The cell dimensions will vary depending on the formation and the characteristics of the ore body. The typical locations of monitor wells for the proposed TCEA are shown in **Figure M.1-2** of Chapter M. As the TCEA is further developed, the mine unit map (i.e, wellfield and monitor well layout) will be developed in detail and submitted to the NDEQ for approval.

- Upper Control Limits and Excursion Monitoring

After baseline water quality is established for the monitor wells for a particular production unit, UCLs will be set for chemical constituents that would indicate a migration of lixiviant from the wellfield. The constituents chosen as indicators of lixiviant migration and for which UCLs are set are chloride, conductivity, and total alkalinity. Chloride was chosen due to its low natural levels in the native groundwater and because chloride is introduced into the lixiviant from the ion exchange process (uranium is exchanged for chloride on the ion exchange resin). Chloride is also a highly mobile constituent in the groundwater and will show up very quickly in the case of a lixiviant migration to a monitor well. Conductivity was chosen because it is an excellent general indicator of overall groundwater quality. Total alkalinity concentrations should be affected during an excursion, as bicarbonate is the major constituent added to the lixiviant during mining. Water levels will be obtained and recorded prior to each well sampling. However, water levels are not used as an excursion indicator. Upper control limits are set at 20 percent above the maximum baseline concentration for the excursion indicator. For excursion indicators with a baseline average below 50 mg/L, the UCL may be determined by adding 5 standard deviations or 15 mg/L to the baseline average for the indicator.

Operational monitoring would consist of sampling the monitor wells on a biweekly basis and analyzing the samples for the excursion indicators (**Table Q.5-1**). In addition, all shallow monitor wells designed to monitor water quality in the Brule Aquifer will, as a minimum, be analyzed annually for uranium and radium-226 to the lowest detection limit available.

- Excursion Verification and Corrective Action

If a single parameter UCL is exceeded or if two or more multiple parameter UCLs are exceeded for a particular well, a verification sample will be collected within 24 hours from the time the first analysis is available. If the second sample does not indicate exceeded UCLs, a third sample shall be taken within 48 hours of the time the first sample was taken.

If the second or third samples indicate an exceeded UCL, the well in question shall be placed on excursion status and monitored on a weekly basis. The NDEQ will be notified by telephone within 24 hours from the time the confirmation sample was taken. The laboratory data from all the samples and a plan of corrective action will be mailed to the Department. These data will be postmarked within 5 days from the time the confirmation sample was taken. In the event neither the second nor third samples indicate exceeded UCLs, then the well shall be returned to its regular sampling frequency.

When three consecutive 1-week sample results are below the exceeded UCL, the excursion status shall be removed from the well. Weekly sampling shall continue for an additional 3 weeks. If the UCL is not exceeded, then biweekly sampling shall resume. Should an excursion occur, a formal report shall be submitted with the quarterly report containing all lab data and the results of the performed corrective actions. If corrective actions have not been effective within 90 days of the excursion confirmation, the injection of fluid shall be terminated in the affected area. Resumption of the injection shall not occur until receipt of approval from the NDEQ Director. All wells on excursion status will continue to be sampled weekly until the excursion is concluded. The wells are sampled weekly until three consecutive 1-week samples are below the exceeded UCL(s). Weekly sampling then continues for an additional three weeks. If no UCL's are exceeded during this sampling period then the biweekly sampling resumes. All of these sampling data are submitted to the NDEQ with the quarterly Mining Monitoring Report (MMR).

Upon receipt of pertinent monitoring data and prior to operation, the UCLs for the monitor wells shall be calculated using the following methods:

i. Determine the maximum recorded value from preoperational sampling and multiply the value by 1.20 to calculate the multiple parameter value.
ii. For those monitor wells where the baseline average of the indicator parameter is 50 mg/L or less, the multiple parameter UCL shall be calculated as equal to 20 percent above the maximum concentration measured for the parameter, baseline average for the parameter plus 5 standard deviations, or baseline average plus 15 mg/L.
iii. Multiply the multiple parameter value by 1.20 to calculate the single parameter value.

These values will be rounded off to the nearest unit.

The samples taken in compliance with the monitoring requirements specified above shall be collected at the well head or at a location approved by the Director. Pumping or air lifting shall be used to evacuate at least one casing volume, and the pH and conductivity shall be allowed to stabilize prior to sampling. Sample filtering, preservation, and hold times shall be in accordance with the latest edition of the U.S. Environmental Protection Agency's

(USEPA's) Approved Methods for Sampling and Sample Preservation of Water and Wastewater (APHA 2005, USEPA 1983).

If an excursion is verified, the following methods of corrective action are instituted (not necessarily in the order given) dependent upon the circumstances:

- A preliminary investigation is completed to determine the probable cause.
- Production and/or injection rates in the vicinity of the monitor well are adjusted as necessary to increase the net over recovery, thus forming a hydraulic gradient toward the production zone.
- Individual wells are pumped to enhance recovery of mining solutions.

Injection into the wellfield area adjacent to the monitor well may be suspended. Recovery operations continue, thus increasing the overall bleed rate and the recovery of wellfield solutions.

Q.5.1.2 Groundwater Monitoring during Restoration

Upon the construction of a new mine unit, one baseline restoration well per 4 acres within the mine unit will be sampled to establish the mine unit baseline water quality. A minimum of three samples are collected from each well. All of the pre-mining sampling of the baseline restoration wells will be at least 300 feet from any active mine unit,or as directed by the NDEQ. The samples shall be collected at least 14 days apart and would be analyzed for the parameters listed in **Table Q.5-2**.

Once mining has ceased in each mine unit, the NDEQ shall be notified in writing and shall proceed to establish the post-mining water quality for all of the parameters listed in the **Table Q. 5-2** for the designated restoration wells, subject to change per NDEQ requirements. This task shall be accomplished by collecting a sample of the lixiviant injected into the mine unit to be representative of the post-mining water quality.

A written restoration plan shall be submitted, including a stabilization period of least 6 months for that mine unit, and after NDEQ approval, restoration will begin. The NDEQ may require additional wells be installed for evaluating the success of restoration efforts. When restoration is deemed to have been completed, sampling and analysis of all designated restoration wells for all of the parameters listed in the approved restoration table shall be completed. See Section T.2 for more detailed discussions of the proposed restoration program including groundwater restoration methods, stabilization phase, and basis of restoration goals.

There shall be a minimum of one injection or production well per acre in each mine unit designated as a restoration well. There shall be a minimum of 10 restoration wells per mine unit. The production well of each standard injection well pattern shall be designated as the restoration well. If there is more than one standard injection well pattern per acre, the production or injection well which is centrally located will be designated as the restoration well. Any monitor well which has an excursion will automatically become an additional restoration well. The designation of the baseline restoration wells will be included in the

Notice of Intent to Operate for the mine unit. The designation of the remaining restoration wells will be included in the restoration plan submitted for that mine unit.

Q.1.5.3 Private Well Monitoring

All private wells within 0.6 mile (1 kilometer) of the currently permitted CBR wellfield area boundary are sampled quarterly with the landowner's consent. CBR will perform similar private well monitoring around the TCEA. Groundwater samples are taken in accordance with the instructions contained in EHSMS Program Volume VI, Environmental Manual. Samples are analyzed for natural uranium and radium-226.

Historical and recent groundwater monitoring of private wells in the TCEA and associated Area of Review (AOR) are discussed in Section K.3 of Chapter K.

CBR conducted a water user survey in 2005 to identify and locate all private water supply wells within a 2.0-mile radius of the proposed TCEA. The water user survey determined the location, depth, casing size, depth to water, and flow rate of all wells within the area that were (or could be) used for domestic, agricultural, or livestock uses. CBR updated the well survey in 2008, 2009 and 2010 for 2.25-mile radius of the proposed TCEA.

Q.6 Evaporation Pond

Once the evaporation ponds are placed into operation, the evaporation leak detection systems and the evaporation pond freeboards shall be monitored as specified in **Table Q.6-1**.

The measurements taken in compliance with the monitoring requirements specified in **Table Q.6-1** shall be taken from the detection system and at the pond. With the exception of specific monitoring requirements identified in this application, all monitoring of the ponds and the detection systems shall be in accordance with the Nuclear Regulatory Commission (NRC) License SUA-1534.

Upon initial pond operation and until approval by the Director to cease such monitoring, the evaporation pond monitor well(s) shall be monitored as specified in **Table Q.6-2**.

A minimum of 5 feet of freeboard shall be maintained in the commercial evaporation ponds during normal operations. The Director shall be notified immediately when the freeboard decreases to less than the specifications.

Should the water depth change abruptly or a leak be detected in the evaporation pond liner, the Department will be immediately notified. The pond fluids will be evacuated as soon as practicable to another location approved by the Director and the pond seal repaired. The extent of any subsurface contamination shall be determined, and a report submitted to the Director within 30 days after the leak is detected. The plan shall also include a plan for corrective action.

All other reporting requirements shall be in accordance with Title 122, Chapter 21.

Q.7 Standard Monitoring Conditions

All monitoring requirements will be in accordance with Title 122, Chapter 20.

Q.7.1 Representative Sampling

Samples and measurements required for the Class III UIC Permit shall be representative of all the volume and nature of the monitored discharge or injection. Monitoring points will not be changed without notification to and the approval of the Department.

Q.7.2 Mechanical Integrity

Mechanical integrity shall be demonstrated at least once every 5 years during the life of the well(s) as required in Title 122, Chapters 18 and 20.

Q.7.3 Test Procedures

Test procedures for the analyses of pollutants required for the Class III UIC permit, unless otherwise specified by the Director, shall conform to the latest edition of the following references:

- *Standard methods for the Examination of Water and Wastewaters*, 21st edition, 2005, American Public Health Association. New York, NY 10019.
- *ASTM. Standards, Part 11*, American Society for Testing and Materials, Philadelphia, PA 19103.
- *Methods for Chemical Analysis of Water and Wastes*, March 1983, Environmental Protection Agency Water Quality Office, Analytical Quality Control Laboratory NERC, Cincinnati, Ohio 45268.

Q.7.4 Additional Monitoring

If sampling occurs for any parameter more frequently than required using approved testing procedures or procedures specified in the permit, the results of the monitoring shall be included in the calculation and reporting of the data submitted in the Mining Monitoring Report.

Q.7.5 Averaging of Measurements

Calculations for all limitations which require averaging shall utilize an arithmetic mean unless otherwise specified by the Director.

Q.8 References

American Public Health Association (APHA). 2005. *Standard methods for the Examination of Water and Wastewaters*, 21st edition. New York, NY 10019

American Society for Testing and Materials (ASTM). 1998. *ASTM Standards, Part 1.* 1998 (updated). Philadelphia, PA 19103.

Crow Butte Resources (CBR). 2003a. *Environmental, Health, and Safety Management System, Volume III, Operating Manual.*

Crow Butte Resources (CBR). 2003b. *Environmental, Health, and Safety Management System, Volume VI, Environmental Manual.*

United States Environmental Protection Agency Water Quality Office. (USEPA). 1983. *Methods for Chemical Analysis of Water and Wastes.* Analytical Quality Control Laboratory NERC, Cincinnati, Ohio 45268. March.

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Table Q.1-1 Injection Well Requirements

Characteristics	Limitations	Monitoring Requirements	
	Maximum Limits	Measurement Frequency	Sample Type
Well Head pressure	100 psi[a]	Once/day	Manifold Gauge
Flow Rate	See Table Q.1-2	Once/day	24 Hr. Average
Injection Fluid[b]			
Chloride	≤5000 mg/L	Once/day	24 Hr. Composite
Sulfate	≤5000 mg/L	Once/day	24 Hr. Composite
Sodium	≤6000 mg/L	Once/day	24 Hr. Composite
Alkalinity	≤4100 mg/L	Once/day	24 Hr. Composite
pH	6.0 to 10.5 S.U.	Once/day	Grab
Bleed Rate	None		Totalized Meter

[a] Formation injection pressures will be limited to 0.62 psi/ft of well depth.
[b] Injection fluid shall be sampled downstream from filter after chemicals are added but before oxidant addition.

Table Q.1-2 Mining Requirements

Total Mine Injection Rates (Cumulative For All Mine Units)		
Production Flow (Maximum)	**Restoration Flow**	**Total Flow (maximum)**
4,500 gpm	Total Flow – Production Flow	4,500 gpm[a] (6,480,000 gpd)

[a] The total injection rate at the facility shall be calculated using a 24-hr average daily collected from flow meters for each well.

Table Q.5-1 Monitor Well Requirements

Monitoring Requirements Upper Control Limit				
Monitor Characteristics	**Sampling Frequency**	**Single Parameter**	**Multiple Parameter**	**Sample Type**
Chloride	Biweekly	mg/L	mg/L	Grab
Conductivity	Biweekly	umhos/cm	umhos/cm	Grab
Alkalinity (as $CaCO^3$)	Biweekly	mg/l	mg/l	Grab
Water Level	Biweekly	Reported to the nearest 0.1 foot from land surface.		
Barometric Pressure	Biweekly			

Table Q.5-2 Restoration Parameters

Current Title 118 Numerical Standards		Parameters Set on Wellfield Averages	Other Parameters	
Parameter	**Standard**	**Parameter**	**Parameter**	**Value**
Arsenic (As)	0.01 mg/L	Calcium (Ca)**	Ammonia (NH^4 as N)	10.0 mg/L
Barium (Ba)	2.0 mg/L	Total Carbonate*	Molybdenum (Mo)	1.0 mg/L
Cadmium (Ca)	0.005 mg/L	Potassium (K)**	Nickel (Ni)	0.15 mg/L
Chloride (Cl)	250 mg/L	Magnesium (Mg)**	Vanadium (V)	0.2 mg/L
Copper (Cu)	1.3 mg/L	Sodium (Na)*		
Fluoride (F)	4.0 mg/L	Total Dissolved Solids (TDS)***		
Iron (Fe)	0.3 mg/L			
Mercury (Hg)	0.002 mg/L			
Manganese (Mn)	0.05 mg/L			
Nitrate as N (NO^3)	10.0 mg/L			
Lead (Pb)	0.015 mg/L			
Radium (Ra)	5.0 pCi/L			
Selenium (Se)	0.05 mg/L			
Uranium (U)	0.03 mg/L			
Sulfate (SO^4)	250 mg/L			
Zinc (Zn)	5.0 mg/L			
pH	6.5-8.5 S.U.			

* Total carbonate shall not exceed 50 percent of the total dissolved solids value.

** One order of magnitude above baseline mean shall be used as a restoration value for some parameters due to the ability of some major ions to vary one order of magnitude depending on pH.

*** The restoration value for total dissolved solids shall be the baseline mean plus one standard deviation.

All parameters listed as parameters with numerical groundwater standards (Title 118 or other sources) are subject to change based on NDEQ procedures.

Note: These restoration parameters are currently used for the existing CBR operating facility (NDEQ Class III UIC Permit No. NE0126611)

Table Q.6-1 Evaporation Pond Monitoring Requirements – Water Level

Monitoring Characteristics	Sampling Frequency
Fluid Level	Weekly*
Freeboard	Weekly

* In the event elevated fluid levels or other conditions of a leak are detected in the underdrain system, the Department shall be notified immediately and monitoring shall be conducted in accordance with the NRC License SUA-1534 until occurrences causing the leak(s) into the underdrain have been corrected, and the results from required monitoring of sample analysis substantiate the corrective actions. Such information shall be reported to the Department. If corrective actions require the pumping of the contents of one evaporation pond into another, the minimum freeboard levels may be temporarily exceeded until such time as the corrective actions have succeeded, and the evaporation pond can be placed back into service.

Table Q.6-2 Evaporation Pond Monitor Well Requirements[a]

Monitoring Characteristics		Sampling Frequency	Sample Type[b]
Conductivity	umhos/cm	Quarterly	Grab
Chloride	mg/L	Quarterly	Grab
Alkalinity (as CaCO3)	mg/L	Quarterly	Grab
Sodium	mg/L	Quarterly	Grab
Sulfate	mg/L	Quarterly	Grab

[a] Sample(s) taken in compliance with the designated monitoring requirements shall be collected at the well head.

[b] Pumping, air lifting, or bailing shall be used to evacuate at least one casing volume, and the pH and conductivity shall be allowed to stabilize prior to sampling. Sample filtering, preservation, and hold times shall be in accordance with the latest edition of USEPA's *Methods for Sampling and Sample Preservation of Water and Wastewater.*

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CHAPTER R. FORMATION PRESSURES, FLUID DISPLACEMENT, AND INJECTION FLUID MOVEMENT

R.1 Expected Changes in Pressure

Groundwater pressure differential is used to control the movement of lixiviant within the mining area. Except during well stimulation, injection pressures will not be allowed to exceed a magnitude which could initiate fractures or propagate existing fractures in the injection zone. A maximum operating wellhead pressure of 100 pounds per square inch (psi) will be used for the Three Crow Expansion Area (TCEA) injection rates. At this injection rate, a maximum allowable formation gradient of 0.62 psi per foot of well depth will not be exceeded. With a maximum injection pressure of 100 psi at the injection wellhead, and the fluid pressure increasing at a rate of 0.62 psi/ft with depth, the pressure at 670 feet bgs (average upper screening interval depth at top of production zone) will be 415 psi. At the top and bottom of the formation (approximately 580 and 940 feet) the formation pressures would be approximately 360 and 583 psi, respectively. Injection rates will be adjusted to maintain wellhead injection and formation gradient pressures below the maximum allowable levels.

Regional information, previous Crow Butte Resources, Inc. (CBR) permit submittals, and historical operational practices indicate that the minimum pressure that could initiate hydraulic fracture is greater than 0.63 psi/ft of well depth (CBR 2007). This value has historically and successfully been applied to current CBR operations. As such, the injection pressure proposed for the TCEA is limited to a similar value of less than 0.62 psi/ft of well depth. Injection pressures also will be limited to the pressure at which the well was integrity tested. The calculated formation gradient of 0.62 psi/ft for the TCEA differs slightly from the 0.63 psi/ft used for the current CPF production area due to use of a U.S. Environmental Protection Agency (USEPA) formula for the latter and differences in production zone depth. Injection pressure calculations are discussed in Chapter P.

Injection operating pressure calculations are discussed in more detail in Chapter P.

In order to prevent fracturing, CBR will monitor injection volumes, rates, and pressures (detailed discussions in Chapter Q). Annulus pressure monitoring is not needed because the annular spacing around the well casing is filled with cement during construction.

Wellhead pressure will be monitored at all injection manifolds. Pressure gauges will be installed at each injection manifold, and pressure will be monitored and recorded at least daily.

Each new production well (extraction and injection) will be pressure-tested to confirm the integrity of the casing prior to being used for mining operations. Wells that fail pressure testing will be repaired, if possible, or abandoned and plugged according to accepted procedure.

R.2 Expected Formation (Native) Fluid Displacement

During operations, leaching solution enters the formations through the injection wells and flows to the recovery wells. Within each mine unit, more water is produced than injected to create an overall hydraulic cone of depression in the production zone, resulting in a “negative pressure gradient" or "pressure sink" within the production zone. Under this negative pressure gradient, the natural groundwater movement from the surrounding area is toward the wellfield, providing additional control of the leaching solution movement. To simplify, the fluid flow in the wellfield is controlled by pumping the production well at a greater rate than the injection wells, which are injecting the fluid. This creates a flow towards the production well because it is being pumped at a greater rate than the fluid being pumped into the nearby injection wells. This negative pressure gradient (i.e., cone of depression) also minimizes the dilution of the lixiviant by uncontrolled fluid movement.

The difference between the amount of water produced and the amount injected is the wellfield "bleed". The minimum over-production or bleed rates will be a nominal 0.5 percent of the total wellfield production rate, and the maximum bleed rate typically approaches 1.5 percent. Over-production is adjusted as necessary to ensure that the perimeter ore zone monitor wells are influenced by the cone of depression resulting from the wellfield production bleed. Maintenance of the bleed will cause an inflow of groundwater into the production area and prevent loss of leach solution. Based on the proposed bleed rate of 0.5 to 1.5 percent of the total mining flow (4,500 gallons per minute [gpm]), groundwater consumption from the TCEA operation is expected to be minimal. These bleed rates have successfully been applied in the current permitted area. Additional volume will be consumed during aquifer restoration, especially the groundwater sweep phase. However, it is expected that the average net consumptive use for the entire operation will be on the order of 50 to 100 gpm for the life of the mine (estimated at 20 years). In this regard, the vast majority (on the order of 99 percent) of groundwater used in the mining process will be treated and reinjected (**Figure M.1-3**). Therefore, potential impacts on groundwater quality due to consumptive use outside the license area are expected to be negligible.

The maintenance of a hydrologic bleed and the close proximity of the perimeter monitor wells around the wellfield, no greater than 300 feet from the mining patterns, will ensure there is negligible migration of mining fluid. The ongoing adjustment of this "over-production" will help to ensure that the perimeter ore zone monitor wells are influenced by the cone of depression resulting from the wellfield production bleed. Vertical migration of fluids is less of a concern than lateral migration due to the underlying and overlying aquitards. The ubiquitous clays present in the Middle Chadron Formation (Peanut Peak Member), which cap the Basal Chadron Formation, exhibit vertical hydraulic conductivities on the order of 10^{-11} cm/sec. Likewise, the underlying Pierre Shale is more than 1,200 feet thick and acts as a significant aquitard. The vastly different piezometric heads between the Basal and Middle Chadron, as well as the results of pumping test #7, support the conclusion that the Basal Chadron is vertically isolated.

The wellfield injection/production pattern to be employed at the TCEA is based on a hexagonal seven-spot pattern, which may be modified to fit the characteristics of the ore body. A typical wellfield layout for these spot patterns is shown in **Figure M.1-1** of Chapter M. **Figure R.1-1** shows a typical uranium in-situ wellfield production and injection schematic, with only one of six injection wells of a seven-spot pattern shown (WNA 2008 Modified). The purpose of this figure is to demonstrate the typical "controlled" flow patterns associated with such an injection/recovery pattern when there is an equal flow rate of injection wells. This pattern is a beneficial recovery method due to the low flow rates of the injection wells that create a high total productivity for the system, and they also provide a nearly uniform solution distribution throughout the ore body (IAEA 2001).

Monitoring of production (extraction) and injection rates and volumes will enable an accurate assessment of water balance for the wellfields (**Figure M.1-3** of Chapter M). Monitor wells completed in the aquifers directly overlying the production zone (Basal Chadron) detect any vertical migration of injection fluids from the production zone. Water levels will be routinely measured in the production zone and overlying aquifer. Sudden changes in water levels within the production zone may indicate that the wellfield flow system is out of balance. Flow rates would be adjusted to correct this situation. Increases in water levels in the overlying aquifer may indicate fluid migration from the production zone. Adjustments to well flow rates or complete shutdown of individual wells may be required to correct this situation. Increases in water levels in the overlying aquifer may also indicate casing failure in a production, injection, or monitor well. Isolation and shutdown of individual wells can be used to determine the well causing the water level increases.

During production, injection of the lixiviant into the wellfield will result in a temporary degradation of water quality in the exempted aquifer compared to pre-mining conditions. Typical lixiviant concentrations of various constituents are presented in **Table J.1-1**. The concentrations (low and high range) in this table could be found in barren lixiviant (injected solution) or pregnant lixiviant (flow from recovery wells to satellite processing facility). Groundwater restoration at the end of wellfield production will restore the groundwater in the production zone to levels at or below those approved by the Nebraska Department of Environmental Quality (NDEQ) and the Nuclear Regulatory Commission (NRC) (see Section T.2 Groundwater Restoration for detailed discussions).

Analysis of pumping test data in 2008 (**Appendix 5**) for the production zone (Lower Basal Chadron Sandstone (LBCS]) in the TCEA indicated transmissivity values ranging from 267 to 743 ft^2/day, with an average transmissivity of 477 ft^2/day (Petrotek 2008). Based on an average sand thickness of 64 feet, the average hydraulic conductivity K was 7.5 ft/day. Assuming a water viscosity of 1.35 cp (50° F) and a density of 1.0, this equates to a permeability of approximately 2,990 millidarcies (md). Storativity (S) of the LBCS aquifer ranged from 4.8 E-05 to 1.6 E-04, with an average value of 8.8 E-04. The testing indicated that the transmissivity of the Basal Chadron Sandstone in the TCEA is relatively consistent with, although slightly higher than, the aquifer properties determined from previous pump tests conducted at the current Class III permit area (Petrotek 2008).

Based on Pump Test # 7 results, all of the LBCS monitor wells and pumping well appear to exhibit hydraulic communication demonstrating that the LBCS Production Zone has hydraulic continuity throughout the Three Crow test area (Petrotek 2008). The LBCS monitor wells were shown to be in communication with the Upper basal Chadron Sandstone (UBCS). There will be additional detailed testing on a wellfield specific basis to demonstrate communication between the production and monitor wells and further verify confinement at the appropriate time during project development. The LBCS has been adequately characterized with respect to hydrologic conditions within the majority of the proposed TCEA. Adequate confinement exists between the LBCS Production Zone and the overlying Brule Formation throughout the TCEA study area. The results of Pump Test # 7 and AEP evaluation indicate that hydrologic properties of the LBCS have been sufficiently characterized to proceed with the TCEA Class III UIC application.

Based on the data evaluated during this study, the variance may impact mining operations planning (e.g., well spacing, completion interval, and injection/production rates) but is not anticipated to negatively impact regulatory issues. This is consistent with regional geologic information and suggests that the individual nature and characteristics of the Brule Formation, Chadron Formation, and the Pierre Shale are laterally consistent with the Crawford Basin.

Groundwater impacts and consumption related to the TCEA operation will be fully assessed in an Industrial Groundwater Permit application that is required by the Nebraska Department of Natural Resources (NDNR). Information from the existing Groundwater Permit for the current license area indicates that the drawdown from mining operations in the Basal Chadron Sandstone is minimal (e.g., less than 10 percent of the available head). Based on drawdown data from years of operation in the current license area and on the formation characteristics from the TCEA Pumping Test #7 (**Appendix 5**), the drawdown effect on the Basal Chadron Sandstone aquifer as a result of operations has been and is expected to remain minimal.

R.3 Direction of Injection Fluid Movement

As stated above, the negative pressure gradient (i.e., cone of depression) created by the layout of the injection wells and associated recovery wells controls the flow direction and minimizes the dilution of the lixiviant by uncontrolled fluid movement. As shown in **Figure M.1-3** of Chapter M, with a total mine flow of 4,500 gpm from production wells and a bleed rate of 1.5 percent, approximately4,432 gpm of refortified lixiviant would be returned to the wellfield via the nearby injection wells. This net flow pattern due to the bleed minimizes the potential for leaching fluid moving away from the wellfield, holding or containing the lixiviant within the desired ore bearing region, and prevents the unwanted excursion of lixiviant away from the ore body. Excursions represent a potential effect on the adjacent groundwater as a result of operations. Monitor wells around the wellfield are used to detect any excursions, as discussed in Chapter Q. However, in the event an excursion is detected, immediate actions are taken to determine and remedy the cause, as applicable (see Chapter Q for detailed discussions of proposed excursion monitoring programs and Section G.5.2.5 for groundwater impacts for the TCEA).

The groundwater flow in the Lower Basal Chadron Sandstone (production zone) is predominantly to the northeast in the TCEA with an average hydraulic gradient ranging from approximately 0.0016 – 0.0028 ft/ft (8.4 to 14.8 ft/mile) (Petrotek 2008) (see discussions in Section F.2.1 of Chapter F). As discussed above, the effect of mining operations (e.g., negative pressure gradient associated with injection of barren lixiviant and recovery pregnant lixiviant) within the wellfields will have a localized impact on the groundwater flow, but will not have a significant impact on the region.

R.4 References

Crow Butte Resources, Inc. (CBR). 2007. Application for Amendment of NRC Source Materials License SUA-1534, North Trend Expansion Area, Technical Report – Volume I. Submitted to NRC on May 30, 2007.

International Atomic Energy Agency (IAEA). 2001. *Manual of acid in-situ leach uranium mining technology*. IAEA-TECDOC-1239. August.

Petrotek Engineering Corporation (Petrotek). 2008. *Three Crow Regional Hydrologic Testing Report – Test #7*. August 2008.

World Nuclear Association. (WNA). 2008. In-situ Leach (ISL) Mining of Uranium. [Webpage]. Located at: http://www.world-nuclear.org/info/inf27.html. Accessed in: March 2008.

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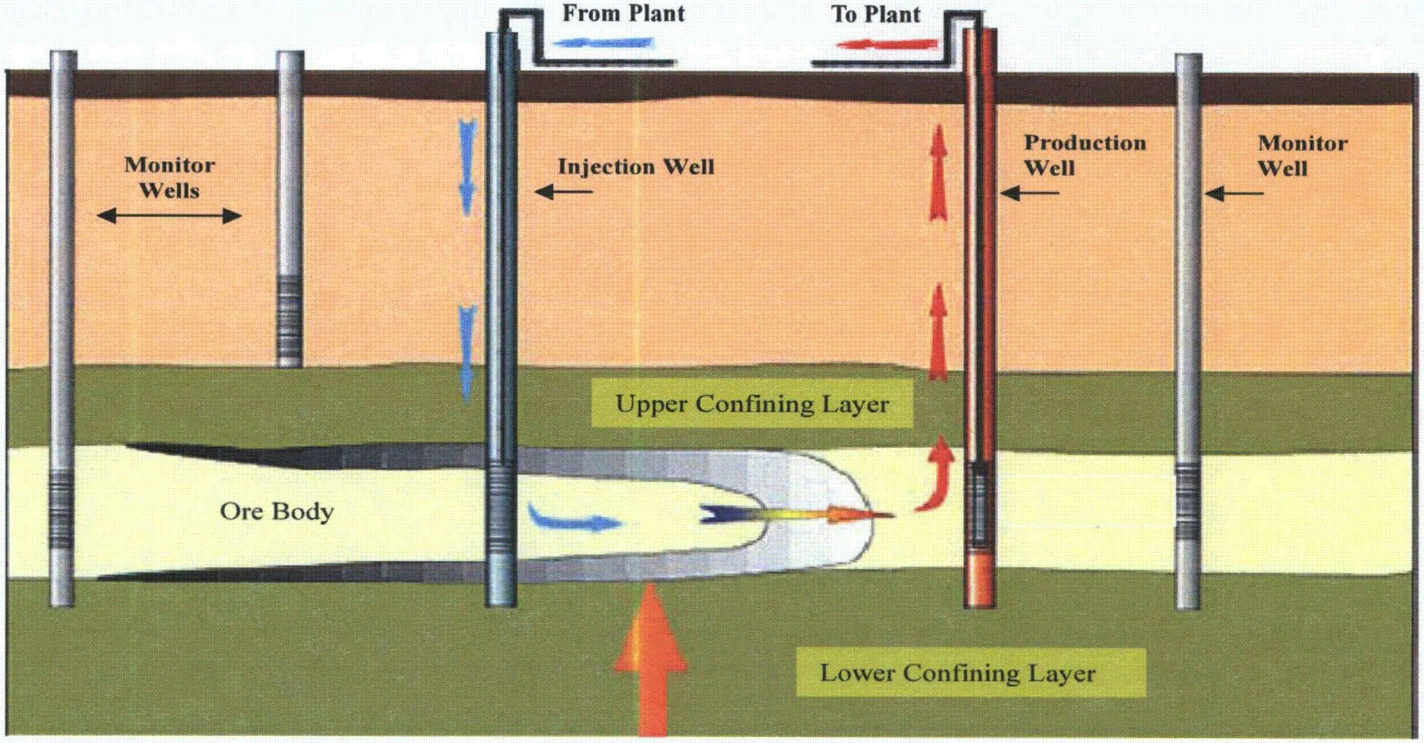

Note: This figure is not intended to duplicate geological conditions at the proposed TCEA. It is only to demonstrate a typical uranium in situ wellfield production and injection schematic. Modified from WNA 2008.

CROW BUTTE RESOURCES, INC.

FIGURE R.1-1
TYPICAL URANIUM IN SITU WELLFIELD PRODUCTION AND INJECTION SCHEMATIC

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

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

K:\CBR_Projects\CO001396_ThreeCrow3_IMAGES\Illustrator\UIC_Fig_R 1-1 Typical Uranium In Situ Wellfield Production...ai @ 01/27/2010

CHAPTER S. CORRECTIVE ACTION PLAN

Title 122, Chapter 34, requires that CBR, in applying for a Class III injection well permit, to identify the location of all wells which penetrate the injection and/or production zone within the facility's area of review (AOR). These wells are discussed and listed in Chapter D. For any such identified wells that are improperly sealed, completed or abandoned, the applicant shall submit a plan identifying steps or modifications that are necessary to prevent movement of fluid into underground sources of drinking water (corrective action).

S.1 Oil and Gas Test Holes

Based on review of public plugging records, all the referenced oil and gas test holes in the Three Crow Expansion Area (TCEA) AOR with drilling depths ranging from 3,347 to 5,424 feet have been properly plugged in accordance with the Nebraska Oil and Gas Conservation Commission regulations (NOGCC 2009). Historical information on these test holes is shown in the well completion reports in **Appendix 1** and summarized in **Table D.1-1.** The test hole locations are shown in **Figure D.1-1** of Chapter D. These test holes date back to 1957, 1962 and 1969. None of the test holes were drilled within the TCEA (**Figure D.1-1** of Chapter D). Based on a review of the above referenced NOGCC database (NOGCC 2009), there are currently no known oil and gas test holes within the AOR that are suspected of being improperly abandoned and requiring corrective action.

S.2 Private Water Wells and CBR Monitor Wells

A water well survey of the TCEA and the AOR was conducted by CBR in 2005 and updated in 2008, 2009 and 2010 (2.25-mile radius). The update tasks consisted of focused-interviews (land owners and local drillers) and a review of the Nebraska Department of Natural Resources state water well database (NDNR 2010). The results of the survey and updates indicate that all of the groundwater pumped from active wells surveyed within a 2.25-mile radius of the proposed TCEA permit boundary is used primarily for agriculture (e.g., livestock watering). **Figure F.2-2** of Chapter F shows the location of all active and abandoned water wells in the TCEA permit boundary and the 2.25-mile review area. **Table F.2-1** of Chapter F lists the active and abandoned groundwater wells in the expansion area and the 2.25-mile review area, with more detailed information on the water well user survey in **Appendices 6 and 7**.

Based on the water user surveys and data/information interpretation, no known private water wells are believed to be completed in the production zone within the TCEA permit boundary or associated AOR. In addition, no known wells completed in the production zone were identified. Assumptions made in the interpretation of available water well data are discussed in Chapter D.

Copies of available affidavits of abandonment for abandoned wells within the AOR are listed in **Appendix 2**. A number of these wells did not have affidavits of abandonment. However, no problems were identified with these wells and the wells are thought to have been completed in the Brule Formation. Abandonment of these wells reduces future risks associated with the wells.

S.3 Corrective Action Plans for Improperly Completed Wells

In the event that CBR identifies any wells completed into the injection zone (Basal Chadron sandstone) within the AOR that are inadequately completed or abandoned, efforts will be made to immediately properly plug the wells. Wells owned or under the control of CBR will be properly plugged, as discussed below. Although no private water wells in the AOR have been identified, in the event such wells owned by a private party are identified, efforts will be made to obtain permission to properly plug such wells in a timely fashion.

For wells which are not adequately sealed, completed or abandoned, CBR will use a drill rig to reopen the hole and then perform the plugging and abandonment procedures specified in Chapter T – Plugging and Abandonment Plan.

In order to minimize the potential for impacts on any private water supply wells within the AOR, CBR will have specific safeguards in place to prevent movement of lixiviant into any such well completed in the injection zone:

- During operations, leaching solution enters the formations through injection wells and flows to recovery wells. Within each wellfield, more water is produced than injected to create an overall hydraulic cone of depression in the production zone. Under the pressure gradient, the natural groundwater movement from the surrounding area is toward the wellfield, providing additional control of the leaching solution movement (over-recovery of lixiviant from a wellfield). During normal operations, CBR will recover 0.5% to 1.5% more solution than is injected. This will result in a hydrologic depression in the vicinity of the wellfield and the groundwater flow will tend to be into the wellfield, preventing migration of the lixiviant from the wellfield.
- In the event that the over-recovery is not effective or controlled properly, CBR will have a series of monitor wells located around the perimeter of the wellfield. These wells will be sampled at a frequency specified by the NDEQ. CBR is committed, and required by its UIC permit, to taking corrective action if any indicator species exceeds the upper control limit specified in the UIC permit.
- CBR will operate with injection pressures that shall not exceed a maximum, which will ensure that the pressure in the injection zone during injection does not initiate new fractures or propagate existing fractures in the injection zone, initiate fractures in the confining zone, or cause migration of injection or formulation fluids into underground sources of drinking water. The maximum injection pressure to be used for the TCEA wellfield operations will be limited to 100 pounds per square inch (psi) at the wellhead. Historically, this maximum injection pressure has been successfully applied to the nearby CBR operations and is well below the pressures used for the mechanical integrity testing of injection wells. The injection pressure monitoring system will have a high-pressure alarm and, if the pressure exceeds the set point, corrective action will be taken.

Corrective action taken may include:

- Increasing the over-recovery rate of the wellfield water balance.

- Rebalancing of injection and production wells to control movement of lixiviant away from the outer monitor ring.
- Cease injection of lixiviant (e.g., shutting down injection pump) or whatever action is necessary to recall the lixiviant.

Injection procedures to be used by CBR for the TCEA operations to ensure that the leach solutions are contained within the designated area of the aquifer being mined are discussed in Chapter M – Injection Procedures.

S.4 References

Nebraska Oil and Gas Conservation Commission (NOGCC). 2009. [Webpage]. Located at: http://www.nogcc.ne.gov/ (Well data and publications). Accessed on December 16, 2009.

Nebraska Department of Natural Resources (NDNR). 2010. Registered Groundwater Wells Data Retrieval. [Web page]. Located at: http://dnrdata.dnr.ne.gov/wellssql/. Accessed on: January 06, 2010.

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CHAPTER T. PLUGGING AND ABANDONMENT PLAN

T.1 Well Plugging and Abandonment

T.1.1 Plugging and Abandonment of Cased Holes

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

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

The plugging method (Balance Method), used at the current permit area is approved by the Nebraska Department of Environmental Quality (NDEQ) (as per Title 122, Chapter 35, Section 007.02B), will be used at the Three Crow Expansion Area (TCEA). The method is generally as follows:

- A mechanical plug may be placed above the screened interval.
- Thirty to 50 feet of coarse bentonite chips will be added to provide a grout seal.
- An approved bentonite-based hole plugging product or cement grout will be placed by tremie pipe from the chips to the top of the casing. The weight of the gel or grout plus the weight of the bentonite chips will be enough to exceed the local Chadron formation pressure plus the maximum injection pressure allowed (100 pounds per square inch [psi]).
- The tremie pipe will be removed (when possible) and the casing will be filled to the surface.
- An approved hole plug will be installed.
- The well casing will be cut off below ground level, capped with cement, and the surface disturbance will be smoothed and contoured.
- The hole will be backfilled and the area revegetated.

Records of abandoned wells will be tabulated and reported to the appropriate agencies after decommissioning. The Nebraska Department of Natural Resources (DNR) also requires filing a well abandonment notice for all registered wells.

T.1.1.1 Plugging and Abandonment Plan

Prior to plugging, abandonment, or restoration activities for the Class III UIC injection wells, Crow Butte Resources, Inc. (CBR) shall submit a written abandonment plan to the NDEQ Director for approval. No plugging, abandonment, or restoration activities, shall take place until the plan has been approved by the Director. CBR will notify the Director 7 days before commencing plugging and abandonment.

Plugging and abandonment plan shall include the plugging, abandonment, and restoration procedures as follows (Title 122, Chapter 35, 007):

- Method and materials used to stabilize the well.
- Plugging information that includes, but is not limited to:
  - Type and number of plugs to be used;
  - Method for placement of the plugs (Balance Method);
  - Placement of each plug including the elevation of the top and bottom; and
  - Type, grade, and quantity of plugging material to be used.
- Abandonment information shall include, but not be limited to, the following:
  - Type, grade, and quantity of the abandonment fluid to be used;
  - Method for placement of the abandonment fluid; and
  - Method and type of surface completion.
- Restoration information shall include, but not be limited to:
  - Surface area to be restored and
  - Process for restoration.

All cement will be American Society for Testing Materials (ASTM) Type I, II or American Petroleum Institute (API) Class B or G. All bentonite products will have specifications outlined in the approved plugging and abandonment plan.

Prior to abandonment, all wells shall be plugged with cement or other approved plugging material in a manner which will prohibit the movement of fluids out of the injection zone into or between underground sources of drinking water.

Records of abandoned wells will be tabulated and reported to the appropriate agencies after decommissioning. The DNR also requires filing a well abandonment notice for all registered wells.

T.1.1.2 Plugging and Abandonment Affidavit

Following completion of the plugging, abandonment, or restoration activities, an affidavit setting forth the significant data in connection with the well (including well details) and the procedure used in plugging, abandonment, or restoration shall be filed with the NDEQ within 90 days after plugging, abandonment, or restoration has been completed. The affidavit will be signed by a qualified witness to the plugging, abandonment, or restoration procedures and duly notarized.

T.1.2 Development Drilling and Abandonment of Uncased Holes

Development drilling will occur within the permit area for the purpose of determining new mine unit locations. CBR shall notify the NDEQ at least 10 days prior to any development drilling within the permit area.

T.1.2.1 Abandonment Mud

Upon completion of a development hole, the hole shall be plugged with an approved abandonment mud in a manner which will prohibit the movement of fluids out of the injection zone or between underground sources of drinking water. The product sheet will state that the product is an abandonment mud (mud). The mud shall be mixed through a hopper and meet the following criteria:

- A viscosity of at least 20 seconds/qt. above the Total Depth (TD) viscosity to exceed 60 seconds/qt. (Using a Marsh funnel) and
- A mud density of a least 8.7 lbs/gal.

The mud shall be circulated through the hole until it returns to the surface. If the formation pressure is such that the density of the mud is not sufficient to hold the plug in place, a weighting agent shall be added to the Plug Gel or a Portland cement slurry shall be used.

T.1.2.2 Hole Plug

An approved hole plug shall be placed 6 feet below the land surface followed by cement which has been mixed with water to within 2 feet of the land surface. The top 2 feet of the hole shall be filled with dirt into which a hole marker, showing section, township, and range, shall be placed.

T.1.2.3 TSurface Reclamation

The topsoil will be removed and stockpiled separately from the rest of the pit material. Upon completion of the hole, the pit will be filled and the dirt mounded to allow for subsidence. The pit will then be leveled, topsoil replaced, and the entire site reseeded with an approved seed mixture.

T.1.2.4 Hole Abandonment Report

A hole abandonment report shall be included with the quarterly report. It shall include the TD, viscosity (seconds/qt.), the abandonment viscosity (second/qt.), the mud density (lbs/gal.), and the amount and type of approved abandonment product used to plug each hole.

T.2 Groundwater Restoration

T.2.1 Groundwater Restoration Methods

T.2.1.1 Introduction

Restoration activities in the current permit area have proven that the groundwater can be restored to the appropriate standards following commercial mining activities. As shown in **Table A.2-1,** Mine Units 2 through 5 are currently undergoing restoration. Mine Unit 1 groundwater restoration has been approved by the NDEQ and the Nuclear Regulatory Commission (NRC) and surface reclamation activities are underway. On February 12, 2003, the NRC issued the final approval of groundwater restoration in Mine Unit 1 at Crow Butte. This approval was the accumulation of 3 years of agency reviews including a license amendment to accept the NDEQ restoration standards as the approved secondary goals. Mine Unit 1 consisted of 40 patterns installed in 9.3 acres immediately adjacent to the Central Plant. Included within the boundaries of Mine Unit 1 were five wells that were originally mined beginning in 1986 as part of the research and development pilot plant operation. Commercial mining activities began in 1991 and were completed in 1994. Mine Unit 1 was successfully restored to the approved primary or secondary restoration standards for all parameters.

CBR's approved restoration plan consists of four steps:

- 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 at least 6 months following successful completion of the restoration stage. Stabilization begins once restoration activities have returned the average concentration of restoration parameters to acceptable levels. Following the stabilization phase, CBR provides a restoration report to the appropriate regulatory agencies.

During mining, and until restoration is complete, a hydrologic bleed will be maintained in each Mine Unit to prevent lateral migration of mining lixiviant. If a proper hydrologic bleed is not maintained, it is possible for affected water to begin migrating toward the monitor well ring. The mobile ions, such as chloride and carbonate, would be detected at the monitor well ring and adjustments would be made to reverse the trend. The maintenance of a hydrologic bleed and the close proximity of the monitor well ring, no greater than 300 feet from the mining patterns, will ensure that there is negligible migration of mining fluid. Vertical migration of fluids is less of a concern than lateral migration due to the underlying and overlying aquitards. The ubiquitous Chadron Formation clays, which cap the Lower Chadron Formation ore body, have vertical hydraulic conductivities on the order of 10 to 11 cm/sec. Likewise, the underlying Pierre Shale is more than 1,200 feet thick and acts as a significant aquitard. The vastly different pieziometric heads between the Lower and Middle Chadron, as well as the results of the pumping test support the conclusion that the Lower Chadron, is vertically isolated.

T.2.1.2 Restoration Process

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

Groundwater Transfer

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

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

For the groundwater transfer step to occur, a newly constructed mine unit must be ready to commence mining. If a mine unit is not available to accept transferred water, groundwater sweep or other activity will be utilized as the first step of restoration. The advantage of using the groundwater transfer technique is that it reduces the amount of water that must ultimately be sent to the wastewater disposal system during restoration.

Groundwater Sweep

During groundwater sweep, water is pumped without injection from the wellfield, causing an influx of baseline quality water from the perimeter of the mining unit, which sweeps the affected portion of the aquifer. The cleaner baseline quality water has lower ion concentrations that act to strip off the cations that have attached to the clays during mining. The affected water near the edge patterns of the wellfield is also drawn into the boundaries of the mine unit. The number of pore volumes transferred during groundwater sweep, if any, depends on the presence of other active mine units along the mine unit boundary, the capacity of the wastewater disposal system, and the success of the groundwater transfer step in lowering TDS.

Groundwater Treatment

Following the groundwater sweep step, water will be pumped from production wells to treatment equipment and then re-injected into the wellfield. Ion exchange (IX), reverse osmosis (RO), and/or Electro Dialysis Reversal (EDR) treatment equipment is generally used during this stage as shown on the generalized restoration flow sheet on **Figure T.2-1**.

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

Another method for reducing the wellfield is through bioremediation. Bioremediation entails adding a nutrient source to the aquifer to stimulate native bacteria. As the bacteria feed on the nutrient source, they generate a reducing environment which in turn causes most metals in solution to precipitate back to their pre-mining state. The concentration of native bacteria colonies returns to normal levels once the organic media are consumed.

A portion of the restoration recovery water can be sent to the RO unit. The use of an RO unit 1) reduces the total dissolved solids in the contaminated groundwater, 2) reduces the quantity of water that must be removed from the aquifer to meet restoration limits, 3) concentrates the dissolved contaminates in a smaller volume of brine to facilitate waste disposal, and 4) enhances the exchange of ions from the formation due to the large difference in ion concentration.

Before the water can be processed by the RO, soluble uranium can be removed by the IX system. The RO unit contains membranes that pass about 60 to 75 percent of the water through, leaving 60 to 90 percent of the dissolved salts in the water that will not pass the membranes. **Table T.2-1** shows typical RO manufacturers' specification data for removal of ion constituents. The clean water, called "permeate", will be re-injected, sent to storage for use in the mining process, or to the wastewater disposal system. The 25 to 40 percent of water that is rejected, called "brine", contains the majority of dissolved salts that contaminate the groundwater and is sent for disposal in the waste system. Make-up water (permeate) may be added to the wellfield injection stream to control the amount of "bleed" in the restoration areas. The typical composition of the permeate solution is shown in **Table T.2-2**.

The reductant (either biological or chemical) added to the injection stream during the groundwater treatment stage will scavenge any oxygen and reduce the oxidation-reduction potential (Eh) of the aquifer. During mining operations, certain trace elements are oxidized. By adding a reductant, the Eh of the aquifer is lowered, thereby decreasing the solubility of these elements. Hydrogen sulfide (H_2S), sodium sulfide (Na_2S), or a similar compound will be added as a reductant. CBR typically uses sodium sulfide due to the chemical safety issues associated with proper handling of H_2S. A comprehensive safety plan regarding reductant use is implemented.

The number of pore volumes treated and re-injected during the groundwater treatment stage will depend on two things: the efficiency of the RO in removing TDS and the success of the reductant in lowering the uranium and trace element concentrations. See Section T.2.1.3 for estimated pore volumes for the TCEA.

Wellfield Recirculation

At the completion of the groundwater treatment stage, wellfield recirculation may be initiated. In order to homogenize the aquifer, the production wells may be pumped and recovered solution may be re-injected into injection wells to recirculate the solutions.

The sequence of the activities will be determined by CBR based on operating experience and waste water system capacity. Not all phases of the restoration stage will be used if any are deemed unnecessary by CBR.

Once the restoration activities are completed, CBR will sample the restoration wells and determine if the mining unit has achieved the restoration values on a mine unit average basis. If so, CBR will notify the NDEQ that it is initiating the Stabilization Stage and will submit supporting documentation that the restoration parameters are at or below the restoration standards. If, at the end of restoration activities, the parameters are not at or below the approved values, CBR will either re-initiate certain steps of the restoration plan or submit documentation to the agencies that the best practical technology has been used in restoration. The documentation will include a justification for alternate parameter value(s) including available water quality data and a narrative of the restoration techniques used.

Pore Volume Calculations

CBR has developed new estimates for pore volumes required for restoration of the TCEA. The number of pore volumes that are displaced during groundwater restoration is as follows: three pore volumes through the ion exchange (IX) columns; six pore volumes through the Reverse Osmosis (RO) unit; and two pore volumes of recirculation. There were nine pore volumes used for Mine Unit 1 at the current CPF operations. For the remainder of the mine units (Mine Units 2 through 11), 11 pore volumes will be used.

The calculated pore volume for the entire Three Crow wellfield will be 1,885,469,763 gallons. This is based on a calculated square footage (2,897,414 ft^2) of the potential wellfield area, an average under-ream interval of 30 feet and a 29% open pore space value.

T.2.2 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 mining operations will be sampled and analyzed for the restoration parameters listed in **Table T.2-3**. The sampling frequency will be one sample per month for a period of 6 months, and if the six samples show that the restoration values for all wells are maintained during the stabilization period with no significant increasing trends, restoration shall be deemed complete.

T.2.3 Reporting

During the restoration process CBR will perform daily, weekly, and monthly analyses as needed to track restoration progress. These analyses will be summarized and discussed in the Monthly Restoration Report submitted to NDEQ. This information will also be included in the final report on restoration.

Upon completion of restoration activities and before stabilization, all designated restoration wells in the mine unit will be sampled for the constituents listed in **Table T.2-3**. If restoration activities have returned the wellfield average of restoration parameters to concentrations at or below those approved by the NDEQ, CBR will proceed with the stabilization phase of restoration.

During stabilization, all designated restoration wells will be sampled monthly for the constituents listed in **Table T.2-3**. At the end of a 6-month stabilization period, CBR will compile all water quality data obtained during restoration and stabilization and submit a final report to the regulatory agencies. If the analytical results continue to meet the appropriate standards for the mine unit and do not exhibit significant increasing trends, CBR would request that the mine unit be declared restored. Following agency approval, the wellfield will be reclaimed and wells will be plugged and abandoned as described in Section T.1.

T.2.4 Basis of Restoration Goals

The primary goal of the groundwater restoration program is to return groundwater affected by mining operations to pre-injection baseline values on a mine unit average as determined by the baseline water quality sampling program. This sampling program is performed for each mine unit before mining operations commence. Should restoration efforts be unable to achieve baseline conditions after diligent application of the best practicable technology (BPT) available, CBR commits, in accordance with the Nebraska Environmental Quality Act and NDEQ regulations, to return the groundwater to the restoration values set by the NDEQ in the Class III UIC Permit. These secondary restoration values ensure that the groundwater is returned to a quality consistent with the use, or uses, for which the water was suitable prior to in-situ leach (ISL) mining. These secondary restoration values are approved by the NDEQ in the individual Notice of Intent (NOI) for each mine unit based on the permit requirements and the results of the baseline monitoring program.

T.2.4.1 RestorationDetermination

Before mining in each mine unit, the baseline groundwater quality is determined. The data are established in each mine unit by assigning and evaluating groundwater quality in the "baseline restoration wells". A minimum of one baseline restoration well for each 4 acres is sampled to establish the mine unit baseline water quality. A minimum of three samples is collected from each well. All of the premining sampling of the baseline restoration wells must be at least 300 feet from any active mine unit, or as required by the NDEQ. The samples are collected at least 14 days apart. The samples are analyzed for the parameters list in **Table T.2-2**.

<u>Designation of Restoration Wells</u>

Within each mine unit, a minimum of one injection or production well per acre shall be designated as a restoration well. There shall be a minimum of ten restoration wells per mine unit. The production well of each standard injection well pattern shall be designated as the restoration well. If there is more than one standard injection well pattern per acre, the production or injection well that is centrally located shall be designated as the restoration well. Any monitor well that has an excursion will automatically become an additional restoration well. The designation of the baseline restoration wells will be included within the NOI for the mine unit. The designation of the remaining restoration wells shall be included in the restoration plan submitted for that mine unit.

T.2.4.2 Establishment of Restoration Parameters

The baseline data are used to establish the restoration standards for each mine unit. As previously noted, the primary goal of restoration is to return the mine unit to preoperational water quality condition on a mine unit average. Because ISL operations alter the groundwater geochemistry, it is unlikely that restoration efforts will return the groundwater to the precise water quality that existed before operations.

Secondary restoration goals are established by NDEQ to ensure that, if baseline water quality is not achievable after diligent application of BPT, the groundwater is suitable for any use for which it was suitable before mining. NRC considers these NDEQ restoration goals as the secondary standards. The NDEQ restoration values are established for each mine unit and are approved with the NOI submittals according to the following analysis:

- For parameters that have numerical groundwater standards established in NDEQ Title 118, the restoration goal is based on the Title 118 maximum contaminant level (MCL).
- If the baseline concentration exceeds the applicable MCL, the standard is set as the mine unit baseline average plus two standard deviations.
- If there is no MCL for an element (e.g., vanadium), the restoration value is based on BPT.
- The restoration value for the major cations (Ca, Mg, K, Na) allows the concentrations of these cations to vary by as much as one order of magnitude as long as the TDS restoration value is met. The total carbonate restoration criterion allows for the total carbonate to be less than 50 percent of the TDS. The TDS restoration value is set at the baseline mine unit average plus one standard deviation.

The current NDEQ restoration standards are listed in **Table T.2-3**.

It is anticipated that the Class III UIC Permit issued for the TCEA will have similar requirements. Under the provisions of Title 122, the NDEQ reviews and approves the establishment of the restoration standards. The restoration value for each mine unit is based on the current Title 118 standard at the time the NOI is approved by the NDEQ.

Appendix 12 contains the restoration tables for Mine Units 1 through 10 in the current commercial license area. These tables provide the baseline average for all restoration parameters as well as the NDEQ restoration standard approved for that mine unit in the NOI. These parameters must be restored to the standard value unless the standard is exceeded by a mean of the preoperational sampling values (baseline mean). The restoration value for parameters whose baseline mean exceeds the standard shall be equal to the mine unit plus two standard deviations (see **Table T.2-3**).

Mine Unit restoration values are contained in **Appendix** 12as follows:

- The mine unit average and NDEQ restoration values for Mine Unit 1 are given in **Appendix 12-1 of Appendix 12** The approval of the NOI which accepted these restoration values was issued on March 6, 1991.
- The mine unit average and NDEQ restoration values for Mine Unit 2 are given in **Appendix 12-2 of Appendix12.** The approval of the NOI which accepted these restoration values was issued on March 25, 1992.
- The mine unit average and NDEQ restoration values for Mine Unit 3 are given in **Appendix 12-3 of Appendix 12**. The approval of the NOI which accepted these restoration values was issued on January 8, 1993.
- The mine unit average and NDEQ restoration values for Mine Unit 4 are given in **Appendix 12-4 of Appendix12**. The approval of the NOI which accepted these restoration values was issued on March 11, 1994.

- The mine unit average and NDEQ restoration values for Mine Unit 5 are given in **Appendix 12-5 of Appendix 12**. The approval of the NOI which accepted these restoration values was issued on October 24, 1995.
- The mine unit average and NDEQ restoration values for Mine Unit 6 are given in **Appendix 12-6 of Appendix 12**. The approval of the NOI which accepted these restoration values was issued on March 3, 1998.
- The mine unit average and NDEQ restoration values for Mine Unit 7 are given in **Appendix 12-7 of Appendix 12**. The approval of the NOI which accepted these restoration values was issued on July 9, 1999.
- The mine unit average and NDEQ restoration values for Mine Unit 8 are given in **Appendix 12-8 of Appendix 12**. The approval of the NOI which accepted these restoration values was issued on July 5, 2002.
- The mine unit average and NDEQ restoration values for Mine Unit 9 are given **Appendix 12-9 of Appendix 12.** The approval of the NOI which accepted these restoration values was issued on October 21, 2003.
- The mine unit average and NDEQ restoration values for Mine Unit 10 are given **Appendix 12-10 of Appendix 12**. The approval of the NOI which accepted these restoration values was issued on January 23, 2007.

CBR Mine Unit 1 groundwater restoration has been approved by the NDEQ and NRC, with NRC approval being given in 2003. **Appendix 12-1** shows the Mine Unit No. 1 water quality parameter values for pre-mining, post-mining, post-restoration, and during the stabilization period (NRC 2007, CBR 2000).

T.2.4.3 Restoration Procedure

At the cessation of mining in each mine unit, NDEQ shall be notified in writing, and shall proceed to establish the post-mining water quality for all parameters listed on the restoration table (**Table T.2-3**) of the designated restoration wells. This may be accomplished by collecting a sample of the lixiviant injected into the mine unit to be representative of the post-mining water quality. These samples may be split between a lab of CBR's choice and a lab of NDEQ's choice.

A written restoration plan shall be submitted, including a stabilization period of at least 6 months for that mine unit, and after NDEQ approval, shall commence restoration. Prior to approval of the restoration plan, additional wells may be installed to evaluate the success of the restoration efforts, if so directed by NDEQ. When it is determined that restoration is complete, sampling and analysis of all designated restoration wells for all of the parameters listed in the restoration table shall be completed. These samples will be split between a lab of CBR's choice and a lab of NDEQ's choice. The results of these samples shall be submitted to NDEQ.

T.2.4.4 Restoration Determination and Stabilization

- Restoration Parameters Achieved

Once the restoration procedure has returned the wellfield average of the restoration parameters to concentrations at or below the parameters approved by NDEQ, the NDEQ shall be notified that stabilization is being initiated. The notification shall include data supporting the fact that restoration parameters have been achieved. During stabilization, all designated restoration wells shall be monitored monthly for all of the parameters listed on the restoration table. At the end of the stabilization period, the data shall be submitted to NDEQ with a request that the wellfield be considered restored if the restoration parameters have been achieved and there is an absence of significant increasing trends for any of the restoration parameters. NDEQ will, in writing, extend the stabilization, require further restoration, or accept the restoration of the mine unit.

- Restoration Parameters Not Achieved

If the restoration parameters established in the NOI have not been met, or if there are significant increasing trends for any of the restoration parameters after application of best available technology, a written justification for alternate values shall be submitted to NDEQ for approval.

If the subsequent restoration is deemed successfully completed by NDEQ, sampling and analysis will be completed of all designated restoration wells for all parameters listed in the restoration table. These samples will be split between a lab of CBR's choice and a lab of NDEQ's choice. The sampling results shall be submitted to NDEQ. Restoration determination shall begin again as outlined in T.2.4.1

If NDEQ determines, with cause, that the alternate values are not justified, then a second restoration plan will be submitted detailing further restoration and, after approval, restoration shall be commenced.

T.3 Surface Reclamation

The following section addresses the final decommissioning methods of disturbed lands including wellfields, plant areas, evaporation ponds, and diversion ditches that will be used on the Crow Butte project sites. The section discusses general procedures to be used during final decommissioning as well as the decommissioning of a particular phase or production unit area.

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

The following is a list of general decommissioning activities:

- Plug and abandon all wells as detailed in Section T.3.4.
- Determine appropriate cleanup criteria for structures and soils.
- Perform radiological surveys and sampling of all facilities, process-related equipment, and materials on site to determine their degree of contamination and identify the potential for personnel exposure during decommissioning.
- Remove from the site all contaminated equipment and materials to an approved licensed facility for disposal or reuse, or relocate to an operational portion of the mining operation.
- Decontaminate items to be released for unrestricted use to levels consistent with the requirements of NRC.

- Survey excavated areas for contamination and remove contaminated materials to a licensed disposal facility.
- Perform final site soil radiation surveys consistent with the requirements of NRC.
- Backfill and recontour all disturbed areas.
- Establish permanent revegetation on all disturbed areas.

The following sections describe, in general terms, the planned decommissioning activities and procedures for the current CPF. These activities and procedures will apply to the TCEA facilities as well as the current facilities. CBR will, prior to final decommissioning of an area, submit to the NRC and NDEQ a detailed decommissioning plan for their review and approval at least 12 months before planned commencement of final decommissioning.

T.3.1 General Surface Reclamation Procedures

The primary surface disturbances associated with the TCEA-associated facilities will be the Satellite Facilities (uranium recovery building, fuel and chemical storage, shop, office, rest rooms and laboratory), evaporation ponds, and wellfield production areas. Surface disturbances also occur during the well drilling program, pipeline installation, and road construction. These more superficial disturbances, however, involve relatively small areas or have very short-term impacts.

The principal objective of the surface reclamation plan is to return disturbed lands to production compatible with the post-mining land use of equal or better quality than the pre-mining condition. For the TCEA, the reclaimed lands should be capable of supporting livestock grazing and providing stable habitat for native wildlife species. Soils, vegetation, wildlife, and radiological baseline data will be used as guidelines for the design, completion, and evaluation of surface reclamation. Final surface reclamation will blend affected areas with adjacent undisturbed lands 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 and sedimentation, and re-establish natural trough drainage patterns.

The following sections provide procedural techniques for surface reclamation of all disturbances addressed in the CBR mine plan. Reclamation procedures are provided for the facility sites, wellfield production units, evaporation ponds, and access and haul roads. Reclamation techniques and procedures for the TCEA Satellite Facility, ponds, and wellfields will follow these same concepts. Reclamation schedules for wellfield production units will be discussed separately because they depend on the progress of mining and the successful completion of groundwater restoration. Cost estimates for bonding calculations are discussed in Chapter U and include all activities that are anticipated to complete groundwater restoration, decontamination, decommissioning, and surface reclamation of wellfield and satellite plant facilities installed. These cost estimates are updated annually to cover work projected for the next year of mining activity.

T.3.1.1 Topsoil Handling and Replacement

In accordance with NDEQ requirements, topsoil is salvaged from building sites (including Satellite buildings) and pond areas. Conventional rubber-tired, scraper-type earth-moving equipment is typically used to accomplish such topsoil salvage operations. The exact location of topsoil salvage operations is determined by wellfield pattern emplacement and designated wellfield access roads within the wellfields, which are determined during final wellfield construction activities.

Topsoil thickness varies within the TCEA. Topsoil is usually thickest in and along drainages where material has been deposited and deep soils have developed. Therefore, topsoil-stripping depths may vary, depending on location and the type of structure being constructed. In cases where it is necessary to strip topsoil in relatively large areas, such as a major road or building site, the field mapping and Soil Conservation Service Soil Surveys will be utilized to determine approximate topsoil depths.

Salvaged topsoil is stored in designated stockpiles. These stockpiles are generally located on the leeward side of hills to minimize wind erosion. Stockpiles are not located in drainage channels. The perimeter of large topsoil stockpiles may be bermed to control sediment runoff. Topsoil stockpiles are seeded as soon as possible after construction with the permanent seed mix.

During mud pit excavation associated with well construction, exploration drilling, and delineation drilling activities, topsoil is separated from subsoil with a backhoe. When use of the mud pit is complete, all subsoil is replaced and topsoil is applied. Mud pits generally remain open for a short time. The success of revegetation efforts at the current site show that these procedures adequately protect topsoil and result in vigorous vegetation growth.

T.3.1.2 Contouring of Affected Areas

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

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

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

T.3.1.3 Revegetation Practices

Revegetation is conducted in accordance with NDEQ requirements. During mining operations, the topsoil stockpiles and as much as practical of the disturbed wellfield and pond areas will be seeded with vegetation to minimize wind and water erosion. After placement of topsoil and contouring for final reclamation, an area will normally be seeded with a seed mixture developed in consultation with the Natural Resources Conservation Service (NRCS) as required by the NDEQ.

T.3.2 Process Facility Site Reclamation

Following removal of structures, subsoil and stockpiled topsoil will be replaced on the disturbances from which they were removed during construction, within practical limits. Areas to be backfilled will be scarified or ripped prior to backfilling to create an uneven surface for application of backfill. This will provide a more cohesive surface to eliminate slipping and slumping. The less suitable subsoil and unsuitable topsoil, if any, will be backfilled first so as to place them in the deepest part of the excavation to be covered with more suitable reclamation materials. Subsoils will be replaced using paddle wheel scrapers, bulldozers, or other appropriate equipment to transfer the earth from stockpile locations or areas of use and to spread it evenly on the ripped disturbances. Grader blades may be used to even the spread of backfill materials. Topsoil replacement will commence as soon as practical after a given disturbed surface has been prepared. Topsoil will be picked up from storage locations by paddle wheel scrapers or other appropriate equipment and distributed evenly over the disturbed areas. The final grading of topsoil materials will be done so as to establish adequate drainage, and the final prepared surface will be left in a roughened condition.

The NRCS shall be consulted for technical assistance in reclaiming the land surface, including appropriate seed mixtures. Topsoil from the ponds and building areas shall be removed, stockpiled, and seeded during operation and reapplied to the contoured surface. Reclamation plans (including the proposed seed mixture) will be submitted to the NDEQ for approval at least 60 days prior to commencement of reclamation. Pond reclamation and decommissioning shall be in accordance with NRC License SUA-1534.

T.3.3 Evaporation Pond Decommissioning

T.3.3.1 Disposal of Pond Water

The volume of water remaining in the lined evaporation ponds after restoration, as well as its chemical and radiological characteristics, will be considered to determine the most practical disposal program. Disposal options for the pond liquid include evaporation, 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 National Pollutant Discharge Elimination System (NPDES) permit. Evaporation of the remaining water may be enhanced by use of sprinkler systems, etc.

T.3.3.2 Pond Sludge and Sediments

Pond sludges and sediments will contain mining process chemicals and radionuclides. Wind-blown sand grains and dust blown into the ponds during their active life also add to the bulk of sludges. This material will be contained within the pond bottom and kept in a dampened condition at all times, especially during handling and removal operation, to prevent the spread of airborne contamination and potential worker exposure through inhalation. Dust abatement techniques will be used as necessary. The sludge will be removed from the ponds and loaded into roll-off containers, dump trucks, or drums and transported to an NRC-licensed disposal facility.

T.3.3.3 Disposal of Pond Liners and leak Detection Systems

Pond liners will be kept washed down and intact as much as practical during sludge removal so as to confine sludges and sediments to the pond bottom. Pond liners will be cut into strips and transported to an NRC-licensed disposal facility or will be decontaminated for release to an unrestricted area. After removal of the pond liners, the pond leak detection system piping will be removed. Materials involved in the leak detection system will be surveyed and released for unrestricted use if not contaminated or transported to an NRC-licensed facility for disposal. The earthen material in the pond bottom and leak detection system trenches will be surveyed for soil contamination. Any contaminated soil in excess of the cleanup criteria in **Table T.3-1** will be removed and disposed at an NRC-licensed disposal facility.

Following the removal of all pond materials and the disposal of any contaminated soils, surface preparation will take place prior to reclamation.

T.3.4 Wellfield Decommissioning

Surface reclamation in the wellfield production units will vary in accordance with the development sequence and the mining/reclamation timetable. Final surface reclamation of each wellfield production unit will be completed after approval of groundwater restoration stability and the completion of well abandonment activities discussed below. Surface preparation will be accomplished as needed so as to blend any disturbed areas into the contour of the surrounding landscape.

Wellfield decommissioning will consist of the following steps:

- The first step of the wellfield decommissioning process will involve the removal of surface equipment. Surface equipment primarily consists of the injection and production feed lines, wellhouses, electrical and control distribution systems, well boxes, and wellhead equipment. Wellhead equipment such as valves, meters, or control fixtures may be salvaged.
- Buried wellfield piping will be removed.
- Wells will be plugged and abandoned according to the procedures described in Section T.1.
- The wellfield area may be recontoured, if necessary, and a final background gamma survey conducted over the entire wellfield area to identify any contaminated earthen materials requiring removal to disposal.

- Final revegetation of the wellfield areas will be conducted according to the revegetation plan.
- All piping, equipment, buildings, and wellhead equipment will be surveyed for contamination prior to release in accordance with the NRC guidelines for decommissioning.

It is estimated that a significant portion of the equipment will meet release limits, which will allow disposal at an unrestricted area landfill. Other materials that are contaminated will be acid-washed or decontaminated with other methods until they are releasable. If the equipment cannot be decontaminated to meet release limits, it will be disposed of at an NRC-licensed disposal facility.

Wellfield decommissioning will be an independent ongoing operation throughout the mining sequence at the Crow Butte site and at the TCEA. 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.

T.3.4.1 Buried Trunklines, Pipes and Equipment

Buried process-related piping, such as injection and production lines, will be removed from the mine unit undergoing decommissioning. Salvageable lines will be held for use in ongoing mining operations. Lines that are not reusable may either be assumed to be contaminated and disposed of at a licensed disposal site or may be surveyed and, if suitable for release to an unrestricted area, may be sent to a sanitary landfill.

T.4 References

Crow Butte Resources, Inc. (CBR). 2000. *Mine Unit 1Restoration Report, Crow Butte Uranium Project*, Source Materials License Application SUA-1534, Crow Butte Resources, Inc., Crawford, Nebraska. NRC ADAMS ML003677938.

U. S. Nuclear Regulatory Commission (NRC). 2007. Prepared by J.A. Davis and G.P. Curtis. *Consideration of Geochemical Issues in Groundwater Restoration at Uranium In-Situ Leach Mining Facilities*. NUREG/CR-6870. January 2007.

Table T.2-1 Typical Reverse Osmosis Membrane Rejection

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

Source: Osmonics, Inc.

Table T.2-2 Analytical Results for Permeate

Major Ions	Units	Reporting Limit	Results
Calcium	mg/L	1.0	<1.0
Magnesium	mg/L	1.0	<1.0
Sodium	mg/L	1.0	15.2
Potassium	mg/L	1.0	1.1
Carbonate	mg/L	1.0	<0.1
Bicarbonate	mg/L	1.0	15.0
Sulfate	mg/L	1.0	5.4
Chloride	mg/L	1.0	14.8
Ammonia as N	mg/L	0.05	<0.05
Nitrite as N	mg/L	0.10	<0.10
Nitrate + Nitrite as N	mg/L	0.10	<0.10
Fluoride	mg/L	0.10	<0.10
Silica	mg/L	1.0	<1.0
Non-Metals			
Total Dissolved Solids	mg/L	10.0	10.0
Conductivity	umho/cm	1.0	47.0
Alkalinity	mg/L	1.0	12.0
pH	std. units	0.10	6.30
Trace Metals			
Aluminum	mg/L	0.10	<0.10
Arsenic	mg/L	0.001	0.001
Barium	mg/L	0.10	<0.10
Boron	mg/L	0.10	0.29
Cadmium	mg/L	0.005	<0.005
Chromium	mg/L	0.05	<0.05
Copper	mg/L	0.01	<0.01
Iron	mg/L	0.05	<0.05
Lead	mg/L	0.001	<0.001
Manganese	mg/L	0.01	<0.01
Mercury	mg/L	0.001	<0.001
Nickel	mg/L	0.05	<0.05
Selenium	mg/L	0.001	<0.001
Vanadium	mg/L	0.10	<0.10
Zinc	mg/L	0.01	0.02
Radiometrics			
Uranium	mg/L	0.0003	0.0082
Radium-226	pCi/L	0.2	3.1
Radium Error Estimate ±	--	--	0.3

Sample Date: 02/22/2001 Report Date: 03/16/2001
pCi/gm – picocuries per gram
mg/L – milligrams per liter
umho/cm – microomhs per centimeter

Table T.2-3 NDEQ Groundwater Restoration Standards

Parameter	NDEQ Title 118 Groundwater Standard	NDEQ Restoration Standard[1]
Ammonium (mg/L)	Not Listed	10.0
Arsenic (mg/L)	0.010	0.010
Barium (mg/L)	2.0	2.0
Cadmium (mg/L)	0.005	0.005
Chloride (mg/L)	250	250
Copper (mg/L)	1.3	1.3
Fluoride (mg/L)	4.0	4.0
Iron (mg/L)	0.3	0.3
Mercury (mg/L)	0.002	0.002
Manganese (mg/L)	0.05	0.05
Molybdenum (mg/L)	(Reserved)	1.0
Nickel (mg/L)	(Reserved)	0.15
Nitrate (mg/L)	10.0	10.0
Lead (mg/L)	0.015	0.015
Radium (pCi/L)	5.0	5.0
Selenium (mg/L)	0.05	0.05
Sodium (mg/L)	(Reserved)	Note 2
Sulfate (mg/L)	250	250
Uranium (mg/L)	0.030	0.030
Vanadium (mg/L)	(Reserved)	0.2
Zinc (mg/L)	5.0	5.0
pH (Std. Units)	6.5 - 8.5	6.5 – 8.5
Calcium (mg/L)	N/A	Note 2
Total Carbonate (mg/L)	N/A	Note 3
Potassium (mg/L)	N/A	Note 2
Magnesium (mg/L)	N/A	Note 2
TDS (mg/L)	500	Note 4

1 NDEQ Restoration Standard based on groundwater standard (MCL) from Title 118. For parameters where the baseline concentration exceeds the applicable MCL, the standard is set as the mine unit baseline average plus two standard deviations.

2 One order of magnitude above baseline is used as the restoration value for some parameters due to the ability of some major ions to vary one order of magnitude depending on pH.

3 Total carbonate shall not exceed 50% of the TDS value.

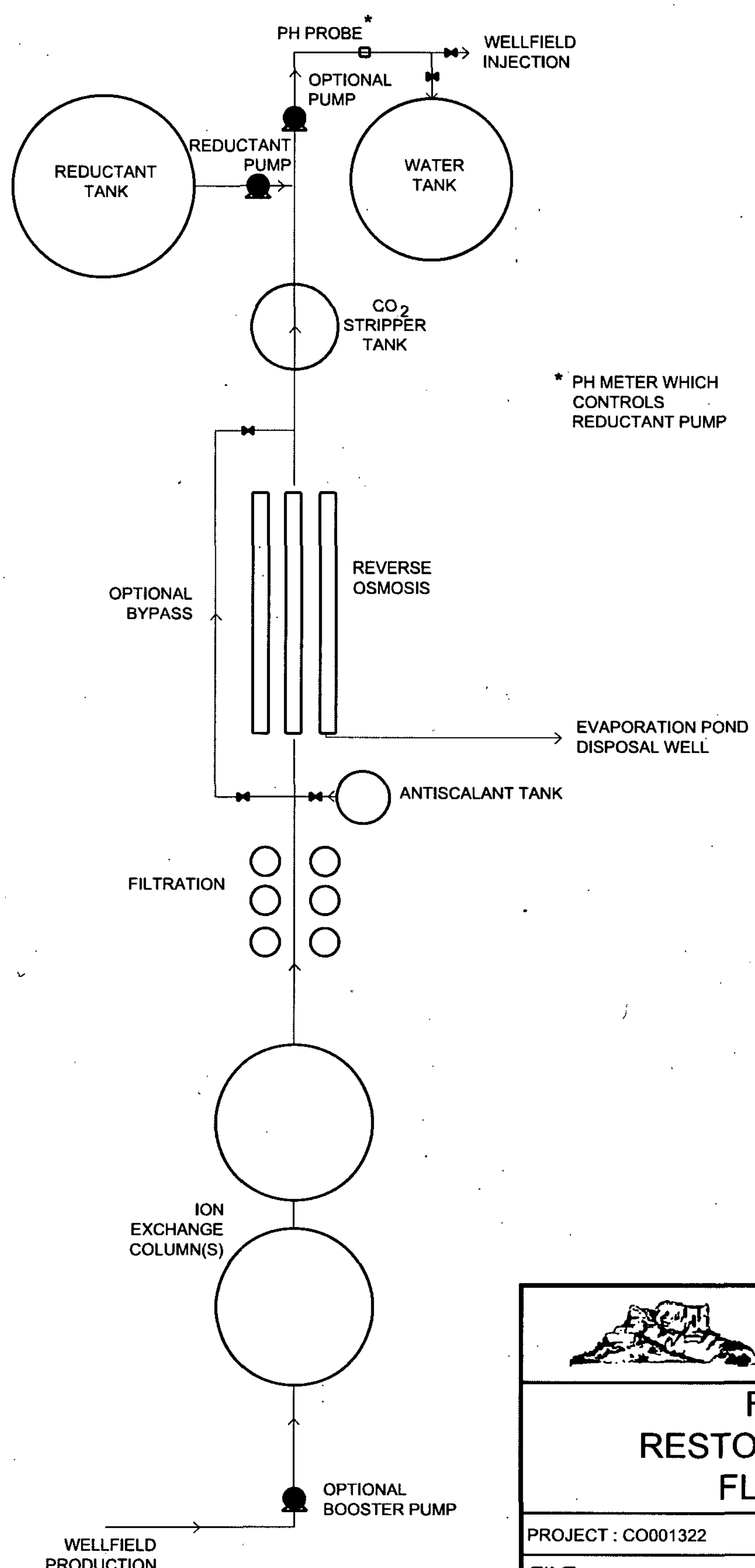
4 The restoration value for TDS shall be the baseline mean plus one standard deviation.

Source: NDEQ Class III UIC Permit Number NE0122611

Table T.3-1 Soil Cleanup Criteria and Goals

Layer Depth	Radium-226 (pCi/gm)		Natural Uranium (pCi/gm)	
	Limit	Goal	Limit	Goal
Surface (0 15 cm)	5	5	230	150
Subsurface (15 cm layers)	15	10	230	230

pCi/gm – picocuries per gram



CROW BUTTE RESOURCES, INC.

FIGURE T.2-1 RESTORATION PROCESS FLOW DIAGRAM

PROJECT : CO001322 MAPPED: JC CHECKED: J. CEARLEY

FILE: Figure T_2-1_RestorationProcessRevised.dwg @ 5/19/2009 12:00 PM

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CHAPTER U. COST ESTIMATE FOR ENVIRONMENTAL PROTECTION

U.1 Decontamination, Decommissioning and Reclamation Cost Estimates

As required by Title 122, Chapter 13, Section 001.01, this section presents a written estimate of the costs for "environmental protection" deemed to be necessary during and after the cessation of operations. These cost estimates focus on costs associated with the restoration and reclamation (decommissioning) of the Three Crow Expansion Area (TCEA) in order to ensure adequate funds are available for permanent closure of the project. The cost estimates address the above-referenced "measures" of concern. The estimated decommissioning costs will be included in the annual surety update required by SUA-1534 submitted to the NDEQ and the NRC for approval prior to construction activities.

Once the estimated costs are approved by the NDEQ, CBR will provide proof of financial surety arrangements prior to commencement of operations, as per Title 122 Chapter 13. The NRC also requires a financial surety arrangement consistent with 10 CFR 40, Appendix A, Criterion 9 to cover costs of reclamation activities. Evidence of financial responsibility in the form of a letter of credit or other form satisfactory to the NDEQ in accordance with Title 122, Chapter 13, shall be provided to the NDEQ in an amount which is equal to or greater than the total costs indicated in the Surety Cost Estimate as required, along with an audit statement from an independent professional auditing firm. CBR will review the cost estimate on an annual basis and update in order to ensure adequacy of the dollar amount. The purpose is to ensure that there are sufficient funds available for decontamination, decommissioning and reclamation of the facility in the event CBR is incapable of performing the tasks.

Groundwater and surface reclamation and restoration methods to be used for the TCEA are discussed in Chapter T. A decommissioning plan shall be based on factors such as the mine plan, baseline environmental information, and any other factors that will assure the long-term physical, geotechnical and geochemical stability of the site. Restoration of a specific mining unit can be started as soon as mining is completed, hence the importance of integrating the mine plan and the decommissioning plan. Restoration of a specific mine unit can occur while uranium recovery operations continue at other mining units. Once groundwater restoration has been completed in the final mining unit and approved by the NDEQ, decommissioning of the satellite processing plant, remaining evaporation ponds and other structures can be initiated.

The cost estimates presented in this section are based on the cost per year to restore one mine unit and reclaim one mine unit (surface and subsurface features). The CBR mine plan calls for sequential restoration and reclamation, and CBR will have approximately two to three mine units in restoration, mining, or reclamation at any one time. The surety cost estimates will be adjusted as necessary when additional mine units are to be brought on line and the proposed operations are better defined. A current and updated surety is required at least 90 days prior to commencement of construction of a new mine unit or significant expansion.

Cost information is presented in the following tables:

Table U.1-2	Three Crow Total Restoration and Reclamation – 2010 Surety Estimate
Table U.1-3	Three Crow Groundwater Restoration – 2010 Surety Estimate
Table U.1-4	Three Crow Wellfield Reclamation – 2010 Surety Estimate
Table U.1-5	Three Crow Well Abandonment Unit – 2010 Surety Estimate
Table U.1-6	Three Crow Satellite Facility Equipment Decommissioning – 2010 Surety Estimate
Table U.1-7	Three Crow Building Demolition Cost – 2010 Surety Estimate
Table U.1-8	Three Crow Evaporation Pond Reclamation – 2010 Surety Estimate
Table U.1-9	Three Crow Miscellaneous Site Reclamation – 2010 Surety Estimate
Table U.1-10	Three Crow Deep Disposal Well Reclamation – 2010 Surety Estimate
Table U.1-11	Three Crow Groundwater Sweep (GWS) [Unit Cost] – 2010 Surety Estimate
Table U.1-12	Three Crow Groundwater Reverse Osmosis (RO) Treatment [Unit Cost] – 2010 Surety Estimate
Table U.1-13	Three Crow Groundwater Recirculation [Unit Cost] – 2010 Surety Estimate
Table U.1-14	Three Crow Well Abandonment [Unit Cost] – 2010 Surety Estimate
Table U.1-15	Three Crow Master Cost Basis – 2010 Surety Estimate

Table U.1-1 presents the primary assumptions that serve as the basis for the surety cost estimates associated with restoration and reclamation of one mine unit. **Table U.1-2** provides a summary of the total estimated costs for projected restoration and reclamation activities ($6,288,713), which includes a contract administration and contingency fees of 10 and 15 percent, respectively. The remaining tables provide a further refinement of the cost estimates and the basis for the tasks and cost estimates. The deep disposal well will operate under a separate UIC permit, but the reclamation cost estimates for this well have been provided as part of the total surety estimate for the Three Crow Expansion Area.

U.2 Restoration and Reclamation Issues Associated with Topography, Geology and Hydrology

There are no major difficulties anticipated with the restoration and reclamation of the groundwater of the TCEA, including plugging and abandonment of wells and disassembly, decontamination, and restoration of the aquifer site. However, restoration of the affected aquifer to "precise pre-existing levels" may not be feasible (see discussions below). CBR has successfully plugged and abandoned numerous wells, and restored the groundwater of Mine Unit 1 in the current permitted area. Similar geological and hydrological conditions at the TCEA would indicate the same results can occur at this proposed mining area. There are no topography issues within the TCEA that would pose as a problem with decontamination and reclamation of surface or subsurface features.

The primary goal of the groundwater restoration program is to return groundwater affected by mining operations to conditions suitable for the uses for which they were suitable before mining. Preference would be to attain pre-injection baseline values on a mine unit average as determined by the baseline water quality sampling program. However, since ISL operations alter the groundwater geochemistry, it is unlikely that restoration efforts will return the groundwater to the "precise" water quality that existed before operations. Should restoration efforts be unable to achieve baseline conditions after diligent application of the best practicable technology (BPT) available, CRB will, in accordance with the Nebraska Environment Quality Act and NDEQ regulations, return the groundwater to the restoration values set by the NDEQ in the Class III UIC permit. A reverse osmosis treatment unit will be used to enhance the treatment of groundwater in an attempt to return the groundwater to as near baseline as possible. Cost estimates presented in the attached tables assume groundwater can be restored to levels acceptable the NDEQ. This is believed to be achievable based on successful restoration of Mine Unit 1 in the current permitted area. Cost estimates are considered to be adequate in addressing other perceived "issues" associated with decommissioning.

Geological, groundwater and surface water environmental impacts associated with operations are discussed in detail in sections H.2.2, H.2.4 and H.2.5 of Chapter H. Restoration determination and establishment of restoration parameters are discussed in Section T.2.4 of Chapter T.

U.3 Post-Operational Monitoring as may be Required by the Environmental Protection Act, Regulations Of Title 122, and/or the Permit.

The primary post-operational monitoring task will be associated with restoration and stabilization of the groundwater in the affected aquifer. Monitoring of designated monitor wells used during operations will continue through restoration and stabilization of a mine unit, and new wells may be added as needed. It is assumed that the plugging of wells and surface reclamation of the mining units and support facilities will take place once the NDEQ has deemed restoration complete and in compliance with applicable regulations.

Restoration and stabilization monitoring procedures are discussed in Section T.2. Cost estimates for the projected monitoring activities are presented in the attached Tables.

U.4 Additional Estimated Costs to Complete Restoration if Abandoned by Permittee

In the event that CBR abandoned the project, and the State was required to complete decommissioning of the site, sufficient funds have been provided in the estimated costs to address such an unlikely event. In addition the estimated costs for actual decommissioning activities and required equipment, cost estimates for supervisors and other required staffing, have been provided for in the estimated costs. There is also a contract administration cost estimate of $503,097 (10% of total estimated costs) and a contingency of $754,646 (15% of total estimated costs). This position of adequately estimated funds is based on restoration of one mine unit and reclamation of one mine unit, which is reflective of the initial operation. As new mine units are added, the surety will be updated to reflect associated increased decommissioning costs. Therefore, sufficient funds will always be available in the event the State is forced to take the project over and complete decommissioning.

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Table U.1-1 Primary Assumptions Serving as the Basis for Surety Cost Estimates Associated with Restoration and Reclamation of One (1) Mine Unit

Assumptions	Quantity
Total number of production wells	30*
Total number of injection wells	50*
Total number of shallow monitor wells	18
Total number of perimeter wells	25
Total number of restoration wells	18
Wellfield Area (ft^2)	3,049,200
Wellfield Area (acres)	70
Affected Ore Zone Area (ft^2)	3,049,200
Average completed thickness (ft)	25
Porosity	0.29
Affected Volume (ft^3)	76,230,000
K gallons per Pore Volume	165,358
Estimated Number of Pore Volumes for Restoration	11
Number of Wells per Wellfield	141
Total Number of Wells	141
Average Well Depth (ft) – Deep Wells	910
Average Well Depth (ft) – Shallow Depth	200

Estimated costs are shown in Table U.1-2 and U.1-3.

*Number of wells per wellhouse: typically 3 wellhouses per wellfield

Table U.1-2 Three Crow Total Restoration and Reclamation Cost Estimate – 2010 Surety Estimate

Task		Cost $
I.	Groundwater Restoration (Table U.1-3)	$ 3,805,422.00
II.	Wellfield Reclamation and Well Abandonment (Tables U.1-4 and U.1-5)	152,523.00
III.	Commercial Plant Reclamation/Decommissioning (Tables U.1-6 and U.1-7)	697,903.00
IV.	Evaporation Pond Reclamation (Table U.1-8)	228,322.00
V.	Miscellaneous Site Reclamation (Table U.1-9)	80,742.00
VI.	Deep Disposal Well Reclamation (Table U.1-10)	66,058.00
Subtotal Reclamation and Restoration Cost Estimate		$ 5,030,970.00
	Contract Administration (10%)	503,097.00
	Contingency (15%)	754,646.00
	TOTAL	$ 6,288,713.00

Table U.1-3 Three Crow Groundwater Restoration – 2010 Surety Estimate

Task		MU 1	MU 2	MU 3	MU 4	MU 5	MU 6	MU 7	MU 8	MU 9	Total
I. IX Treatment Costs											
PV's Required		3	0	0	0	0	0	0	0	0	0
Total Kgals for Treatment		496074	0	0	0	0	0	0	0	0	0
IX Treatment Unit Cost ($/Kgal)	(Table U.1-11)	$0.70	$0.70	$0.70	$0.70	$0.70	$0.70	$0.70	$0.70	$0.70	$0.70
Subtotal IX Treatment Costs per Wellfield		**$347,251.80**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Total IX Treatment Costs		**$347,251.80**	**$0.00**								
II. Reverse Osmosis Costs											
PV's Required		6	0	0	0	0	0	0	0	0	0
Total Kgals for Treatment		992148	0	0	0	0	0	0	0	0	0
Reverse Osmosis Unit Cost ($/Kgal)	(Table U.1-12)	$2.02	$2.02	$2.02	$2.02	$2.02	$2.02	$2.02	$2.02	$2.02	$2.02
Subtotal Reverse Osmosis Costs per Wellfield		**$2,004,138.96**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Total Reverse Osmosis Costs		**$2,004,138.96**	**$0.00**								
III. Recirculation Costs											
PV's Required		2	-	0	0	0	0	0	0	0	0
Total Kgals for Treatment		330716	-	0	0	0	0	0	0	0	0
Recirculation Unit Cost ($/Kgal)	(Table U.1-13)	$0.46	$0.46	$0.46	$0.46	$0.46	$0.46	$0.46	$0.46	$0.46	$0.46
Subtotal Recirculation Costs per Wellfield		**$152,129.36**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Total Recirculation Costs		**$152,129.36**	**$0.00**								
IV. Consumables											
Spare parts, filters and consumables = $ 20,188.35 /year											
Active restoration period (months)		54.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Consumable usage (months restoration x annual rate estimate)		$91,133.58	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Subtotal Consumables per Mine Unit		**$91,133.58**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Total Consumables Costs		**$91,133.58**	**$0.00**								

Table U.1-3 Three Crow Groundwater Restoration – 2010 Surety Estimate

Task		MU 1	MU 2	MU 3	MU 4	MU 5	MU 6	MU 7	MU 8	MU 9	Total
V. Monitoring and Sampling Costs											
Guideline 8 analysis =	$200.00 analysis										
6 parameter in-house analysis =	$50.04 analysis										
Total restoration wells		18	0	0	0	0	0	0	0	0	0
Total monitor wells		43	0	0	0	0	0	0	0	0	0
IX Treatment duration (months)		9.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Reverse Osmosis duration (months)		37.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Recirculation duration (months)		6.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stabilization duration (months)		12	0	0	0	0	0	0	0	0	
A. Restoration Well Sampling											
1. Well Sampling prior to restoration start											
# of Wells		18	0	0	0	0	0	0	0	0	0
$/sample		$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	
2. IX Treatment Sampling											
# of Wells		18	0	0	0	0	0	0	0	0	
Total # samples		180	0	0	0	0	0	0	0	0	0
$/sample		$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	
3. RO Sampling											
# of Wells		18	0	0	0	0	0	0	0	0	
Total # samples		684	0	0	0	0	0	0	0	0	0
$/sample		$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	
4. Recirculation Sampling											
# of Wells		18	0	0	0	0	0	0	0	0	
Total # samples		126	0	0	0	0	0	0	0	0	0
$/sample		$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	
5. Stabilization Sampling (Guideline 8)											
# of Wells		18	0	0	0	0	0	0	0	0	
Total # samples		54	0	0	0	0	0	0	0	0	0
$/sample		$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	$200.00	
6. Stabilization Sampling (6 parameter in-house)											
# of Wells		18	0	0	0	0	0	0	0	0	
Total # samples		216	0	0	0	0	0	0	0	0	0
$/sample		$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	

Table U.1-3 Three Crow Groundwater Restoration – 2010 Surety Estimate

Task	MU 1	MU 2	MU 3	MU 4	MU 5	MU 6	MU 7	MU 8	MU 9	Total
7. Monitor Well Sampling										
# of Wells	43	0	0	0	0	0	0	0	0	
$/sample	$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	$50.04	
Total # samples (2.2/mo for entire period)	6260	0	0	0	0	0	0	0	0	0
8. Other Laboratory Costs										
Radon, urinalysis, etc. = $912.05 month										
Total for Other Laboratory Costs:	$49,405.75	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Subtotal Monitoring and Sampling Costs per Mine Unit	**$456,299.35**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Total Monitoring and Sampling Costs	**$456,299.35**	**$0.00**								
VI. Supervisory Labor Cost										
Engineer Support = $9,250.31 month										
HP Technician support = $4,677.49 month										
Active restoration period (months)	54.17	0	0	0	0	0	0	0	0	
Stabilization period (months)	12	0	0	0	0	0	0	0	0	
1 Engineer support during active restoration	$501,089.29	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
2 HP Technician support during active restoration	$253,379.63	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
3 Engineer support during final stabilization										$0.00
4 HP Technician support during final stabilization										$0.00
5 Cost reduction due to concurrent restoration of Mine Units				$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Subtotal Supervisory Labor per Mine Unit	**$754,468.92**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
Total Supervisory Labor Costs	**$754,468.92**									
TOTAL RESTORATION COST PER WELLFIELD	**$3,805,421.97**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**

MU = Mine Unit PV = Pore Volumes HP = Health Physicists

Table U.1-4 Three Crow Wellfield Reclamation – 2010 Surety Estimate

Task	MU1	MU2	MU3	MU4	MU5	MU6	MU7	MU8	MU9	Totals
Wellfield Piping										
Assumptions:										
Number of Wellhouses	1	0	0	0	0	0	0	0	0	1
Total Mine Unit surface area (acres)	70	0	0	0	0	0	0	0	0	70
Total length of small diameter production and injection lines (laterals) (ft)	27000	0	0	0	0	0	0	0	0	27000
Total length of 3/8-inch hose (ft)	0	0	0	0	0	0	0	0	0	0
Total length 1-1/4-inch stinger pipe (ft)	5000	0	0	0	0	0	0	0	0	5000
Total length of 2-inch downhole production pipe (ft)	16500	0	0	0	0	0	0	0	0	16500
Total Length of Trunkline (6-inch) (ft)	0	0	0	0	0	0	0	0	0	0
Total Length of Trunkline (8-inch) (ft)	1500	0	0	0	0	0	0	0	0	1500
Total Length of Trunkline (10-inch) (ft)	0	0	0	0	0	0	0	0	0	0
Total Length of Trunkline (12-inch) (ft)	0	0	0	0	0	0	0	0	0	0
Total Length of All Trunkline (ft)	1500	0	0	0	0	0	0	0	0	1500
Total number of production wells	30	0	0	0	0	0	0	0	0	30
Total number of injection wells	50	0	0	0	0	0	0	0	0	50
Total number of shallow monitor wells	18	0	0	0	0	0	0	0	0	18
Total number of perimeter monitor wells	25	0	0	0	0	0	0	0	0	25
I. Production and Injection Piping										
A. Removal and Loading										
Production and Injection Piping Removal Unit Cost ($/ft of pipe)	$0.67	$0.67	$0.67	$0.67	$0.67	$0.67	$0.67	$0.67	$0.67	
Subtotal Production and Injection Piping Removal and Loading Costs	*$18,090.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$18,090.00*
B. Pipe Shredding										
Production and Injection Piping Shredding Unit Cost ($/ft of pipe)	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	
Subtotal Production and Injection Piping Removal and Loading Costs	*$2,160.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$2,160.00*
C. Equipment Costs										
Cat 924G Loader Unit Costs for removal (450'/day)	$26,400.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Shredder Unit Costs for shredding (450'/day)	$5,760.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Subtotal Equipment Costs	*$32,160.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$32,160.00*
D. Transport and Disposal Costs (NRC-Licensed Facility)										
Chipped Volume Reduction (ft^3/ft)	0.0069	0.0069	0.0069	0.0069	0.0069	0.0069	0.0069	0.0069	0.0069	
Chipped Volume per Wellfield (yd^3)	6.9	0	0	0	0	0	0	0	0	
Volume for Disposal Assuming 25% Void Space (yd^3)	8.6	0	0	0	0	0	0	0	0	8.6
Transportation and Disposal Unit Cost ($\$/yd^3$) Unpackaged Bulk	$357.12	$357.12	$357.12	$357.12	$357.12	$357.12	$357.12	$357.12	$357.12	
Subtotal Production and Injection Piping Transport and Disposal Costs	*$3,071.23*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$3,071.23*
Total Production and Injection Piping Costs	**$55,481.23**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$55,481.23**

Table U.1-4 Three Crow Wellfield Reclamation – 2010 Surety Estimate

Task	MU1	MU2	MU3	MU4	MU5	MU6	MU7	MU8	MU9	Totals
II. Trunklines										
A. Removal and Loading										
Trunkline Removal Unit Cost ($/ft of pipe)	$1.51	$1.51	$1.51	$1.51	$1.51	$1.51	$1.51	$1.51	$1.51	
Subtotal Trunkline Removal and Loading Costs	*$2,265.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$2,265.00*
B. Pipe Shredding										
Trunkline Shredding Unit Cost ($/ft of pipe)	$1.51	$1.51	$1.51	$1.51	$1.51	$1.51	$1.51	$1.51	$1.51	
Subtotal Trunkline Shredding Costs	*$2,265.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$2,265.00*
C. Equipment Costs										
Cat 924G Loader Unit Costs for removal (200'/day)	$3,300.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Shredder Unit Costs for shredding (200'/day)	$720.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Subtotal Equipment Costs	*$4,020.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$4,020.00*
D. Transport and Disposal Costs (NRC-Licensed Facility)										
Chipped Volume Reduction (6-inch) (ft^3/ft)	0.0651	0.0651	0.0651	0.0651	0.0651	0.0651	0.0651	0.0651	0.0651	
Chipped Volume Reduction (8-inch) (ft^3/ft)	0.1103	0.1103	0.1103	0.1103	0.1103	0.1103	0.1103	0.1103	0.1103	
Chipped Volume Reduction (10-inch) (ft^3/ft)	$0.17	$0.17	$0.17	$0.17	$0.17	$0.17	$0.17	0.1712	0.1712	
Chipped Volume Reduction (12-inch) (ft^3/ft)	0.2408	0.2408	0.2408	0.2408	0.2408	0.2408	0.2408	0.2408	0.2408	
Chipped Volume per Wellfield (yd^3)	6.1	0	0	0	0	0	0	0	0	
Volume for Disposal Assuming 25% Void Space (ft^3)	7.6	0	0	0	0	0	0	0	0	7.6
Transportation and Disposal Unit Cost ($/$ft^3$)	$357.12	$357.12	$357.12	$357.12	$357.12	$357.12	$357.12	$357.12	$357.12	
Subtotal Transport and Disposal Costs	*$2,714.11*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$2,714.11*
Total Trunkline Costs	**$11,264.11**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$11,264.11**
III. Downhole Pipe										
A. Removal and Loading										
Downhole Piping Removal Unit Cost ($/ft of pipe)	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	$0.08	
Downhole Hosing Removal Unit Cost ($/ft of pipe)	$0.15	$0.15	$0.15	$0.15	$0.15	$0.15	$0.15	$0.15	$0.15	
Removal of 1-1/4-inch stinger pipe	$400.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Removal of downhole production pipe	$1,320.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Removal of downhole hose	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Subtotal Downhole Piping Removal and Loading Costs	*$1,720.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$1,720.00*
B. Pipe Shredding										
Downhole Piping Shredding Unit Cost ($/ft of pipe)	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	$0.07	
Subtotal Downhole Piping Shredding Costs	*$1,505.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$1,505.00*
C. Equipment Costs										
Smeal Unit Costs for removal	$1,075.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Shredder Unit Costs for shredding	$458.67	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Subtotal Equipment Costs	*$1,533.67*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$1,533.67*

Table U.1-4 Three Crow Wellfield Reclamation – 2010 Surety Estimate

Task	MU1	MU2	MU3	MU4	MU5	MU6	MU7	MU8	MU9	Totals
D. Transport and Disposal Costs (NRC-Licensed Facility)										
Chipped Volume Reduction - 1-1/4-inch stinger (ft^3/ft)	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	
Chipped Volume Reduction - 2-inch downhole production (ft^3/ft)	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	
Volume Reduction - 3/8-inch hose (ft^3/ft)	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	0.0313	
Chipped Volume - 1-1/4-inch stinger (ft^3)	22	0	0	0	0	0	0	0	0	
Chipped Volume - 2-inch downhole production (ft^3)	122	0	0	0	0	0	0	0	0	
Volume 3/8-inch hose (ft^3)	0	0	0	0	0	0	0	0	0	
Volume for Disposal Assuming 25% Void Space (yd^3)	6.7	0	0	0	0	0	0	0	0	6.7
Transportation and Disposal Unit Cost ($\$/yd^3$) (Unpackaged Bulk)	$357.12	$357.12	$357.12	$357.12	$357.12	$357.12	$357.12	$357.12	$357.12	
Subtotal Downhole Piping Transport and Disposal Costs	*$2,392.70*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$2,392.70*
Total Downhole Piping Costs	**$7,151.37**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$7,151.37**
IV. Surface Reclamation										
A. Removal and disposal of contaminated soil around wells										
Volume of contaminated soil (0.37 yd^3 per injection and production well)	29.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.60
Disposal of contaminated soil $150.27 per yd^3	$4,447.99	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$4,447.99
Equipment (Cat 924G loader at 2 yd^3/hr)	$814.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Labor (1 man-hour per 2 Yd^3)	$279.31	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Subtotal removal and disposal of contaminated soil	*$5,541.30*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$5,541.30*
B. Recontour and seeding										
Recontour and seeding (est. $300/acre)	$21,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Subtotal Recontour and Seeding	*$21,000.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$21,000.00*
Total Surface Reclamation	**$26,541.30**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$26,541.30**
V. Well Houses										
Total Quantity	1	0	0	0	0	0	0	0	0	
Average Well House Weight (Lbs.)	6000	6000	6000	6001	6002	6003	6004	6005	6006	
A. Removal										
Dismantlement at 2-man-days per wellhouse (man-days)	2	0	0	0	0	0	0	0	0	
Dismantlement Labor Costs	$301.96	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$301.96
Equipment (Cat 924G at 2 hours per wellhouse) (hrs)	2	0	0	0	0	0	0	0	0	
Equipment Costs	$110.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$110.00
Subtotal Well House Dismantlement Costs	*$411.96*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$411.96*
B. Disposal										
Total Disposal Weight (6000 lbs per wellhouse) (Lbs)	6000	0	0	0	0	0	0	0	0	
Subtotal Disposal Costs	*$115.02*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$0.00*	*$115.02*
Total Well House Removal and Disposal Costs	**$526.98**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$526.98**
TOTAL REMOVAL AND DISPOSAL COSTS PER WELLFIELD	**$100,964.99**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$100,964.99**

MU = Mine Unit

Table U.1-5 Three Crow Well Abandonment – 2010 Surety Estimate

Task	MU1	MU2	MU3	MU4	MU5	MU6	MU7	MU8	MU9	Totals
I. Well Abandonment (Wellfields)										
# of Production Wells	30	0	0	0	0	0	0	0	0	
# of Injection Wells	50	0	0	0	0	0	0	0	0	
# of Perimeter Monitoring Wells	25	0	0	0	0	0	0	0	0	
# of Shallow Monitoring Wells	18	0	0	0	0	0	0	0	0	
Total Number of Deep Wells	105	0	0	0	0	0	0	0	0	105
Total Number of Shallow Wells	18	0	0	0	0	0	0	0	0	18
Average Diameter of Casing (inches)	5	5	5	5	6	7	8	9	10	
Production, Injection and Perimeter Well Average Depth (ft)	910	0	0	0	0	0	0	0	0	101
Shallow Well Average Depth (ft)	200	0	0	0	0	0	0	0	0	22
Total Mine Unit Well Depth (ft)	99150	0	0	0	0	0	0	0	0	99150
Well Abandonment Unit Cost ($/ft. of well)	$0.52	$0.52	$0.52	$0.52	$0.52	$0.52	$0.52	$0.52	$0.52	
Subtotal Abandonment Cost per Wellfield	$51,558.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$51,558.00
II. Downhole Pump Disposal										
Number of Downhole Pumps	0									
Pump Disposal Volume(ft^3)	0.5									
Total Pump Disposal Volume(yd^3)	$0.00									$0.00
Downhole Pump Disposal Rate ($/$yd^3$)	**$357.12**									$357.12
Subtotal Downhole Pump Disposal	$0.00									$0.00
TOTAL WELLFIELD ABANDONMENT COSTS	**$51,558.00**									

MU = Mine Unit

Table U.1-6 Three Crow Satellite Facility Equipment Decommissioning – 2010 Surety Estimate

I. Removal and Loading Costs	
Tankage	
Number of Contaminated Tanks	10
Volume of Contaminated Tank Construction Material (ft^3)	397
Number of Chemical Tanks	0
Disposal Void Factor	1.25
A. Labor to Remove and Load Tankage	
Number of Persons	2
Tanks/Day	1
Number of Days	10
$/Day/Person	$150.98
Subtotal Removal Labor Costs	$3,019.60
B. Labor to Clean Chemical Tankage	
Number of Persons	1
Tanks/Day	1
Number of Days	0
$/Day/Person	$150.98
Subtotal Cleaning Labor Costs	*$0.00*
C. Equipment	
Saws, scaffolding, etc.	$6,000.00
Subtotal Equipment Costs	*$6,000.00*
Total Equipment Removal and Loading Costs	**$9,019.60**
II. Transportation and Disposal Costs (NRC-Licensed Facility)	
A. Tankage	
Volume of Tank Construction Material (ft^3)	397
Volume for Disposal Assuming Void Space (yd^3)	18.40
Transportation and Disposal Unit Cost ($/$yd^3$) (Unpackaged Bulk)	$357.12
Subtotal Tankage Transportation and Disposal Costs	*$6,571.01*
B. Contaminated PVC Pipe	
Volume of Shredded PVC Pipe (ft^3)	153.6
Volume for Disposal Assuming Void Space (yd^3)	7.1
Transportation and Disposal Unit Cost ($/$yd^3$) (Unpackaged Bulk)	$357.12
Subtotal Contaminated PVC Pipe Transportation and Disposal Costs	*$2,535.55*
C. Pumps	
Volume of Process Pumps (yd^3) (no void factor used)	2.4
Transportation and Disposal Unit Cost ($/$yd^3$) (Unpackaged Bulk)	$357.12
Subtotal Pump Transportation and Disposal Costs	*$857.09*
D. Filters (injection, backwash and yellowcake filters)	
Volume of Filters (yd^3) (no void factor used)	0.0
Transportation and Disposal Unit Cost ($/$yd^3$) (Unpackaged Bulk)	$357.12
Subtotal Filter Transportation and Disposal Costs	*$0.00*
E. Dryer	
Dryer Volume (yd^3) (no void factor used)	0.0
Transportation and Disposal Unit Cost ($/$yd^3$) (Unpackaged Bulk)	$357.12
Total Dryer Transportation and Disposal Costs	*$0.00*
Total Contaminated Equipment Transportation and Disposal Costs	**$9,963.65**

Table U.1-6 Three Crow Satellite Facility Equipment Decommissioning – 2010 Surety Estimate

III. Transportation and Disposal (Solid Waste for Landfill Disposal)	
A. Cleaned Tankage	
Volume of Tank Construction Material (ft^3)	0
Number of Landfill Trips	1
Transportation and Disposal Unit Cost ($/Load)	$212.00
Subtotal Tankage Transportation and Disposal Costs	*$212.00*
B. Uncontaminated PVC Pipe	
Volume of Shredded PVC Pipe (ft^3)	0
Number of Landfill Trips	1
Transportation and Disposal Unit Cost ($/Load)	$212.00
Subtotal PVC Pipe Transportation and Disposal Costs	*$212.00*
Total Uncontaminated Equipment Transportation and Disposal Costs	**$424.00**
IV. Supervisory Labor Costs During Plant Decommissioning	
Estimated Duration (months)	6
Engineer	$55,501.86
Radiation Technician	$28,064.94
Total Supervisory Labor Costs	**$83,566.80**
SUBTOTAL EQUIPMENT REMOVAL AND DISPOSAL COSTS PER FACILITY	$102,974.05
Building Area (Ft^2)	37100
Building Equipment Removal and Disposal Cost per Square Foot	$2.78
TOTAL EQUIPMENT REMOVAL AND DISPOSAL COSTS	**$102,974.05**

Table U.1-7 Three Crow Building Demolition – 2010 Surety Estimate

I. Decontamination Costs	
A. Wall Decontamination	
Area to be Decontaminated (ft^2)	0
HCl Application Rate (Gallons/ft^2)	1
HCl Acid Cost	$1.65
Subtotal Wall Decontamination Materials Costs	*$0.00*
B. Concrete Floor Decontamination	
Area to be Decontaminated (ft^2)	9,000
HCl Application Rate (Gallons/ft^2)	2
HCl Acid Cost	$1.65
Subtotal Floor Decontamination Materials Costs	*$29,700.00*
C. Decontamination Labor	
Labor (man-days)	2
Subtotal Decontamination Labor Cost	*$301.96*
D. Decontamination Equipment Costs	
Sprayer pump	$500.00
Recycle pump	$500.00
Sprayer with hose	$1,000.00
Subtotal Decontamination Equipment Costs	*$2,000.00*
E. Decontamination Waste Disposal (to Ponds)	
Total gallons HCl waste	18,000
Pumping costs (5 HP/30 gpm)	$178.73
Subtotal Decontamination Costs	*$32,180.69*
Total Decontamination Costs	**$32,180.69**
II. Demolition Costs	
Assumptions (based on 2007 costs):	
Dismantling interior steel, tanks, pumps, etc.	$159,450.00
Dismantling plant building	$79,725.00
A. Building Dismantling	
Dismantle interior components (2007 $'s escalated by CPI)	$157,217.70
Plant building dismantling (2007 $'s escalated by CPI)	$78,608.85
Subtotal Building Dismantling	*$235,826.55*
B. Concrete Floor Removal	
Area of direct-dispose concrete floors (ft^2)	13,400
Removal Rate ($/$ft^2$)	$14.04
Subtotal Concrete Floor Removal	*$188,136.00*
Total Demolition Costs	**$423,962.55**

Table U.1-7 Three Crow Building Demolition – 2010 Surety Estimate

III. Disposal Costs	
A. Concrete Floor	
Area of Direct-Dispose Concrete Floor (ft^2)	13,400
Average Thickness of Concrete Floor (ft)	0.75
Volume of Concrete Floor (ft^3)	10,050
Volume of Concrete Floor (Yd^3)	372
Transportation and Disposal Unit Cost ($\$/Yd^3$) (Unpackaged Bulk)	$357.12
Subtotal Concrete Floor Disposal Costs	*$132,848.64*
Total Disposal Costs	**$132,848.64**
IV Plant Site Reclamation	
A. Plant Site Earthwork	
Material to be Moved (Yd^3)	20,000
D8N Bulldozer Earthwork Rate (Yd^3/hr)	700
D8N Hourly Rate	$165.79
Subtotal Plant Site Earthwork	*$4,736.86*
B. Revegetation	
Area requiring Revegetation (Ac)	4
Revegetation Unit Cost ($/Ac)	300
Subtotal Plant Site Revegetation	*$1,200.00*
Total Plant Site Reclamation Costs	**$5,936.86**
SUBTOTAL BUILDING DEMOLITION AND DISPOSAL COSTS	$594,928.74
Building Area (Ft^2)	37,100
Building Demolition Cost per Square Foot	$16.04
TOTAL BUILDING DEMOLITION AND DISPOSAL COSTS	**$594,928.74**

Table U.1-8 Three Crow Evaporation Pond Reclamation – 2010 Surety Estimate

	Assumptions/Data:		
		Number of Ponds	3
		Area of Ponds (ft^2)	250,000
		Thickness of Liner Material (ft)	0.00833
		Leak detection piping size (in)	4
		Leak detection piping length (ft/pond)	2,100
		Earthwork Requirements (Yd^3/pond)	60,000
		Surface Restoration/Revegetation (Acres)	20
		Sludge Production Rate (Yd^3 sludge/gal)	0.000000102
		(1 Yd^3 sludge/9,772,000 gal R&D Phase)	
		Estimated 2010 Total Production (gallons)	5,256,000
		Liner Removal Rate (ft^2/man-day)	10,000
		Sludge Removal Rate (Yd^3/man-day)	8.33
I.	**Pond Liner and Piping Removal**		
	A.	Pond Liner and Piping Removal Labor	
		Area of Ponds	750,000
		Liner Removal Rate (ft^2/Man-Day)	10,000
		Total Man-Days	75
		Labor Rate ($/man-day)	$150.98
		Subtotal Liner and Piping Removal Labor Costs	*$11,323.50*
	B.	Pond Liner and Piping Removal Equipment	
		Total Man-Days Removal Effort	75
		Size of Crew	4
		Total Days Removal Effort	18.75
		Cat 924G Loader Hourly Rate ($/hr)	$55.00
		Subtotal Liner and Piping Removal Equipment Costs	*$8,250.00*
	Total Pond Liner and Piping Removal Costs		**$19,573.50**
II.	**Pond Sludge Removal**		
		Pond Sludge Estimate	
		Estimated Production Flow (gal)	5,256,000
		Historical Sludge Production Rate	0.000000102
		Estimated Pond Sludge Volume (Yd^3)	1
	A.	Pond Sludge Removal Labor	
		Pond Sludge Volume (Yd^3)	1
		Sludge Removal Rate (Yd^3/man-day)	8.33
		Total Man-Days	0
		Labor Rate ($/man-day)	$150.98
		Subtotal Pond Sludge Removal Labor Costs	*$0.00*
	B.	Pond Sludge Removal Equipment	
		Total Man-Days Removal Effort	0
		Size of Crew	3
		Total Days Removal Effort	0
		Cat 924G Loader Hourly Rate ($/hr)	$55.00
		Subtotal Pond Sludge Removal Equipment Costs	*$0.00*
	Total Pond Sludge Removal Costs		**$0.00**

Table U.1-8 Three Crow Evaporation Pond Reclamation – 2010 Surety Estimate

III.	**Pond Byproduct Material Disposal**	
	A. Pond Liner Disposal	
	Area of Pond Liner (ft^2)	750,000
	Thickness of Pond Liner (ft)	0.00833
	Volume of Pond Liner (ft^3)	6,248
	Void Space Factor	1.25
	Total Disposed Volume (yd^3)	289
	Disposal Unit Costs ($/$yd^3$) (Unpackaged Bulk)	$357.12
	Subtotal Pond Liner Disposal Costs	*$103,207.68*
	B. Pond Piping Disposal	
	Total Length of Piping	6,300
	Piping Volume Factor (ft^3/ft)	0.0103
	Total Volume Pond Piping (ft^3)	65
	Void Space Factor	1.25
	Total Disposed Volume (yd^3)	3.0
	Disposal Unit Costs ($/$yd^3$) (Unpackaged Bulk)	$357.12
	Subtotal Pond Piping Disposal Costs	*$1,071.36*
	C. Pond Sludge Disposal	
	Total Volume Pond Sludge (Yd^3)	1
	Disposal Unit Costs ($/$yd^3$) (Soil rate)	$150.27
	Subtotal Pond Sludge Disposal Costs	*$150.27*
	Total Byproduct Material Disposal Costs	**$104,429.31**
IV	**Pond Site Reclamation**	
	A. Pond Earthwork Requirements	
	Earthwork Requirements (Yd^3)	180,000
	D8N Bulldozer Earthwork Rate (Yd^3/hr)	700
	Total D8N Hours	257
	D8N Hourly Rate	$165.79
	Subtotal Pond Earthwork	*$42,608.03*
	B. Revegetation	
	Area requiring Revegetation (Ac)	20
	Revegetation Unit Cost ($/Ac)	$300.00
	Subtotal Plant Site Revegetation	*$6,000.00*
	Total Pond Site Reclamation Costs	**$48,608.03**
V.	**Supervisory Labor Costs During Pond Reclamation**	
	Estimated Duration (months)	4
	Engineer Rate ($/month)	$9,250.31
	Total Engineer Labor	$37,001.24
	Radiation Technician Rate ($/month)	$4,677.49
	Total Radiation Technician Labor	$18,709.96
	Total Supervisory Labor Costs	**$55,711.20**
TOTAL EVAPORATION POND RECLAMATION PER POND		**$228,322.04**
TOTAL EVAPORATION POND RECLAMATION COSTS		**$228,322.04**

Table U.1-9 Three Crow Miscellaneous Site Reclamation – 2010 Surety Estimate

I. Access Road Reclamation	
Assumptions	
Road Reclamation production rate (Yd^3/hr)	200
Length of Main Access Roads (ft)	500
Average Main Access Road width (ft)	25
Depth of Main Access Road Gravel Surface (ft)	1
Surface Area of Main Access Road (Ac)	0.3
Length of Wellfield Access Roads (ft)	500
Average Wellfield Access Road width (ft)	12
Depth of Wellfield Access Road Gravel Surface (ft)	0.5
Surface Area of Wellfield Road (Ac)	0.1
A. Main Access Road Dirtwork	
Main Access Road Gravel Volume (Yd^3)	463
Total reclamation time (hrs)	2
D8N Unit Operating Cost ($/hr)	$165.79
Subtotal Main Access Road Gravel Roadbase Removal Costs	*$331.58*
B. Wellfield Road Dirtwork	
Wellfield Road Gravel Volume (Yd^3)	111
Total reclamation time (hrs)	1
D8N Unit Operating Cost ($/hr)	$165.79
Subtotal Wellfield Road Gravel Roadbase Removal Costs	*$165.79*
E. Discing/Seeding	
Assumptions	
Surface Area (acres)	0.4
Discing/Seeding Unit Cost ($/acre)	$300.00
Subtotal Discing/Seeding Costs	*$120.00*
Total Access Road Reclamation Costs	**$617.37**
II. Wastewater Pipeline Reclamation	
Assumptions	
Pipeline Removal Rate (ft./man-day)	67
Pipeline Shredding Rate (ft./man-day)	1,500
Number of Pond Pipelines	2
Length of Pond Pipelines (ft)	2,000
Average Pipe Size (Sch 40)	4
A. Pipeline Removal Costs	
Length of Pipelines (ft)	4,000
Removal Rate (ft/man-day)	67
Removal Labor Rate ($/man-day)	$150.98
Cat 924G Loader Use (days)	60
Cat 924G Loader Cost	$26,400.00
Subtotal Pipeline Removal Costs	*$35,458.80*

Table U.1-9 Three Crow Miscellaneous Site Reclamation – 2010 Surety Estimate

B. Pipeline Shredding Costs	
Length of Pipelines (ft)	4,000
Shredding Rate (ft/man-day)	1,500
Shredding Labor Rate ($/man-day)	$150.98
Shredder Use (days)	3
Shredder Cost	$288.00
Subtotal Pipeline Shredding Costs	*$740.94*
C. Pipeline Transportation and Disposal (NRC-Licensed Facility)	
Pipe Diameter (inches)	4
Chipped Volume Reduction (ft^3/ft)	0.0103
Subtotal Volume of Shredded PVC Pipe (yd^3)	1.5
Disposal Void Factor	1.25
Final Disposal Volume (yd^3)	1.88
Transportation and Disposal Unit Cost ($\$/yd^3$) (Unpackaged Bulk)	$357.12
Subtotal Pipeline Disposal Costs	*$671.39*
Total Wastewater Pipeline Reclamation Costs	**$36,871.13**
III. Electrical Distribution System Removal	
Assumptions	
Length of High Voltage Lines	500
High Voltage Line Removal Rate ($/ft.)	$0.59
High Voltage Line Removal Cost ($/ft.)	$295.00
Substation Removal	$1,175.00
Total Electrical Distribution System Removal Costs	**$1,470.00**
IV. Supervisory Labor Costs During Miscellaneous Reclamation	
Estimated Duration (months)	3
Engineer Rate ($/month)	$9,250.31
Total Engineer Labor	$27,750.93
Radiation Technician Rate ($/month)	$4,677.49
Total Radiation Technician Labor	$14,032.47
Total Supervisory Labor Costs	**$41,783.40**
TOTAL MISCELLANEOUS RECLAMATION COSTS	**$80,741.90**

Sch - Schedule

Table U.1-10 Three Crow Deep Disposal Well Reclamation – 2010 Surety Estimate

Task	Cost $$
I. Cost Basis	
A. Plugging and Abandonment	
Cost Estimate from April 2009 2nd Well Permit Application for plugging and abandonment	$60,292.00
April 2009 CPI	213.20
June 2009 CPI	215.70
Subtotal Escalated April 2009 Plugging and Abandonment Costs	*$60,998.99*
B. Site Reclamation	
Cost Estimate from April 2009 2nd Well Permit Application for site reclamation	$5,000.00
April 2009 CPI	213.20
June 2009 CPI	215.70
Subtotal Escalated April 2009 Reclamation Costs	*$5,058.63*
TOTAL DEEP DISPOSAL WELL RECLAMATION COSTS	**$66,057.62**

CPI: Consumer Price Index

Table U.1-11 Three Crow Groundwater IX Treatment (GIX) Restoration [Unit Costs] – 2010 Surety Estimate

Assumptions:

1. All pumps are 5 hp pumping at 32 gpm
2. Cost of electricity = 0.0797 Kw hr
3. Horsepower to kilowatt conversion = 0.746 Kw/HP
4. Operator labor costs = 150.98 man-day
5. Labor costs are based on 36 pumps at 1,150 gpm

Wellfield Pumping Electrical Costs per 1000 Gallons

1000 gal	X	5 hp / 32 gpm	X	1 hr / 60 min	X	0.746 kwh / hp	X	$ 0.0797 / kwh	= $	0.155

Wellfield Pumping Labor Costs per 1000 Gallons

1000 gal	X	1 min / 1150 gal	X	1 man-day / 480 min	X	$150.98 / man-day	X	2 operators	= $	0.547

Groundwater IX Production Rate

1150 gal / min	X	60 min / hr	X	24 hr / day	X	365 day / year	X	1 year / 12 month	=	50,370,000 gallons / month

TOTAL GWS COSTS PER 1000 GALLONS	=	**$**	**0.70**

Table U.1-12 Three Crow Groundwater Reverse Osmosis (RO) Treatment [Unit Costs] – 2010 Surety Estimate

Assumptions:

1. All pumps are 5 hp pumping at 32 gpm
2. Membrane Replacement — $0.025 per 1000 gal
3. Cost of electricity = $0.0797 Kw hr
4. Horsepower to kilowatt conversion = 0.746 Kw/HP
5. Operator labor costs = $150.98 man-day
6. RO System horsepower requirements for 600 gpm rated flow based upon:
   - RO Unit Pump — 195 hp
   - Permeate/Injection pump — 60 hp
   - Waste pump — 12 hp
   - TOTAL: — 267 hp
7. Chemical costs:
   - Reductant = $0.385 lb
   - Antiscalant = $15.90 gal

Membrane Replacement Costs per 1000 Gallons

1000 gal	X	$660 membrane/ cost per month / 26,280,000 gallons per month	= $	0.025 per Kgal

Wellfield Pumping Electrical Costs per 1000 Gallons

1000 gal	X	5 / 32	hp / gpm	X	1 / 60	hr / min	X	0.746 kwh / hp	X	$ 0.0797 / kwh	= $	0.155 per Kgal

Reverse Osmosis Electrical Costs per 1000 Gallons

1000 gal	X	267 / 600	hp / gpm	X	1 / 60	hr / min	X	0.746 kwh / hp	X	$ 0.0797 / kwh	= $	0.441 per Kgal

Reverse Osmosis Labor Costs per 1000 Gallons

1000 gal	X	1 / 600	min / gal	X	1 / 480	man-day / min	X	$150.98 / man-day	X	2	operators	= $	1.048 per Kgal

Treatment chemical costs per 1000 Gallons

Antiscalant:

1000 gal	X	0.000008330 / 1	gal antiscalant / gal	X	$15.90 / gal antiscalant	= $	0.132 per Kgal

Reductant:

1000 gal	X	0.000560 / 1	lbs reductant / gal	X	$0.385 / lb reductant	= $	0.216 per Kgal

Reverse Osmosis Production Rate

600	gal / min	X	60	min / hr	X	24	hr / day	X	365	day / year	X	1 / 12	year / month	=	26,280,000 gallons / month

TOTAL RO COSTS PER 1000 GALLONS = $ 2.02

RO - Reverse Osmosis

Table U.1-13 Three Crow Groundwater Recirculation [Unit Costs] – 2010 Surety Estimate

Assumptions:

1. All pumps are 5 hp pumping at 32 gpm
2. Cost of electricity = $0.0797 Kw hr.
3. Horsepower to kilowatt conversion = $0.746 Kw/HP
4. Operator labor costs = $150.98 man-day
5. System horsepower requirements for 1,150 gpm rated flow based upon:
   injection pump 30 hp

Wellfield Pumping Electrical Costs per 1000 Gallons

1000 gal	X	5 hp / 32 gpm	X	1 hr / 60 min	X	1 kwh / hp	X	$ 0.0797 / kwh	= $	0.155 per Kgal

Wellfield Injection Electrical Costs per 1000 Gallons

1000 gal	X	30 hp / 1150 gpm	X	1 hr / 60 min	X	1 kwh / hp	X	$ 0.0797 / kwh	= $	0.026 per Kgal

Recirculation Labor Costs per 1000 Gallons

1000 gal	X	1 min / 1150 gal	X	1 man-day / 480 min	X	151 / man-day	X	1 operators	= $	0.274 per Kgal

Recirculation Production Rate

1150 gal / min	X	60 min / hr	X	24 hr / day	X	365 day / year	X	1 year / 12 month	=	50,370,000 gallons / month

TOTAL RECIRCULATION COSTS PER 1000 GALLONS = $ 0.46

Table U.1-14 Three Crow Well Abandonment [Unit Costs] – 2010 Surety Estimate

Assumptions:

1. Use backhoe for 0.25 hr/well to dig, cut off, and cap well.
2. Drill rig used 2.5 hrs to plug well.
3. Labor for installing chips, etc. will require 2 workers at 0.5 hrs per well

Well Abandonment Costs								**Cost per Foot (based on 900 ft wells)**
Labor Costs	1	hours	X	$18.87	per hour	=	$18.87	$0.02
Cat 416 Backhoe	0.25	hours	X	$45.32	per hour	=	$11.33	$0.01
Drill rig	2.5	hours	X	$141.00	per hour	=	$352.50	$0.39
Well Cap	1	each	X	$8.03	each	=	$8.03	$0.01
Materials per foot of well (Variable Cost)								
Cement	0.0714	lbs/ft	X	$0.08	per pound			$0.01
Bentonite Chips	0.007	tubes/ft	X	$7.46	per tube			$0.05
Plug Gel	0.0086	sacks/ft	X	$3.35	per sack			$0.03
TOTAL ESTIMATED COST PER FOOT							=	**$0.52**

Table U.1-15 Three Crow Master Cost Basis – 2010 Surety Estimate

		MU1	MU2	MU3	MU4	MU5	MU6	MU7	MU8	MU9
Total number of production wells		30	0	0	0	0	0	0	0	0
Total number of injection wells		50	0	0	0	0	0	0	0	0
Total number of shallow monitor wells		18	0	0	0	0	0	0	0	0
Total number of perimeter monitor wells		25	0	0	0	0	0	0	0	0
Total number of restoration wells		18	0	0	0	0	0	0	0	0
Wellfield Area (ft^2)		3,049,200	0	0	0	0	0	0	0	0
Wellfield Area (acres)		70.00	0	0	0	0	0	0	0	0
Affected Ore Zone Area (ft^2)		3,049,200	0	0	0	0	0	0	0	0
Avg. Completed Thickness		25.0	0	0	0	0	0	0	0	0
Porosity		0.29	0	0	0	0	0	0	0	0
Affected Volume (ft^3)		76,230,000	0	0	0	0	0	0	0	0
Kgallons per Pore Volume		165,358	0	0	0	0	0	0	0	0
Number of Patterns in Unit(s)										
	Current	0	0	0	0	0	0	0	0	0
	Estimated next report	30	0	0	0	0	0	0	0	0
	Total Estimated	30	0	0	0	0	0	0	0	0
Number of Wells in Unit(s)										
Production Wells										
	Current	0	0	0	0	0	0	0	0	0
	Estimated next report	30	0	0	0	0	0	0	0	0
	Total Estimated	30	0	0	0	0	0	0	0	0
Injection Wells										
	Current	0	0	0	0	0	0	0	0	0
	Estimated next report	50	0	0	0	0	0	0	0.	0
	Total Estimated	50	0	0	0	0	0	0	0	0
Shallow Monitor Wells										
	Current	0	0	0	0	0	0	0	0	0
	Estimated next report	18	0	0	0	0	0	0	0	0
	Total Estimated	18	0	0	0	0	0	0	0	0
Perimeter Monitor Wells										
	Current	0	0	0	0	0	0	0	0	0
	Estimated next report	25	0	0	0	0	0	0	0	0
	Total Estimated	25	0	0	0	0	0	0	0	0
Number of Wells per Wellfield		141	0	0	0	0	0	0	0	0
Total Number of Wells		141								
Average Well Depth (ft) - Deep Wells		910	0	0	0	0	0	0	0	0
Average Well Depth (ft) - Shallow Wells		200	0	0	0	0	0	0	0	0

Table U.1-15 Three Crow Master Cost Basis – 2010 Surety Estimate (continued)

Electrical Costs			
	2009 Rate	2010 Est Rate	
Power cost (adj for current actual cost)	$0.0759	$0.0797	kwHr
Kilowatt to Horsepower	0.746	$0.75	Kw/HP
Horsepower per gallon per minute	0.167	$0.167	HP/gpm

Labor Rates			
	2009	2010 Est Rate (CPI)	
Operator Labor Cost	$153.12	$150.98	day
Engineer Cost	$9,381.65	$9,250.31	month
Radiation Technician Costs	$4,743.90	$4,677.49	month

Chemical Costs			
	2009 Rate	2010 Est Rate	
Antiscalant for RO (adj for current actual cost)	$15.22	$15.90	gal
Reductant (adj for current actual cost)	$0.37	$0.39	lb
Cement (adj for current actual cost)	$0.07	$0.08	pound
Bentonite Tubes (adj for current actual cost)	$7.10	$7.46	tube
Salt (adj for current actual cost)	$127.60	$133.98	ton
Plug Gel (adj for current actual cost)	$3.19	$3.35	sack
Well Cap (adj for current actual cost)	$7.65	$8.03	each
Hydrochloric Acid (adj for current actual cost)	$1.24	$1.65	gallon

Analytical Costs			
Guideline 8 (contract lab adjusted for current contract cost)	$200.00	$200.00	analysis
6 parameter (in-house) Est Rate (CPI)	$50.75	$50.04	analysis
Other (radon, bio, etc.) Est Rate (CPI)	$925.00	$912.05	month

Spare Parts			
	2009	2010 Est Rate (CPI)	
Restoration spare parts estimate	20475	$20,188.35	year

CPI Escalators (CPI U, U.S. City Average)	
1988 CPI (average)	118.30
April 2009 CPI (deep well estimate)	213.20
2008 CPI (June 2008 used in last update)	218.80
Current CPI (June 2009)	215.70
2009 Escalation Factor	0.986

Table U.1-15 Three Crow Master Cost Basis – 2010 Surety Estimate (continued)

Equipment Costs						
Equipment	Base Rental Rate ($/hr)	Labor Costs ($/hr)	Repair Reserve Costs ($/hr)	Fuel Costs ($/hr)	Mob & Demob ($/hr)	Total ($/hr)
Cat 924G Loader	$26.50	$18.87	$3.00	$6.63	inc.	$55.00
Cat 416 Backhoe	$16.50	$18.87	$3.10	$6.85	inc.	$45.32
Shredder	$12.00			inc	inc	$12.00
Cat D8N Bulldozer	$110.00	$18.87	$11.50	$25.42	inc.	$165.79
Pulling Unit	$37.50	inc	inc	inc	inc	$37.50
Mixing Unit	$5.00			inc	inc	$5.00
Drill Rig	$141.00	inc	inc	inc	inc	$141.00

Basis:
Cat 924G, 416 and D8N rental rates from Nebraska Machinery (Aug '09); others estimated.
Repair Reserve costs based on from Nebraska Machinery (Aug '09).
Current diesel usage from from Nebraska Machinery (Aug 08), with current (Aug 09) costs for off-road fuel: $2.21 gallon

Labor rate based on current operator labor rate

Pipe Volumes			
Nominal Pipe Size	Wall Thickness (inches)	Pipe OD (inches)	Volume per foot (ft^3/ft)
3/8-inch O2 hose		0.37500	0.03130
2-inch Sch. 40 downhole	0.15400	2.37500	0.00740
1-1/4-inch Sch. 40 stinger	0.14000	1.66000	0.00440
2-inch SDR 13.5 inj & prod.	0.14815	2.29630	0.00690
4-inch SDR 35	0.11430	4.22860	0.01030
6-inch Sch. 40 process pipe	0.28000	6.56000	0.03840
6-inch Trunkline	0.49100	6.56600	0.06510
8-inch Trunkline	0.63900	8.54800	0.11030
10-inch Trunkline	0.79600	10.65400	0.17120
12-inch Trunkline	0.94400	12.63700	0.24080

Table U.1-15 Three Crow Master Cost Basis – 2010 Surety Estimate (continued)

Pipe Removal and Shredding Costs

Activity	Removal Rate (ft/man-day)	Shredding Rate (ft/man-day)	Labor Rate (day)	Activity Cost per foot
2-inch SDR 13.5 inj & prod. Removal	225		$150.98	$0.67
2-inch SDR 13.5 inj & prod. Shredding		1920	$150.98	$0.08
Trunkline Removal	100		$150.98	$1.51
Trunkline Shredding		100	$150.98	$1.51
Downhole Pipe Removal	2000		$150.98	$0.08
Downhole Pipe Shredding		2250	$150.98	$0.07
Downhole Hose Removal	1000		$150.98	$0.15
Waste and RO Building Pipeline Removal	67		$150.98	$2.25
Waste and RO Building Pipeline Shredding		1500	$150.98	$0.10

Waste Disposal Costs

Waste Form	Fee		Density Correction Factor (Tons/Yd^3)	Fee per Cubic Yard	Transport Cost		Total Transportation and Disposal	
Soil, Bulk Byproduct Material	$194.45	per Ton	0.54	$105.00	$45.27	per Yd^3	$150.27	per Yd^3
Unpackaged Bulk Byproduct Material (e.g., pipe, equipment)	$742.50	per Ton	0.42	$311.85	$45.27	per Yd^3	$357.12	per Yd^3
Solid Waste (landfill)	$0.02	per Lb			Incl.	per Lb	$0.02	per Lb
Solid Waste (landfill)	$212.00	per Load			Incl.	per Load	$212.00	per Load
Void Factor (for disposal)	$1.25							

Table U.1-15 Three Crow Master Cost Basis – 2010 Surety Estimate (continued)

Plant Dismantling							
Plant Components:	**Number**	**Units**	**Estimated Disposal Volume**	**Units**	**Activity**	**Units**	**2007 Cost**
Contaminated Tanks	10	each	39.7	Ft^3 each	Dismantle interior steel, tanks, piping and electrical:		$159,450
Uncontaminated Tanks	0	each	39.7	Ft^3 each	Dismantle Plant Building		$79,725
Pumps	13	each	5	Ft^3 each			
Downhole Pumps	0	each	0.5	Ft^3 each	Concrete floor removal rate	Current Cost $\$/ft^2$	$14.04
Contaminated Piping	4000	feet	e by piping size and material				
Uncontaminated Piping	0	feet					
Filters	0	each	100	Ft^3 each			
Dryer	0	each	400	Ft^3 each			
Average PVC Pipe Diameter (inches)	3						

Plant Decontamination					
Direct Dispose Plant Floor Area	13400	ft^2	Decon Solution (HCl) Floor Application Rate	2	gal/ft^2
Uncontaminated Plant Floor Area	4400	ft^2			
Decontaminated Plant Floor Area*	9000	ft^2			
Average concrete thickness	0.75	ft			
Plant Wall Area	0	ft^2	Decon Solution (HCl) Wall Application Rate	1	gal/ft^2

CPI - Consumer Price Index HCL - Hydrochloric Acid