40-8968

November 8, 1996

Mr. Richard F. Clement, Jr., President
Hydro Resources, Inc.
2929 Coors Blvd., NW
Suite 101
Albuquerque, NM 87120

SUBJECT: TRANSMITTAL OF COMMENTS ON HYDRO RESOURCES, INC.'S LICENSE APPLICATION FOR THE CROWNPOINT, NEW MEXICO PROJECT

Dear Mr. Clement:

The purpose of this letter is to transmit the enclosed staff evaluations regarding Hydro Resources, Inc.'s (HRI) proposed in situ leach mining project at Crownpoint, NM. All of the enclosed comments pertain to the hydrologic portion of the staff's review. These conclusions will be used as the technical basis supporting the staff's review and findings in the environmental impact statement (EIS). Please be advised that these conclusions are preliminary, and have yet to undergo formal NRC management and legal review, which will be accomplished prior to issuance of the final EIS.

The aforementioned enclosure consists of both open and closed comments. The open issues are Comments 50, 74, 75, 95, 97, and 98. The latter two comments are new issues based on the staff's continuing review of HRI's license application. The closed issues are Comments 28-31, 52, 57, and 96. The staff may generate additional comments in the area of ground water hydrology based on its continuing review of HRI's responses. Any comments will be forwarded to you as soon as they are finalized.

If you have any questions concerning this subject, please contact Mr. Robert Carlson of my staff at (301) 415-8165.

Sincerely,

Original Signed By:]

Daniel M. Gillen, Assistant Chief
Uranium Recovery Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

cc: M. Pelizza, HRI
B. Saulsbury, ORNL

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OPEN COMMENTS

ENCLOSURE

50. **COMMENT:** Degradation of Crownpoint Water Supply Wells By Restored Solution Mine Ground Water

EVALUATION OF RESPONSE:

APPLICANT'S RESPONSE: The applicant was asked to demonstrate that ground water degraded by solution mining activities, even after restoration for both of the Unit 1 and the Crownpoint properties, will not degrade the town of Crownpoint water supply (mining over the whole of both properties should be considered, not just the first 5 years at the Crownpoint property). The applicant replied (HRI, 1996a) that "*The basic concept and regulation of in situ mining industry have been designed to protect the fresh ground-water supplies that may be located near an in situ mine. The controls in place both during mining and restoration have been shown to protect ground water away from the mine. To arbitrarily state that mines in remote areas away from water supply wells are inherently safer, implies that residual contamination is acceptable in such area but not in others. The implication would appear to be contrary to the regulations*". The NRC staff notes that the restoration criteria proposed for the Crownpoint and Unit 1 sites are similar to what the NRC has licensed in remote locations. However, the risk of applying these criteria in close proximity to a public water supply located in the zone of mining is significantly different.

The applicant noted that the license area boundary for the Crownpoint site has been redrawn with the result that the closest water supply well to the site boundary is 1,500 feet for the Crownpoint site and 11,000 feet for Unit 1 site. The applicant also states that federal and state Underground Injection Control (UIC) programs have defined the appropriate Area of Review for Class III wells, as proposed herein, as 1/4 mile (40 CFR 146.6 and NMWQCCR 2.202). The new site boundary places the town of Crownpoint water wells outside the 1/4 mile review distance. The NRC staff notes that the NRC does not have regulatory responsibility for the Underground Injection Program. The NRC staff also points out that 40 CFR § 146.6 (b) states that "a fixed radius not less than one fourth (1/4) mile may be used" (i.e. the radius may exceed 1/4 miles, but cannot be less than 1/4 mile).

The applicant also states that the degree of water level changes as a result of pumping from the town wells is not reflective of the rate of water movement. Referencing the modeled summer gradient premining ground water flow field (Figure 50-2), HRI indicated that it would require 35.6 years for the ground water to move from the closest Crownpoint license boundary to the closest water supply well (BIA 6) and 1,657 years to move from the closest Unit 1 boundary to NTUA 1.

The applicant further states that radionuclide ground-water concentrations limit the use of water (Ra-226, Rn-222 and U_3O_8) before mining in uranium-bearing aquifers. In addition, the presence of high radionuclide concentrations does not affect surrounding water supply wells because these parameters are not mobile and remain in the ore-body

not in the water supply wells. The NRC staff observes that the town of Crownpoint water supply wells are completed in the same uranium ore body proposed for mining, and produce good quality water. The NRC staff also observes that water data collected to date from the Crownpoint site indicate that significantly more good water quality wells have been drilled than bad So it is reasonable to conclude that the probability is high that good water quality can be located within the site boundary.

The applicant also states that the leach solution to be used is not significantly different than native ground water within the ore body. Furthermore, ground-water restoration is performed uniformly throughout the mine zone and verified statistically at individual sampling points. The confidence of the statistics can be increased by increasing sampling points (more wells) or increasing samples (stability period). However, the scientific principle which assures restoration is sound.

The applicant also points out that HRI's Crownpoint core study has shown that selenium and molybdenum will not be elevated during mining to the extent they were at the Mobil Section 9 Pilot Test. Furthermore, radionuclides, especially uranium, will be elevated during the mining process. However, after restoration dissolved radionuclides will be rapidly attenuated before they can reach the Crownpoint wells. The NRC staff has commented on many of these observations in it's evaluation of Comment 52.

Ground-Water Quality Impacts on Town of Crownpoint Wells:

Alternatives - Crownpoint Site:

In evaluating this question, the NRC staff evaluated three alternatives for the Unit 1 and Crownpoint properties. The applicant has proposed that worst case ground-water restoration targets be the higher of average premining ground-water quality, background data, or maximum permissible values. The applicant proposes that maximum permissible values be the lower of either State of New Mexico (NMWQCC 3-103.A and 3-103b) or EPA (40 CFR § 141 and 143.3) primary and secondary standards. For uranium, 300 pCi/ml (0.44 mg/l) will be used. This concentration was obtained from Table 2 of Appendix B, of 10 CFR § 20 and is suitable for unrestricted release of natural uranium to water.

Pumping by the Town of Crownpoint controls the direction of ground-water flow in the Westwater Canyon underneath both the Crownpoint and Unit 1 sites. This means that ground water in the Westwater Canyon aquifer beneath both properties is moving towards the Town of Crownpoint wells where it will be pumped into the town water supply system. Therefore, if uranium solution mining takes place at either the Unit 1 or Crownpoint site and the town continues to pump from it's existing water supply wells as it has in the past; water which has gone through the solution mining and restoration process will eventually reach the Town of Crownpoint water supply system. This situation is very analogous to a factory (or another town) using and returning water to a surface water body immediately upstream of a community which is using the same surface

water body as a source of drinking water.

To determine if ground water degraded by solution mining activities, even after restoration for both of the Unit 1 and the Crownpoint properties, could threaten the town of Crownpoint water supply, the NRC staff evaluated the following three alternatives for the Unit 1 and Crownpoint properties:

1. No Restoration of the Ground Water after mining.
2. Restoration to Secondary Restoration Goal.
3. Restoration to Primary Restoration Goal.

In evaluating these alternatives, it was assumed for all parameters where premining baseline values are below EPA water quality standards, that future public water supply wells would be located within the well fields of both the Unit 1 and Crownpoint sites. Therefore, if a scenario is found to be acceptable for these parameters, it should be acceptable with respect to future impacts on the water quality at the existing town of Crownpoint water supply wells.

However, for those parameters where premining baseline might exceed EPA water quality standards, the NRC conducted a modeling study to determine the projected impact on the water quality at the existing town of Crownpoint water supply wells. This approach was taken because if premining baseline values exceed federal drinking water standards, the well field will be restored to premining baseline averages. If these well field baseline concentrations are greater than baseline concentrations at the town water supply wells, then the previous assumption that acceptable restoration of the well field equals acceptable water quality impacts at the town wells cannot be made. Therefore, additional analysis for these parameters was done. An inspection of premining baseline data reveled that this situation only exists for radium and uranium.

Alternative 1 - No Ground-Water Restoration - Crownpoint Site

Table 50-1 contains a projected list of water quality concentrations in a well field at the end of mining, but prior to restoration activities in either the Unit 1 or Crownpoint properties. These concentrations were obtained from data collected from pregnant lixiviant at the Mobil Crownpoint Pilot *In Situ* Leach Project (Table 4.5, page 4-8, NRC, 1994) and from data submitted by the applicant on the Wyoming Mineral Corporation "E" Well Field (HRI, 1996a, response to NRC comment 52). Mobil Crownpoint Pilot data was chosen, because it was local to the site, was a large scale test, and was in the same aquifer as the proposed mining operations. The Irigary "E" Well Field was an sodium bicarbonate *in situ* uranium mining and restoration test well field that was operated in low total dissolved solids water similar in water quality to the Westwater Canyon aquifer. Irigary "E" Well Field data for barium, ammonia, magnesium, potassium, carbonate and vanadium was used, since data on these parameters was missing from the Mobil Pilot

test data. Irigary "E" Well Field data for uranium, total dissolved solids, and chloride was used, since it was felt that these better represented post mining conditions. Chloride is added to the ground water by the uranium processing plant and is not a result of interaction between the lixiviant and the host rock. Chloride values at the Mobil Pilot test are much higher than is seen at other *in situ* operations in low total dissolved solids ground waters, and probably reflects how Mobil operated it's processing plant. As a result, total dissolved solid concentrations would have been influenced by the increased chloride concentrations. Uranium values in the mobil test also appear to be much higher than would be expected for a production facility at the end of mining. For these reasons the Irigary "E" Well Field data was felt to more representative of these parameters.

From an inspection of projected post mining water concentrations (No Action Alternative, Table 50-1) it can be seen that radium-226, selenium, uranium, sulfate, chloride, manganese, total dissolved solids, and molybdenum greatly exceed both State of New Mexico and EPA drinking water standards. Therefore, water quality would degrade to the point that the ground water could not be used as a source of drinking water without treatment.

Alternative 2 - Restoration to Secondary Goal Values - Crownpoint Site

This alternative assumed that ground-water quality would be restored to Secondary Goal values. Health impacts analyses have been conducted for the EPA primary and secondary standards and therefore the impact of restoring the ground-water quality to these concentrations should preserve the water use of the aquifer. The restoration of uranium to 0.44 mg/l should not be a threat to public health. This concentration was derived from the concentration of 300 pCi/ml in Table 2 of Appendix B, of 10 CFR § 20, which identifies a concentration of 300 pCi/ml (0.44 mg/l) for unrestricted release of natural uranium (sum of uranium isotopes) to water.

Alternative 3 - Restoration to Primary Goal Values - Crownpoint Site

In this alternative it was assumed that the ground-water quality would be returned to the primary goal of restoration to premining well field baseline averages. Table 50-1 contains average water quality concentrations for the Crownpoint site. With the exception of radium, all of these concentrations are below EPA primary and secondary standards. Therefore, the impact of restoring the ground-water quality to these concentrations should preserve the water use of the aquifer.

However the average baseline for radium at the Crownpoint site is calculated to be 65.85 pCi/l. This concentration exceeds both state (30 pCi/l) and federal standards (5 pCi/l). At the town of Crownpoint wells (HRI, 1992, page 2-117) radium-226 baseline values range from 0.18 to 0.2 pCi/l. Therefore, the NRC staff conducted a modeling exercise to determine if restoring to a radium concentration of 65 pCi/l in the well

fields was acceptable at the town of Crownpoint wells.

The amount of dilution from ground water flow (advection) and well head dilution was modeled. As a first step, the NRC staff reviewed ground-water model results submitted by the applicant (Reed, 1993). This analytical model simulated premining ground water gradients as the result of summer pumping rates (as opposed to less pumping during the winter months) by the town of Crownpoint. In this model it was assumed that the town wells were pumped continuously from the Westwater Canyon aquifer at the following rates:

1. Well NTUA-1 27.7 gpm
2. Well NTUA Conoco 58.7 gpm
3. Well BIA-3 79.4 gpm
4. Well BIA-5 6.2 gpm
5. Well BIA-6 100.0 gpm

This comes to 0.5 million m^3/yr (439 acre-ft/yr). This is about 1.4 times the reported well capacities (BIA and NTUA wells) of 0.4 million m^3/yr (316 acre-ft/yr) for the town of Crownpoint (U.S. NRC, 1994, p. 3-33). The applicant obtained transmissivity data calculated from pump tests conducted near the town of Crownpoint and obtained the aquifer thickness value from well log data. The applicant input the following parameters into the code:

1. Transmissivity = 2,550 gpd/ft
2. Storage Coefficient = 0.000086
3. Porosity = 0.251
4. Aquifer Thickness = 201 ft

The computer model then simulated 3,121 years of pumping so that water levels and ground-water velocities were essentially not changing with time. Some of the results of the model are displayed in Figure 50-2 from HRI, 1996a. This figure shows flow pathways, selected ground-water velocities, and selected flow times to the town of Crownpoint wells. The model calculates that it would take 35.6 years for the ground water to flow from the boundary of the Crownpoint site in Section 29 (east of town) to well BIA-6; 90.4 years from the boundary of the Crownpoint property in Section 19 (west of town) to well NTUA-1; and 1,657.5 years from the eastern most Unit 1 site boundary in Section 14 to the town wells.

The NRC staff notes that the calculated ground-water flow times of 35.6 and 90 years for ground water to move to the closest water supply well are time periods within which it is quite likely that the town of Crownpoint could still be using water from the Westwater Canyon aquifer in the present area of the town wells. However, these time periods are also long enough that the pollution impact of the mining operation would occur long after solution mining restoration activities had finished, making corrective action by the applicant impossible.

In Figure 50-2, flow pathway lines indicate the direction ground water

was predicted to take as it flowed into the town wells. From an analysis of the flow lines it can be seen that contamination from both the Crownpoint and Unit 1 sites would flow into wells NTUA-1 and BIA-6. Furthermore, since the ground-water flow pathways from both sites are converging on the town wells advective forces do not contribute to dilution.

Dilution is possible at the well head if uncontaminated water flows into the well from other directions. In this case, the uncontaminated water would dilute (reduce the concentration) of contaminates in the ground water. An analysis of the ground-water flow pathways for the Crownpoint site indicates that well NTUA-1 receives only contaminated water and can take no dilution credit. However, well BIA-6 may pull up to half of it's water from an uncontaminated source. For the Unit 1 property, well NTUA-1 pulls about sixty percent of it's water from an uncontaminated source and BIA-6 may pull as much as seventy percent of it's water from an uncontaminated source.

In modeling the concentration of water quality parameters at the Crownpoint wells, the NRC staff used baseline water quality to dilute the predicted post restoration concentration by the amount estimated at the well head. Well head dilution was calculated for three scenarios: (1) radium-226 movement from the boundary of the Crownpoint property in Section 19 (west of town) to well NTUA-1; (2) radium-226 movement from the boundary of the Crownpoint site in Section 29 (east of town) to well BIA-6; and radium-226 movement from the eastern most Unit 1 site boundary in Section 14 to well NTUA-1. It was observed that the combined effect of both the Unit 1 and Crownpoint sites on modeled well head concentrations should be no worse than the modeled concentrations at well NTUA-1 from the Crownpoint site alone.

Since no dilution was allowed in modeling the movement of radium from the Crownpoint site to well NTUA-1, modeled radium concentrations remained at 65.85 pCi/l. The model of radium-226 movement from the Crownpoint site to well BIA-6 allowed some dilution at the well head, which resulted in predicted concentrations of 33 pCi/l. For the Unit 1 site alone, modeled well head dilution effects were similar to the analysis for the Crownpoint site and well BIA-6 and resulted in radium-226 concentrations of 31 mg/l. Modeled concentrations of radium for all three scenarios of water movement to the town of Crownpoint well exceeded both State of New Mexico and EPA drinking water standards.

The previous analysis assumes that dissolved constituents in the ground water do not chemically react with the solid material in the aquifer. For many water quality parameters this is unrealistically conservative. To investigate the role that geochemical interactions may have on modeled concentrations of radium-226 at the well head, the geochemical process of adsorption was investigated. Geochemical factors influencing the transport of solutes are: complexation, ionic-strength, acid-base, redox state, precipitation-dissolution, and adsorption-desorption. Of these factors, only adsorption and precipitation remove solutes from ground-water flow (Walton, 1984). The other reactions may enhance or

restrict such removal. In most cases the dominating reaction is adsorption (Walton, 1984).

The ability of an aquifer skeleton to adsorb solutes is due mainly to the existence of clay, organic matter, or other colloidal-sized materials. Certain ions may be reversibly adsorbed and subsequently released back to ground-water flow through desorption once the contaminated ground water has passed and cleaner more dilute ground water has taken its place (Walton, 1984, pages 12.1 to 12.5). Alternatively, certain ions may be irreversibly adsorbed and therefore may not return to the ground-water flow.

One of the common methods used to model geochemical absorption is through the use of the distribution coefficient commonly known as K_d (Freeze, 1979, pages 402 to 408). The K_d approach attempts to predict the partitioning of solutes between the liquid and solid phases in a porous medium. This approach is based on the measure of the fraction of the mass of solute on solid phase per unit mass of solid phase to the concentration of solute in solution. This approach assumes (1) that the chemical parameters are under chemical equilibrium; (2) they are found in low concentrations in the ground water; (3) that absorption is quick relative to the ground-water flow, (4) that the absorption is linear; and (5) that it is reversible (Walton, 1984, page 12.9, de Marsily, 1986, page 256, and Freeze, 1979). Because the K_d approach assumes that the adsorption reactions are reversible, the net effect of the K_d approach is to retard or delay the rate at which solutes move through the aquifer (Freeze, 1979). However, chemical solutes with K_d values that are orders of magnitude greater than 1 are essentially immobile (Walton, 1984, page 12.11).

To model the effect of chemical retardation, equation 4.3-5 was derived from Equations 4.3-1 and 4.3-2, which were obtained from Freeze (1979; Figure 9.11, page 404).

(Equation 4.3-1)

$$x_{nr}=vt$$

Where:

x_{nr} = distance moved by a nonretarded contaminate plume.
v = Seepage velocity or average velocity of ground water.
t = time

(Equation 4.3-2)

$$x_r = \frac{vt}{1 + (\frac{\rho_b}{n} \times K_d)}$$

Where:

x_r = distance moved by a retarded contaminate plume.
n = Porosity
ρ_b = Average mass density
K_d = Distribution coefficient or the mass of solute on the solid phase per unit mass of solid phase divided by the concentration of solute in solution.

(Equation 4.3-3)

If

$$If \quad x_{nr} = x_r$$

(Equation 4.3-4)

Then

$$vt_{nr} = \frac{vt_r}{1 + (\frac{\rho_b}{n} \times K_d)}$$

Where:

t_{nr} = time for nonretarded contaminate plume to move distance "x".
t_r = time for retarded contaminate plume to move distance "x".

(Equation 4.3-5)

Therefore:

$$t_r = t_{nr} \times (1 + (\frac{\rho_b}{n} \times K_d))$$

Flow times were obtained from the results of the ground water flow model (HRI, 1996a, Figure 50-2). The same porosity value as the flow model was used and an average mass density for sandstone of 2.1 g/ml (Walton, 1984, Table 12.4, page 12.14) was used. For radium, a K_d reflective of reducing conditions was chosen. This is because under reducing conditions radium is likely to be more mobile. This is manifested in an indirect way. Manganese oxide is a strong adsorber of radium. The

absence of manganese oxide on aquifer solids under reducing conditions eliminates, perhaps, the strongest adsorption sites for radium, whereas under oxidizing conditions manganese oxide is much more abundant. Under reducing conditions organic matter could be an adsorber of radium.

This means that after ground-water restoration, if the radium moves through an oxidized zone and sufficient manganese oxide is present, the radium should be strongly adsorbed onto the manganese oxide. If the radium moves through the reduced zone the primary adsorption sites should be onto aquifer solids (primarily organic matter) from which it can later desorb. At the Crownpoint and Unit 1 properties the ground-water flow direction has been altered from the direction that existed when the uranium deposit was created. Some of the town wells pump water from the reduced side of the ore body and some wells pump water from the oxidized side of the ore body. Current ground-water flow modeling indicates that ground water from the Crownpoint or Unit 1 site could flow through either the reduced or oxidized side of the roll front, or both. Radium K_ds for oxidizing environments fall in the 500 ml/g range (Sheppard, 1990, Allard, 1979, Krishnaswami, 1982, Serene, 1982, Meijer, 1995, Wescott, 1995, Barney, 1984). For reducing conditions in sandstone with low organic matter Barney, 1984, determined a radium-226 K_d of 5? mg/l. It was this lower K_d that was used to model the retardation of radium-226.

The scenario of radium movement from the Crownpoint site to well NTUA-1, produced a travel time for radium of 41,505 years. For the scenario of contaminate movement from the Crownpoint site to well BIA-6, radium had a travel time of 16,481 years. For the scenario of contaminant movement from Unit 1 site to well NTUA-1 radium had a travel time of 758,535 years. Calculated travel times of these lengths indicate that for all practical purposes radium is immobile and will not reach the town wells in sufficient concentrations to exceed either State of New Mexico or EPA drinking water standards.

Uranium concentrations in the ground water beneath the Crownpoint site average 0.001 mg/l, and at the town of Crownpoint wells range from 0.0006 mg/l to 0.003 mg/l (HRI, 1992, page 2-117). These concentrations are well below NRC concentrations for uranium contained in Table 2 of Appendix B, of 10 CFR § 20. However, the calculated average concentration for uranium may be a function of the placement of the current wells relative to the ore body. At the Church Rock site, an average uranium concentration of 1.8 mg/l is calculated. When wells are located within the ore body, it is possible that some well fields may have average uranium baseline values that exceed 0.44 mg/l. This raises the concern that uranium could migrate to the Town of Crownpoint wells. To address this concern the NRC conducted the same modeling exercise for uranium that was conducted for radium.

Uranium is a cation that is least susceptible to chemical adsorption in oxidizing high bicarbonate environments (i.e., the conditions produced by uranium solution mining). For soils, Sheppard reports K_ds as low as 15 ml/g. In the highly oxidizing, low organic matter conditions of

volcanic tuffs. K_ds are reported to range from 0 to 54 ml/g, averaging 4. However, it is reasonable that at the end of solution mining, the uranium in solution would have been oxidized and have been complexed with bicarbonate. Aqueous carbonate complexation plays an important role in reducing uranium absorption at higher pH (Pabalan, 1996). In addition, the K_d for uranium decreases with increasing uranium concentration, particularly in the intermediate ph range (6-9) (Pabalan, 1996). Therefore, after solution mining, the dissolved uranium should be in uranium's most mobile form for oxidizing environments. As a result, uranium was assigned a K_d of zero in our transport calculations.

Since uranium could take either reducing or oxidizing pathways to the town water supply wells, for modeling purposes, it was assumed that oxidizing conditions existed all the way to the town wells. Therefore, for the scenario of uranium movement from the boundary of the Crownpoint property in Section 19 (west of town) to well NTUA-1, uranium concentrations at the well head would be above the 0.44 mg/l. For the other two scenarios of contaminant movement to the town wells, any concentration that exceeded 0.93 mg/l at the Unit 1 or Crownpoint sites would exceed a concentration of 0.44 mg/l at the town wells. However, the Unit 1 calculation assumes that uranium would move entirely through oxidized rock. The modeled ground-water flow paths from the Unit 1 site into the reduced side of the ore body, the distance (2 miles) from the town wells, and the average travel time (1,657 years) would strongly suggest that the assumption that the uranium would not encounter reducing conditions or other adsorption mechanism between the Town of Crownpoint is probably unduly conservative. In reality, it is reasonably certain uranium concentrations should be significantly reduced in concentration before water from the Unit 1 site reaches the Crownpoint wells.

Water Quality Mitigation - Crownpoint Site

The no action alternative is an unacceptable alternative to ground water restoration. Restoration of Ground-Water quality to EPA primary and secondary drinking water quality standards and restoration of ground-water quality to baseline values will maintain the use of the ground water and not pose any significant health risks. If uranium is not restored to values less than 0.44 mg/l at the Crownpoint site; uranium concentrations may exceed this value at the Town of Crownpoint wells.

The NRC has yet to approve successful restoration of a production scale well field at any of its licensed sites. Furthermore, site specific tests conducted by the applicant, have not demonstrated that the proposed restoration standards can be achieved at a production scale. Therefore, prior to the injection of lixiviant (i.e. prior to the extraction of uranium) at either the Unit 1 and Crownpoint sites, a restoration demonstration should be conducted at the Church Rock property. The demonstration should be conducted at a large enough scale that production-scale ground-water restoration is demonstrated.

In addition, prior to the injection of lixiviant at the Unit 1 site, bonding should be provided to cover the cost of town well replacement, pipeline construction, and compatibility costs between the BIA and NTUA public water supply systems. Therefore, should the applicant fail to achieve worst case restoration objectives or the town water supply be seriously threatened by an excursion, the town community will have the financial capability to develop and obtain a water supply system of equal quantity and a water quality that is below EPA primary and secondary standards.

To eliminate (1) the threat of uranium transport to the town water supply, (2) a vertical excursion (See NRC Evaluation of Comment 75) and (3) any possible threat from a horizontal excursion (See NRC Evaluation of Comment 74) at the Town of Crownpoint wells, it is recommended that before the injection of lixiviant at the Crownpoint site, the town water wells should be replaced, pipelines constructed, and the two water supply systems connected. The wells should be located so that the Town of Crownpoint continues to have a water supply system of equal quantity and a water quality that can be maintained below EPA primary and secondary drinking water standards and the 0.44 mg/l uranium concentration. Furthermore, the existing town wells should be abandoned and sealed so that they cannot become future pathways for the vertical movement of contaminants.

The applicant has committed (HRI, 1996b) to "*replacement of any existing Town of Crownpoint water wells if needed, because of regulatory concern with the proximity of those wells to HRI's in situ mining operation. Wells would be moved beyond a minimum distance from active in situ mining operations, as agreed upon by the regulatory authorities in discussions with the company*".

ACTION NEEDED: Agree to the recommendations in Comment 50 or propose another acceptable alternative.

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Table 50-1: Comparison of Proposed Restoration Standards Dated 9-19-96 to State and Federal Standards.

PARAMETER	No Action Alternative (mg/l)	Secondary Goal Alternative (mg/l)	Primary Goal Alternative (mg/l)
Parameters With Primary Standards			
Arsenic	0.054	0.05	0.0
Barium	0.1	2.0	0.05
Cadmium	0.01	0.01	0.0
Chromium	0.02	0.05	0.0
Fluoride	0.3	4.0	0.35
Lead	0.005	0.05	0.0
Mercury	0.0	0.002	0.0
Nickel	0.09	0.1	0.0
Nitrate	0.17	10.0	0.05
Radium-226[1]	150.0	5.0	65.85
Selenium	4.6	0.05	0.0
Uranium	33.5	BL	0.001
Parameters With Secondary Standards			
Sulfate	1,176.0	250.0	54.9
Chloride.	317.0	250.0	10.9
Copper	0.04	1.0	0.0
Iron	0.02	0.3	0.0
Manganese	5.85	0.05	0.0
TDS	3,364.0	500.0	367.8
pH[2]	7.2	6.5-8.5	9.0
Parameters Without EPA Standards			
Boron	0.2	BL	0.06
Molybdenum	62.0	BL	0.0
Ammonia	1.07	BL	0.03
Calcium	320.0	BL	2.68
Magnesium	21.6	BL	0.44
Sodium	1,600.0	BL	120.3
Potassium	7.0	BL	10.58
Carbonate	0.0	BL	26.42
Bicarbonate	1,005.0	BL	201.22
Vanadium	0.48	BL	0.0

BL = Premining Baseline Well Field Average. Same as Average Baseline Alternative.
1. pCi/l
2. units

74. **COMMENT:** Westwater Canyon Horizontal Excursion Control - Crownpoint Property

EVALUATION OF RESPONSE: The applicant was asked to demonstrate that excursions can be controlled in the Westwater Canyon Member so that the Crownpoint public water supply will not be degraded. The applicant recognizes (HRI, 1996a) that the municipal water wells pump at different rates and for varying time periods. In the Crownpoint ground-water flow model (Reed, 1993), the applicant simulates well field operation during summer pumping (as opposed to less pumping during the winter months) by the town of Crownpoint, and shows that the modeled ground-water flow paths are all contained by the overall hydraulic sink in the well field. The applicant also states that in the Crownpoint area, drawdown due to long term pumping from the municipal water wells is believed to have reached a near equilibrium condition, similar to the time when continued drawdown is very slight or asymptotic. Thus pumping at different rates and cyclical pumping impact the drawdown and hydraulic gradient in the areas close to the individual wells, but do not appreciably alter the gradient beyond several hundred feet.

The NRC staff has made observations and expressed opinions on the use of this model to demonstrate excursion containment in its evaluation of the applicant's responses to NRC Comments 54, 77, and 78. In NRC Comment 78 the NRC staff concludes that it considers this modeling exercise only a general demonstration that simplified representations of well fields and aquifers can successfully contain mining fluids under a constant flow field. Due to the lack of data and model design, the model was not able to take into account variations in aquifer properties, variations in water levels over time, and actual well field design and operation.

To prevent excursions during mining and after aquifer restoration the applicant has agreed to maintain a continuous bleed at the Crownpoint property until the well fields have been declared fully restored to the required permit/regulatory limits (HRI, 1996a). The applicant committed to continue the bleed in restored well fields at the Crownpoint property after restoration is verified through a stability monitoring period and until HRI receives written approval from the NRC to discontinue the bleed (HRI, 1996b). Furthermore, the applicant committed to maintain emergency generator capacity, capable of maintaining a 50 gpm bleed from the mine zone throughout the mining and restoration life of the mine (HRI, 1996b).

Crownpoint site well CP-8 is located one mile from the nearest Crownpoint water supply well (NTUA-1), and from data provided in HRI, 1996a (Comment 80, plot of Crownpoint-Historic Water Levels) it is observed that water levels in Well CP-8 could change by 20 feet or more during a year. In addition, Figure 5 of the applicants response to Comment 84 and Figure 8 of Appendix C, of HRI, 1992, shows water level changes on the order of five feet occurring over a period of five to six days. Therefore, it appears that ground-water gradients can be altered

over the Crownpoint property in short periods of time by town ground-water withdrawals.

With sufficient balanced over-pumping of ground water, well field solutions should be kept in the well field. The local ground-water flow direction and velocity are continuously changing due to events that cannot be controlled by the applicant (i.e. individual wells being turned off and on). Therefore, mining operations will have to maintain confinement under changing hydrologic conditions. As a result, the risk of horizontal excursions is increased over hydrologic conditions commonly encountered by uranium solution mining operations. However, the NRC evaluation of Comment 50 contains a recommendation to move the Town of Crownpoint wells prior to the injection of lixiviant. This action would greatly reduce the influence of the town wells on the Crownpoint site well field and therefore, reduce the potential for excursions to occur. It would also have the effect of increasing the distance between the town wells and the well field which would allow more time for excursion definition and correction. Therefore, this comment is considered open until the applicant has adequately responded to the recommendations in the NRC evaluation of Comment 50.

ACTION NEEDED: Respond to the recommendations in the NRC evaluation of Comment 50 or propose another acceptable alternative.

REFERENCES:

HRI, 1992. Crownpoint Project In-Situ Mining Technical Report. June 12, 1992.

HRI, 1996a. . Transmittal to Joe Holonich (NRC) titled "Request for Additional Information, Questions 49-91, Water Resources Protection and Cost/Benefit Analysis; Safety Analysis Review and Environmental Review for Hydro Resources, Inc", dated April 1 and 5, 1996.

HRI, 1996b. Transmittal to Daniel M. Gillen (NRC) from Mark Pelizza (HRI) titled "Response to Request for Further Clarification and Additional Information of Responses; Safety Analysis Review and Environmental Review for the Hydro Resources, Inc., Uranium Solution Mining License Application, Crownpoint, New Mexico." dated August 15, 1996.

Reed, S., 1993. Analysis of Hydrodynamic Control, HRI, Inc., Crownpoint and Church Rock New Mexico Uranium Mines, Geraghty & Miller, Inc. October 7, 1993.

75. **COMMENT:** Dakota Sandstone Vertical Excursion Control - Crownpoint Property

EVALUATION OF RESPONSE: The applicant was asked to demonstrate that if a vertical excursion occurs, it can be controlled in the Dakota Sandstone aquifer so that the Crownpoint public water supply will not be degraded. The applicant (HRI, 1996) believes that the possibility for the occurrence of vertical excursions is very low, because of the thick aquitards over the production zone, the quality of the plugged exploration holes and old mine shafts, and because of the future proposed integrity testing that will be applied to all wells. To detect leaks, the applicant proposes to monitor water levels and water quality in the overlying aquifer. Furthermore, in the event of a vertical excursion, the applicant proposes to proceed immediately to determine the cause of the leakage and reverse the trend. The applicant will also drill a guard well 100 feet from the excursion well, between the excursion well and the Town of Crownpoint wells. If the upper control limits are exceeded in the guard well, the procedure will be repeated until unaffected water is encountered. The applicant further states that a guard well will be used to monitor corrective action and to assure that an excursion cannot migrate to the public water supply.

The NRC staff observes that drilling a guard well 100 feet down-gradient from the excursion well is a good initial first step in excursion definition. However, the NRC staff also observes that guard wells cannot be correctly located to assure an excursion will not migrate to the public water supply before the time consuming process of identifying the extent and location of the excursion is finished.

It is the staff's opinion, that given the site geology, the previous borehole sealing procedures, and the applicant's planned well integrity testing program; the risk of a vertical excursion occurring should be low. However, the staff also observes that because upper monitor wells do not encircle the well field area, but are commonly located in the center of well fields, they may not detect an excursion if a strong ground-water gradient is present. Should an excursion occur down ground-water gradient of the Dakota Sandstone aquifer monitor wells, the excursion may move undetected towards the town water supply wells.

At the Crownpoint site this is important, because three of the town of Crownpoint's water wells are completed in the Dakota Sandstone as well as the Westwater Canyon Member. These wells are BIA-5, BIA-3, and BIA-6. Pumping from the town wells could cause ground water in the Dakota Sandstone underneath the Crownpoint site to flow towards the town of Crownpoint water supply wells. In addition well BIA-5 is also completed in the Cow Springs aquifer. This means that should a vertical excursion take place in the Dakota Sandstone or the Cow Springs aquifer, contamination could move towards the Crownpoint water supply wells.

Given the location and completion of the town wells, should a vertical excursion occur, there will be a need to speedily identify and correct

the excursion. Furthermore should a vertical excursion occur, there will eventually be a need for a strong ground-water restoration effort in the upper or lower aquifer, because the water which has been contaminated by the excursion will eventually reach the town water supply. Therefore, to mitigate any potential impact of a vertical excursion, it is recommended in the NRC evaluation of Comment 50 that before mining is allowed at the Crownpoint site, the town of Crownpoint wells must be replaced. Furthermore the wells should be abandoned and sealed so that they cannot become future pathways for the vertical movement of contaminants. Therefore, this comment is considered open until the applicant has adequately responded to the recommendations in the NRC evaluation of Comment 50.

ACTION NEEDED: Respond to the recommendations in the NRC evaluation of Comment 50 or propose another acceptable alternative.

REFERENCES:

HRI, 1996. Transmittal to Joe Holonich (NRC) titled "Request for Additional Information, Questions 49-91, Water Resources Protection and Cost/Benefit Analysis; Safety Analysis Review and Environmental Review for Hydro Resources, Inc", dated April 1 and 5, 1996.

95. **COMMENT:** Effect of Groundwater Drawdown on Town of Crownpoint Wells

EVALUATION OF RE ONSE: The staff's evaluation of this comment asked the applicant to describe the potential pumping cost and well yield impacts on the town well's ability to continue to supply water for the town of Crownpoint due to the projected drawdowns as a result of (1) the combined effect of mining and restoring the Unit 1 and Crownpoint properties, (2) mining and restoring only the Unit 1 property, and (3) mining and restoring only the Crownpoint property.

The applicant modeled drawdown effects due to mining and restoration activities from the combined effect of the Crownpoint and Unit 1 properties in their response to NRC Comment 60 (HRI, 1996a). The cumulative drawdown at the end of 21 years of mining at both Unit 1 and Crownpoint is shown in Attachment 60-1 of the applicant's response. This model projects a drawdown effect of 55 feet on well NTUA-1 (49 to 55 feet for the area of the town wells). The maximum projected drawdown from mining and restoration at the two properties is anticipated to occur after 17 years, and produces a drawdown effect of 80 feet on well NTUA-1 (70 to 80 feet for the area of the town wells).

The applicant responded (HRI, 1996b) that an adequate water column exists in the Crownpoint area to assure that well yield will not be affected with even the worst case drawdown (i.e. if the current water column is 1,500 ft. then 1,420 ft. will still be available). The applicant further concludes that it is unlikely that the submersible pump will actually need to be lowered into the well as a result of the drop of well water levels. However, if additional pipe is needed to lower the submersible pump, the applicant estimates a one time cost of $5,000.00 for this work. Again this cost is conservative because the additional pipe would normally be added during routine well servicing at the nominal cost of the pipe.

However, a drop in fluid levels could result in increased pumping costs. The applicant presented worst case calculations of the most affected well during operations. The applicant provided calculations to show the increased pumping costs from the lower projected water levels at Town of Crownpoint wells BIA #3, BIA #5, BIA #6, NTUA-1, and NTUA Conoco. The additional annual cost due to ground-water restoration activities at the Crownpoint site was calculated to be $3,023. The additional annual cost due to ground-water restoration activities at the Unit 1 site was calculated to be $1,443. The additional annual cost due to ground-water restoration activities at the Crownpoint and Unit 1 sites was calculated to be $4,466.

Therefore, the NRC staff concludes that water level drawdowns caused by restoration activities at each property or the two properties together could result in a one time cost of $5,000/well for a total of $25,000. Worst case pumping costs during ground-water restoration activities could range from $1,443/yr to $4,466/yr. Therefore, when ground water restoration activities begin at a production scale at either the Unit 1

or the Crownpoint sites it is recommended that the applicant bond for the projected increased pumping and well work over costs that might be incurred by the town of Crownpoint.

ACTION NEEDED: Prior to restoration activities, bond for the projected increased pumping and well work over costs that might be incurred by the town of Crownpoint or propose another acceptable alternative.

REFERENCES

HRI, 1996a, transmittal to Daniel Gillen (NRC), from Mark Pelizza (HRI) titled "Response to Request for Further Clarification and Additional Information of Responses; Safety Analysis Review and Environmental Review for the Hydro Resources, Inc., Uranium Solution Mining License Application, Crownpoint, New Mexico", dated August 15, 1996.

HRI, 1996b, transmittal to Daniel Gillen (NRC), from Mark Pelizza (HRI) titled "Response to additional Comments Dated September 16, 1996 on the License Application for an In-Situ Mining Facility at Crownpoint, New Mexico, Q3/57, Q3/95 and Q3/96", dated September 27, 1996.

97. **COMMENT:** Potential for Excursions at Unit 1 Site

DISCUSSION: The potential for horizontal excursion should be less than at the Crownpoint site, because it is much more distant (2 miles) from the Town of Crownpoint water wells. There should be little effect from variations in pumping rates on water levels at the Unit 1 site, and with a properly balanced well field, the occurrence of horizontal excursions should be low. However, it is recommended that prior to the injection of lixiviant at the Unit 1 site, that bonding be provided to cover the cost of town well replacement, pipeline construction, and compatibility costs between the BIA and NTUA public water supply systems. This would mean that should the town water supply be seriously threatened by a horizontal excursion, the town community will have the financial capability to develop and obtain a water supply system of equal quantity and quality.

The potential for vertical excursions to occur is very low, because of the thick aquitards over and under the production zone, the quality of the plugged exploration holes, and because of the future proposed integrity testing that will be applied to all wells (HRI, 1996). To detect leaks the applicant proposes to monitor water levels and water quality in the overlying aquifer. Furthermore, in the event of a vertical excursion, the applicant proposes to proceed immediately to determine the cause of the leakage and reverse the trend (HRI, 1996).

Given the site geology, the previous borehole sealing procedures, and the applicant's planned well integrity testing program, the risk of a vertical excursion occurring should be low. Three of the town of Crownpoint's water wells (wells BIA-5, BIA-3 and BIA-6) and a local well (Mobil Monument Windmill) located one half mile east of the Crownpoint site in Section 28 (T17N, R12W) are completed in the Dakota Sandstone. However, these wells are two miles from the Unit 1 boundary and should not produce a strong hydrologic gradient at that distance. This means that the advective and dispersive forces from the point of leakage into the upper aquifer will not be as strongly influenced by the local ground-water gradient. This in turn would allow the plume to spread and increase the potential for vertical excursion detection. Therefore, should an excursion go undetected it should be small in size.

In the Westwater Canyon which is under the pumping influence of five large public water supply wells, the applicant has modeled that it would take 1,657 years for the water to flow from the Unit 1 site to the Town of Crownpoint. Therefore, any flow of ground water in the Cow Springs aquifer or the Dakota Sandstone aquifer towards the town of Crownpoint should take much longer.

However, while the potential for a vertical excursion is judged to low, it is recommended that prior to the injection of lixiviant at the Unit 1 site, that bonding be provided to cover the cost of town well abandonment and replacement for the wells BIA-5, BIA-3, and BIA-6, which are open to the Dakota Sandstone. This would mean that should the town

water supply be seriously threatened by a vertical excursion into the Dakota sandstone, the town community will have the financial capability to develop and obtain a water supply system of equal quantity and quality.

ACTION NEEDED: As proposed in the evaluation of Comment 50, prior to the injection of lixiviant at the Unit 1 site bond to cover the cost of town well replacement, pipeline construction, and compatibility costs between the BIA and NTUA public water supply systems or propose another acceptable alternative.

REFERENCES:

HRI, 1996, transmittal to Daniel Gillen (NRC), from Mark Pelizza (HRI) titled "Response to Request for Further Clarification and Additional Information of Responses: Safety Analysis Review and Environmental Review for the Hydro Resources, Inc., Uranium Solution Mining License Application, Crownpoint, New Mexico", dated August 15, 1996.

98. **COMMENT:** Potential for Excursions at Church Rock Site

DISCUSSION: With a properly balanced well field at the Church Rock site, the occurrence of horizontal excursions should be low. The applicant provided aquifer modelling results (HRI, 1996b), by Geraghty and Miller, Inc. This model demonstrated that the project could be conducted while controlling lixiviant migration. The model was run using site data on the hydraulic characteristics of the Westwater sandstone and the applicant's projected operational data. The results of the model indicate that a cone of depression would be formed (Figure 4.1) during the project. A ground-water divide would develop between each mine unit and locations down-gradient during the production and restoration phases of the project. Therefore, ground-water and lixiviant migration would be controlled by forcing water to flow into the well fields.

However, the model did not include the mine tunnels in it's design. Since the tunnels will be inside the well field, most of the hydrologic effects of the mine tunnels on the lateral movement of ground water should be internal to the well field. As a result, if the outer ring of injection or production wells are outside the tunnel area, the potential for lateral excursions by a properly balanced well field should be low. However, at this time the applicant has not provided the NRC with detailed well field designs. For *in situ* mining applications this information is usually developed after the license is issued and as mining successively progresses over the property. Nevertheless, uranium *in situ* mining in areas with preexisting tunnels is a unique situation. Therefore, to provide additional confidence that excursions can be controlled in the areas containing mine tunnels, it is recommended that prior to the injection of lixiviant in the area of tunnels, a modeling demonstration be conducted of the planned well fields to confirm that they can be properly operated in the presence of the preexisting tunnels without causing horizontal excursions.

Given the thick aquitards over and under the production zone, the planned well integrity testing program and the potential for old boreholes to squeeze shut, the risk of a vertical excursion occurring outside the area of former mining activities should be low. To detect leaks, the applicant proposes to monitor water levels and water quality in the overlying aquifer. Furthermore, in the event of a vertical excursion; the applicant proposes to proceed immediately to determine the cause of the leakage and reverse the trend (HRI, 1996a).

In the area of the shaft and tunnels the potential for vertical excursions to occur is greater than in areas without shafts and tunnels. However, it should be possible to mine in the Westwater Canyon aquifer and not create a vertical excursion. This can be accomplished by sealing off the shafts or structuring well field pressures so that in the area around the shafts they are less than overlying aquifer pressures. At this time the applicant has not specifically demonstrated how this will be accomplished.

The applicant will monitor for vertical excursions and correct them when they occur. In recognition of the increased potential for vertical excursions to occur, the applicant proposes to place monitor wells in locations where raises from the existing mine workings in the Westwater Canyon penetrate the confining shales/clays. In addition, monitor wells will be placed at the standard density in unaffected Brushy Basin "B" Sand adjacent to the shafts.

The Cow Springs aquifer is separated from the Westwater Canyon aquifer at each of the three sites by the Recapture shale, which is estimated to be about 55 m (180 ft) thick at the Church Rock site. A large number of holes were drilled into the Recapture Shale at each of the three properties. However, most of these holes only penetrated the upper 1.5 m to 12 m (5 to 40 ft). None of these holes penetrated the entire thickness of the Recapture Shale (HRI, 1996a). From an inspection of the materials submitted in the application, NRC staff have not found any instances where this unit is absent beneath the site. Due to the large thickness of the Recapture shale and the low potential that drill holes in the site boundary have penetrated the Recapture Shale, there should be little risk of a vertical excursion into the Cow Springs aquifer.

At this time the applicant has not provided the NRC with detailed well field designs. Uranium *in situ* mining in areas with preexisting tunnels is a unique situation. Therefore, to provide additional confidence that excursions can be controlled in the areas containing mine tunnels, it is recommended that prior to the injection of lixiviant in the area of tunnels, that a modeling demonstration be conducted of the planned well fields to confirm that they can be properly operated in the presence of the preexisting tunnels without causing vertical excursions. In addition, the detection of vertical excursions will require increased attention, because the existing shafts provide direct communication between the mine zone and the upper aquifers. Therefore, prior to mining in the area of tunnels; it is recommended that a report be provided to the NRC explaining how the upper aquifer monitor well locations will provide adequate coverage for the well field as well as the area around the vertical shafts.

ACTION NEEDED: Prior to the injection of lixiviant in the area containing mine tunnels at the Church Rock site, provide a modeling demonstration of the planned well fields to confirm that they can be properly operated in the presence of the preexisting tunnels without causing vertical or horizontal excursions or suggest another acceptable alternative. In addition, prior to the injection of lixiviant in the area of tunnels; provide a report explaining how upper aquifer monitor well locations will provide adequate coverage for the well field, as well as the area around the vertical shafts.

REFERENCES:

HRI, 1996a, , Transmittal to Joe Holonich (NRC) titled "Request for Additional Information, Questions 49-91, Water Resources Protection

and Cost/Benefit Analysis; Safety Analysis Review and Environmental Review for Hydro Resources, Inc", dated April 1 and 5, 1996.

HRI, 1996b, Transmittal to Daniel M. Gillen (NRC) from Mark Pelizza (HRI) titled "Response to Request for Further Clarification and Additional Information of Responses, Safety Analysis Review and Environmental Review for the Hydro Resources, Inc., Uranium Solution Mining License Application, Crownpoint, New Mexico," dated August 15, 1996.

CLOSED COMMENTS

28. **COMMENT:** Solid/Liquid Waste Disposal

EVALUATION OF RESPONSE: The applicant was asked to provide a detailed description of the applicant's plan for disposing of all contaminated solid wastes generated by the project (e.g., spent resin, sludge in retention ponds, retention pond liners, well field and processing plant equipment). It was further requested that the description include the location of off-site NRC-licensed waste disposal facilities that could potentially be used. The applicant plans to dispose of all solid waste generated by the project that cannot meet criteria for release to unrestricted use (e.g., spent resin, sludge in retention ponds, retention pond liners, well field and processing plant equipment) at a NRC-licensed or similar-agreement state-licensed disposal facility (HRI, 1996). Currently, the applicant is contracted with Energy Fuels Nuclear to use their Blanding, Utah site. In their response, the applicant identified five other potential disposal locations which are currently licensed to receive this type of solid waste. The NRC staff consider this comment closed.

REFERENCES:

HRI, 1996, Transmittal to Joe Holonich (NRC) from Mark Pel zza HRI, Inc., titled "HRI, Inc. Response to Nuclear Regulato mmission's Questions 1 through 48, dated February 20, 1996.

29. **COMMENT:** Solid/Liquid Waste Disposal

EVALUATION OF RESPONSE: The applicant was asked to provide a detailed description of the applicant's plan for disposing of all waste water generated during well field production, uranium recovery and processing and aquifer restoration. This description should include the chemical composition of all waste water streams before and after treatment. The applicant (HRI, 1996) described several options for waste water disposal; (1) evaporation, (2) deep well disposal (Class I), (3) fresh water reinjection (Class V or Class III), (4) surface water discharge, (5) land application, and (6) a combination of any and all options. Purification/waste reduction process associated with the evaporation and deep well disposal options include; (1) ion exchange, (20 barium chloride treatment, (3) reverse osmosis, and (4) brine concentration.

During well field production the applicant proposes to disposal of waste water by evaporation. No deep well injection applications have been submitted by the applicant at this time. Any deep wells would have be permitted subject to the provisions of 40 CFR 144-148 and 10 CFR 20.2002. Product water (clean water) will be reinjected into the Westwater Canyon aquifer. During ground-water restoration any and all the disposal options could be used.

The applicant provided tables of waste water quality along with a description of the source of the data. The NRC staff consider this comment closed.

REFERENCES:

HRI, 1996, Transmittal to Joe Holonich (NRC) from Mark Pelizza HRI, Inc., titled "HRI, Inc. Response to Nuclear Regulatory Commission's Questions 1 through 48, dated February 20, 1996.

30. **Comment:** Solid/Liquid Waste Disposal

Evaluation of Response: The applicant stated that excess treated waste water could be reinjected into the Westwater Canyon sandstone outside the mining areas. The applicant was asked to describe the chemical composition of the treated waste water that would be reinjected. The applicant was also asked if the waste water would be compatible with existing ground water in the Westwater Canyon sandstone.

The applicant stated (HRI, 1966) that water reinjected into the Westwater Canyon aquifer would consist of either reverse osmosis product or distillate from brine concentration. It was further stated that the water quality of the injected water would be better than the preexisting water quality of the Westwater Canyon aquifer and that radionuclide concentrations would be below values listed in 10 CFR 20, Appendix B.

The applicant also stated that the water injected into the Westwater Canyon aquifer would be compatible with the formation. Furthermore, loss of permeability due to swelling clays is not anticipated. However, if a decrease in well bore efficiency is noted, the applicant proposes to mix formation water with the water reinjected to assure similar ionic proportions.

The applicant notes that wells used to return the water to the formation, are aquifer recharge wells which fall into Class V category of 40 CFR 144.6. The staff recognizes that the applicant must acquire an injection permit from the appropriate state or federal agency before reinjecting treated waste water outside the mining unit. The permitting will likely require analysis and demonstrations of water compatibilities before injection can proceed. The NRC staff consider this comment closed.

REFERENCES:

HRI, 1996, Transmittal to Joe Holonich (NRC) from Mark Pelizza HRI, Inc., titled "HRI, Inc. Response to Nuclear Regulatory Commission's Questions 1 through 48, dated February 20, 1996.

31. **COMMENT**: Solid/Liquid Waste Disposal

EVALUATION OF RESPONSE: The applicant was asked to describe plans for handling and disposing of the material in the existing lined impoundments at the Crownpoint facility. The applicant stated that the material in the ponds is windblown sand, drill cuttings, and drill mud (bentonite). Radionuclide analysis shows that the material contains very low concentrations of uranium, radium, thorium, and lead 210. The applicant plans to dispose of the drilling mud at Section 12, (17N, R13W) located northwest of the Crownpoint plant site. The applicant acquired this land from Mobil Oil Corp. who used it for drill mud disposal. This is also the property identified for land disposal of ground-water restoration water. The applicant plans to dispose of this material by disking (blending) it with the native soil and then reseeding the area with a seed mix specified in the response. The NRC staff consider this comment closed.

REFERENCES:

HRI, 1996, Transmittal to Joe Holonich (NRC) from Mark Pelizza HRI, Inc., titled "HRI, Inc. Response to Nuclear Regulatory Commission's Questions 1 through 48, dated February 20, 1996

52. **COMMENT:** Achievement of Restoration After Four Pore Volumes

EVALUATION OF RESPONSE: The applicant was asked to provide a technical evaluation that shows how restoration can be achieved after four pore volumes and to provide a technical evaluation that shows how the estimated number of pore volumes to restore were determined. Furthermore, the applicant was asked to relate the number of pore volumes to the size of ponds, proposed land application and water use (i.e. if larger pore volumes result in increased size of ponds, land application areas, or water use, what are the new numbers).

In their response (HRI, 1996) the applicant discussed each of the restoration demonstrations presented in the application. For the Church Rock Core Restoration #1 (Slow Leach) demonstration, the applicant noted that of the 12 parameters which exceeded pre-core leach values after the study, only radium and uranium exceeded New Mexico Drinking Water (NMWQCC 3-103) standards. The applicant states that the other parameters meet the proposed restoration standard (baseline or drinking water quality) in 4 pore volumes or less.

The applicant noted in the Church Rock Core Restoration #1 (Slow Leach) demonstration that after four pore volumes of restoration, uranium values dropped to asymptotic levels in less than four pore volumes. However, the concentration of uranium at the termination of restoration hovered near the NMWQCC 3-103 standard of 5 ppm. The applicant believes that the core study overstated final uranium concentrations, and is not reflective of actual field conditions for two reasons:

1. Uranium was not depleted in a core study as in a commercial operation. Restoration in cores studies, or most field restoration demonstrations such as the Teton test or Mobil Section 9 test, begin restoration before the uranium is depleted in the rock being leached.

2. The laboratory environment does not replicate the actual geochemical regime. In the field, natural reductant quickly reduces uranium concentrations and renders the uranium insoluble when oxidant is shut down. Natural reductant is not available in core studies.

The applicant believes that the radium-226 results of the Church Rock core are reflective of core handling. HRI believes that small concentrations of radium were continuously leached from the crushed rock matrix, even during the restoration phase. It was also stated that ground water samples from the oxidized Church Rock mine workings analysis showed radium values well below those found in the crushed core, and are typical of what HRI has stated will be in leach solution.

The applicant concludes that the Church Rock Core Restoration #1 (Slow Leach), shows that most indicator parameters reached asymptotic conditions (i.e. little change in ground-water clean up is occurring due to restoration activities) in the 3 to 4 pore volume range. The

applicant believes that the information provided shows little additional progress after four pore volumes.

As shown in the Table titled "Church Rock Core Restoration - Slow Leach" in Appendix B of Holonich, 1996, the NRC staff notes that in addition to uranium and radium, bicarbonate, chloride, conductivity, sulfate, and total dissolved solids could not be restored to baseline in four pore volumes or less. In fact in this experiment, it took greater than twelve pore volumes to return them to baseline. However, sulfate, chloride, and total dissolved solids were returned to New Mexico drinking water standards in approximately two pore volumes (there are no drinking water standards for bicarbonate and conductivity). Therefore, from the data provided, with the exception of uranium and radium, all parameters could be returned to the New Mexico drinking water standard, but could not meet the baseline objective of the restoration standard in 4 pore volumes.

The applicant stated that restoration of uranium to NMWQCC 3-103 standards of 5 ppm has not been problematic with field operations: commercial or pilot. The applicant also stated that the industry results, with both field and pilot restoration, provide compelling evidence that restoration of radium is achievable. The applicant provided copies of restoration demonstration data for Wyoming and New Mexico and from it's Texas production scale facilities.

The NRC regulates solution mining in Wyoming and New Mexico. In the past it has approved restoration of several test patterns (although not all listed). However, the NRC has yet to approve restoration of a production scale well field.

From the data provided, the NRC staff observe that the Texas restoration demonstrations were in ground waters of lower water quality than the New Mexico properties. Total dissolved solids in the Texas properties ranged from 880 ppm to 2170 ppm and averaged 1652 ppm. The drinking water standard for total dissolved solids is 1000 ppm. However, with the exception of HRI well CP-2 (Crownpoint Property) total dissolved values range from 281 ppm to 658 ppm and average 373 ppm and at the Unit 1 site total dissolved solids average 285 mg/l up to a maximum value of 590 mg/l. It should be noted that the NRC staff regards the water quality values of the major ions obtained from well CP-2 with considerable skepticism. The water-quality data collected from this well is anomalously high in total dissolved solids (2,888 ppm), chloride (1,325 ppm, where as it is commonly in the 2 ppm to 15 ppm range), potassium (847 ppm, where as it is commonly in the 2 ppm to 20 ppm range) calcium (120 ppm, where as it is commonly in the 1 ppm to 9 ppm range), and magnesium (12 ppm, where as it is commonly in the 0.05 ppm to 0.5 ppm range). The NRC staff suspects that well drilling and completion materials may have contaminated the water chemistry samples collected from this well. In any case, the poorer water quality reported from the Texas properties means that restoration parameters were easier to obtain and did not have to return to drinking water quality as is the case in the New Mexico properties.

For the Church Rock Core Restoration #2 (Fast Leach) demonstration the applicant noted that restoration plots of commonly affected ions show that the common ions were restored to levels that became asymptotic in 4 pore volumes. As in the restoration of Church Rock Core Restoration #1 only radium and uranium exceeded NMWQCC 3-103 standards. With respect to radium the applicant does not believe that the Church Rock core study accurately represents expected field results. In addition to the reasons listed for Church Rock Core Restoration #1:

1. The baseline radium-226 value used in the study is lower than would be expected during field conditions (the industry average is approximately 159 pCi/l

2. The restored value of 231 pCi/l is in the normal range of radium values found within uranium ore bodies.

With the exception of radium-226 and uranium the applicant concludes that restoration was concluded in less than four pore volumes.

However as shown in the Table titled "Church Rock Core Restoration - Fast Leach" in Appendix B of Holonich, 1996 the NRC staff notes that in addition to uranium and radium, bicarbonate, chloride, conductivity, and sulfate solids could not be restored to baseline in four pore volumes or less. In this experiment, it took greater than nine pore volumes to return these parameters to baseline. However, sulfate, and chloride were returned to New Mexico drinking water standards in approximately two pore volumes (there are no drinking water standards for bicarbonate and conductivity). Therefore, from the data provided, with the exception of uranium and radium all the parameters could be returned to the New Mexico drinking water standard, but could not meet the baseline objective of the restoration standard in four pore volumes.

The applicant states that the Teton pilot test provides additional evidence above and beyond a core study and adds useful, real world information to the overall restoration picture, such as:

1. Pregnant lixiviant increased total dissolved solids to the anticipated range of leach solution. During leaching in the field, trace metals, particularly arsenic and selenium, responded higher than is commonly found during leaching. Uranium and radium-226 responded to the leach solution as is typically encountered during commercial restorations.

2. A larger amount of rock was exposed to lixiviants with this type of test than with a core test.

3. With an *in situ* push/pull, the ability exists to determine the natural formations ability to re-reduce uranium.

The applicant notes that in the Teton pilot test, common ions were restored in two pore volumes, but that selenium, boron, nitrate, and

arsenic remained above baseline. However, boron, nitrate, and arsenic were restored to concentrations below the restoration standard of NMWQCC 3-103. It is also stated that while selenium exceeded their restoration standard of NMWQCC 3-103, the applicant observes that selenium was not a problem in the Church Rock core tests or in the Church Rock mine workings.

With respect to uranium and radium the applicant notes that for the Teton test:

1. Uranium values were higher than either core and were elevated to commercial concentrations.

2. Restoration began with uranium values well above those which will be encountered after commercial well field depletion, yet before restoration begins.

3. Uranium removal during the test was minimal, theoretically making restoration more difficult, because the resource (or source of contamination) was not depleted.

4. Both uranium and radium were reduced below NMWQCC 3-103 in less than 4 pore volumes.

However as shown in the Table titled "Teton Exploration Single Hole Pilot Demonstration" in Appendix B of Holonich, 1996 the NRC staff notes that uranium, radium, bicarbonate, calcium, selenium, boron, conductivity, nitrate, and sodium could not be restored to baseline in 4 pore volumes. With the exception of selenium, all of the parameters were restored below the New Mexico drinking water-quality standards in less than 4 pore volumes. The NRC staff still notes that the Teton Exploration single well method may not adequately represent restoration of a full-scale well field. This method is not representative because: (1) considerable dilution from uncontaminated ground water occurs during the clean up phase; (2) at most one pore volume is leached; (3) there is a relatively short contact time of the rock with lixiviant (5 days); and (4) fresh lixiviant is not being continuously injected into the formation as would occur in an operating solution mine.

In describing the Crownpoint Core Restoration demonstration, the applicant reported that the response of common ions, show that their values become asymptotic in four pore volumes or less; a point that the applicant considers a "reasonable effort". At the four pore volume point, all common ions are consistent with the NMWQCC 3-103 standard. The applicant also points out that arsenic, barium, vanadium, and ammonia were also not elevated above the NMWQCC 3-103 standard.

The applicant further reports that radium-226 and uranium were restored in the Crownpoint core study. Uranium was restored to NMWQCC 3-103 standards after five pore volumes. The applicant believes that restoration to NMWQCC 3-103 standards is achievable after four pore volumes because:

1. Restoration began in the 130 ppm uranium concentration range, an order of magnitude higher than would be expected in a commercial situation.

2. Natural reductants, which assist uranium restoration, are not as strong in an oxidized core.

Even though radium-226 was above both the baseline values and NMWQCC 3-103 standards at the end of restoration, the applicant believes that radium will be restored to baseline in less than four pore volumes. The applicant believes the baseline for radium-226 in the ore zone will be higher than the 57 pCi/l achieved in the restoration demonstration.

The NRC staff observes that from the data provided, with the exception of radium, all the parameters could be returned to the New Mexico drinking water standard, but could not meet the baseline objective of the restoration standard in four pore volumes.

The applicant reports that the Mobil Section 9 Pilot Test successfully restored all parameters (except molybdenum and arsenic) to NMWQCC 3-103 standards or baseline in four pore volumes or less. The applicant further states that HRI core results have indicated that molybdenum will not be present in Unit 1 or Crownpoint properties. It is further reported that arsenic values were restored to NMWQCC 3-103 standards in 7 pore volumes.

From the data provided, the NRC staff notes that, many of the parameters could not be returned to baseline within 4 pore volumes. Furthermore, radium was not returned to NMWQCC 3-103 standards after 16.7 pore volumes. Radium was restored after 16.7 pore volumes to 37.4 pCi/l and after 4 pore volumes was restored to about 50 pCi/l.

The applicant proposes a concurrent restoration demonstration at each property to fine-tune the water circulation volumes, and thereafter, the surety requirements. The applicant further notes that any concern can be addressed by emplacing a conservative surety prior to the field ground-water restoration demonstration, to address NRC's worst-case pore volume amounts.

In summary, it is the applicants opinion that radium-226 will be the only parameter where NMWQCC 3-103 standards will be consistently exceeded. However, for this parameter, the applicant indicates that restoration to baseline will be achieved, because it believes that baseline exceeds NMWQCC 3-103 standards. The applicant believes that uranium and radium-226 will not migrate from the well field after restoration.

In Section 4.7.3.2 of the Draft Environmental Impact Statement, it is concluded that ground-water quality would be restored not only to drinking water standards, but also to baseline conditions. However, it is the NRC staff's observation that baseline was not achieved for several parameters after ground-water restoration activities.

Therefore, for environmental impact analysis, it is now the NRC staff's decision that the "base case" for ground-water quality impacts will be built on the assumption that ground-water quality will be restored to drinking-water standards or baseline, **which ever is greater**.

The applicant also stated that in the field, natural reductant quickly reduces dissolved uranium concentrations and renders the uranium insoluble when oxidant is shut down. However, the NRC staff observes that this assumption is based on the idea that future ground water flow will be through the reduced zone of the aquifer. At the Crownpoint and Unit 1 properties the ground-water flow has been altered from the flow direction when the deposit was created. Therefore, flow directions may be through oxidized sections of the aquifer as opposed to reduced sections of the aquifer and the uranium may be mobile for some distance after ground-water restoration activities. Furthermore, as recognized in the applicant's response to NRC Comment 34, the dewatering effects of the old mine workings at the Church Rock property subjected the Westwater Canyon Member to oxidizing conditions. The implication is that for some distance around the old Church Rock mine workings (i.e. into areas that were not mined by the underground operation) dewatering may have significantly diminished or eliminated reducing conditions in the aquifer. Therefore, uranium may move a greater distance than would normally be predicted before it encounters reducing conditions in the aquifer.

The applicant has based it's estimates of water use, pond size, and land application areas assuming it will take four pore volumes to restore the ground-water quality (HRI, 1996a). Should more pore volumes be required to restore the ground water, the volume of water used will increase and the pond size and land application areas may increase in size. The amount of this increase will be strongly influenced by the ground-water restoration approach chosen.

The staff believes that restoration to average-baseline or water-use is unlikely to be achieved in four pore volumes. However, the staff also recognizes that achieving ground-water restoration to these standards should be a function of the level of restoration effort or approach. Therefore, it is the decision of the staff that surety (bonding) for ground-water restoration of the initial well fields should be based on greater than four pore-volume estimates. Furthermore, surety should be maintained at this level until it has been demonstrated that production scale restoration can be achieved in four pore-volumes or less. The NRC staff consider this comment closed.

REFERENCES:

HRI, 1996, . Transmittal to Joe Holonich (NRC) titled "Request for Additional Information, Questions 49-91, Water Resources Protection and Cost/Benefit Analysis; Safety Analysis Review and Environmental Review for Hydro Resources, Inc", dated April 1 and 5, 1996.

Holonich, J., 1996, letter from Joe Holonich (U.S. Nuclear Regulatory Commission) to Mark Pelizza, Hydro Resources, Inc., title "Request For Additional Information; Water Resources Protection and Cost/Benefit Analysis; Safety Analysis Review and Environmental Review For The Hydro Resources, Inc. (HRI) Uranium Solution Mining License Application, Crownpoint, New Mexico", February 9, 1996.

57. **COMMENT:** Excursion Definition and Corrective Action Procedures

EVALUATION OF RESPONSE: The staff's evaluation of this comment asked the applicant to revise the application documents to include a methodology for timely cleanup of confirmed excursions. In their response (HRI, 1996) the applicant proposed one of the following two courses of action in the event an excursion is not corrected within 60 days of confirmation.

1. If the well(s) is still on excursion 60 days after confirmation, injection of lixiviant within the well field on excursion shall be terminated until such time that aquifer cleanup is complete; or

2. HRI provides an increase to the reclamation bond, in an amount that is agreeable to NRC, which will cover the full cost of correcting and cleanup of the excursion. The bond increase will remain in force until the excursion has been corrected.

HRI further states that the written 60 day excursion report will state and justify which course of action will be followed.

The NRC staff consider this proposal acceptable. The NRC staff will require that a written report shall be submitted to the NRC within 60 days of excursion confirmation. The report shall describe the excursion event, corrective actions taken, and results obtained. If wells are still on excursion at the time the report is submitted, the report shall also contain a schedule for submittal of future reports to the NRC describing the excursion event, corrective actions taken, and results obtained. In the case of a vertical excursion at the time the report is submitted, the report shall also contain a projected completion date when characterization of the extent of this vertical excursion will be completed.

If wells are still on excursion at the time the 60 day report is submitted to NRC, and the bonding option is chosen, well field restoration bonding will be adjusted upward. To calculate the increase in bonding for horizontal excursions, it shall be assumed that the entire thickness of the aquifer between the well field and the monitor wells on excursion has been contaminated with lixiviant. It will also be assumed that the width of the excursion is the distance between monitor wells on excursion plus one monitor well spacing distance on either side of the excursion. When the excursion has been corrected, the additional bonding requirements resulting from the excursion will be removed.

To calculate the increase in bonding for vertical excursions, an initial estimate of the area contaminated above background shall be made. All estimates will assume that the entire thickness of the upper aquifer has been contaminated. As characterization of the extent of contamination proceeds, bonding may be increased or decreased as appropriate. Once the extent of contamination has been determined, the area which has been

contaminated above background will be the area used to calculate the increased level of bonding. When the vertical excursion has been cleaned up, the additional bonding requirements resulting from the excursion will be removed.

In calculating the increase in bonding for horizontal and vertical excursions, the same formula used to calculate the number of pore volumes required to restore a well field shall be applied to the assumed areas of contamination. This approach of adjustable bonding has the advantage of providing an incentive to the licensee for timely cleanup of excursions, as well as adjusting surety levels appropriately to cover increased restoration costs resulting from these excursions. In calculating the area impacted by an excursion and the volume of water required to effect restoration, a conservative approach is taken to ensure that adequate funds are available to clean up the ground water should the licensee fail to correct and clean up the excursion. The NRC staff consider this comment closed.

REFERENCES:

HRI, 1996, transmittal to Daniel Gillen (NRC), from Mark Pelizza (HRI) titled "Response to additional Comments Dated September 16, 1996 on the License Application for an In-Situ Mining Facility at Crownpoint, New Mexico, Q3/57, Q3/95 and Q3/96", dated September 27, 1996.

96. **COMMENT:** Multiple Ground-Water Standards

EVALUATION OF RESPONSE: The applicant was asked to provide legible maps that fit on standard letter size paper and show for each site the areas of the property that are considered Indian and non-Indian land. Alternatively, the applicant was asked to propose a single restoration standard for all three sites.

The applicant has proposed a single standard for all three sites. Restoration criteria would be established on a parameter-by-parameter basis, and the primary goal of restoration would be to return all parameters to average premining baseline conditions (HRI, 1996a and b). In the event water-quality parameters cannot be returned to average premining baseline levels through reasonable restoration efforts, the secondary goal will be to return the water quality to the maximum concentration limits as specified in EPA 40 CFR § 141 and 143.3 secondary and primary drinking water regulations. As proposed by the applicant (HRI, 1996a and b), the secondary restoration goal for barium and fluoride, will be set to the State of New Mexico primary drinking water standard. For uranium, 300 pCi/ml (0.44 mg/L) will be used. This concentration was obtained from Table 2 of Appendix B, of 10 CFR § 20 and is suitable for unrestricted release of natural uranium to water. This means that the secondary restoration goal will be equal to or below both State of New Mexico and EPA primary and secondary drinking water standards for consitituents. Table 96-1 shows the primary and secondary restoration goals.

This goal is consistent with the NRC Staff Technical Position Paper titled "Groundwater Monitoring at Uranium In Situ Solution Mines." dated December 1981. On page ?4 of this document it is stated that "*The following are recommended restoration targets.*

a. Restoration results in a return to baseline ground-water quality for all indicators in all affected ground waters and in all restoration water quality monitor wells.

b. Where the baseline concentration of a particular indicator is less than drinking water standards, the appropriate established state and federal criteria may be used to establish maximum permissible values for restoration purposes."

The applicant further stated that consistent with relevant statutory and regulatory provisions, as well as the provisions of other NRC *in situ* licenses, if the applicant finds it impracticable to restore to primary or secondary goals, the applicant may request a license amendment from the NRC allowing some change in restoration requirements on a parameter by parameter basis (HRI, 1996b).

It is the NRC staff's opinion that if a ground-water parameter cannot be returned to it's secondary goal, the applicant will have to make a health demonstration to the NRC that leaving the parameter at the higher

concentration is not a threat to public health and safety and on a parameter by parameter basis that the water use would not be significantly degraded. The NRC staff consider this comment closed.

REFERENCES:

HRI. 1996a. transmittal to Joe Holonich (NRC) from Richard Clement (HRI). dated October 18. 1996.

HRI. 1996b. transmittal to Joe Holonich (NRC) from Richard Clement (HRI) dated November 6. 1996.

Table 96-1: Primary and Secondary Restoration Goals

Parameter	Primary Goal (mg/L)	Secondary Goal (mg/L)
Alkalinity	Well Field Average	Well Field Average
Ammonium (as Nitrate)	Well Field Average	10.0
Arsenic	Well Field Average	0.05
Barium	Well Field Average	1.0
Bicarbonate	Well Field Average	Well Field Average
Boron	Well Field Average	Well Field Average
Cadmium	Well Field Average	0.01
Calcium	Well Field Average	Well Field Average
Carbonate	Well Field Average	Well Field Average
Chloride	Well Field Average	250.0
Chromium	Well Field Average	0.05
Copper	Well Field Average	1.0
Fluoride	Well Field Average	2.0
Iron	Well Field Average	0.3
Lead	Well Field Average	0.05
Magnesium	Well Field Average	Well Field Average
Manganese	Well Field Average	0.05
Mercury	Well Field Average	0.002
Molybdenum	Well Field Average	Well Field Average
Nickel	Well Field Average	0.1
Nitrate	Well Field Average	10.0
Potassium	Well Field Average	Well Field Average
pH[1]	Well Field Average	6.5-8.5
Radium-226[2]	Well Field Average	5.0
Selenium	Well Field Average	0.05
Silver	Well Field Average	Well Field Average
Sodium	Well Field Average	Well Field Average
Sulfate	Well Field Average	250.0
TDS	Well Field Average	500.0
Uranium	Well Field Average	0.44
Vanadium	Well Field Average	Well Field Average
Zinc	Well Field Average	5.0

1. units
2. pCi/L