DATA ON GROUNDWATER IMPACTS AT THE EXISTING ISR FACILITIES

INTRODUCTION

On December 11, 2008, the U.S. Nuclear Regulatory Commission (NRC) held a briefing on the status of uranium recovery facilities during which the staff briefed the Commissioners on the status of uranium recovery applications, in-situ recovery (ISR) facilities generic environmental impact statement (GEIS), rulemaking for groundwater protection at ISR facilities, and Native American outreach. Following that briefing, the Commission directed the NRC staff to provide it with the data it has in hand that assesses environmental impacts to the groundwater from previously licensed ISR facilities (Staff Requirements Memorandum dated January 8, 2009, SRM M081211).

This report addresses that request. The NRC staff found relevant information from three NRC licensed ISR facilities and from Research and Development (R&D) ISRs that were licensed in the late 1970s to early 1980s. The existing data on impacts to groundwater at the Texas licensed facilities were not available for NRC review and not summarized in this report.

POTENTIAL GROUNDWATER IMPACTS AT AN ISR FACILITY

Before an NRC-licensed ISR can begin operations at the project site, the licensee must obtain an Underground Injection Control (UIC) permit from the U.S. Environmental Protection Agency (EPA) or EPA-authorized State. The permit must exempt the portion of the aquifer subject to uranium mining from classification as an underground source of drinking water. The portion of the aquifer where uranium extraction occurs is referred to as the “production zone.” Once uranium recovery operations begin, several different types of environmental impact can occur: impacts to groundwater quality in the production zone during operation and after restoration following the cessation of operation, impacts from the migration of extraction fluids to the aquifer outside the production zone and aquifers above and below the production zone, and impacts to aquifers above the production zone from well casing failures.

Within the production zone, the impacts from operations include elevated levels of various constituents introduced with the extraction fluids (e.g., oxygen, bicarbonate, and hydrogen peroxide) and chemical species that become mobile during the extraction process (e.g., uranium and other metals). After ISR operations are completed at a facility, NRC requires the licensee to restore the exempted aquifer water quality to pre-operational (or baseline conditions), drinking water standards, or alternate concentration limits. The primary goal of restoration is to return the production zone to pre-operational conditions, which would result in no impact; however, that is usually not attainable for all constituents at most ISRs. NRC regulations allow restoration to other standards that are protective of public health and safety and the environment but as restoration to these standards results in changes from pre-operational conditions, restoration results in impacts.

During operations, extraction fluids may directly impact the aquifer surrounding the production zone. A migration of fluids towards the surrounding aquifer is referred to as an excursion. Any excursion from an active wellfield is monitored and is closely controlled. A perimeter monitoring well network surrounds the production zone at a distance of 300 to 500 feet to detect excursions before they can cross the horizontal boundary of the exempted portion of the aquifer. Monitoring wells are also installed in the aquifer above and below the exempted aquifer to

detect vertical excursions. Licensees are required to correct excursions detected by the monitoring wells.

Another potential direct impact to the surrounding aquifers during operations is an uncontrolled release of fluids from the subsurface wells due to its loss of well integrity at a depth other than the screened horizon. This potential impact is primarily limited to overlying aquifers as production wells generally do not extend below the exempted aquifer. Impacts to overlying aquifers may occur from well failures involving either injection fluids or extraction fluids.

Several existing facilities also have the capability for disposal of 11e.(2) byproduct liquid waste through on-site deep well injection. An exemption from the EPA underground source of drinking water requirements is required for each deep well injection. This classification differs from the classification of the exempted aquifer for ISR operations because the injected fluids will remain permanently in this exempted aquifer.

Lastly, the potential exists for impacting the groundwater (e.g., from an undetected excursion) in the region of an operating ISR. As such, NRC-licensed ISR facilities are required to periodically monitor regional groundwater's for potential impacts from licensed operations.

The data in hand on the environmental impacts to the groundwater from ISR facilities are discussed below.

DISCUSSION OF GROUNDWATER IMPACTS AT NRC-LICENSED FACILITIES

There are currently three operating facilities licensed by the NRC. Two facilities, COGEMA's Irigaray/Christensen Ranch facility and PRI's Smith Ranch/Highland Uranium Project (HUP) facility, operate in Wyoming and Crow Butte Resources Crow Butte facility operates in Nebraska. This report presents data from those licensed operating facilities. A fourth facility, Hydro Resources, Inc., Crown Point facility in New Mexico, has an NRC license but has never operated. Documentation for 34 early licensed R&D facilities were also reviewed for this paper. Data from these R&D facilities are similar in extent to the information provided in this paper for the existing, operational licensed facilities.

Exempted Aquifer – Restoration

The NRC requires an applicant for an ISR license to document the restoration process in the license application. The staff reviews this information to ensure its potential effectiveness and adequacy in terms of defining an appropriate surety. During the restoration process, the licensee has the flexibility within certain parameters to adjust the process to meet the goal. After a licensee determines that the active restoration is completed, a licensee discontinues active restoration to allow stabilization monitoring. After the stabilization monitoring is complete, the licensee submits a restoration report for NRC approval. Generally, the restoration report is based on individual wellfields rather than one facility-wide report.

NRC staff has approved 11 wellfield restorations at the 3 existing licensed facilities. All of the restorations had levels of one or more parameters above baseline levels (a baseline level is defined as the mean value determined from a selected ground of wells screened in the exempted aquifer prior to ISR operations). The restoration data from the currently licensed facilities have shown that this goal is attainable for many parameters (50 to 70 percent of the 35 parameters commonly monitored) but is not attainable for other constituents, in particular, the

major and trace cations with solubilities most susceptible to the oxidation state of the aquifer water (i.e., iron, manganese, arsenic, selenium, uranium, vanadium and radium-226).

The data for the approved restorations are as follows:

> Nine wellfield restorations, Wellfield Units 1 through 9, have been approved for the COGEMA Irigaray project. The restorations have been effective in reducing the levels of 50 percent of the parameters to their baseline levels. Of those parameters that did not meet the baseline levels, COGEMA reported that 13 parameters exceeded the observed range in baseline data for that parameter. The parameters that did not meet the range in baseline data are alkalinity, ammonium, barium, carbonate, chloride, calcium, conductivity, lead, magnesium, manganese, sodium, total dissolved solids, and radium-226.
>
> One wellfield restoration, HUP Wellfield A, has been approved for the PRI HUP facility. The restoration was effective in reducing the levels of most parameters, 70 percent of the parameters have been restored to their baseline levels. The parameters that did not meet their baseline levels are alkalinity, arsenic, bicarbonate, chloride, calcium, conductivity, iron, magnesium, manganese, pH, sodium, selenium, sulfate, total dissolved solids, uranium, and radium-226.
>
> One wellfield restoration, Mine Unit 1, has been approved for the CBR facility. The restoration was effective in reducing 70 percent of the parameters to their baseline levels. The parameters that did not meet their baseline levels are alkalinity, arsenic, bicarbonate, calcium, iron, magnesium, molybdenum, potassium, uranium, vanadium and radium-226.

The data in hand for the R&D indicate similar results as on the impacts to the production aquifer following restoration as summarized above for the currently existing ISR facilities. The R&D facilities generally required significantly more time to reach levels for an NRC approved restoration due to the use of an extraction fluid that included added ammonium at several early R&D facilities. A license condition on the makeup of the extraction fluid for the existing ISR facilities effectively prohibits the use of ammonium in the extraction fluids.

For the approved restorations, the impacts to groundwater in the exempted aquifer met all regulatory standards for the state or EPA UIC program, met the quality designated for its class of use prior to ISR operations, have been shown to decrease in the future due to natural attenuation processes, and have been shown to meet drinking water standards at the perimeter of the exempted aquifer. Therefore, the impacts to the exempted aquifer for each of the approved restorations do not pose a threat to human health or the environment.

Aquifers Surrounding the Exempt Production Aquifer

Excursions

By license condition, all existing licensees must: (1) establish approved excursion parameters and define an acceptable excursion monitoring well network on a production unit basis; (2) perform bi-monthly sampling at the monitoring well network for the excursion parameters; (3)

report to the NRC Project Manager within 24 hours (48 hours in some cases) of an initiation of an excursion with a follow-up report within in 30 days; and (4) perform weekly confirmatory monitoring for a well on excursion status until corrective actions prove successful to eliminate the excursion status. All existing licensees are required by license condition to maintain on-site a record of excursions and the associate corrective actions. These reports are examined by NRC staff during routine inspections of the facilities. A license condition for one licensee (COGEMA) also requires quarterly reporting on all wells on excursion status until termination of the excursion status.

Based on a review of historical licensing documentation, the number of excursions reported for the three existing NRC-licensed operating facilities and the duration of the excursions constitute a small percentage of the total number of samples analyzed over that period. The data indicate that excursions have been controlled by the pumping and injection processes. In some cases, the excursions continued for several years. The impact to groundwater was investigated for each long-term excursion and it was determined that the associated impact did not pose a threat to human health or the environment. Continued monitoring is required for several of the wells on long-term excursion status until the wellfield restoration is complete to ensure acceptable impact to groundwater throughout the ISR operations. Detailed information on excursions at the licensed operating ISR facilities is provided in Table 1.

Well Integrity Failures

By license condition, all existing licensees must perform mechanical integrity tests (MITs) for all injection and production wells initially, to ensure that the wells are constructed properly, and subsequently, on a routine schedule, to ensure that the wells do not develop leaks. The facility must maintain this information on-site for NRC review during routine inspections.

Based on a review of the historical licensing documentation, the number of MIT failures reported for the three existing NRC-licensed facilities indicates that the mechanical integrity testing programs provide early detection of well failures prior to impacts to the environment. Overall, the frequency rate of the MIT failures is low for all existing facilities, except for a brief period in 2002 during which an abnormally high failure rate was reported for the PRI facility. The high failure rate was attributed to the use of inferior casing material for the wells. The facility promptly corrected the situation and no impacts were reported during monitoring of the upper aquifer. One MIT failure at the Crow Butte facility was attributed to a casing coupling failure which resulted in impacts to the shallow aquifer. The impacts were mitigated. The staff currently reviews casing material proposed for new facilities based on these lessons learned.

The data in hand indicates that MIT failures do occur. At two of the three existing licensed ISR facilities, investigations into impacts to the overlying aquifers are not immediately performed. However, the aquifer immediately overlying the production zone is monitored on a continual basis for excursions and the monitoring data indicate no impacts to that aquifer attributable to a well failure. At the third licensed facility, the impacts to the overlying aquifers are investigated following an MIT failure. The impacts at that facility did not pose a threat to human health or the environment for five of the six MIT failures. In the case of the single failure that did result in measurable unacceptable impacts, the impacts were mitigated to levels that were protective of human health or the environment. Detailed information on MIT failures at the licensed operating ISR facilities is provided in Table 2.

On-Site Liquid Waste Disposal by Deep Well Injection

Two of the three NRC licensed facilities have on-site deep injection wells for disposal of waste liquid 11e.(2) byproduct material waste. In a license application, an applicant must document the location of each disposal well, its depth and separation from potable aquifers, anticipated rate of injection, and liquid chemistry of the byproduct waste. The NRC generally approves usage of an on-site disposal through deep well injection if this action is approved through the EPA 40 CFR Part 146 UIC program or state-approved UIC program and as long as exposure at the wellhead is protective of human health and the environment.

During the life of the facility, the licensee must maintain records on the disposal well usage and provides annual reports to the NRC. In addition, the licensee must perform routine MIT tests on each disposal well.

The data for the existing NRC-licensed operating facilities indicate that on-site deep well disposal of byproduct material waste has been conducted in a manner that is protective of human health and the environment.

Regional Aquifers

Annual reporting that includes monitoring of the aquifers regionally (i.e., at a distance from the operations) is a license condition for all existing NRC-licensed operating ISR facilities. The constituents analyzed for the regional monitoring program include uranium and radium-226. The sampling locations include domestic wells, livestock wells or any nearby groundwater source. Based on a review of historical licensing documentation, data from the regional monitoring at all existing ISR facilities indicate that no impacts attributable to an ISR facility were observed at the regional monitoring locations. In addition, the staff is unaware of any situation indicating that: (1) the quality of groundwater at a nearby water supply well has been degraded; (2) the use of a water supply well has been discontinued; or, (3) a well has been relocated because of environmental impacts attributed to an ISR facility.

The data in hand on regional monitoring at the existing ISR licensed facilities includes the following:

> For the COGEMA Irigaray/Christensen Ranch facility, semi-annual monitoring is required for seven regional ranch water supply wells.
>
> For the PRI Smith Ranch/HUP facility, quarterly monitoring is required at 18 groundwater sites throughout its permit area.
>
> For the CBR Crow Butte facility, semi-annual monitoring is required at 19 groundwater sites within 1 kilometer of a wellfield.

SUMMARY AND CONCLUSIONS

Potential environmental impacts to groundwater at an ISR facility can result from inadequate restoration of the production aquifer following completion of the ISR operations, leakage from a failure of the subsurface well materials, or an excursion of the leaching fluids to the aquifers surrounding the production or exempted aquifer.

For NRC-approved restorations of the production aquifer, the staff acknowledges that several parameters require a long time to reach pre-mining concentration levels after operations at an ISR facility are completed. However, the concentration levels at the time of restoration approval have been determined to be protective of human health and the environment.

Excursions and MIT failures have been reported but, in most cases, are controlled and do not pose a threat to human health or environment to the surrounding aquifers. In the case of excursions, several long-term excursions have been reported for two existing ISR facilities. The existing impacts were investigated and determined not to pose a threat to human health or the environment. In the case of MIT failures, two license facilities do not investigate the impacts to the overlying aquifers; however, routine monitoring of the aquifer immediately overlying the production zone at those facilities has not detected impacts attributed to an MIT failure. At the third facility, the impacts to the overlying aquifers are investigated for each MIT failure. For five of the six reported MIT failures at that facility, no impacts to groundwater were identified. For one reported failure, the impacts were mitigated to levels protective of human health and the environment.

Regional groundwater monitoring is required for all three existing facilities. The monitoring data indicated no impacts attributed to the migration of impacted groundwater from the existing facility.

TABLE 1

DATA IN HAND ON EXCURSIONS AT THE NRC-LICENSED OPERATING ISR FACILITIES

COGEMA Irigaray/Christensen Ranch Facility

Thirty-one excursion events were reported for the COGEMA Irigaray/Christensen Ranch facility. Of the 31 excursion events, 20 events were horizontal excursions and 11 events were vertical excursions. Most horizontal excursions were short-lived as the licensee was able to correct the situation by controlling the pumping and/or extraction rates at the nearby wellfield. Because the wellfields were undergoing restoration rather than operation (the database reviewed for excursions extended from the present back to the year 2000 during which time wellfields at the COGEMA facility were undergoing restoration), the control by changing pumping rates was slightly more difficult because the pumping and injection rates were low during the restoration process. Vertical excursions were less likely to occur but generally their durations were longer than horizontal excursions.

One horizontal excursion event at COGEMA was not controlled in a timely manner during 2004-2005. The Wyoming Department of Environmental Quality (WDEQ) released a well from excursion status based on a request by the licensee. The request was based on supporting documentation in which the licensee stated that the Best Practicable Technology had been applied during the wellfield restoration, the chemical makeup exceeded the baseline data but was consistent with the pre-mining class of use for the aquifer, area of the aquifer denoted by the “excursion” was limited in extent, and the chemistry of the production zone was not the source of the excursion. The licensee proposed quarterly monitoring at that well until final regulatory approval of the restoration activities. In 2008, the licensee submitted restoration data for Mine Unit 5. The excursion in question was addressed in that restoration package. The licensee indicated that while the excursion parameters (chloride, conductivity and alkalinity) remained elevated, the levels of trace metals and radionuclides were not elevated and consistent with attenuation within the wellfield. As part of its review process, NRC staff has requested additional information on the chemistry at this well. The restoration data currently are under NRC staff review.

The duration of vertical excursions at the COGEMA facility was generally longer than the typical horizontal excursion. In fact, most “long-term” vertical excursion events were terminated prior to reaching pre-excursion levels by the regulatory agencies following an in-depth review of impacts. It was shown that all parameters stabilized below the levels the state required for the pre-mining use of the aquifer. Therefore, the environmental impacts to the aquifer from the excursion were considered negligible and excursion status was terminated.

PRI Smith Ranch/HUP Facility

Twelve excursion events were reported for the PRI Smith Ranch/HUP facility. All 12 excursion events were horizontal excursions. Eleven of the 12 excursion events occurred at the HUP project. One event was induced by drawdown

during the required sampling of the well based on the geologic conditions. Sampling procedures for the wells in that vicinity were modified to minimize drawdown during the sampling. Unlike COGEMA, PRI does not routinely report the termination of their excursion events. The NRC guidance for a review of an ISR license application only addresses a timely notification for the initiation of an excursion but not a notification for its termination. The termination is addressed during NRC routine inspections and/or the licensee's quarterly (60-day) reports.

Seven wells at the PRI facility have been on excursion status for at least 60 days. The excursions at four (4) wells were attributed to effects of a former underground mine in the area of the wellfields and those at the other three wells were during wellfield restorations. The reported data on the long-term excursion events indicate that the water quality meets the WDEP pre-mining class of use for the aquifer. The NRC staff will review the data during the wellfield restoration report to ensure that the environmental impacts are protective of human health and the environment at the completion of the wellfield operations.

CBR Crow Butte Facility

Twenty excursion events were reported for the CBR Crow Butte facility. Eleven events were horizontal excursions of which four excursions lasted for up to six years. Three of the four excursions were due to wellfield geometry, i.e., the excursion event was at monitoring wells between wellfields (within the exempted aquifer) and the elevated levels were attributed to production at both wellfields. The fourth excursion was located in an area where the production zone wells were partially penetrating, i.e., within the lower portion of the exempted aquifer. Fully penetrating wells were installed and a control on the excursion was returned. The nine vertical excursions were attributed to natural fluctuations in the parameter levels in the upper aquifer and therefore, concluded not to be an excursion.

TABLE 2

DATA IN HAND ON MIT FAILURES AT THE NRC-LICENSED OPERATING FACILITIES

COGEMA Irigaray/Christensen Ranch Facility

One-hundred thirty-five MIT failures have been reported for the COGEMA Irigaray/Christensen Ranch facility since 1998. The failure rate has been consistent on an annual basis at less than five percent of the wells tested.

PRI Smith Ranch/HUP Facility

Eighteen MIT failures were reported for the PRI Smith Ranch/HUP from the fourth quarter of 1999 to the first quarter of 2002. The MIT reports are included in submittals to Wyoming Department of Environmental Quality for the mining permit. The MIT failures are reviewed by NRC personnel during routine inspections. The failure rate was approximately equal to the rate reported for COGEMA (five percent of the wells tested).

During the fourth quarter of 2002, PRI reported an abnormally high failure rate. The source of the failure rate was attributed to faulty casing material. The casings were replaced. No impact to the surrounding overlying aquifer was detected during the excursion monitoring.

CBR Crow Butte Facility

Six MIT failures were reported for the CBR Crow Butte facility. The MIT failures were investigated to determine the depth of the casing failure. Five failures were determined to be at shallow depths. One failure resulted in impacts to the shallow groundwater in the immediate vicinity of the well. Those impacts were remediated to the aquifer baseline levels.