CROW BUTTE RESOURCES, INC.

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January 4, 2000

Mr. John Surmeier, Chief
Uranium Recovery Branch
Division of Waste Management
Office of Nuclear Material Safety and Safeguards
Mail Stop T-7-J-8
U.S. Nuclear Regulatory Commission
11545 Rockville Pike
Rockville, Maryland 20850

Re: Docket No. 40-8943
License No. SUA-1534
Annual Report of Changes, Tests or Experiments

Dear Mr. Surmeier:

Crow Butte Resources, Inc. (CBR) is providing the annual report that summarizes the changes, tests or experiments made under License Condition 9.4 of SUA-1534. This report is made in accordance with the reporting requirements contained in License Condition 12.7.

CBR's source material license was renewed on March 4, 1998. The renewed license contained Performance Based License Conditions (PBLC). In a PBLC, CBR is allowed to make changes or conduct tests and experiments under certain conditions. These changes, test and experiments must be reviewed and approved by the CBR Safety and Environmental Review Panel (SERP). During 1999, the CBR SERP approved three changes, all associated with the startup of new mining areas. A fourth SERP meeting was held to review spill trends and responses during the first part of 1999.

The following materials are attached to provide the required summary information and documentation required by License Condition 12.7.

- SERP Evaluation Index, which summarizes each SERP Action and tracks any modifications to an approved action because of subsequent SERP actions.

- A copy of each approved SERP Evaluation. These evaluations describe the change or test approved and the safety and environmental evaluation performed by the SERP.

- Highlighted versions of page changes made to the License Renewal Application (LRA) because of the SERP actions taken in 1999. These highlighted page changes use a strikethrough to denote deleted text and an underline to indicate new text.

- Page replacement versions of page changes for insertion in the updated NRC copy of the LRA. These pages have a revision date in the footer.

If you have any questions or require further information, please do not hesitate to contact me at (308) 665-2215.

Sincerely,
CROW BUTTE RESOURCES, INC.

Michael L. Griffin
Manager of Environmental and Regulatory Affairs

Enclosures: As Stated

cc: Mr. William Ford – NRC

Safety and Environmental Review Panel

1999 Evaluation Index

SERP Evaluation Number	Date	Action Taken	Modifications
SERP 99-01	June 7, 1999	Review of January to May, 1999 spill events	None
SERP 99-02	July 8, 1999	Review and approval of Mine Unit 7 baseline monitoring, restoration values and operational monitoring criteria (UCLs)	None
SERP 99-03	July 23, 1999	Review and approval of Wellhouse 25 in Mine Unit 6 and Wellhouse 28 in Mine Unit 7	None
SERP 99-04	November 22, 1999	Review and approval of Wellhouse 30 in Mine Unit 7	None

CROW BUTTE RESOURCES, INC.

License Renewal Application

Affected Pages (highlighted version)

1999 SERP Actions

6. RESTORATION, RECLAMATION, AND DECOMMISSIONING

6.1 GROUNDWATER RESTORATION

Prior to discussing restoration methodologies, discussion of the ore body genesis and chemical and physical interactions between the ore body and the lixiviant is provided.

6.1.1 ORE BODY GENESIS

The Crow Butte uranium deposit is a roll front deposit in a fluvial sandstone. The deposit is very similar to those in the Wyoming basins such as Gas Hills, Shirley Basin and the Powder River Basin. The origin of the uranium in the deposit could be from within the host rock itself either from the feldspar or volcanic ash content of the Basal Chadron Sandstone. The source of the uranium could also be volcanic ash of the Middle Chadron Formation which overlays the Basal Chadron Sandstone. Regardless of the source of the uranium, it has been precipitated in several long sinuous roll fronts. The individual roll fronts are developed within subunits of the Basal Chadron Sandstone. The Basal Chadron Sandstone is divided into local subunits by thin clay beds that confined the uranium bearing waters to several distinct hydrological subunits of the sandstone. These clay beds are laterally continuous for hundreds of feet but control the deposition of the uranium over greater distances as other clay beds exert vertical control when the locally controlling beds pinch out. Precipitation of the uranium resulted when the oxidizing water containing the uranium entered reducing conditions. These reducing conditions probably resulted from H_2S and to a lesser degree from organic material and pyrite.

Solution mining of the deposit is accomplished by reversing the natural processes that deposited the uranium. Oxidizing solution is injected into the mineralized portion of the Basal Chadron Sandstone to oxidize the reduced uranium and to complex it with bicarbonates. The uranium bearing solution is then drawn through the mineralized portion of the sandstone between the clay beds towards recovery wells by pumping. The presence of reducing agents will increase oxidant requirements over that necessary to only oxidize the uranium.

Since the deposition of the uranium was controlled between clay beds within the Basal Chadron Sandstone, the mining solutions will be largely confined to this portion of the sandstone by selectively screening these intervals. This will limit the contamination and thus the required restoration of unmineralized portions of the sandstone.

6.1.2 CHEMICAL AND PHYSICAL INTERACTIONS OF LIXIVIANT WITH ORE BODY

The following discussion is based on a range of lixiviant conditions from 0.5 to 3.0 grams per liter total carbonate and a pH from 6.5 to 9.0. This represents the normal range of operating conditions for the Crow Butte Commercial Plant.

6.1.2.1 ION EXCHANGE

The main ion exchange reaction is the exchange of sodium from the lixiviant onto exchangeable sites on ore minerals with the release into solution of calcium, magnesium and potassium. This reaction can be shown as follows:

$$Ca_{clay} + 2\,Na^{+}_{solution} = 2\,Na_{clay} + Ca^{++}_{solution}$$

Similar reactions can be written for magnesium and potassium. Due to higher solubility of their sulfate and carbonate compounds and their low concentrations in Basal Chadron Sandstone and the ore, magnesium and potassium in solution have no impact. The limited solubility of calcium carbonate, and to a lesser degree, calcium sulfate, may lead to the potential for calcium precipitation.

Laboratory tests have indicated that the maximum calcium ion exchange capacity of the ore in a sodium lixiviant with a 3.0 g/l total carbonate strength is 1.21 milliequivalents of calcium per 100 grams of ore. This equates roughly to 1/2 pound of calcium or about 1.2 pounds of calcium carbonate per ton of ore that could potentially be precipitated. Not all of this calcium, however, will be realized since laboratory testing is run in such a way as to indicate the maximum amount of calcium which can be exchanged. Somewhat less than this will be released and only a portion of that precipitated. There is no way to directly control the buildup of calcium in the lixiviant circuit. In practice, one controls the lixiviant carbonate concentration and the lixiviant pH. The formation characteristics dictate an equilibrium calcium concentration in the lixiviant system and ion exchange and/or precipitation will occur until the equilibrium is satisfied. The overproduction bleed represents a departure from this equilibrium and as such has some effect on the amount of calcium exchanged. If the bleed is kept generally small, on the order of a few percent, the effect of the bleed on the ion exchange is small.

6.1.2.2 PRECIPITATION

In the presence of carbonate ions and bicarbonate ions in the lixiviant system, calcium ions will precipitate provided the limit of saturation has been reached. Calcium precipitation is a function of total carbonate, pH and temperature. For example, at 15° C, a pH of 7.5 and 1 gram/liter carbonate in lixiviant, the equilibrium solubility of calcium will be approximately 40 to 100 ppm. Some uncertainty is seen in these numbers due to the effect of ionic strength and supersaturation considerations. However, these figures do illustrate the effect of carbonate concentration and pH on the equilibrium solubility of calcium.

The amount of calcium produced depends on the ion exchange which is taking place, while the precipitation of calcium is a function of the lixiviant chemistry, and the degree of supersaturation which is observed in the system. As a first approximation, the proportion of calcium precipitation occurring above ground and underground will occur in the ratio of the residence times. In other words, if the residence time is much longer underground than it is above ground, as is the case for most every in-situ leach operation including Crow Butte, then more of the calcium will precipitate underground than above ground. The calcium precipitation is a function of turbulence in the solution, changes in CO_2 partial pressure or pH, and the presence of surface area. The most likely places for calcium to precipitate are underground where the ore provides abundant surface area for precipitation, at or near the injection or production wellbore where changes in pressure, turbulence and CO_2 partial pressure are all observed, and on the surface in the filters, in pipes, and in tanks. If all the calcium were to precipitate (based on 1.2 pounds of $CaCO_3$ per ton of ore) the precipitate would occupy about 0.15% of the void space in that ton of ore.

Calcium may be removed from the system in the following ways: filters will be routinely backwashed to the ponds and periodically will be acid cleaned if necessary to remove precipitated calcium carbonate from the filter housing or filter media; the solution bleed taken to compensate for over production will also serve to eliminate some calcium from the system. Should precipitation of calcium carbonate at or near the wellbore of the wellfield wells become a problem, these wells are air lifted, surged, water jetted, or acidified as necessary to remove the precipitated calcium. Any water recovered from these wells containing dissolved calcium carbonate or particulate calcium carbonate is collected and placed into the waste disposal system. A liquid seal is maintained on any calcium carbonate in the evaporation ponds. Upon decommissioning, calcium carbonate from the plant equipment and pond residues will be disposed of in either a licensed tailings pond or a commercial disposal site.

The other possible precipitating species, which has been identified, is iron, which could probably precipitate as either the hydroxide or the carbonate, causing some fouling. Such fouling is usually evidenced by reduction in the ion exchange capacity of the resin in the extraction circuit. Should this fouling become a serious problem, the resin can be washed and the wash solution disposed of in the waste disposal system. Due to the small amount of iron present in the Basal Chadron Sandstone, iron precipitation has not been a problem.

6.1.2.3 HYDROLYSIS

Hydrolysis reactions, which involve minerals and hydrogen or hydroxide ions, do not play an important role in the ore/lixiviant interaction. In the pH range of 6.5 to 9.0, the concentration of hydrogen and hydroxide ions is so small that these types of reactions do not occur to any great degree. The only potential impact would be a small increase in the dissolved silica content of the lixiviant system, a possible small increase in the cations associated with the silicious minerals. The hydrolysis reaction does not have a significant effect on operations.

6.1.2.4 OXIDATION

The oxidant consumers in the Basal Chadron Sandstone are hydrogen sulfide in the groundwater, uranium, vanadium, iron pyrite, and other trace and heavy metals. The impacts of these oxidant consumers on the operation of the plant would be to generally increase the oxidant consumption over that which would be required for uranium alone. The second effect would be to release iron and sulfate into solution from the oxidation of pyrite. A third effect would be to increase the levels of some trace metals such as arsenic, vanadium and selenium into solution. As mentioned previously, the iron solubilized will most likely be precipitated as the hydroxide or carbonate, depending upon its oxidation state. Any vanadium, which is oxidized along with the uranium, will be solubilized by the lixiviant, recovered with the uranium and could potentially contaminate the precipitated yellowcake product. The Crow Butte plant uses hydrogen peroxide precipitation of uranium in an effort to reduce the amount of vanadium precipitated in the product. Oxidation will also solubilize arsenic and selenium. The restoration program will return these substances to acceptable levels. A final potential oxidation reaction is the partial oxidation of sulfur species resulting in compounds such as polythionates that can foul ion exchange resins. In in-situ operations using chemistries similar to Crow Butte, these sulfur species are completely oxidized to sulfate, which poses no problems.

6.1.2.5 ORGANICS

Organic materials are generally not present in the Crow Butte ore body at levels greater than 0.1 to 0.2%. Where present their effect is to increase the oxidant consumption and make uranium leaching a bit more difficult. On longer flow paths, organic material could potentially reprecipitate uranium, should all of the oxidant be consumed and conditions become reducing. Another potential impact of organics could be the coloring and fouling of leach solutions should the organics be mobilized. As the plant is operated in the pH range of 6.5 to 9.0, mobilization of the organics and coloring of the leach solution is avoided.

6.1.3 RESTORATION GOALS

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

The baseline data support establishment of the upper control limits and restoration standards for each mine unit. The upper control limits and restoration standards for each Mine Unit, beginning with Mine Unit 6, are determined by the Safety and Environmental Review Panel (SERP) during the approval process for the new Mine Unit. The NDEQ restoration values are established as the average plus two standard deviations for any parameter that exceeds the applicable drinking water standard. If a drinking water standard exists for a parameter, and baseline is below that standard, the drinking water standard is used to establish the restoration value. If there is no drinking water standard for an element, for example vanadium, the restoration value will be based on best practicable technology. The restoration value for the major cations (Ca, Mg, K, Na) should allow for the concentrations of these cations to vary by as much as one order of magnitude as long as the TDS restoration value is met. The total carbonate restoration criteria should allow for the total carbonate to be less than 50% of the TDS. The TDS restoration value is set at the average plus one standard deviation.

Mine unit averages and secondary goals for Mine Units 1 through 5 are given in Tables 6.1-1 through 6.1-5. The mine unit average and NDEQ restoration values for Mine Unit 6 are given in Table 6.1-6. The CBR SERP determined these restoration values on March 4, 1998. The mine unit average and NDEQ restoration values for Mine Unit 7 are given in Table 6.1-7. The CBR SERP determined these restoration values on July 9, 1999. NDEQ Permit Number NE0122611 requires that a Mine Unit be returned to a wellfield average of these restoration values. These concentrations were approved by the NDEQ with the Notice of Intent to Operate submittals. Post mining water quality for Mine Unit 1 can be found in Table 6.1-~~7~~8.

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

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

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

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

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

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

Parameter	Groundwater Standard	MU-1 Baseline	MU-1 Standard Deviation	MU-1 NDEQ Restoration Value
Ammonium (mg/l)	10.0	<0.372		10.0
Arsenic (mg/l)	0.05	<0.00214		0.05
Barium (mg/l)	1.0	<0.1		1.0
Cadmium (mg/l)	0.01	<0.00644		0.01
Chloride (mg/l)	250.0	203.9	38	250.0
Copper (mg/l)	1.0	<0.017		1.0
Fluoride (mg/l)	4.0	0.686	0.04	4.0
Iron (mg/l)	0.3	<0.0441		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.011		0.05
Molybdenum (mg/l)	1.0	<0.0689		1.0
Nickel (mg/l)	0.15	<0.0340		0.15
Nitrate (mg/l)	10.0	<0.050		10.0
Lead (mg/l)	0.05	0.0315		0.05
Radium (pCi/L)	5.0	229.7	177.1	584.0
Selenium (mg/l)	0.01	<0.00323		0.01
Sodium (mg/l)	N/A	412	19.2	4120
Sulfate (mg/l)	250.0	356.2	9.4	375
Uranium (mg/l)	5.0	0.0922	0.089	5.0
Vanadium (mg/l)	0.2	<0.0663		0.2
Zinc (mg/l)	5.0	<0.036		5.0
pH (Std. Units)	6.5 - 8.5	8.46	0.2	6.5 – 8.5
Calcium (mg/l)	N/A	12.5	3.2	125.0
Total Carbonate (mg/l)	N/A	351	31.1	585
Potassium (mg/l)	N/A	12.5	1.5	125.0
Magnesium (mg/l)	N/A	3.2	0.8	32.0
TDS (mg/l)	N/A	1170.2	47.6	1170.2

Table 6.1-2: Baseline and Restoration Values for Mine Unit 2

Parameter	Groundwater Standard	MU-2 Baseline	MU-2 Standard Deviation	MU-2 NDEQ Restoration Value
Ammonium (mg/l)	10.0	0.37	0.07	10.0
Arsenic (mg/l)	0.05	<0.001		0.05
Barium (mg/l)	1.0	<0.1		1.0
Cadmium (mg/l)	0.01	<0.007		0.01
Chloride (mg/l)	250.0	208.6	30.8	250.0
Copper (mg/l)	1.0	<0.013		1.0
Fluoride (mg/l)	4.0	0.67	0.04	4.0
Iron (mg/l)	0.3	<0.045		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.01		0.05
Molybdenum (mg/l)	1.0	<0.073		1.0
Nickel (mg/l)	0.15	<0.037		0.15
Nitrate (mg/l)	10.0	<0.039		10.0
Lead (mg/l)	0.05	<0.035		0.05
Radium (pCi/L)	5.0	234.5	411.8	1058.0
Selenium (mg/l)	0.01	<0.001		0.01
Sodium (mg/l)	N/A	410.8	18.2	4108
Sulfate (mg/l)	250.0	348.2	10.3	369.0
Uranium (mg/l)	5.0	0.046	0.037	5.0
Vanadium (mg/l)	0.2	<0.07		0.2
Zinc (mg/l)	5.0	<0.026		5.0
pH (Std. Units)	6.5 - 8.5	8.32	0.2	6.5 – 8.5
Calcium (mg/l)	N/A	13.4	2.4	134.0
Total Carbonate (mg/l)	N/A	366.9	13.3	585.0
Potassium (mg/l)	N/A	12.6	2.5	126.0
Magnesium (mg/l)	N/A	3.5	0.4	35.0
TDS (mg/l)	N/A	1170.4	41	1170.4

Table 6.1-3: Baseline and Restoration Values for Mine Unit 3

Parameter	Groundwater Standard	MU-3 Baseline	MU-3 Standard Deviation	MU-3 NDEQ Restoration Value
Ammonium (mg/l)	10.0	<0.329		10.0
Arsenic (mg/l)	0.05	<0.001		0.05
Barium (mg/l)	1.0	<0.1		1.0
Cadmium (mg/l)	0.01	<0.01		0.01
Chloride (mg/l)	250.0	197.6	16.7	250.0
Copper (mg/l)	1.0	<0.0108		1.0
Fluoride (mg/l)	4.0	0.719	0.05	4.0
Iron (mg/l)	0.3	<0.05		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.01		0.05
Molybdenum (mg/l)	1.0	<0.1		1.0
Nickel (mg/l)	0.15	<0.05		0.15
Nitrate (mg/l)	10.0	<0.0728		10.0
Lead (mg/l)	0.05	<0.05		0.05
Radium (pCi/L)	5.0	165	222.5	611.0
Selenium (mg/l)	0.01	<0.00115		0.01
Sodium (mg/l)	N/A	428	27.6	4280
Sulfate (mg/l)	250.0	377.0	13.4	404.0
Uranium (mg/l)	5.0	0.115	0.158	5.0
Vanadium (mg/l)	0.2	<0.1		0.2
Zinc (mg/l)	5.0	<0.0131		5.0
pH (Std. Units)	6.5 - 8.5	8.37	0.3	6.5 – 8.5
Calcium (mg/l)	N/A	13.3	3.1	133.0
Total Carbonate (mg/l)	N/A	358.7	24.8	592.0
Potassium (mg/l)	N/A	13.9	4.0	139.0
Magnesium (mg/l)	N/A	3.5	0.9	35.0
TDS (mg/l)	N/A	1183.0	47.4	1183.0

Table 6.1-4: Baseline and Restoration Values for Mine Unit 4

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

Table 6.1-5: Baseline and Restoration Values for Mine Unit 5

Parameter	Groundwater Standard	MU-5 Baseline	MU-5 Standard Deviation	MU-5 NDEQ Restoration Value
Ammonium (mg/l)	10.0	0.28	0.05	10.0
Arsenic (mg/l)	0.05	<0.001		0.05
Barium (mg/l)	1.0	<0.10		1.0
Cadmium (mg/l)	0.01	<0.01		0.01
Chloride (mg/l)	250.0	191.9	7.9	250.0
Copper (mg/l)	1.0	<0.01		1.0
Fluoride (mg/l)	4.0	0.64	0.07	4.0
Iron (mg/l)	0.3	<0.05		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.01		0.05
Molybdenum (mg/l)	1.0	<0.10		1.0
Nickel (mg/l)	0.15	<0.05		0.15
Nitrate (mg/l)	10.0	<0.1		10.0
Lead (mg/l)	0.05	<0.05		0.05
Radium (pCi/L)	5.0	166.0	184.6	535.0
Selenium (mg/l)	0.01	<0.002		0.01
Sodium (mg/l)	N/A	397.6	14.4	3976
Sulfate (mg/l)	250.0	364.5	10.5	385.0
Uranium (mg/l)	5.0	0.072	0.056	5.0
Vanadium (mg/l)	0.2	<0.10		0.2
Zinc (mg/l)	5.0	<0.02		5.0
pH (Std. Units)	6.5 - 8.5	8.5	0.1	6.5 – 8.5
Calcium (mg/l)	N/A	12.6	1.8	126.0
Total Carbonate (mg/l)	N/A	372	13.0	590.0
Potassium (mg/l)	N/A	11.5	1.2	115.0
Magnesium (mg/l)	N/A	3.4	0.4	34.0
TDS (mg/l)	N/A	1179.5	22.5	1202.0

Table 6.1-6: Baseline and Restoration Values for Mine Unit 6

Parameter	Groundwater Standard	MU-6 Baseline	MU-6 Standard Deviation	MU-6 NDEQ Restoration Value
Alkalinity (mg/l)	N/A	305	11.5	N/A
Ammonium (mg/l)	10.0	0.32	0.05	10.0
Arsenic (mg/l)	0.05	0.002		0.05
Barium (mg/l)	1.0	0.100		1.0
Bicarbonate (mg/l)	N/A	359	18.6	see Total Carbonate
Boron (mg/l)	N/A	0.823	0.035	N/A
Cadmium (mg/l)	0.01	0.009		0.01
Carbonate (mg/l)	N/A	8.1	4.3	see Total Carbonate
Chloride (mg/l)	250.0	206	15.4	250.0
Chromium (mg/l)	N/A	0.050		N/A
Copper (mg/l)	1.0	0.012		1.0
Fluoride (mg/l)	4.0	0,65	0.03	4.0
Iron (mg/l)	0.3	0.050		0.3
Mercury (mg/l)	0.002	0.001		0.002
Manganese (mg/l)	0.05	0.010		0.05
Molybdenum (mg/l)	1.0	0.102		1.0
Nickel (mg/l)	0.15	0.050		0.15
Nitrate (mg/l)	10.0	0.1		10.0
Nitrite (mg/l)	N/A	0.1		N/A
Lead (mg/l)	0.05	0.050		0.05
Radium (pCi/L)	5.0	80.6	121.9	325
Selenium (mg/l)	0.01	0.001		0.01
Silica	N/A	10.9	0.6	N/A
Sodium (mg/l)	N/A	400	12.8	4000
Specific Conductivity (µmho/cm)	N/A	1,978	42.3	N/A
Sulfate (mg/l)	250.0	361	14.6	390
Uranium (mg/l)	5.0	0.133	0.212	5.0
Vanadium (mg/l)	0.2	0.098		0.2
Zinc (mg/l)	5.0	0.011		5.0

Table 6.1-6: Baseline and Restoration Values for Mine Unit 6

Parameter	Groundwater Standard	MU-6 Baseline	MU-6 Standard Deviation	MU-6 NDEQ Restoration Value
pH (Std. Units)	6.5 - 8.5	8.6	0.2	6.5 – 9.0
Calcium (mg/l)	N/A	12.8	2.3	128
Total Carbonate (mg/l)	N/A	367.1	22.9	596
Potassium (mg/l)	N/A	11.9	1.7	119
Magnesium (mg/l)	N/A	3.2	0.7	32
TDS (mg/l)	N/A	1192	28.1	1220

Table 6.1-7: Baseline and Restoration Values for Mine Unit 7

Parameter	Groundwater Standard	MU-7 Baseline	MU-7 Standard Deviation	MU-7 NDEQ Restoration Value
Alkalinity (mg/l)	N/A	297	19.1	N/A
Ammonium (mg/l)	10.0	0.42	0.08	10.0
Arsenic (mg/l)	0.05	0.001		0.05
Barium (mg/l)	1.0	0.10		1.0
Bicarbonate (mg/l)	N/A	347	20.4	see Total Carbonate
Boron (mg/l)	N/A	0.91	0.049	N/A
Cadmium (mg/l)	0.01	0.007		0.01
Carbonate (mg/l)	N/A	8.9		see Total Carbonate
Chloride (mg/l)	250.0	198	22.6	250.0
Chromium (mg/l)	N/A	0.05		N/A
Copper (mg/l)	1.0	0.01		1.0
Fluoride (mg/l)	4.0	0.70	0.05	4.0
Iron (mg/l)	0.30	0.05		0.30
Mercury (mg/l)	0.002	0.001		0.002
Manganese (mg/l)	0.05	0.01		0.05
Molybdenum (mg/l)	1.00	0.10		1.00
Nickel (mg/l)	0.15	0.05		0.15
Nitrate (mg/l)	10.0	0.1		10.0
Nitrite (mg/l)	N/A	0.1		N/A
Lead (mg/l)	0.05	0.05		0.05
Radium (pCi/L)	5.0	142	148.0	438
Selenium (mg/l)	0.01	0.004		0.01
Silica	N/A	12.9	1.1	N/A
Sodium (mg/l)	N/A	387	21.6	3,870
Specific Conductivity (umho/cm)	N/A	1,979	85.5	N/A
Sulfate (mg/l)	250.0	346	20.1	386
Uranium (mg/l)	5.0	0.110	0.138	5.0
Vanadium (mg/l)	0.2	0.10		0.2
Zinc (mg/l)	5.0	0.01		5.0

Table 6.1-7: Baseline and Restoration Values for Mine Unit 7

Parameter	Groundwater Standard	MU-7 Baseline	MU-7 Standard Deviation	MU-7 NDEQ Restoration Value
pH (Std. Units)	6.5 - 8.5	8.6	0.3	6.5 – 9.2
Calcium (mg/l)	N/A	12.2	2.6	122
Total Carbonate (mg/l)	N/A	356		588
Potassium (mg/l)	N/A	12.9	3.0	129
Magnesium (mg/l)	N/A	3.2	0.7	32
TDS (mg/l)	N/A	1,176	40.7	1,217

Table 6.1-~~7~~8: Post Mining Water Quality for Mine Unit 1 Restoration Well Sampling

	PM-1	PM-4	PM-5	PT-5	IJ-6	IJ-13	IJ-25	IJ-28	IJ-45	PR-8	PR-15	PR-19
Ca (mg/l)	87.9	87.1	80.8	87.9	87.6	93.9	89.4	89.6	89.9	85.4	86.7	98.3
Mg (mg/l)	22.6	20.6	22.7	23.8	21.4	23.9	22.5	23.1	24.8	23.2	23.1	23.8
Na (mg/l)	1154	942	1054	1144	1054	1174	1177	1182	1126	1144	1172	1083
K (mg/l)	32.7	26.3	30	30	27.2	31.3	30	31.3	32.7	30	30	28.6
CO_3 (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0
HCO_3 (mg/l)	1099	900	972	981	1057	1086	1111	1207	1104	1170	1170	959
SO_4 (mg/l)	1109	959	1115	1240	1031	1209	1119	1112	1134	1115	1115	1283
Cl (mg/l)	598	455	586	594	544	598	594	619	607	603	603	590
NH_4 (mg/l)	0.33	0.67	0.14	0.33	0.44	0.07	< 0.05	< 0.05	0.33	0.27	0.15	0.49
NO_2 (mg/l)	< 0.01	0.02	0.09	< 0.01	0.11	< 0.01	< 0.01	< 0.01	0.04	0.05	< 0.01	0.05
NO_3 (mg/l)	1.06	< 0.1	0.97	0.99	1.29	0.74	0.86	1.3	1.25	1.46	1.6	0.46
F (mg/l)	0.37	0.26	0.54	0.45	0.45	0.37	0.38	0.45	0.43	0.43	0.4	0.35
SiO_2 (mg/l)	25.7	18.2	35.3	24.7	33.3	34.3	26.4	31.6	28.3	33.2	30	22.2
TDS (mg/l)	3694	3121	3756	3851	3515	3899	3751	3886	3873	3820	3807	3765
Cond (µmho/cm)	5843	4841	5590	5964	5445	6012	5807	6025	5916	5819	5940	5819
$CaCO_3$ (mg/l)	901	738	797	804	866	890	911	989	905	959	959	786
pH (Std. units)	7.65	6.87	6.85	7.28	7.16	7.35	7.65	7.81	7.37	7.46	7.78	6.92
Trace Metals												
Al (mg/l)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.29
As (mg/l)	0.018	0.007	0.018	0.017	0.031	0.028	0.02	0.028	0.023	0.028	0.024	0.011
Ba (mg/l)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
B (mg/l)	1.17	1.44	1.09	1.36	1.06	1.26	1.13	1.19	1.15	1.23	1.25	1.17

Table 6.1-~~7~~8: Post Mining Water Quality for Mine Unit 1 Restoration Well Sampling

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

6.1.4 RESTORATION STAGE

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. Crow Butte Resources will monitor the quality of selected wells during restoration to determine the efficiency of the operations and to determine if additional techniques are necessary.

6.1.4.1 GROUNDWATER TRANSFER

Prior to commencing restoration activities, the regulatory agencies will be notified that mining has ceased in a given mine unit and Crow Butte Resources will proceed to establish post mining water quality data for all of the required parameters listed in Table 6.1-1 through 6.1-7. ~~The designated wells will be sampled and may be split with the NDEQ if requested.~~

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

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

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

6.1.4.2 GROUNDWATER SWEEP

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

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

6.1.4.3 GROUNDWATER TREATMENT

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

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

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

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

Figure 6.1-1: Restoration Process Schematic

Before the water can be processed by the reverse osmosis unit, the soluble uranium must be removed by the ion exchange system. The water is then filtered, the pH lowered for decarbonation to prevent calcium carbonate plugging of the membranes, and then pressurized by a pump. The reverse osmosis unit contains membranes which pass about 60 to 75 percent of the water through, leaving 60 to 90 percent of the dissolved salts in the water that will not pass the membrane. Table 6.1-89 shows typical manufacturers specification data for removal of ion constituents. The clean water, called permeate, will be re-injected, sent to storage for use in the mining process, or sent to the waste disposal system. The twenty-five to forty percent of water that is rejected, referred to as the brine, contains the majority of dissolved salts that contaminate the groundwater and is sent for disposal in the wastewater system.

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

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

6.1.5 STABILIZATION PHASE

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

Table 6.1-~~8~~9: Typical Membrane Rejection
Source: Osmonics, Inc.

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

6.1.6 REPORTING

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

Upon completion of restoration activities and prior to stabilization, all designated restoration wells in the mine unit will be sampled for the required constituents listed in Tables 6.1-1 through 6.1-67. These samples may be split with NDEQ if required. Assay results will be submitted to NDEQ and USNRC as required. If restoration activities have returned the wellfield average of restoration parameters to concentrations at or below those approved by the regulatory agencies, Crow Butte Resources will notify the regulatory agencies it is commencing the stabilization phase of restoration.

During stabilization all designated restoration wells will be sampled monthly for the required constituents listed in Table 6.1-1 through 6.1-7. At the end of a six month stabilization period Crow Butte Resources will compile all water quality data obtained during restoration and stabilization and submit a final report to the regulatory agencies. At that time, Crow Butte Resources would request that the mine unit be declared restored.

6.1.7 CURRENT RESTORATION STATUS

The approval of the Notice of Intent to Operate for Mine Unit 4 was received from the NDEQ on March 11, 1994. With the approval, active mining operations ceased in Mine Unit 1 and restoration was initiated. On March 23, 1994 the baseline restoration wells were sampled to establish the post mining water quality. The results of this sampling are given in Table 6.1-78.

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

6.2 DECONTAMINATION AND DECOMMISSIONING

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

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

The following is a list of general decommissioning activities:

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

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

6.2.1 PROCESS BUILDINGS AND EQUIPMENT

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

6.2.1.1 REMOVAL AND DISPOSAL ALTERNATIVES

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

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

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

6.2.1.1.1 DISPOSAL AT A LICENSED FACILITY

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

- Flush inside of tanks, pumps, pipes, etc., with water or acid to reduce interior contamination as necessary for safe handling.
- The exterior surfaces of process equipment will be surveyed for contamination. If the surfaces are found to be contaminated the

equipment will be washed down and decontaminated to permit safe handling.

- The equipment will be disassembled only to the degree necessary for transportation. All openings, pipe fittings, vents, etc., will be plugged or covered prior to moving equipment from the plant building.

- Equipment in the building, such as large tanks, may be transported on flatbed trailers. Smaller items, such as links of pipe and ducting material, may be placed in plastic lined covered dump trucks or drummed in barrels for delivery to the receiving facility.

- Contaminated buried process trunk lines and sump drain lines will be excavated and removed for transportation to a licensed disposal facility.

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

6.2.1.1.2 DISPOSAL TO UNRESTRICTED USE

If a piece of equipment is to be released for unrestricted use it will be appropriately surveyed before leaving the licensed area. Both interior and exterior surfaces will be surveyed to detect potential contamination. Appropriate decontamination procedures will be used to clean any contaminated areas and the equipment resurveyed and documentation of the final survey retained to show that unrestricted use criteria were met prior to releasing the equipment or materials from the site. Criteria to be used for release to unrestricted use will be USNRCs *"Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Materials*" May 1987 Revision (Annex B) or the most current standards for decontamination at that time.

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

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

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

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

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

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

6.2.2 EVAPORATION POND DECOMMISSIONING

6.2.2.1 DISPOSAL OF POND WATER

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

6.2.2.2 POND SLUDGE AND SEDIMENTS

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

6.2.2.3 DISPOSAL OF POND LINERS AND LEAK DETECTION SYSTEMS

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

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

6.2.2.4 ON SITE BURIAL

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

6.2.3 WELLFIELD DECOMMISSIONING

Wellfield decommissioning will consist of the following steps:

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

- Removal of buried well field piping.
- Wells will be plugged and abandoned according to the procedures described below.
- The well field area may be recontoured, if necessary, and a final background gamma survey conducted over the entire well field area to identify any contaminated earthen materials requiring removal to disposal.
- Final surface reclamation of the well field areas will be conducted according to the surface reclamation plan described in Section 6.3.
- All piping, boxes and wellhead equipment will be surveyed for contamination prior to release in accordance with the USNRC guidelines for decommissioning.

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

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

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

6.2.3.1 WELL PLUGGING AND ABANDONMENT

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

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

The plugging method will be as follows:

- An approved abandonment mud (a mud-polymer mix) will be mixed in a cement unit and pumped down a hose, which is lowered to the bottom of the well casing using a reel.
- When the hose is removed, the casing is topped off and a cement plug placed on top.
- A hole is then dug around the well, and, at a minimum, the top three feet of casing removed.
- The hole is backfilled and the area revegetated.

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

6.2.3.2 BURIED TRUNKLINES, PIPES AND EQUIPMENT

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

6.2.4 DECONTAMINATION

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

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

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

- Areas of potential surface contamination will be identified using a gross gamma survey on an adequately spaced grid.
- Spot-checks of areas around the site of potentially contaminated areas.
- The final soil background survey on areas which have been prepared for surface reclamation using a grid spacing adequate for confirming clean up to applicable standards.

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

6.2.5 DECOMMISSIONING HEALTH PHYSICS AND RADIATION SAFETY

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

Health physics survey conducted during decommissioning will be guided by applicable sections of 10 CFR 20 and USNRC Regulatory Guide No. 8.30

entitled "*Health Physics Surveys in Uranium Mills*" or other applicable standards at the time.

6.2.6 EQUIPMENT AND MATERIAL SURVEYS

Any site equipment to be released for unrestricted use will be surveyed for alpha contamination and beta gamma as necessary to document levels for release, according to USNRC *"Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Materials"*, May 1987 Revision (Annex B) or the most current standards for decontamination at that time.

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

6.2.7 RECORDS AND REPORTING PROCEDURES

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

6.3 SURFACE RECLAMATION

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

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

6.3.1 WELLFIELD RECLAMATION

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

6.3.2 PROCESS FACILITIES RECLAMATION

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

6.3.3 CONTOURING OF AFFECTED AREAS

Due to the relatively minor nature of disturbances created by in-situ mining, there are only a few areas disturbed to the extent to which subsoil and geologic materials are removed causing significant topographic changes 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 re-establishment of drainage patterns will be accomplished by returning the earthen materials moved during construction to their approximate original locations.

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

6.4 BONDING ASSESSMENT

6.4.1 BOND CALCULATIONS

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

6.4.2 FINAL SURETY ARRANGEMENTS

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

ATTACHMENT 6.1

License Renewal Application

Affected Pages (replacement pages)

1999 SERP Actions

6. RESTORATION, RECLAMATION, AND DECOMMISSIONING

6.1 GROUNDWATER RESTORATION

Prior to discussing restoration methodologies, discussion of the ore body genesis and chemical and physical interactions between the ore body and the lixiviant is provided.

6.1.1 ORE BODY GENESIS

The Crow Butte uranium deposit is a roll front deposit in a fluvial sandstone. The deposit is very similar to those in the Wyoming basins such as Gas Hills, Shirley Basin and the Powder River Basin. The origin of the uranium in the deposit could be from within the host rock itself either from the feldspar or volcanic ash content of the Basal Chadron Sandstone. The source of the uranium could also be volcanic ash of the Middle Chadron Formation which overlays the Basal Chadron Sandstone. Regardless of the source of the uranium, it has been precipitated in several long sinuous roll fronts. The individual roll fronts are developed within subunits of the Basal Chadron Sandstone. The Basal Chadron Sandstone is divided into local subunits by thin, clay beds that confined the uranium bearing waters to several distinct hydrological subunits of the sandstone. These clay beds are laterally continuous for hundreds of feet but control the deposition of the uranium over greater distances as other clay beds exert vertical control when the locally controlling beds pinch out. Precipitation of the uranium resulted when the oxidizing water containing the uranium entered reducing conditions. These reducing conditions probably resulted from H_2S and to a lesser degree from organic material and pyrite.

Solution mining of the deposit is accomplished by reversing the natural processes that deposited the uranium. Oxidizing solution is injected into the mineralized portion of the Basal Chadron Sandstone to oxidize the reduced uranium and to complex it with bicarbonates. The uranium bearing solution is then drawn through the mineralized portion of the sandstone between the clay beds towards recovery wells by pumping. The presence of reducing agents will increase oxidant requirements over that necessary to only oxidize the uranium.

Since the deposition of the uranium was controlled between clay beds within the Basal Chadron Sandstone, the mining solutions will be largely confined to this portion of the sandstone by selectively screening these intervals. This will limit the contamination and thus the required restoration of unmineralized portions of the sandstone.

6.1.2 CHEMICAL AND PHYSICAL INTERACTIONS OF LIXIVIANT WITH ORE BODY

The following discussion is based on a range of lixiviant conditions from 0.5 to 3.0 grams per liter total carbonate and a pH from 6.5 to 9.0. This represents the normal range of operating conditions for the Crow Butte Commercial Plant.

6.1.2.1 ION EXCHANGE

The main ion exchange reaction is the exchange of sodium from the lixiviant onto exchangeable sites on ore minerals with the release into solution of calcium, magnesium and potassium. This reaction can be shown as follows:

$$Ca_{clay} + 2\ Na^{+}_{solution} = 2\ Na_{clay} + Ca^{++}_{solution}$$

Similar reactions can be written for magnesium and potassium. Due to higher solubility of their sulfate and carbonate compounds and their low concentrations in Basal Chadron Sandstone and the ore, magnesium and potassium in solution have no impact. The limited solubility of calcium carbonate, and to a lesser degree, calcium sulfate, may lead to the potential for calcium precipitation.

Laboratory tests have indicated that the maximum calcium ion exchange capacity of the ore in a sodium lixiviant with a 3.0 g/l total carbonate strength is 1.21 milliequivalents of calcium per 100 grams of ore. This equates roughly to 1/2 pound of calcium or about 1.2 pounds of calcium carbonate per ton of ore that could potentially be precipitated. Not all of this calcium, however, will be realized since laboratory testing is run in such a way as to indicate the maximum amount of calcium which can be exchanged. Somewhat less than this will be released and only a portion of that precipitated. There is no way to directly control the buildup of calcium in the lixiviant circuit. In practice, one controls the lixiviant carbonate concentration and the lixiviant pH. The formation characteristics dictate an equilibrium calcium concentration in the lixiviant system and ion exchange and/or precipitation will occur until the equilibrium is satisfied. The overproduction bleed represents a departure from this equilibrium and as such has some effect on the amount of calcium exchanged. If the bleed is kept generally small, on the order of a few percent, the effect of the bleed on the ion exchange is small.

6.1.2.2 PRECIPITATION

In the presence of carbonate ions and bicarbonate ions in the lixiviant system, calcium ions will precipitate provided the limit of saturation has been reached. Calcium precipitation is a function of total carbonate, pH and temperature. For example, at 15° C, a pH of 7.5 and 1 gram/liter carbonate in lixiviant, the equilibrium solubility of calcium will be approximately 40 to 100 ppm. Some uncertainty is seen in these numbers due to the effect of ionic strength and supersaturation considerations. However, these figures do illustrate the effect of carbonate concentration and pH on the equilibrium solubility of calcium.

The amount of calcium produced depends on the ion exchange which is taking place, while the precipitation of calcium is a function of the lixiviant chemistry, and the degree of supersaturation which is observed in the system. As a first approximation, the proportion of calcium precipitation occurring above ground and underground will occur in the ratio of the residence times. In other words, if the residence time is much longer underground than it is above ground, as is the case for most every in-situ leach operation including Crow Butte, then more of the calcium will precipitate underground than above ground. The calcium precipitation is a function of turbulence in the solution, changes in CO_2 partial pressure or pH, and the presence of surface area. The most likely places for calcium to precipitate are underground where the ore provides abundant surface area for precipitation, at or near the injection or production wellbore where changes in pressure, turbulence and CO_2 partial pressure are all observed, and on the surface in the filters, in pipes, and in tanks. If all the calcium were to precipitate (based on 1.2 pounds of $CaCO_3$ per ton of ore) the precipitate would occupy about 0.15% of the void space in that ton of ore.

Calcium may be removed from the system in the following ways: filters will be routinely backwashed to the ponds and periodically will be acid cleaned if necessary to remove precipitated calcium carbonate from the filter housing or filter media; the solution bleed taken to compensate for over production will also serve to eliminate some calcium from the system. Should precipitation of calcium carbonate at or near the wellbore of the wellfield wells become a problem, these wells are air lifted, surged, water jetted, or acidified as necessary to remove the precipitated calcium. Any water recovered from these wells containing dissolved calcium carbonate or particulate calcium carbonate is collected and placed into the waste disposal system. A liquid seal is maintained on any calcium carbonate in the evaporation ponds. Upon decommissioning, calcium carbonate from the plant equipment and pond residues will be disposed of in either a licensed tailings pond or a commercial disposal site.

The other possible precipitating species, which has been identified, is iron, which could probably precipitate as either the hydroxide or the carbonate, causing some fouling. Such fouling is usually evidenced by reduction in the ion exchange capacity of the resin in the extraction circuit. Should this fouling become a serious problem, the resin can be washed and the wash solution disposed of in the waste disposal system. Due to the small amount of iron present in the Basal Chadron Sandstone, iron precipitation has not been a problem.

6.1.2.3 HYDROLYSIS

Hydrolysis reactions, which involve minerals and hydrogen or hydroxide ions, do not play an important role in the ore/lixiviant interaction. In the pH range of 6.5 to 9.0, the concentration of hydrogen and hydroxide ions is so small that these types of reactions do not occur to any great degree. The only potential impact would be a small increase in the dissolved silica content of the lixiviant system, a possible small increase in the cations associated with the silicious minerals. The hydrolysis reaction does not have a significant effect on operations.

6.1.2.4 OXIDATION

The oxidant consumers in the Basal Chadron Sandstone are hydrogen sulfide in the groundwater, uranium, vanadium, iron pyrite, and other trace and heavy metals. The impacts of these oxidant consumers on the operation of the plant would be to generally increase the oxidant consumption over that which would be required for uranium alone. The second effect would be to release iron and sulfate into solution from the oxidation of pyrite. A third effect would be to increase the levels of some trace metals such as arsenic, vanadium and selenium into solution. As mentioned previously, the iron solubilized will most likely be precipitated as the hydroxide or carbonate, depending upon its oxidation state. Any vanadium, which is oxidized along with the uranium, will be solubilized by the lixiviant, recovered with the uranium and could potentially contaminate the precipitated yellowcake product. The Crow Butte plant uses hydrogen peroxide precipitation of uranium in an effort to reduce the amount of vanadium precipitated in the product. Oxidation will also solubilize arsenic and selenium. The restoration program will return these substances to acceptable levels. A final potential oxidation reaction is the partial oxidation of sulfur species resulting in compounds such as polythionates that can foul ion exchange resins. In in-situ operations using chemistries similar to Crow Butte, these sulfur species are completely oxidized to sulfate, which poses no problems.

6.1.2.5 ORGANICS

Organic materials are generally not present in the Crow Butte ore body at levels greater than 0.1 to 0.2%. Where present their effect is to increase the oxidant consumption and make uranium leaching a bit more difficult. On longer flow paths, organic material could potentially reprecipitate uranium, should all of the oxidant be consumed and conditions become reducing. Another potential impact of organics could be the coloring and fouling of leach solutions should the organics be mobilized. As the plant is operated in the pH range of 6.5 to 9.0, mobilization of the organics and coloring of the leach solution is avoided.

6.1.3 RESTORATION GOALS

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

The baseline data support establishment of the upper control limits and restoration standards for each mine unit. The upper control limits and restoration standards for each Mine Unit, beginning with Mine Unit 6, are determined by the Safety and Environmental Review Panel (SERP) during the approval process for the new Mine Unit. The NDEQ restoration values are established as the average plus two standard deviations for any parameter that exceeds the applicable drinking water standard. If a drinking water standard exists for a parameter, and baseline is below that standard, the drinking water standard is used to establish the restoration value. If there is no drinking water standard for an element, for example vanadium, the restoration value will be based on best practicable technology. The restoration value for the major cations (Ca, Mg, K, Na) should allow for the concentrations of these cations to vary by as much as one order of magnitude as long as the TDS restoration value is met. The total carbonate restoration criteria should allow for the total carbonate to be less than 50% of the TDS. The TDS restoration value is set at the average plus one standard deviation.

Mine unit averages and secondary goals for Mine Units 1 through 5 are given in Tables 6.1-1 through 6.1-5. The mine unit average and NDEQ restoration values for Mine Unit 6 are given in Table 6.1-6. The CBR SERP determined these restoration values on March 4, 1998. The mine unit average and NDEQ restoration values for Mine Unit 7 are given in Table 6.1-7. The CBR SERP determined these restoration values on July 9, 1999. NDEQ Permit Number NE0122611 requires that a Mine Unit be returned to a wellfield average of these restoration values. These concentrations were approved by the NDEQ with the Notice of Intent to Operate submittals. Post mining water quality for Mine Unit 1 can be found in Table 6.1-8.

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

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

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

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

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

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

Parameter	Groundwater Standard	MU-1 Baseline	MU-1 Standard Deviation	MU-1 NDEQ Restoration Value
Ammonium (mg/l)	10.0	<0.372		10.0
Arsenic (mg/l)	0.05	<0.00214		0.05
Barium (mg/l)	1.0	<0.1		1.0
Cadmium (mg/l)	0.01	<0.00644		0.01
Chloride (mg/l)	250.0	203.9	38	250.0
Copper (mg/l)	1.0	<0.017		1.0
Fluoride (mg/l)	4.0	0.686	0.04	4.0
Iron (mg/l)	0.3	<0.0441		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.011		0.05
Molybdenum (mg/l)	1.0	<0.0689		1.0
Nickel (mg/l)	0.15	<0.0340		0.15
Nitrate (mg/l)	10.0	<0.050		10.0
Lead (mg/l)	0.05	0.0315		0.05
Radium (pCi/L)	5.0	229.7	177.1	584.0
Selenium (mg/l)	0.01	<0.00323		0.01
Sodium (mg/l)	N/A	412	19.2	4120
Sulfate (mg/l)	250.0	356.2	9.4	375
Uranium (mg/l)	5.0	0.0922	0.089	5.0
Vanadium (mg/l)	0.2	<0.0663		0.2
Zinc (mg/l)	5.0	<0.036		5.0
pH (Std. Units)	6.5 - 8.5	8.46	0.2	6.5 – 8.5
Calcium (mg/l)	N/A	12.5	3.2	125.0
Total Carbonate (mg/l)	N/A	351	31.1	585
Potassium (mg/l)	N/A	12.5	1.5	125.0
Magnesium (mg/l)	N/A	3.2	0.8	32.0
TDS (mg/l)	N/A	1170.2	47.6	1170.2

Table 6.1-2: Baseline and Restoration Values for Mine Unit 2

Parameter	Groundwater Standard	MU-2 Baseline	MU-2 Standard Deviation	MU-2 NDEQ Restoration Value
Ammonium (mg/l)	10.0	0.37	0.07	10.0
Arsenic (mg/l)	0.05	<0.001		0.05
Barium (mg/l)	1.0	<0.1		1.0
Cadmium (mg/l)	0.01	<0.007		0.01
Chloride (mg/l)	250.0	208.6	30.8	250.0
Copper (mg/l)	1.0	<0.013		1.0
Fluoride (mg/l)	4.0	0.67	0.04	4.0
Iron (mg/l)	0.3	<0.045		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.01		0.05
Molybdenum (mg/l)	1.0	<0.073		1.0
Nickel (mg/l)	0.15	<0.037		0.15
Nitrate (mg/l)	10.0	<0.039		10.0
Lead (mg/l)	0.05	<0.035		0.05
Radium (pCi/L)	5.0	234.5	411.8	1058.0
Selenium (mg/l)	0.01	<0.001		0.01
Sodium (mg/l)	N/A	410.8	18.2	4108
Sulfate (mg/l)	250.0	348.2	10.3	369.0
Uranium (mg/l)	5.0	0.046	0.037	5.0
Vanadium (mg/l)	0.2	<0.07		0.2
Zinc (mg/l)	5.0	<0.026		5.0
pH (Std. Units)	6.5 - 8.5	8.32	0.2	6.5 – 8.5
Calcium (mg/l)	N/A	13.4	2.4	134.0
Total Carbonate (mg/l)	N/A	366.9	13.3	585.0
Potassium (mg/l)	N/A	12.6	2.5	126.0
Magnesium (mg/l)	N/A	3.5	0.4	35.0
TDS (mg/l)	N/A	1170.4	41	1170.4

Table 6.1-3: Baseline and Restoration Values for Mine Unit 3

Parameter	Groundwater Standard	MU-3 Baseline	MU-3 Standard Deviation	MU-3 NDEQ Restoration Value
Ammonium (mg/l)	10.0	<0.329		10.0
Arsenic (mg/l)	0.05	<0.001		0.05
Barium (mg/l)	1.0	<0.1		1.0
Cadmium (mg/l)	0.01	<0.01		0.01
Chloride (mg/l)	250.0	197.6	16.7	250.0
Copper (mg/l)	1.0	<0.0108		1.0
Fluoride (mg/l)	4.0	0.719	0.05	4.0
Iron (mg/l)	0.3	<0.05		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.01		0.05
Molybdenum (mg/l)	1.0	<0.1		1.0
Nickel (mg/l)	0.15	<0:05		0.15
Nitrate (mg/l)	10.0	<0.0728		10.0
Lead (mg/l)	0.05	<0.05		0.05
Radium (pCi/L)	5.0	165	222.5	611.0
Selenium (mg/l)	0.01	<0.00115		0.01
Sodium (mg/l)	N/A	428	27.6	4280
Sulfate (mg/l)	250.0	377.0	13.4	404.0
Uranium (mg/l)	5.0	0.115	0.158	5.0
Vanadium (mg/l)	0.2	<0.1		0.2
Zinc (mg/l)	5.0	<0.0131		5.0
pH (Std. Units)	6.5 - 8.5	8.37	0.3	6.5 – 8.5
Calcium (mg/l)	N/A	13.3	3.1	133.0
Total Carbonate (mg/l)	N/A	358.7	24.8	592.0
Potassium (mg/l)	N/A	13.9	4.0	139.0
Magnesium (mg/l)	N/A	3.5	0.9	35.0
TDS (mg/l)	N/A	1183.0	47.4	1183.0

Table 6.1-4: Baseline and Restoration Values for Mine Unit 4

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

Table 6.1-5: Baseline and Restoration Values for Mine Unit 5

Parameter	Groundwater Standard	MU-5 Baseline	MU-5 Standard Deviation	MU-5 NDEQ Restoration Value
Ammonium (mg/l)	10.0	0.28	0.05	10.0
Arsenic (mg/l)	0.05	<0.001		0.05
Barium (mg/l)	1.0	<0.10		1.0
Cadmium (mg/l)	0.01	<0.01		0.01
Chloride (mg/l)	250.0	191.9	7.9	250.0
Copper (mg/l)	1.0	<0.01		1.0
Fluoride (mg/l)	4.0	0.64	0.07	4.0
Iron (mg/l)	0.3	<0.05		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.01		0.05
Molybdenum (mg/l)	1.0	<0.10		1.0
Nickel (mg/l)	0.15	<0.05		0.15
Nitrate (mg/l)	10.0	<0.1		10.0
Lead (mg/l)	0.05	<0.05		0.05
Radium (pCi/L)	5.0	166.0	184.6	535.0
Selenium (mg/l)	0.01	<0.002		0.01
Sodium (mg/l)	N/A	397.6	14.4	3976
Sulfate (mg/l)	250.0	364.5	10.5	385.0
Uranium (mg/l)	5.0	0.072	0.056	5.0
Vanadium (mg/l)	0.2	<0.10		0.2
Zinc (mg/l)	5.0	<0.02		5.0
pH (Std. Units)	6.5 - 8.5	8.5	0.1	6.5 – 8.5
Calcium (mg/l)	N/A	12.6	1.8	126.0
Total Carbonate (mg/l)	N/A	372	13.0	590.0
Potassium (mg/l)	N/A	11.5	1.2	115.0
Magnesium (mg/l)	N/A	3.4	0.4	34.0
TDS (mg/l)	N/A	1179.5	22.5	1202.0

Table 6.1-6: Baseline and Restoration Values for Mine Unit 6

Parameter	Groundwater Standard	MU-6 Baseline	MU-6 Standard Deviation	MU-6 NDEQ Restoration Value
Alkalinity (mg/l)	N/A	305	11.5	N/A
Ammonium (mg/l)	10.0	0.32	0.05	10.0
Arsenic (mg/l)	0.05	0.002		0.05
Barium (mg/l)	1.0	0.100		1.0
Bicarbonate (mg/l)	N/A	359	18.6	see Total Carbonate
Boron (mg/l)	N/A	0.823	0.035	N/A
Cadmium (mg/l)	0.01	0.009		0.01
Carbonate (mg/l)	N/A	8.1	4.3	see Total Carbonate
Chloride (mg/l)	250.0	206	15.4	250.0
Chromium (mg/l)	N/A	0.050		N/A
Copper (mg/l)	1.0	0.012		1.0
Fluoride (mg/l)	4.0	0.65	0.03	4.0
Iron (mg/l)	0.3	0.050		0.3
Mercury (mg/l)	0.002	0.001		0.002
Manganese (mg/l)	0.05	0.010		0.05
Molybdenum (mg/l)	1.0	0.102		1.0
Nickel (mg/l)	0.15	0.050		0.15
Nitrate (mg/l)	10.0	0.1		10.0
Nitrite (mg/l)	N/A	0.1		N/A
Lead (mg/l)	0.05	0.050		0.05
Radium (pCi/L)	5.0	80.6	121.9	325
Selenium (mg/l)	0.01	0.001		0.01
Silica	N/A	10.9	0.6	N/A
Sodium (mg/l)	N/A	400	12.8	4000
Specific Conductivity (µmho/cm)	N/A	1,978	42.3	N/A
Sulfate (mg/l)	250.0	361	14.6	390
Uranium (mg/l)	5.0	0.133	0.212	5.0
Vanadium (mg/l)	0.2	0.098		0.2
Zinc (mg/l)	5.0	0.011		5.0

Table 6.1-6: Baseline and Restoration Values for Mine Unit 6

Parameter	Groundwater Standard	MU-6 Baseline	MU-6 Standard Deviation	MU-6 NDEQ Restoration Value
pH (Std. Units)	6.5 - 8.5	8.6	0.2	6.5 – 9.0
Calcium (mg/l)	N/A	12.8	2.3	128
Total Carbonate (mg/l)	N/A	367.1	22.9	596
Potassium (mg/l)	N/A	11.9	1.7	119
Magnesium (mg/l)	N/A	3.2	0.7	32
TDS (mg/l)	N/A	1192	28.1	1220

Table 6.1-7: Baseline and Restoration Values for Mine Unit 7

Parameter	Groundwater Standard	MU-7 Baseline	MU-7 Standard Deviation	MU-7 NDEQ Restoration Value
Alkalinity (mg/l)	N/A	297	19.1	N/A
Ammonium (mg/l)	10.0	0.42	0.08	10.0
Arsenic (mg/l)	0.05	0.001		0.05
Barium (mg/l)	1.0	0.10		1.0
Bicarbonate (mg/l)	N/A	347	20.4	see Total Carbonate
Boron (mg/l)	N/A	0.91	0.049	N/A
Cadmium (mg/l)	0.01	0.007		0.01
Carbonate (mg/l)	N/A	8.9		see Total Carbonate
Chloride (mg/l)	250.0	198	22.6	250.0
Chromium (mg/l)	N/A	0.05		N/A
Copper (mg/l)	1.0	0.01		1.0
Fluoride (mg/l)	4.0	0.70	0.05	4.0
Iron (mg/l)	0.30	0.05		0.30
Mercury (mg/l)	0.002	0.001		0.002
Manganese (mg/l)	0.05	0.01		0.05
Molybdenum (mg/l)	1.00	0.10		1.00
Nickel (mg/l)	0.15	0.05		0.15
Nitrate (mg/l)	10.0	0.1		10.0
Nitrite (mg/l)	N/A	0.1		N/A
Lead (mg/l)	0.05	0.05		0.05
Radium (pCi/L)	5.0	142	148.0	438
Selenium (mg/l)	0.01	0.004		0.01
Silica	N/A	12.9	1.1	N/A
Sodium (mg/l)	N/A	387	21.6	3,870
Specific Conductivity (µmho/cm)	N/A	1,979	85.5	N/A
Sulfate (mg/l)	250.0	346	20.1	386
Uranium (mg/l)	5.0	0.110	0.138	5.0
Vanadium (mg/l)	0.2	0.10		0.2
Zinc (mg/l)	5.0	0.01		5.0

Table 6.1-7: Baseline and Restoration Values for Mine Unit 7

Parameter	Groundwater Standard	MU-7 Baseline	MU-7 Standard Deviation	MU-7 NDEQ Restoration Value
pH (Std. Units)	6.5 - 8.5	8.6	0.3	6.5 – 9.2
Calcium (mg/l)	N/A	12.2	2.6	122
Total Carbonate (mg/l)	N/A	356		588
Potassium (mg/l)	N/A	12.9	3.0	129
Magnesium (mg/l)	N/A	3.2	0.7	32
TDS (mg/l)	N/A	1,176	40.7	1,217

Table 6.1-8: Post Mining Water Quality for Mine Unit 1 Restoration Well Sampling

	PM-1	PM-4	PM-5	PT-5	IJ-6	IJ-13	IJ-25	IJ-28	IJ-45	PR-8	PR-15	PR-19
Ca (mg/l)	87.9	87.1	80.8	87.9	87.6	93.9	89.4	89.6	89.9	85.4	86.7	98.3
Mg (mg/l)	22.6	20.6	22.7	23.8	21.4	23.9	22.5	23.1	24.8	23.2	23.1	23.8
Na (mg/l)	1154	942	1054	1144	1054	1174	1177	1182	1126	1144	1172	1083
K (mg/l)	32.7	26.3	30	30	27.2	31.3	30	31.3	32.7	30	30	28.6
CO_3 (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0
HCO_3 (mg/l)	1099	900	972	981	1057	1086	1111	1207	1104	1170	1170	959
SO_4 (mg/l)	1109	959	1115	1240	1031	1209	1119	1112	1134	1115	1115	1283
Cl (mg/l)	598	455	586	594	544	598	594	619	607	603	603	590
NH_4 (mg/l)	0.33	0.67	0.14	0.33	0.44	0.07	< 0.05	< 0.05	0.33	0.27	0.15	0.49
NO_2 (mg/l)	< 0.01	0.02	0.09	< 0.01	0.11	< 0.01	< 0.01	< 0.01	0.04	0.05	< 0.01	0.05
NO_3 (mg/l)	1.06	< 0.1	0.97	0.99	1.29	0.74	0.86	1.3	1.25	1.46	1.6	0.46
F (mg/l)	0.37	0.26	0.54	0.45	0.45	0.37	0.38	0.45	0.43	0.43	0.4	0.35
SiO_2 (mg/l)	25.7	18.2	35.3	24.7	33.3	34.3	26.4	31.6	28.3	33.2	30	22.2
TDS (mg/l)	3694	3121	3756	3851	3515	3899	3751	3886	3873	3820	3807	3765
Cond (µmho/cm)	5843	4841	5590	5964	5445	6012	5807	6025	5916	5819	5940	5819
$CaCO_3$ (mg/l)	901	738	797	804	866	890	911	989	905	959	959	786
pH (Std. units)	7.65	6.87	6.85	7.28	7.16	7.35	7.65	7.81	7.37	7.46	7.78	6.92
Trace Metals												
Al (mg/l)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.29
As (mg/l)	0.018	0.007	0.018	0.017	0.031	0.028	0.02	0.028	0.023	0.028	0.024	0.011
Ba (mg/l)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
B (mg/l)	1.17	1.44	1.09	1.36	1.06	1.26	1.13	1.19	1.15	1.23	1.25	1.17

Table 6.1-8: Post Mining Water Quality for Mine Unit 1 Restoration Well Sampling

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

6.1.4 RESTORATION STAGE

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. Crow Butte Resources will monitor the quality of selected wells during restoration to determine the efficiency of the operations and to determine if additional techniques are necessary.

6.1.4.1 GROUNDWATER TRANSFER

Prior to commencing restoration activities, the regulatory agencies will be notified that mining has ceased in a given mine unit and Crow Butte Resources will proceed to establish post mining water quality data for all of the required parameters listed in Table 6.1-1 through 6.1-7.

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

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

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

6.1.4.2 GROUNDWATER SWEEP

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

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

6.1.4.3 GROUNDWATER TREATMENT

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

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

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

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

Figure 6.1-1: Restoration Process Schematic

Before the water can be processed by the reverse osmosis unit, the soluble uranium must be removed by the ion exchange system. The water is then filtered, the pH lowered for decarbonation to prevent calcium carbonate plugging of the membranes, and then pressurized by a pump. The reverse osmosis unit contains membranes which pass about 60 to 75 percent of the water through, leaving 60 to 90 percent of the dissolved salts in the water that will not pass the membrane. Table 6.1-9 shows typical manufacturers specification data for removal of ion constituents. The clean water, called permeate, will be re-injected, sent to storage for use in the mining process, or sent to the waste disposal system. The twenty-five to forty percent of water that is rejected, referred to as the brine, contains the majority of dissolved salts that contaminate the groundwater and is sent for disposal in the wastewater system.

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

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

6.1.5 STABILIZATION PHASE

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

Table 6.1-9: Typical Membrane Rejection
Source: Osmonics, Inc.

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

6.1.6 REPORTING

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

Upon completion of restoration activities and prior to stabilization, all designated restoration wells in the mine unit will be sampled for the required constituents listed in Tables 6.1-1 through 6.1-7. These samples may be split with NDEQ if required. Assay results will be submitted to NDEQ and USNRC as required. If restoration activities have returned the wellfield average of restoration parameters to concentrations at or below those approved by the regulatory agencies, Crow Butte Resources will notify the regulatory agencies it is commencing the stabilization phase of restoration.

During stabilization all designated restoration wells will be sampled monthly for the required constituents listed in Table 6.1-1 through 6.1-7. At the end of a six month stabilization period Crow Butte Resources will compile all water quality data obtained during restoration and stabilization and submit a final report to the regulatory agencies. At that time, Crow Butte Resources would request that the mine unit be declared restored.

6.1.7 CURRENT RESTORATION STATUS

The approval of the Notice of Intent to Operate for Mine Unit 4 was received from the NDEQ on March 11, 1994. With the approval, active mining operations ceased in Mine Unit 1 and restoration was initiated. On March 23, 1994 the baseline restoration wells were sampled to establish the post mining water quality. The results of this sampling are given in Table 6.1-8.

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

6.2 DECONTAMINATION AND DECOMMISSIONING

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

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

The following is a list of general decommissioning activities:

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

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

6.2.1 PROCESS BUILDINGS AND EQUIPMENT

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

6.2.1.1 REMOVAL AND DISPOSAL ALTERNATIVES

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

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

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

6.2.1.1.1 DISPOSAL AT A LICENSED FACILITY

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

- Flush inside of tanks, pumps, pipes, etc., with water or acid to reduce interior contamination as necessary for safe handling.
- The exterior surfaces of process equipment will be surveyed for contamination. If the surfaces are found to be contaminated the

equipment will be washed down and decontaminated to permit safe handling.

- The equipment will be disassembled only to the degree necessary for transportation. All openings, pipe fittings, vents, etc., will be plugged or covered prior to moving equipment from the plant building.

- Equipment in the building, such as large tanks, may be transported on flatbed trailers. Smaller items, such as links of pipe and ducting material, may be placed in plastic lined covered dump trucks or drummed in barrels for delivery to the receiving facility.

- Contaminated buried process trunk lines and sump drain lines will be excavated and removed for transportation to a licensed disposal facility.

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

6.2.1.1.2 DISPOSAL TO UNRESTRICTED USE

If a piece of equipment is to be released for unrestricted use it will be appropriately surveyed before leaving the licensed area. Both interior and exterior surfaces will be surveyed to detect potential contamination. Appropriate decontamination procedures will be used to clean any contaminated areas and the equipment resurveyed and documentation of the final survey retained to show that unrestricted use criteria were met prior to releasing the equipment or materials from the site. Criteria to be used for release to unrestricted use will be USNRCs *"Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Materials*" May 1987 Revision (Annex B) or the most current standards for decontamination at that time.

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

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

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

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

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

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

6.2.2 EVAPORATION POND DECOMMISSIONING

6.2.2.1 DISPOSAL OF POND WATER

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

6.2.2.2 POND SLUDGE AND SEDIMENTS

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

6.2.2.3 DISPOSAL OF POND LINERS AND LEAK DETECTION SYSTEMS

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

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

6.2.2.4 ON SITE BURIAL

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

6.2.3 WELLFIELD DECOMMISSIONING

Wellfield decommissioning will consist of the following steps:

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

- Removal of buried well field piping.

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

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

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

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

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

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

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

6.2.3.1 WELL PLUGGING AND ABANDONMENT

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

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

The plugging method will be as follows:

- An approved abandonment mud (a mud-polymer mix) will be mixed in a cement unit and pumped down a hose, which is lowered to the bottom of the well casing using a reel.
- When the hose is removed, the casing is topped off and a cement plug placed on top.
- A hole is then dug around the well, and, at a minimum, the top three feet of casing removed.
- The hole is backfilled and the area revegetated.

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

6.2.3.2 BURIED TRUNKLINES, PIPES AND EQUIPMENT

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

6.2.4 DECONTAMINATION

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

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

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

- Areas of potential surface contamination will be identified using a gross gamma survey on an adequately spaced grid.
- Spot-checks of areas around the site of potentially contaminated areas.
- The final soil background survey on areas which have been prepared for surface reclamation using a grid spacing adequate for confirming clean up to applicable standards.

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

6.2.5 DECOMMISSIONING HEALTH PHYSICS AND RADIATION SAFETY

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

Health physics survey conducted during decommissioning will be guided by applicable sections of 10 CFR 20 and USNRC Regulatory Guide No. 8.30

entitled "*Health Physics Surveys in Uranium Mills*" or other applicable standards at the time.

6.2.6 EQUIPMENT AND MATERIAL SURVEYS

Any site equipment to be released for unrestricted use will be surveyed for alpha contamination and beta gamma as necessary to document levels for release, according to USNRC "*Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Materials*", May 1987 Revision (Annex B) or the most current standards for decontamination at that time.

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

6.2.7 RECORDS AND REPORTING PROCEDURES

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

6.3 SURFACE RECLAMATION

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

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

6.3.1 WELLFIELD RECLAMATION

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

6.3.2 PROCESS FACILITIES RECLAMATION

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

6.3.3 CONTOURING OF AFFECTED AREAS

Due to the relatively minor nature of disturbances created by in-situ mining, there are only a few areas disturbed to the extent to which subsoil and geologic materials are removed causing significant topographic changes 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 re-establishment of drainage patterns will be accomplished by returning the earthen materials moved during construction to their approximate original locations.

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

6.4 BONDING ASSESSMENT

6.4.1 BOND CALCULATIONS

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

6.4.2 FINAL SURETY ARRANGEMENTS

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

ATTACHMENT 6.1

Crow Butte Resources, Inc.

Safety and Environmental Review Panel

Evaluation Report – SERP 99-01

Spill Review Meeting

June 7, 1999

The Crow Butte Resources, Inc. (CBR) Safety and Environmental Review Panel (SERP) met to review spills at the Crow Butte Uranium Project.

The SERP appointed for this evaluation consisted of the following members:

Name	Title	Area of Expertise
Steve Magnuson	Vice President, Manager of Operations	Operations
Chuck Miller	Plant Manager	Operations
Mike Griffin	Manager of Environmental and Regulatory Affairs	Regulatory Affairs/ Radiation Safety
Rhonda Grantham	Corporate RSO	Radiation Safety
Leland Huffman	Wellfield Engineer	Wellfield Operations

Mr. Magnuson is the SERP Chairman. Mr. Griffin was appointed SERP Secretary for this evaluation.

Purpose of SERP Evaluation

The primary purpose of the CBR SERP is to review and approve changes, tests or experiments in accordance with NRC Source Materials License SUA-1534. However, the SERP is not limited by the license to these facility change evaluations. CBR determined that it would be beneficial to have the SERP review spills at the Crow Butte project on a periodic basis to perform a root cause analysis. The SERP may also review potential changes to equipment or procedures that may reduce the likelihood of spills.

SERP 99-01 reviewed spill reports for the period of January 1 to May 31, 1999. During this period, there were 19 spills involving mining solutions. In addition, there were two spills involving process chemicals and one spill involving ion exchange resin. None of the spills were reportable to the Nebraska Department of Environmental Quality (NDEQ) or the Nuclear Regulatory Commission.

Wellfield Spills

The nineteen spills involving mining solutions all occurred in the wellfield. With the exception of one spill that occurred in a newly constructed part of the wellfield, all spills were located at a wellhead. A breakdown of the causes of these spills is as follows:

- Piping Component Failure 5

The piping component failures principally involved the ¼ inch brass piping that is used for the wellhead pressure indicator, pressure relief valve, and bleed valve. The SERP discussed the purpose of this ¼ inch piping system and whether it could be relocated or redesigned to minimize failures due to freezing or impact. The vent system is needed due to the use of oxygen stingers to allow venting and pressure relief. The SERP discussed whether the stingers could be shortened and/or the oxygen addition rate reduced to reduce the safety hazard present. Another suggestion was the installation of a bypass or weep hole to equalize the annulus and injection line pressures. The Wellfield Engineer and Plant Manager will investigate these potential changes.

- Leaking Bung at Wellhead 5

The leaking bungs on the wellhead involved the old design bung fitting that was used until Wellhouse 22. This design was discontinued in favor of the new design where the 1¼ or 2 inch line is threaded completely though the bulkhead. These old design penetrations are being retired as they cause problems. They may still be used on wells that are in restoration.

- Bleed valve open/leaking 3

Three instances of a partially open bleed valves resulted in spills. These ¼ inch ball valves are at the end of the pressure relief piping and are used to vent gases from the annular space in the well to restore flow. On two occasions, it was believed that a wellhead cover blowing off the wellhead in high winds bumped the valve handle. The SERP discussed the need for wellhead covers. The SERP also discussed the potential to relocate the ¼ inch piping so the valve was not susceptible to being bumped. Removal of valve handles and placing them in the wellhead area for use when needed was also discussed. The Wellfield Engineer will discuss these suggestions with the Wellfield Operators and determine what action could be taken to minimize this cause of spills.

- Stuck/leaking pressure relief valve 3

Pressure relief valves are installed on wells that use oxygen stingers. These relief valves were installed to prevent abnormally high pressures in these wells that had caused wellhead failures in the past. The leaks in these relief valves were apparently due to valves that had failed to reseat after lifting. In all cases, the valves were removed and replaced. On wells where relief valves are lifting frequently, the 100 psi relief is replaced with a 125 psi valve.

- Maintenance/construction/other 3

The spills in this category involved maintenance or construction activities that resulted in spills. In one instance, the spline was not replaced at a wellhead after swabbing, causing a leak when the well was restarted. On another occasion, the water truck was overfilled during well maintenance activities. The spill involving construction activities was apparently due to defective valves at the end of a new trunk line that were returned for warranty replacement by the manufacturer.

Wellfield Inspections

One of the spills caused by a failure of a piping component involved well I-1104. The leak was at a split ¼ inch Tee that had apparently been leaking for an extended period of time. The leak was small enough that it was not visible outside the wellhead cover and did not cause a high flow alarm. The gamma survey performed after the spill noted elevated gamma radiation levels above background that required soil sampling. The soil sampling indicated a small (1 m^2) area with radium-226 concentrations over 100 pCi/gm. It is not clear whether this localized area of elevated radium-226 was due to the leak occurring over an extended period of time or whether the area had elevated levels from previous construction or maintenance activities.

As a result of this spill, the Wellfield Engineer had an inspection of all operating wells performed by the wellfield operations crew. This inspection of 516 wells resulted in discovery of four minor leaks that were included in the total for the period. The SERP agreed that periodic well inspections should be a priority and that all on-line wells should be inspected at least once per month. It currently takes approximately six man-days to perform a complete wellfield inspection.

Spill Reporting

The SERP discussed consistent spill reporting. It was noted that an operator that was not experienced in determining spill depth and running the Spill Program discovered one of the spills. The Manager of Environmental and Regulatory Affairs and the Corporate RSO will provide a short training session to each shift of plant operators to ensure that spill investigation and reporting methods are consistent.

Spill Procedure Revision

It was noted that the Standard Operating Procedure (SOP) for spill response (C-19, Solution Spills) does not completely incorporate guidance from NRC on spills that may have a radiological impact. The SOP requires reporting any spill that results in soil radium-226 concentrations that exceed the cleanup criteria. However, the NRC guidance letter on spill reporting states that this should be based upon the magnitude and location of the spill. The SOP does not include this portion of the guidance. It was recommended that SOP C-19 be revised to include verbatim NRC guidance on reportable spills.

Plant Spills

- Process Chemical Spills 2

There were two spills of 50% hydrogen peroxide that occurred during the period. Both spills were the result of overfilling the hydrogen peroxide day tank by siphoning from the bulk tank. The day tank is located immediately adjacent to the north doors at the plant building, allowing hydrogen peroxide to leave the plant building. The spills were not reportable to NDEQ, EPA or NRC.

The Plant Manager reported that a vacuum breaker had been installed in the fill line from the bulk tank to the day tank to prevent siphons.

- Ion Exchange Resin Spill 1

A spill of ion exchange resin occurred during a resin transfer to empty an ion exchange column for maintenance. Since the resin transfer tank will not always fully contain the resin from a column, additional tankage is sometimes necessary to empty a column. A temporary tank was located in the plant building and had been used for this purpose for previous transfers from other ion exchange columns. However, the tank was removed from the plant building. When the next column was emptied, the operators connected to a trailer-mounted tank that was located outside the north doors of the plant. A drain valve on the tank was left open, resulting in a spill of an estimated 9 cubic feet of resin on the ground outside the plant.

The resin had been eluted, rinsed and transferred with potable water. Therefore, the only expected radiological concern involved residual uranium ionically bound to the resin bead. The resin was cleaned up. The sampling survey to release the area is currently being designed. The Manager of Environmental and Regulatory Affairs noted that the termination criteria for uranium is changed by final rule effective June 11, 1999. The

Crow Butte site-specific limit for uranium has not been determined by modeling at this time, so the cleanup criterion for this area is not known. Visual inspections indicate that all resin was removed.

The Plant Manager stated that plant operators had been instructed in the logbook to not transfer radioactive materials outside the restricted area.

Approved this 7th day of June 1999.

Steve Magnuson, Vice President, Manager of Operations
SERP Chairman

Chuck Miller, Plant Manager

Mike Griffin, Manager of Environmental and Regulatory Affairs
SERP Secretary

Rhonda Grantham, Corporate Radiation Safety Officer

Leland Huffman, Wellfield Engineer

CROW BUTTE RESOURCES, INC.

Memorandum

To: SERP 99-01 Members

From: Mike Griffin

Subject: Status of SERP Spill Review Actions

Date: July 14, 1999

cc: Steve Collings, SERP file

SERP 99-01 met on June 7, 1999 and reviewed spill reports for the period of January 1 to May 31, 1999. As a result of this review, there were several recommendations for equipment and procedural improvements that were identified to reduce the number of spills at the Crow Butte Uranium Project. This memo provides an update to the SERP 99-01 members of the status of their recommendations.

Piping component failures involved the ¼ inch brass piping that is used for the wellhead pressure indicator, pressure relief valve, and bleed valve. The SERP discussed several suggestions that could potentially reduce the number of failures due to this cause. No final design or operational changes have been made at this time. Evaluation of alternatives continues.

Partially open bleed valves from wellhead covers blowing off in high winds and bumping the valve handle was another cause of spills that was reviewed by the SERP. A change was made to the wellhead design that involved rotating the bleed valve piping 90 degrees so that it is perpendicular to the main penetration. This change will place the bleed valve handle in a location that will protect it from inadvertent mispositioning due to impact. All new wellheads will be fitted with this design. The new design will be installed in new wells beginning with Wellhouse 30 and any other wells requiring a new wellhead.

The SERP discussed the best methods to assure consistent spill reporting. The Standard Operating Procedure (SOP) for spill response (C-19, *Solution Spills*) was revised to incorporate guidance from NRC on spills that may have a radiological impact. SOP S-05, *Emergency Preparedness*, was also revised to improve the chemical spill response and reporting requirements. On July 9 and July 14, all plant operators and maintenance personnel were trained by the Plant Manager and Manager of Environmental and Regulatory Affairs in the new spill reporting requirements. A review was held of primary responsibilities, reporting requirements, data collection requirements and methods to estimate spill area, depth and volume.

SERP 99-01 Members: Steve Magnuson, Rhonda Grantham, Chuck Miller, Mike Griffin

Crow Butte Resources, Inc.

Safety and Environmental Review Panel

Evaluation Report – SERP 99-02

Mine Unit 7 Approval

July 8, 1999

The Crow Butte Resources, Inc. (CBR) Safety and Environmental Review Panel (SERP) met to review and approve Mine Unit 7 at the Crow Butte Uranium Project.

The SERP appointed for this evaluation consisted of the following members:

Name	Title	Area of Expertise
Steve Magnuson	Vice President, Manager of Operations	Management
Chuck Miller	Plant Manager	Operations
Mike Griffin	Manager of Environmental and Regulatory Affairs	Regulatory Affairs/ Radiation Safety
Rhonda Grantham	Corporate RSO	Radiation Safety

Mr. Magnuson is the SERP Chairman. Mr. Griffin was appointed SERP Secretary for this evaluation.

Purpose of SERP Evaluation

The purpose of this evaluation by the CBR SERP was to review and approve Mine Unit 7 for operation. The SERP evaluation was conducted in accordance with CBR Standard Operating Procedure (SOP) C-2, *Safety and Environmental Review Panel.* The SERP reviewed the Mine Unit 7 Notice of Intent to Operate and preoperational monitoring data and evaluated this information as compared with the requirements of the licensing basis, including the following documents:

- Title 10, Code of Federal Regulations;
- Source Materials License SUA-1534, Amendment No. 4 dated April 22, 1999;
- *Application for Renewal of USNRC Radioactive Source Materials License SUA-1534*, Crow Butte Resources, Inc. December 1995;
- *Environmental Assessment for Renewal of Source Materials License No. SUA-1534*, USNRC February 1998;

- *Safety Evaluation Report for Renewal of Source Materials License No. SUA-1534*, USNRC February 1998.

In addition, the SERP evaluated compliance with the State of Nebraska Department of Environmental Quality (NDEQ) Underground Injection Control (UIC) Permit No. NE0122611.

License Condition 9.4 allows CBR to make changes that are not presented in the approved application if such changes:

- Do not conflict with any requirement specifically stated in the license or impair CBR's ability to meet all applicable NRC regulations;

- Do not degrade essential safety or environmental commitments in the application or reclamation plan; and

- Are consistent with the conclusions of action analyzed and selected in the Environmental Assessment (EA).

Title 10 Code of Federal Regulations

The proposed change will have no impact on CBR's ability to meet all applicable NRC regulations.

Source Materials License SUA-1534 Requirements

Amendment 4 to SUA-1534 dated April 22, 1999 was reviewed for specific requirements related to approval and operation of a new mine unit.

License Condition 9.5: This License Condition requires that CBR maintain an NRC-approved financial surety arrangement to cover reclamation of all existing operations and planned expansions for the upcoming year. If such expansion is not covered in the annual update to the existing surety arrangement, an updated surety must be provided to NRC at least 90 days prior to beginning construction.

The current surety arrangement approved by NRC includes the operation of the first half of Mine Unit 7 during 1999. CBR does not plan to operate more than the first half of Mine Unit 7 during this year.

License Condition 9.10: This License Condition requires that CBR conduct operations within the permit area boundaries shown in the License Renewal Application (LRA), as amended.

Mine Unit 7 falls within this permit area boundary.

License Condition 10.2: This License Condition requires that all wells be constructed as described in the LRA and that Mechanical Integrity Tests (MITs) be conducted before the well can be utilized.

The well construction methods in use for Mine Unit 7 are the same as those described in the LRA. The SERP reviewed the MIT information contained in the Notice of Intent to Mine (NOI) submitted to the NDEQ. The package in the NOI included the MITs for wells associated with Wellhouse 28 and the required monitoring wells. MITs for future wellhouses in Mine Unit 7 cannot be reviewed since these wells have not been installed. Therefore, the SERP can only review Wellhouse 28 wells, baseline restoration wells and the monitoring wells of Mine Unit 7 for compliance with this License Condition. All MIT data sheets reviewed met the requirements.

License Condition 10.3: This License Conditions contains requirements for establishing pre-operational baseline groundwater quality including well density, sampling frequency and parameters, and determination of groundwater restoration goals.

10.3(A): A total of 25 injection or production wells are identified for Mine Unit 7, which comprises 94.3 acres. The SERP reviewed the well placement. The wells meet the density requirement of this License Condition (i.e., 1 per every 4 acres) and are evenly spaced in the Mine Unit. Samples were collected at least 14 days apart.

10.3(B): The samples were analyzed for all parameters listed in this portion of the License Condition.

10.3(C): Groundwater restoration goals were proposed for Mine Unit 7 that were based upon the mine unit average of all baseline restoration (BLR) wells. The goals are an arithmetic mean of the averages for the three samples taken for each of the 25 wells.

The SERP discussed two issues related to restoration goals for Mine Unit 7. The first related to the reporting level for cadmium. Eight of the BLR wells were originally sampled in 1992 and 1993 as perimeter monitor wells for Mine Unit 3 and 4. At that time, the reporting level for cadmium was 0.01 mg/l. The rest of the BLR wells for Mine Unit 7 were sampled and analyzed in 1999 with a cadmium reporting level of 0.005 mg/l. All results for all samples were less than the reporting level. The SERP discussed the options of setting the restoration goal at the average of the different reporting levels or at the lowest reporting level (0.005 mg/l). The SERP determined that using an arithmetic average of the reporting levels to determine the restoration goal would be consistent with prior methods when the data was reported with different reporting levels (e.g., Mine Unit 1). Therefore, the baseline value for cadmium for Mine Unit 7 will be 0.007 mg/l.

The second issue related to the table of proposed restoration values that was presented to the SERP for approval. This table is similar in format to the tables prepared for Mine Units 1 through 6 and as contained in the LRA. However, several parameters that are contained in License Condition 10.3(B) are not listed on these tables. These parameters include alkalinity, bicarbonate, boron, carbonate, chromium, nitrite, silica and specific conductivity. (Temperature is also listed in License Condition 10.3(B), but is not appropriate for a table listing restoration goals). The apparent reason that these parameters are not listed in the restoration table is that the format of the table follows the requirements of the NDEQ UIC Permit, which does not include these parameters. The SERP noted that the analysis for each parameter had been completed and the baseline average and standard deviation had been computed. The parameters were simply not listed in the restoration goal table.

The SERP determined to revise the restoration goal table for Mine Unit 7 to include all parameters required by License Condition 10.3(B) (with the exception of temperature) to ensure meeting the requirements to determine a parameter-by-parameter goal. The SERP also decided to revise the table in the LRA for Mine Unit 6, which was approved by the CBR SERP in March 1998. The Mine Unit 6 package also contained the analytical data and computation of the average for these parameters. Prior restoration tables for Mine Units 1 through 5 had been submitted to NRC for approval prior to issuance of the performance-based license. Therefore, the SERP decided not to update these tables in the LRA.

License Condition 10.4: This License Condition contains requirements for determining Upper Control Limits (UCLs) for upper and perimeter monitor wells including well density, sampling schedule, analytes, and UCL calculational method.

10.4(A): A total of 25 shallow monitors and 16 perimeter monitor wells are identified for Mine Unit 7, which comprises 94.3 acres. The SERP reviewed the well placement. The wells meet the density requirement of this License Condition (i.e., 1 per every 5 acres for shallow monitor wells) and are evenly spaced in the Mine Unit. Samples were collected at least 14 days apart.

10.4(B): The samples were analyzed for all parameters listed in this portion of the License Condition.

10.4(C): The proposed UCLs for each shallow and perimeter monitor well were calculated as required in this License Condition.

License Condition 10.16: This License Condition specifies the spacing for the monitor wells drilled after April 1999. None of the monitor wells associated with Mine

Unit 7 were drilled after this date; however, the perimeter monitor well spacing meets this requirement of the License.

The SERP concluded that all specific license requirements will continue to be met if this change is approved.

Environmental Assessment

The SERP reviewed the contents of the Environmental Assessment (EA) prepared by NRC in February 1998 to determine whether the proposed change could cause substantive safety or environmental impacts.

Section 3.3 of the EA discusses wellfield design and construction. In 3.3.1 (page 20), the EA states that CBR analyzes the monitor wells for 35 parameters. This statement does not match License Condition 10.4(B), which requires that the monitor wells be sampled for the five excursion indicators only. In such a case, the License is the governing document, and the preoperational monitoring program complies with the license.

Well construction and testing as described in the EA has been completed for the wells associated with Wellhouse 28 and submitted with the NOI. Other wells that will be contained in Mine Unit 7 have not been drilled, constructed and/or tested and therefore cannot be approved by the SERP.

Section 3.3.1 discusses leak testing of wellfield piping. At the time that the SERP was held, final construction testing had not been completed on the Wellhouse 28 portion of Mine Unit 7 and other portions were in the design or construction phase. Therefore, the SERP could not review construction completion to approve startup of Wellhouse 28 or future wellhouses in Mine Unit 7.

Financial Surety

The proposed change is covered in the NRC-approved financial surety maintained by CBR.

Safety Evaluation Report

The Safety Evaluation Report (SER) principally provides the basis for worker safety at Crow Butte and does not specifically address the issues related to approval of Mine Unit 7.

NDEQ UIC Permit

The SERP reviewed the requirements of the NDEQ UIC Permit they relate to startup of Mine Unit 7.

- CBR had not received the approved NOI from NDEQ at the time that the SERP was held, so approval of startup is contingent upon receiving NDEQ approval and adequately responding to any concerns or questions that are expressed.
- The NOI was submitted as required on Page 4 of the permit.
- All monitor wells and restoration wells were installed and monitored as required by permit.
- All monitor wells were shown to be functionally operation as required.
- Restoration goals were determined for every parameter included in Table 1 as required.

Degradation of Essential Safety or Environmental Commitment

SUA-1534 allows CBR to make changes as long as they do not degrade the essential safety or environmental commitments made in the application. The SERP determined that safety commitments made in the LRA and discussed in the EA could not be confirmed at the time that the SERP met because the final testing and checks for Wellhouse 28 had not been completed. Therefore, the SERP could not approve startup of Wellhouse 28. When testing and final checks for Wellhouse 28 are completed, the SERP will review this information at that time and determine whether approval for startup of Wellhouse 28 of Mine Unit 7 will be granted. Future Wellhouses will be evaluated and approved prior to startup.

The SERP was satisfied that the well locations and preoperational monitoring performed for the baseline restoration wells, shallow monitor wells, and perimeter monitor wells had been completed as required in the licensing basis documents and the NDEQ permit. With the changes noted in this evaluation, the restoration goals and UCLs had been properly determined and documented. Therefore, the SERP approves the determination of restoration goals and excursion monitoring criteria for Mine Unit 7.

Approved this 8th day of July 1999.

Steve Magnuson, Vice President, Manager of Operations
SERP Chairman

Chuck Miller, Plant Manager

Mike Griffin, Manager of Environmental and Regulatory Affairs
SERP Secretary

Rhonda Grantham, Corporate Radiation Safety Officer

Baseline and Restoration Values for Mine Unit 7

Parameter	Groundwater Standard	MU-7 Baseline	MU-7 Standard Deviation	MU-7 NDEQ Restoration Value
Alkalinity (mg/l)	N/A	297	19.1	N/A
Ammonium (mg/l)	10.0	0.42	0.08	10.0
Arsenic (mg/l)	0.05	0.001		0.05
Barium (mg/l)	1.0	0.10		1.0
Bicarbonate (mg/l)	N/A	347	20.4	see Total Carbonate
Boron (mg/l)	N/A	0.91	0.049	N/A
Cadmium (mg/l)	0.01	0.007		0.01
Carbonate (mg/l)	N/A	8.9		see Total Carbonate
Chloride (mg/l)	250.0	198	22.6	250.0
Chromium (mg/l)	N/A	0.05		N/A
Copper (mg/l)	1.0	0.01		1.0
Fluoride (mg/l)	4.0	0.70	0.05	4.0
Iron (mg/l)	0.30	0.05		0.30
Mercury (mg/l)	0.002	0.001		0.002
Manganese (mg/l)	0.05	0.01		0.05
Molybdenum (mg/l)	1.00	0.10		1.00
Nickel (mg/l)	0.15	0.05		0.15
Nitrate (mg/l)	10.0	0.1		10.0
Nitrite (mg/l)	N/A	0.1		N/A
Lead (mg/l)	0.05	0.05		0.05
Radium (pCi/L)	5.0	142	148.0	438
Selenium (mg/l)	0.01	0.004		0.01
Silica	N/A	12.9	1.1	N/A
Sodium (mg/l)	N/A	387	21.6	3,870
Specific Conductivity (μmho/cm)	N/A	1,979	85.5	N/A
Sulfate (mg/l)	250.0	346	20.1	386
Uranium (mg/l)	5.0	0.110	0.138	5.0
Vanadium (mg/l)	0.2	0.10		0.2
Zinc (mg/l)	5.0	0.01		5.0
pH (Std. Units)	6.5 - 8.5	8.6	0.3	6.5 – 9.2

Baseline and Restoration Values for Mine Unit 7

Parameter	Groundwater Standard	MU-7 Baseline	MU-7 Standard Deviation	MU-7 NDEQ Restoration Value
Calcium (mg/l)	N/A	12.2	2.6	122
Total Carbonate (mg/l)	N/A	356		588
Potassium (mg/l)	N/A	12.9	3.0	129
Magnesium (mg/l)	N/A	3.2	0.7	32
TDS (mg/l)	N/A	1,176	40.7	1,217

Crow Butte Resources, Inc.

Safety and Environmental Review Panel

Evaluation Report – SERP 99-03

Wellhouse 25 and 28 Approval

July 23, 1999

The Crow Butte Resources, Inc. (CBR) Safety and Environmental Review Panel (SERP) met to review and approve operation of Wellhouses 25 and 28 at the Crow Butte Uranium Project.

The SERP appointed for this evaluation consisted of the following members:

Name	Title	Area of Expertise
Steve Magnuson	Vice President, Manager of Operations	Management
Chuck Miller	Plant Manager	Operations
Jim Stokey	Senior Engineer	Wellfield Construct
Mike Griffin	Manager of Environmental and Regulatory Affairs	Regulatory Affairs/ Radiation Safety
Rhonda Grantham	Corporate RSO	Radiation Safety

Mr. Magnuson is the SERP Chairman. Mr. Griffin was appointed SERP Secretary for this evaluation.

Purpose of SERP Evaluation

The purpose of this evaluation by the CBR SERP was to review and approve Wellhouses 25 and 28 for operation. The SERP evaluation was conducted in accordance with CBR Standard Operating Procedure (SOP) C-2, *Safety and Environmental Review Panel.* The SERP reviewed the Wellhouse startup checklists and supporting documentation and evaluated this information as compared with the requirements of the licensing basis, including the following documents:

- Title 10, Code of Federal Regulations;
- Source Materials License SUA-1534, Amendment No. 4 dated April 22, 1999;
- *Application for Renewal of USNRC Radioactive Source Materials License SUA-1534*, Crow Butte Resources, Inc. December 1995;

- *Environmental Assessment for Renewal of Source Materials License No. SUA-1534*, USNRC February 1998;
- *Safety Evaluation Report for Renewal of Source Materials License No. SUA-1534*, USNRC February 1998.

License Condition 9.4 allows CBR to make changes that are not presented in the approved application if such changes:

- Do not conflict with any requirement specifically stated in the license or impair CBR's ability to meet all applicable NRC regulations;

- Do not degrade essential safety or environmental commitments in the application or reclamation plan; and

- Are consistent with the conclusions of action analyzed and selected in the Environmental Assessment (EA).

Title 10 Code of Federal Regulations

The proposed change will have no impact on CBR's ability to meet all applicable NRC regulations.

Source Materials License SUA-1534 Requirements

Amendment 4 to SUA-1534 dated April 22, 1999 was reviewed for specific requirements related to approval and operation of a wellhouse.

License Condition 9.3: This License Condition requires that CBR conduct operations in accordance with commitments contained in the approved License Renewal Application (LRA).

The well construction methods in use for Wellhouses 25 and 28 are the same as those described in the LRA. The SERP reviewed the Well House Start-up Checklist for Wellhouse 25 and 28. This checklist was developed by the Wellfield Construction staff to document completion of all required actions prior to initiating operations in a wellhouse. Some of these actions are required by regulatory requirements, while some were developed over the course of mining experience at Crow Butte. Nine additional items were recommended by the CRSO to ensure that all commitments made in the LRA and CBR Standard Operating Procedures have been completed. The Senior Engineer reviewed these items and stated that all had been completed and appropriate controls were in place.

SERP 99-02 reviewed the MIT information contained in the Notice of Intent to Mine (NOI) which included the MITs for wells associated with Wellhouse 28. All MIT data sheets reviewed met the requirements.

A copy of the Well House Start-Up Checklist and a checklist covering the nine additional items is attached to this SERP Evaluation. Supporting documentation in the form of pressure tests and ground continuity checks are also attached.

Environmental Assessment

The SERP reviewed the contents of the Environmental Assessment (EA) prepared by NRC in February 1998 to determine whether the proposed change could cause substantive safety or environmental impacts.

Well construction and testing as described in the EA has been completed for the wells associated with Wellhouses 25 and 28. This information was submitted to the NDEQ for approval with the Notice of Intent to Mine (NOI).

Section 3.3.1 discusses leak testing of wellfield piping. The SERP reviewed the completion of pressure testing for piping systems associated with Wellhouses 25 and 28 and found that they meet the intent of the EA.

Financial Surety

The proposed change is covered in the NRC-approved financial surety maintained by CBR.

Safety Evaluation Report

The Safety Evaluation Report (SER) principally provides the basis for worker safety at Crow Butte and does not specifically address the issues related to approval of Wellhouses 25 and 28.

Degradation of Essential Safety or Environmental Commitment

SUA-1534 allows CBR to make changes as long as they do not degrade the essential safety or environmental commitments made in the application. The SERP determined that safety commitments made in the LRA and discussed in the EA have been met and that startup of Wellhouse 25 in Mine Unit 6 and Wellhouse 28 of Mine Unit 7 will not degrade the safety and environmental commitments.

Based upon this evaluation of the licensing basis, the CBR SERP hereby approves startup and operation of Wellhouse 25 in Mine Unit 6 and Wellhouse 28 in Mine Unit 7.

CROW BUTTE RESOURCES, INC.

Approved this 23rd day of July 1999.

Steve Magnuson, Vice President, Manager of Operations
SERP Chairman

Chuck Miller, Plant Manager

Jim Stokey, Senior Engineer

Mike Griffin, Manager of Environmental and Regulatory Affairs
SERP Secretary

Rhonda Grantham, Corporate Radiation Safety Officer

Well House Start-Up Checklist

House # 25
Start-up Date:

Item	Description	Person	Comments	Date Completed	Initial
1	**Permit to operate**	Brost/Stokey		12/22/98	TS
2	Review pressure testing data	Kirk/Stokey		2/11/99	TS
3	Map of 2" lines	Kirk		12/21/99	TS
4	Layout map in house	Kirk/Wade		5/18/99	TS
5	Check valve stations	Kirk/Stokey			TS
6	Check berms	Kirk/Stokey	SM - MG · JS Propane tel. Fixed	7-20-99	JS
7	Pressure check oxygen lines	Kirk		4/16/99	TS
8	Continuity check on producers	Don		4/16/99	TS
9	Ground fault check	Chuck/REA		2/11/99	TS
10	Communications wire check	Stokey		2/16/99	TS
11	Heater size check	Prosser		3/12/99	TS
12	UPS installed and operational check	Chuck/Stokey		3/15/99	TS
13	Wet house alarm installed	Chuck/Stokey		2/16/99	TS
14	Wet house alarm checked	Pete/Jay		4/23/99	TS
15	Oxygen solenoid checked	Pete/Jay			PJ
16	Install fuse on power supply	Chuck/Stokey		NA	TS
17	Program Control View	Roberts		2/2/99	TS
18	Program PLC	Stokey		12/21/98	TS
19	Key/switch on for alarming	Pete/Jay			PJ
20	Set dip switches	Jay		5/3/99	TS
21	Fire extinguisher w/placard	Kirk		1/21/99	TS
22	Off tags and lockouts	Pete/Jay		3/26/99	TS
23	Contaminated and uncontaminated cans	Pete/Jay		5/11/99	TS

Well House Start-Up Checklist

House # 25
Start-up Date: 7/26/99

Item	Description	Person	Comments	Date Completed	Initial
1	Complete Pressure Testing (Trunkline and House)	McDowell/Stokey		2-11-99	JS
2	Pipelines checked for leaks	McDowell		2-11-99	JS
3	Pipelines buried	McDowell		2-11-99	JS
4	Pressure gauge on injection manifold	Prosser		2-11-99	JS
5	Injection lines equipped with totalizing flow meters	Prosser/Stokey		2-11-99	JS
6	Injection and Production total flows can be measured	Stokey		2-11-99	JS
7	Unused trunkline locked out by two separate means	McDowell		2-12-99	JS
8	Isolation valves are closed and chained	McDowell		2-12-99	JS
9	Processor installed well house	Stokey		2-11-99	JS
10	Complete 2" lateral inspection	McDowell/Stokey		7-21-99	JS
11	Visually inspect entire system to plant	McDowell/Stokey		7-21-99	JS

/

Lateral Completion Form

Well House # 25

Kirk McDowell

Well No.	Completed WELLS	LOCK-OUTS ON UNCOMPLETED WELLS Plug Number	Date Installed	Initial	LOCK-OUTS Date Removed	Initial
P 1355	H/U					
P 1583	H/U					
P 1584	H/U					
P 1585	H/U					
P 1588	H/U					
P 1639	H/U					
P 1733	H/U					
P 1746	H/U					
P 1751	H/U					
P 1756	H/U					
P 1761	H/U					
P 1770	H/U					
P 1774	H/U					
P 1778	H/U					
P 1788	H/U					
P 1799	H/U					
P 1800	H/U					
P 1832	H/U					
P 1833	H/U					
P 1850	H/U					
P 1862	H/U					
P 1869	H/U					
P 1890	H/U					
I 1354	H/U					
I 1356		003	7-14-99	BS		
I 1586	H/U					
I 1587	H/U					
I 1638	H/U					
I 1640	H/U					
I 1641	H/U					
I 1653	H/U					
I 1654	H/U					
I 1655	H/U					
I 1656		001	7-14-99	BS		
I 1665	H/U					
I 1666	H/U					
I 1730	H/U					
I 1731	OK JS					
I 1732	H/U					
I 1734	H/U					
I 1740	H/U					

Well No.	Completed WELLS	LOCK-OUTS ON UNCOMPLETED WELLS Plug Number	Date Installed	Initial	LOCK-OUTS Date Removed	Initial
I 1741	H/U					
I 1752	H/U					
I 1755	H/U					
I 1757	H/U					
I 1762	H/U					
I 1773	H/U					
I 1775	H/U					
I 1776	H/U					
I 1777	H/U					
I 1784		002	7/14/99	BS		
I 1785	H/U					
I 1786	H/U					
I 1787	H/U					
I 1797	H/U					
I 1798	H/U					
I 1801	H/U					
I 1802	H/U					
I 1817	H/U					
I 1818	H/U					
I 1819	H/U					
I 1825	H/U					
I 1849	H/U					
		Capped 077 in W.H.				
P1918 →		11006	7-20-99	[illegible]		

On 2-2-99 the O^2 line was pressure checked from 18-28 to WH 25.

Start 1140 @ 150 psi
Stop 1245 @ 150 psi

[illegible]

ON 6-27-99 the O^2 line was pressure checked from K to WH 30

Start 950 @ 150 PSI
End 1025 @ 150 PSI

ON 6-30-99 The inj. trunk line and 2" lines were pressure checked ~~from~~ using a centrifical pump. The line was checked from valve station K thru WH 30 to 19-3.

inj Start 1045 @ 100 PSI
End 1115 @ 97 PSI
~~Prod. Start 1120 @ 100 PSI~~
~~7-1-99 End 1150 @ 98 PSI~~

[illegible] 7-13-99

On 11-5-98 [redacted] 18-2 to WH23
O^2 line was pressure checked. Line was pressurized to 140 psi. 30 minutes later it had a reading of 140 psi.
Keith McDowell

WH 25

On 1-28-99 the inj. trunk lines and inj. 2nd lines were pressured to 100 psi with a centrifical pump using potable water.

Start 100 psi @ 1125
Stop 99 psi @ 1205
Pressured from 18-25 to well field in WH 25.

On 2-2-99 the prod. trunk line and prod. 2nd lines were pressured to 100 psi from 18-25 to the well field in WH 25 with a centrifical pump & potable water.
Start 100 psi @ 1105
Stop 98 psi @ 1135

Well House Start-Up Checklist

House # 28
Start-up Date: 7/15/99

Item	Description	Person	Comments	Date Completed	Initial
1	**Permit to operate**	Brost/Stokey	in Denver	7-20-99	MB
2	Review pressure testing data	Kirk/Stokey		7-19-99	JS
3	Map of 2" lines	Kirk		4-15-99	KM
4	Layout map in house	Kirk/Wade		7-19-99	WB
5	Check valve stations	Kirk/Stokey		7-20-99	KM
6	Check berms	Kirk/Stokey	Existing Berm will be OK.	7-19-99	JS
7	Pressure check oxygen lines	Kirk		8-27-99	KM
8	Continuity check on producers	Don/Jim/Stoky		7-20-99	LP
9	Ground fault check	Chuck/REA		7-15-99	CRM
10	Communications wire check	Stokey		7-18-99	JS
11	Heater size check	Prosser		7-20-99	LP
12	UPS installed and operational check	Chuck/Stokey		7-16-99	JS
13	Wet house alarm installed	Chuck/Stokey		7-16-99	JS
14	Wet house alarm checked	Pete/Jay		7-20-99	JS
15	Oxygen solenoid checked	Pete/Jay		7-21-99	Pd
16	Install fuse on power supply + Panel	Chuck/Stokey		7-20-99	JS
17	Program Control View	Roberts		7-20-99	TR
18	Program PLC	Stokey		7-19-99	JS
19	Key/switch on for alarming	Pete/Jay	Set to On JS	7-20-99	JS
20	Set dip switches	Jay		7-20-99	JS
21	Fire extinguisher w/placard	Kirk		7-14-99	KM
22	Off tags and lockouts	Pete/Jay		7-21-99	JS
23	Contaminated and uncontaminated cans	Pete/Jay		7-21-99	Pd

Well House Start-Up Checklist

House # 28
Start-up Date: 7/26/99

Item	Description	Person	Comments	Date Completed	Initial
1	Complete Pressure Testing (Trunkline and House)	McDowell/Stokey		7-19-99	JS
2	Pipelines checked for leaks	McDowell		7-19-99	JS
3	Pipelines buried	McDowell		7-19-99	JS
4	Pressure gauge on injection manifold	Prosser		7-19-99	JS
5	Injection lines equipped with totalizing flow meters	Prosser/Stokey		7-19-99	JS
6	Injection and Production total flows can be measured	Stokey		7-19-99	JS
7	Unused trunkline locked out by two separate means	McDowell		7-20-99	JS
8	Isolation valves are closed and chained	McDowell		7-20-99	JS
9	Processor installed well house	Stokey		7-21-99	JS
10	Complete 2" lateral inspection	McDowell/Stokey		7-21-99	JS
11	Visually inspect entire system to plant	McDowell/Stokey		7-21-99	JS.

Lateral Completion Form

Well House # 28

Well No.	Completed WELLS	LOCK-OUTS ON UNCOMPLETED WELLS Plug Number	Date Installed	Initial	LOCK-OUTS Date Removed	Initial
PBL28	OK					
P1955	OK					
P1957	OK					
P1972A	OK					
P2014	OK					
P2032	OK					
P2035	OK					
P2057	OK					
P2075	OK					
P2089	OK					
P2092	OK					
P2097	OK					
P2101	OK					
P2103	OK					
P2108	OK					
P2113	OK					
P2120	OK					
P2121A	OK					
P2125	OK					
P2130	OK					
P2136	OK					
P2139	OK					
P2144	OK					
P2159	OK					
P2191	OK					
P2196	OK					
P2197	OK					
P2271	OK					
P2272	OK					
P2280	OK					
I1950	OK					
I1952	OK					
I1953	OK					
I1954	OK					
I1956	OK					
I1962	OK					
I1971		909	7-20-99	RS		
I1990		904	7-19-99	[illegible]		
I1994	OK					
I2007	OK					
I2009	OK					

Well No.	Completed WELLS	LOCK-OUTS ON UNCOMPLETED WELLS Plug Number	Date Installed	Initial	LOCK-OUTS Date Removed	Initial
I2012	OK					
I2013	OK					
I2015	OK					
I2026	OK					
I2027	OK					
I2031	OK					
I2034	OK					
I2050	OK					
I2056	OK					
I2058	OK					
I2073	OK					
I2074	OK					
I2078	OK					
I2086	OK					
I2090	OK					
I2091	OK					
I2093	OK					
I2094	OK					
I2098	OK					
I2100	OK					
I2102	OK					
I2104	OK					
I2106	OK					
I2107	OK					
I2110	OK					
I2111	OK					
I2118	OK					
I2119	OK					
I2124	OK					
I2137	OK					
I2138	OK					
I2142	OK					
I2150	OK					
I2152	OK					
I2273	OK					
I2274	OK					
I2276	OK					
I2277	OK					
I2281	OK					

Signed: [signature]
Wellfield Construction Foreman

Date of final inspection: ____________

Continuity Check

Well House #28

	Well No.	Well to House Continuity OHMS	Comments	Date	Initial
*	PBL28	.3			
	P1955	.5			
	P1957	.6			
	P1972A	1.4			
	P2014	.3			
	P2032	.3			
Bad wire →	P2035	.5			
	P2057	.5			
	P2075	1			
	P2089	.5			
	P2092	1			
	P2097	.7			
*	P2101	.6			
☆	P2108	.5			
	P2103	.7			
	P2113	1.2			
	P2120	.9			
	P2121	1			
	P2125	.6			
check yellow →	P2130	.9			
*	P2136	7			
No wires *	P2139	0.8			
	P2144	.8			
	P2159	1.1			
	P2191	.8			
	P2196	.8			
*	P2197	.8			
	P2271	.3			
	P2272	.8			
	P2280	1.4			

On 2-2-99 the O^2 line was pressure checked from 18-25 to WH 25.

Start 1140 @ 150 PSI
Stop 1245 @ 150 PSI

Keith McDowell

ON 6-27-99 the O^2 line was pressure checked from K to WH 30

start 950 @ 150PSI
END 1025 @ 150PSI

ON 6-30-99 The inj. trunk line and 2" lines were pressure checked ~~from~~ ~~2~~ using a centrifical pump. The line was checked from valve station K thru WH 30 to ~~B~~ 19-3.

inj start 1045 @ 100 PSI
End 1115 @ 97 PSI
~~Prod. start 1120 @ 100 PSI~~
~~7-1-99 End 1150 @ 98 PSI~~

Keith McDowell 7-13-99

On 11-5-98 ([redacted]) 18-2 to WH23
O^2 line was pressure checked. Line was pressurized to 140 psi. 30 minutes later it had a reading of 140 psi.
Keith McDowell

WH 25

On 1-28-99 the inj. trunk lines and inj. 2nd lines were pressured to 100 psi with a centrifical pump using potable water.

Start 100 psi @ 1125
Stop 99 psi @ 1205

Pressured from 18-25 to well field in WH 25.

On 2-2-99 the prod. trunk line and prod. 2: lines were pressured to 100 psi from 18-25 to the well field in WH 25 with a centrifical pump & potable water.

Start 100 PSI @ 1105
Stop 98 PSI @ 1135

On 7-1-99 the Prod.
trunk lines and 2" lines
from K thru WH30 to
19-3 were pressure
checked using a
centrifical pump.

Start 1120 @ 100 PSI
End 1150 @ 98 PSI
Kurt McDowell
7-13-99

Crow Butte Resources, Inc.

Safety and Environmental Review Panel

Evaluation Report – SERP 99-04

Wellhouse 30 Approval

November 22, 1999

The Crow Butte Resources, Inc. (CBR) Safety and Environmental Review Panel (SERP) met to review and approve operation of Wellhouse 30 at the Crow Butte Uranium Project.

The SERP appointed for this evaluation consisted of the following members:

Name	Title	Area of Expertise
Steve Magnuson	Vice President, Manager of Operations	Management
Mike Griffin	Manager of Environmental and Regulatory Affairs	Regulatory Affairs/ Radiation Safety
Chuck Miller	Plant Manager	Operations
Jim Stokey	Senior Engineer	Wellfield Construct
Rhonda Grantham	Corporate RSO	Radiation Safety

Mr. Magnuson is the SERP Chairman. Mr. Griffin was appointed SERP Secretary for this evaluation.

Purpose of SERP Evaluation

The purpose of this evaluation by the CBR SERP was to review and approve Wellhouse 30 for operation. The SERP evaluation was conducted in accordance with CBR Standard Operating Procedure (SOP) C-2, *Safety and Environmental Review Panel.* The SERP reviewed the Wellhouse startup checklists and supporting documentation and evaluated this information as compared with the requirements of the licensing basis, including the following documents:

- Title 10, Code of Federal Regulations;
- Source Materials License SUA-1534, Amendment No. 5 dated September 23, 1999;
- *Application for Renewal of USNRC Radioactive Source Materials License SUA-1534*, Crow Butte Resources, Inc. December 1995;
- *Environmental Assessment for Renewal of Source Materials License No. SUA-1534*, USNRC February 1998;

- *Safety Evaluation Report for Renewal of Source Materials License No. SUA-1534*, USNRC February 1998.

License Condition 9.4 allows CBR to make changes that are not presented in the approved application if such changes:

- Do not conflict with any requirement specifically stated in the license or impair CBR's ability to meet all applicable NRC regulations;
- Do not degrade essential safety or environmental commitments in the application or reclamation plan; and
- Are consistent with the conclusions of action analyzed and selected in the Environmental Assessment (EA).

Title 10 Code of Federal Regulations

The proposed change will have no impact on CBR's ability to meet all applicable NRC regulations.

Source Materials License SUA-1534 Requirements

Amendment 5 to SUA-1534 dated September 23, 1999 was reviewed for specific requirements related to approval and operation of a wellhouse.

Mine Unit 7 was previously approved by the CBR SERP (see SERP 99-02). Therefore, no review of monitor well location or installation or baseline sampling and Upper Control Limit determination is required for Wellhouse 30.

License Condition 10.2: This License Condition requires that CBR all wells in accordance with the methods contained in the Section 3.1.2 of the approved License Renewal Application (LRA)

The well construction methods in use for Wellhouse 30 are the same as those described in the LRA. In the approval of Wellhouse 30 dated October 21, 1999, the Nebraska Department of Environmental Quality (NDEQ) noted that some Well Completion Reports indicated that cement was not recirculated to the surface during well construction. The drawings depicting the well construction methods that are contained in Section 3.1.2 of the LRA indicate that cement is returned to the surface. The Chief Geologist has indicated that the difficulty in obtaining cement return in some areas (including Wellhouse 30) is apparently related to zones in the area that act to divert cement from the annular space around the casing. CBR has previously filled this void in the top of the annular space by the addition of native soil or bentonite.

Discussions are underway with the NDEQ for proper construction methods to address this issue. CBR has begun an initial program to identify the volume of void spaces in wells that were recently installed and did not obtain cement return. As noted below, all Wellhouse 30 wells passed the mechanical integrity test (MIT). Based upon this, NDEQ identified this as a concern for all future wells. In the meantime, the NDEQ has approved operation of Wellhouse 30 as constructed. The CBR SERP will review and approve the proposed changes to the construction methods when agreement is reached with the NDEQ.

License Condition 10.2 also requires that CBR perform mechanical integrity tests (MIT) for all injection and production wells. All MIT data sheets were contained in the Notice of Intent to Operate submitted to the NDEQ for Wellhouse 30 and were reviewed by the SERP. The records indicate that the MITs performed in Wellhouse 30 met the requirements.

<u>License Condition 9.3:</u> This License Condition requires that CBR conduct operations in accordance with the representations contained in the LRA. Section 3.1.3 of the LRA discusses construction materials, instrumentation, and monitoring requirements. Section 3.3 also discusses instrumentation, including wellhouse injection and production instrumentation and wet building alarms for wellhouses. Section 7.2.3 of the LRA requires that leak tests be performed on all wellfield piping before placing the system into production operations.

The SERP reviewed the Well House Start-up Checklist for Wellhouse 30. This checklist was developed by the Wellfield Construction staff to document completion of all required actions before initiating operations in a wellhouse. Some of these actions are required by regulatory and licensing requirements, while some were developed over the course of mining experience at Crow Butte. The Senior Engineer reviewed these items and stated that all had been completed and the appropriate controls were in place.

A copy of the Well House Start-Up Checklist is attached to this SERP Evaluation. Supporting documentation in the form of pressure tests and ground continuity checks are also attached.

<u>Environmental Assessment</u>

The SERP reviewed the contents of the Environmental Assessment (EA) prepared by NRC in February 1998 to determine whether the proposed change could cause substantive safety or environmental impacts.

Well construction and testing as described in the EA has been completed for the wells associated with Wellhouse 30.

Section 3.3.1 discusses leak testing of wellfield piping. The SERP reviewed the completion of pressure testing for piping systems associated with Wellhouse 30 and found that they meet the intent of the EA.

Financial Surety

The proposed change is covered in the NRC-approved financial surety maintained by CBR.

Safety Evaluation Report

The Safety Evaluation Report (SER) principally provides the basis for worker safety at Crow Butte and does not specifically address the issues related to approval of Wellhouse 30.

Degradation of Essential Safety or Environmental Commitment

SUA-1534 allows CBR to make changes as long as they do not degrade the essential safety or environmental commitments made in the application. The SERP determined that safety commitments made in the LRA and discussed in the EA have been met and that startup of Wellhouse 30 in Mine Unit 7 will not degrade the safety and environmental commitments.

Based upon this evaluation of the licensing basis, the CBR SERP hereby approves startup and operation of Wellhouse 30 in Mine Unit 7.

Approved this 22nd day of November 1999.

Steve Magnuson, Vice President, Manager of Operations
SERP Chairman

Mike Griffin, Manager of Environmental and Regulatory Affairs
SERP Secretary

Chuck Miller, Plant Manager

Jim Stokey, Senior Engineer

Rhonda Grantham, Corporate Radiation Safety Officer

Well House Start-Up Checklist

House # 30
Start-up Date: 11/30/99

Item	Description	Person	Comments	Date Completed	Initial
1	**Permit To Operate**	Brost/Stokey	Done	10-30-99	[illegible]
2	Complete Pressure Testing (Trunkline and House)	McDowell/Stokey		11-19-99	[illegible]
3	Pipelines checked for leaks	McDowell	Done	11-12	[illegible]
4	Pipelines buried	McDowell	Done	11-12	[illegible]
5	Pressure gauge on injection manifold	Prosser	Done	11-12-99	JP
6	Injection lines equipped with totalizing flow meters	Prosser/Stokey	Done	11-12-99	JP
7	Injection and Production total flows can be measured	Stokey		11-22-99	[illegible]
8	Unused trunkline locked out by two separate means	McDowell	Done	11-12	[illegible]
9	Isolation valves are closed and chained	McDowell		11-19	[illegible]
10	Map of 2" lines	McDowell		11-22	[illegible]
11	Well-field Layout map in house	McDowell/Wade		11-19	[illegible]
12	Check berms	Stokey/Griffin		11-22	WG
13	Pressure check oxygen lines	McDowell	Done	11-12	[illegible]
14	Continuity check on producers	Bass/Prosser/Stokey	NA	—	—
15	Ground fault check	REA/Miller/Stokey		11-22-99	[illegible]
	Communications wire check	Stokey		11-22-99	[illegible]
17	~~Heat trace~~ check SETTING ON HEATERS	Prosser/Stokey	Pre set.	11-12-99	JP
18	Processor installed well house	Stokey		11-22-99	[illegible]
19	UPS installed and operational	Stokey		11-19-99	[illegible]
20	Wet house alarm installed	Stokey		11-19-99	[illegible]
21	Wet house alarm checked	Dunn/Douthit/Stokey		11-22-99	[illegible]
22	Oxygen solenoid checked looks ok	Dunn/Douthit/Stokey		11-22-99	JD
23	Check fuses in control panel	Stokey		11-19-99	[illegible]
24	Program control view	Roberts/Stokey		11-19-99	[illegible]
25	Program PLC	Stokey		11-18-99	[illegible]
26	Switch on for alarming	Dunn/Douthit/Stokey		11-22-99	[illegible]
27	Set Scalar Card 'K' Factors	Dunn/Douthit		11-22-99	JD
28	Fire extinguisher w/placard	McDowell		11-19-99	[illegible]
29	Off tags and lockouts	Prosser/Dunn/Douthit	NA	—	—
30	Contaminated and uncontaminated cans	Dunn/Douthit		11-22-99	PD
31	Complete 2" lateral inspection	McDowell/Stokey	Done	11-12	[illegible]
	Visually inspect entire system to plant	McDowell/Stokey		11-22	[illegible]

STATE OF NEBRASKA

DEPARTMENT OF ENVIRONMENTAL QUALITY
Suite 400, The Atrium
1200 'N' Street
P.O. Box 98922
Lincoln, Nebraska 68509-8922
Phone (402) 471-2186

OCT 2 1 1999

Mike Johanns
Governor

Mr. Steve Collings
Crow Butte Resources, Inc.
1670 Broadway, Suite 3450
Denver, CO 80202

Dear Mr. Collings:

On October 7, 1999 the Nebraska Department of Environmental Quality received a submittal of information from Crow Butte Resources, Inc. The submittal serves as Notice of Intent to Operate and contains Well Completion Reports and Casing Integrity Test Reports for recently installed wells (Wellhouse 30) in the construction of Mine Unit 7.

The Department has reviewed the information submitted and determined that it is adequate and complete. Upper Control Limits and Restoration Values established for Mine Unit 7 have already been submitted and approved. Approval of the additional portion of Mine Unit 7 will not alter those values. The Department hereby approves the Notice of Intent to Operate the additional portion of Mine Unit 7.

It should be noted, that during the review of Well Construction Reports contained in the Notice of Intent to Operate, the Department became concerned that in 23 of the 75 wells constructed, the cement was not circulated back to the surface. According to Permit Number NE0122611, Part III., A., all wells will be constructed according to Section 10.2 of the November 1987 Application and Supporting Environmental Report for a Commercial Permit. In this section, both well construction methods outlined indicate that the cement will be returned to the surface. In the future, in order to stay in compliance with the Permit conditions, the cement must be returned to the surface and documented as such in all newly constructed wells.

If you have any questions concerning this matter, please contact David Miesbach of my staff at (402) 471-4982. Thank-you.

Sincerely,

Michael J. Linder
Director

ML/dlm
pc: Dave Carlson, NDEQ
Mike Griffin, CBR

CROW BUTTE RESOURCES, INC.

Well House Pressure Check Verification

Pressure check for Well House WH 30. **Date:** 11-18-99

Injection:
On 11-9-99 the injection trunk lines and 2" laterals were pressured to 100 psi. This was done using a centrifugal pump and potable water. The time interval was as follows:

Start: 100 psi at 1100 (AM) / PM
Stop: 98 psi at 1130 (AM) / PM

The section of trunk line checked was from valve station 19-30 to the well field in WH 30.

Production:
On 11-8-99 the production trunk lines and 2" laterals were pressured to 100 psi. This was done using a centrifugal pump and potable water. The pressure and time interval was as follows:

Start: 100 psi at 0810 (AM) / PM
Stop: 98 psi at 0840 (AM) / PM

The section of trunk line checked was from valve station 19-30 to the well field in WH 30.

Oxygen:
On 10-21 the oxygen line was pressured to 150 psi. The pressure and time interval was as follows:

Start: 150 psi at 1200 (AM) PM
Stop: 150 psi at 1240 AM / (PM)

The section of trunk line checked was from valve station 19-30 to the well field in WH 30.

Kurt McDowell

Well field Construction Foreman

Well No.	Completed WELLS	LOCK-OUTS ON UNCOMPLETED WELLS			LOCK-OUTS	
		Plug Number	Date Installed	Initial	Date Removed	Initial
I 2200	KM					
I 2203	KM					
I 2204	KM					
I 2218	KM					
I 2230	KM					
I 2231	KM					
I 2232	KM					
I 2233	KM					
I 2235	KM					
I 2249	KM					
I 2250	KM					
I 2253	KM					
I 2255	KM					
I 2267	KM					
I 2282	KM					
I 2304	KM					
I 2311	KM					
I 2313	KM					
I 2314	KM					
I 2321	KM					
I 2323	KM					
I 2324	KM					
I 2325	KM					
I 2326	KM					
I 2329	KM					
I 2333	KM					
I 2334	KM					
I 2342	KM					
I 2343	KM					
I 2344	KM					
I 2349	KM					
I 2355	KM					
I 2362	KM					
I 2365	KM					
I 2371	KM					
I 2372	KM					
I 2373	KM					
I 2374	KM					
I 2376	KM					

Well House # 30

		LOCK-OUTS ON UNCOMPLETED WELLS			LOCK-OUTS	
Well No.	Completed WELLS	Plug Number	Date Installed	Initial	Date Removed	Initial
P 2036	KM					
P 2037	KM					
P 2040	KM					
P 2060	KM					
P 2219	KM					
P 2305	KM					
P 2310	KM					
P 2322	KM					
P 2332	KM					
P 2339	KM					
P 2340	KM					
P 2350	KM					
P 2359	KM					
P 2360	KM					
P 2385	KM					
P 2038	KM					
P 2201	KM					
P 2220	KM					
P 2303	KM					
P 2328	KM					
P 2331	KM					
P 2341	KM					
P 2354	KM					
P 2361	KM					
P 2366	KM					
P 2367	KM					
P 2368	KM					
P 2369	KM					
P 2370	KM					
P 2384	KM					
I 1973	KM					
I 1974	KM					
I 1975	KM					
I 1976	KM					
I 1977	KM					
I 2077	KM					
I 2132	KM					
I 2133	KM					
I 2158	KM					
I 2160	KM					
I 2199	KM					

GROUND RESISTANCE TEST

DATE: NOVEMBER 22,1999

LOCATION	ROD #1	ROD #2	ROD #3	ROD #4	SYSTEM	TOTAL
WELLFIELD HOUSE # 30	0.7	11.4			19.0	0.6

TOTAL RESISTANCE = 1 / (1/R1 +1/R2...1/Rn) =OHMS

BY: C. R. MILLER___C R Miller_____ CBR
KEVI N SCHULZE__Kevin D. Schulze__NWRPPI

Well House #30

Well No.		Well to House Continuity OHMS	Comments	Date	Initial
P	2036	.9		11-22-99	JP
P	2037	.7		11-22-99	JP
P	2038	.7		11-22-99	JP
P	2040	.4		11-22-99	JP
P	2060	.5		11-22-99	JP
P	2201	1.1		11-23-99	JP
P	2219	1.4		11-23-99	JP
P	2220	1		11-23-99	JP
P	2303	.8		11-23-99	JP
P	2305	.4		11-23-99	JP
P	2310	.7		11-23-99	JP
P	2322	.5		11-23-99	JP
P	2328	.6		11-23-99	JP
P	2331	.8		11-23-99	JP
P	2332	1.3		11-23-99	JP
P	2339	1		11-23-99	JP
P	2340	.8		11-23-99	JP
P	2341	.6		11-24-99	JP
P	2350	.7		11-24-99	JP
P	2354	.4		11-24-99	JP
P	2359	.3		11-24-99	JP
P	2360	.7		11-24-99	JP
P	2361	.8		11-24-99	JP
P	2366	.7		11-24-99	JP
P	2367	.8		11-24-99	JP
P	2368	.7		11-24-99	JP
P	2369	.8		11-24-99	JP
P	2370	1.1		11-24-99	JP
P	2384	.8		11-29-99	JP
P	2385	.6		11-29-99	JP