COGEMA

License No. SUA-1341
Docket No. 40-8502

June 21, 2006

Mr. Stephen J. Cohen, Hydrogeologist
Fuel Cycle Facilities Branch
Division of Fuel Cycle Safety and Safeguards
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
11545 Rockville Pike
Rockville, Maryland 20852-2738

RE: Response to NRC RAI, COGEMA Irigaray Mine Restoration Report (TAC LU0113)

Dear Mr. Cohen:

Please find attached to this letter COGEMA Mining, Inc.'s response to the U.S. Nuclear Regulatory Commission's (NRC) Request for Additional Information (RAI) dated May 11, 2006. As stated in our response, the report for the Irigaray mine submitted to NRC on November 7, 2005 presents the results of the Production Units 1 through 9 groundwater restoration. The results show that 27 of 29 constituents were restored to baseline values. Additionally, the report documents the results of flow and contaminant transport modeling that was used to demonstrate that certain residual concentrations of constituents will not degrade the aquifer class of use outside of the monitor well ring. The Wyoming Department of Environmental Quality unconditionally approved this restoration effort by letter dated November 1, 2005.

In their RAI, NRC asked questions pertaining to the compliance with the primary restoration targets and aspects of the fate and transport modeling. We believe that our responses are sensitive to NRC's questions or concerns, and show that COGEMA has complied with all requirements of our license. We also believe that the modeling and sensitivity analyses performed are technically sound and are very conservative, and that there should be no requirement to perform any further modeling.

Your timely review of our responses and approval of the restoration effort will be greatly appreciated. We are very anxious to commence with the plugging and abandonment of the Irigaray Production Unit wells, as we are already into the summer construction season, which in itself is quite limited. As such, please do not hesitate to contact me with any questions regarding our response, or if you have specific questions on the modeling please feel free to directly contact Mr. Errol Lawrence with Petrotek Engineering, (303) 880-9175.

Sincerely,

Donna L. Wichers
General Manager

cc: E. Lawrence, H. Demuth – Petrotek Engineering Corporation
L. Arbogast - COGEMA

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RESPONSES TO NRC REQUEST FOR ADDITIONAL INFORMATION
COGEMA MINING, INC. IRIGARAY MINE
RESTORATION REPORT

COGEMA Mining Inc (COGEMA) has prepared responses to the May 11, 2006 request for additional information from the U.S. Nuclear Regulatory Commission (NRC) regarding the July 2004 Irigaray Mine Wellfield Restoration Report. The report was submitted to NRC on November 7, 2005. The Wyoming Department of Environmental Quality (WDEQ) approved the restoration results on November 1, 2005. NRC comments are presented in italics, followed by COGEMA's responses in bold lettering.

Comment No. A1. Please review the ranges of individual restoration/stabilization data to determine compliance with the primary target restoration values. COGEMA presents target restoration values in the form of ranges of baseline values in Table 4-6 of its Irigaray restoration report. These ranges are compared to average stabilization values for each constituent as also presented in Table 4-6. A review of COGEMA's NRC license and WDEQ Permit No. 478 indicates that COGEMA should have compared ranges of individual restoration/stabilization data values to the baseline ranges (referred to as tolerance limits in the WDEQ permit and NRC license) to determine whether or not the primary goal of mine unit restoration has been achieved.

Basis: *License Condition 10.16 requires that COGEMA restore ground water quality to baseline as described in Section 6.1 of the license application. The primary goal of restoration shall be to return the ground water quality, on a production-unit average, to baseline concentrations on a parameter-by-parameter basis. Both the WDEQ Permit No. 478 and the NRC license applications indicate that ranges of individual restoration values should be compared to baseline ranges.*

Response: As stated under the basis for this comment, the primary goal of restoration shall be to return the groundwater quality, *on a production-unit average*, to baseline concentrations on a parameter by parameter basis. This restoration goal is consistent with COGEMA's WDEQ/LQD permit and LQD guidance. COGEMA has prepared the restoration report with this goal as the primary focus. However, in response to NRC's request, COGEMA has prepared a summary table that compares the ranges of individual restoration values to baseline ranges. The summary table comparing the restoration/stabilization and baseline ranges is attached.

Based on that comparison, the individual restoration/stabilization data falls within the baseline ranges for all constituents except the following:

Ca, Mg, Na, HCO3, Cl, NH_4, TDS, conductivity, alkalinity, Pb, Ba, Mn and Ra-226.

Of those constituents, Ca, Mg, Na, HCO3, conductivity, and alkalinity do not have groundwater standards. A single sample exceeded the baseline range for Ba but was below both the EPA and WDEQ water quality standards. All of the Cl samples were below the WDEQ standard and the secondary EPA standard. A single sample exceeded the baseline range for Pb (monitor well JI-84). The Pb sample appears to be an outlier as it is the only detectable concentration out of 33 samples submitted, and analyzed in the 4th round. Previous sampling of monitor well JI-84 indicated Pb was below the detection limit.

TDS exceeds the baseline range in 5 samples out of 33 samples and Mn exceeds the baseline range in 12 samples. However both TDS and Mn have only secondary EPA drinking water standards.

Radium 226 exceeds the baseline range in 3 samples. However, Ra-226 is known to be relatively immobile in aqueous systems. Also, original groundwater quality sample data yields a baseline mean for Ra-226 of 39.6 pCi/l, which almost 6 times greater than the EPA MCL and WDEQ standard. Of the 46 wells included in the baseline sampling group, original conditions at all but one well exceeded the EPA MCL on at least one of the sampling rounds.

Although NH_4 exceeds the baseline range for a number of samples, it should be noted that the current groundwater standard is for NH_3 as N at 0.5 mg/l. The speciation of ammonia is a critical factor for assessing the fate and transport of ammonia. Dissolved ammonia exists as equilibrium of un-ionized ammonia (NH_3) and ammonium ions (NH_4^+). The speciation is strongly dependent on pH and temperature and to a lesser extent on ionic strength. As pH increases, the relative proportion of un-ionized ammonia to total ammonia increases. As temperature increases, the fraction of un-ionized ammonia also increases. A detailed description of ammonia chemistry is provided in COGEMA, 2005; Response to LQD/DEQ January 10, 2005 Comments; Irigaray Wellfield Restoration Report; TFN 4 1/170; May 4, 2005).

Using average pH (7.46 p.u.) and temperature (15.2 C) conditions present within the restored aquifer at Irigaray, the conversion factor to compute NH_3 from NH_4 is approximately 0.008. This conversion factor results in all samples from the 4th stability round having lower NH_3 concentration than the WDEQ standard. Therefore, current levels of residual NH_4 do not present a threat to public health and safety or the environment or unacceptably degrade water uses of adjacent ground water resources.

> *Comment No. B1. Please explain COGEMA's rationale for orienting the ground water flow model grid with the longitudinal axis of the ore body instead of the principal ground water flow direction. Aligning model grids along the principal direction of ground water flow is typical, otherwise numerical errors could occur resulting in an exaggerated dispersion.*

Response: As shown on Figures B5 through B8 in Appendix B of the restoration report, the groundwater flow direction is not uniform across the area of interest (model domain). Groundwater enters the modeled area from the southeast and east and exits to the northwest. The convergent nature of the flow system into the wellfield makes it impossible to orient the model grid with a single principal direction of groundwater flow. Under the current grid orientation, two of the three directional components of groundwater flow are aligned parallel with the gridding.

It should be noted that it is usually preferred to align the model grid such that the x and y axis are co-linear with the principal directions of the hydraulic conductivity tensor (K_x and K_y) (Anderson and Woessner, *Applied Groundwater Modeling, Simulation of Flow and Advective Transport*, 1992), not necessarily the principal direction of groundwater flow. For this model, it is assumed that the aquifer is isotropic in the xy plane and that there is no difference between the hydraulic conductivity tensors K_x and K_y. Therefore, the orientation of the grid is not a critical factor in the design of this model.

Acceptability of a model with respect to artificial oscillation and numerical dispersion is determined using the calculated criteria of the Peclet number and the Courant number. The Peclet number is calculated by :

Lx/a_L

where : Lx is the cell dimension, and

a_L is the longitudinal dispersivity

The Peclet number should be less than 2 to minimize numerical dispersion (Zheng and Bennett, *Applied Contaminant Transport Modeling, Theory and Practice*, 1995). For the Irigaray model the Peclet number is calculated as:

Pe = 25 ft / 25 ft = 1,

which is below the criteria threshold.

The Courant number can be used to evaluate the suitability of model time steps. The time step (Lt) should be selected such that it is less than the time it takes for the solute to move across a single model cell (Lx) (Anderson & Woessner, *Applied Groundwater Modeling, Simulation of Flow and Advective Transport*, 1992). The Courant number is calculated by:

C = v Lt / Lx

where v is the groundwater velocity.

The Courant number should be equal to or less than one. For the Irigaray model, the maximum time step was 100 days. Groundwater velocity for the model is calculated as 0.01 ft/d using the model parameters for hydraulic conductivity (0.5 ft/d), hydraulic gradient (0.005 ft/ft) and porosity (0.24). The model cell dimension is 25 ft, resulting in a Courant number of 0.04. Numerical dispersion in the Irigaray model is acceptable based on the comparison to published and widely accepted criteria.

Comment No. B2. Please explain the use of 1 vertical grid cell per model layer. Coarse grids, such as 1 vertical grid cell per layer, could induce an artificially increased numerical dispersion. Consequently, model results using such a coarse grid could result in smaller concentrations at the downstream monitoring wells than would otherwise result from a finer vertical grid.

RESPONSE: This model was an attempt at providing as simple a representation of site conditions as possible while including pertinent hydrogeologic features of the site. The model was designed to represent the Upper Irigaray Sandstone (UIS) with three distinct layers representing the mineralized zone and the overlying and underlying nonmineralized zones. There are slight variations in layer properties (hydraulic conductivity, porosity, and thickness) to represent the conceptual model that was presented in the model report. MODFLOW only allows the use of a single vertical grid cell per model layer. To introduce additional vertical grid cells requires adding additional model layers. There is no basis in the conceptual model to further sub-divide the mineralized zone into smaller layers (i.e., changes in aquifer properties).

It should be noted that the primary criteria used to evaluate the suitability of a model with respect to numerical dispersion are the Peclet and Courant numbers, which were discussed in the response to Comment B1. The Irigaray model, as it is currently constructed, satisfies the Peclet and Courant number criteria for minimizing

numerical dispersion.

Comment No. B3. Please provide justification for the range of dispersivity values used in transport modeling to demonstrate that offsite water quality would remain below Class I ground water standards. It appears that COGEMA used scale-dependent dispersivity values biased on Gelhar et al (1993), and used 1,000 ft as the plume size for estimating dispersivity values. However, a plume length covering the distance between the monitoring well ring and the ore body (approximately 400 ft) would be more appropriate for the following reasons. The 1000-ft plume used by COGEMA was estimated through modeling, which adds an additional level of uncertainty to the dispersivity estimate. Conversely, the transport observation points coincide with the monitoring well ring, and the distance between the monitoring well ring and the ore body is a fixed distance. This 400-ft distance would be a more certain scaling factor than the 1,000-ft factor use by COGEMA and would result in lower dispersivity values.

RESPONSE: Within the constraints of the model, the distance from the ore body to the monitor well represents the minimal distance that the plume must travel to be observed at the monitor well ring. The focus of the model was to determine, not only estimates of arrival time, but also estimates of the maximum concentration that might be observed at any of the monitor ring wells. As seen in the breakthrough curves on Figures 5-11, 5-15 and 5-21 of the restoration report, the first arrival of a constituent derived from the Irigaray site precedes the peak concentration by tens to hundreds of years. The maximum concentration observed at the monitor wells generally coincides with the arrival of the center of mass of the plume, which in this case is approximately equivalent to the central portion of the wellfield. The width of the wellfield parallel to the direction of groundwater flow is generally 400 to 500 feet. If we assume the average width to be 400 feet, then the midpoint of the initial plume is approximately 200 feet from the edge of the wellfield. Therefore, the distance from the monitor ring wells to the point in the plume that results in the maximum concentration is approximately 600 feet. This value is a reasonable scaling factor for estimating an appropriate dispersivity value for the model.

The USEPA has an online calculator to determine dispersivity based on plume length. (http://www.epa.gov/athens/learn2model/part-two/onsite/longdisp.htm) Two methods are included in the online calculator. The first is a simple dispersivity to plume length ratio of 1:10, supported by data posted by Gelhar, Welty and Rehfeldt (1992). Using this method, and assuming a 600-foot long plume, the dispersivity for the Irigaray model would be 60 ft. A second method is calculated using the equation developed by Xu and Eckstein (1995);

$$\alpha_x = 0.83[\log_{10}(L_p)]^{2.414}$$

α_x = longitudinal dispersivity estimate
L_p = Plume Length *(L_p is in meters)*

Using this formula, and a plume length of 600 feet (183meters) the calculated dispersivity is 19.5 feet.

The value used for dispersivity in the Irigaray model was 25 feet, which falls within the range calculated using both methods from the USEPA online calculator. The 25 feet value is closer to the low end of that range, again demonstrating a conservative approach to the model.

Recognizing the uncertainty in estimating dispersivity for purposes of modeling the

Irigaray site (or any site for that matter), COGEMA included a sensitivity analysis as part of the modeling report. Figure 5-26 of the report shows the results of simulations with dispersivity values of 10, 20, 25, 30, and 50 feet. As shown on the Figure, higher dispersivity values result in earlier first arrivals and higher initial concentrations. However the maximum concentration is lower with the higher dispersivity value simulations. Note that even in the simulation using a dispersivity of 10 foot, the maximum selenium concentration does not exceed the WDEQ standard.

Comment No. B4. Please justify the use of uniform ground water concentration values for the source term in the contaminant transport model. A review of the data spreadsheets attached to the report indicates that constituent concentrations in ground water vary spatially within the ore body. However, spatial variation was not considered during source-term development Nonuniform source-term concentrations in the transport model may lead to higher downstream concentrations in certain locations than estimates using a uniform source term. Furthermore, nonuniform source terms would be more representative of actual field conditions.

Basis: *According to NUREG-1569, Section 6.13(4)(c), if a constituent cannot technically or economically be restored to its secondary standard within the exploited production zone, an applicant must demonstrate that leaving the constituent at the higher concentration would not threaten public health and safety or the environment or unacceptably degrade water uses of adjacent ground water resources. Ground water flow and contaminant transport modeling are essential to understanding potential impacts of residual contamination on ground water quality.*

RESPONSE: The Irigaray groundwater flow and transport model was developed as a simple but conservative approach to evaluate future migration of residual constituents derived from the uranium ISL operation. The model does not consider most of the attenuating factors that will substantially reduce constituent concentrations before reaching the wellfield monitor well ring (sorption, cation ion exchange, precipitation, etc). The model is premised on the assumption that mixing from dispersion based soley on advective transport is responsible for attenuation of constituents and minimizes reliance on geochemical reactions. Minimizing reliance on geochemical processes is extremely conservative and results in overprediction of constituent concentrations downgradient of the site. Although the model incorporates a number of conservative assumptions, the results indicate sufficient reduction of constituent concentrations to meet WDEQ standards at the monitor well ring.

This model was intended to provide a conservative estimate of water quality concentrations at the monitor well ring resulting from the average residual restoration concentration within the wellfield boundary. Consistent with LQD regulations and guidance along with COGEMA's LQD permit and condition 10.16 of the NRC license, the average restoration concentration within the wellfield boundary is the criterion used to assess the adequacy of restoration.

Undoubtedly, use of a non-uniform source term concentration will result in both higher and lower downgradient concentrations in certain localized areas, if the other current model parameters are used. However, because the pre-mining and post-mining attenuation capacity of the aquifer is largely ignored in this model, use of a non-uniform source term concentration will not necessarily provide a more representative evaluation of future migration. Increasing the specificity of a single parameter, such as including a non-uniform source term, does not in any way increase the accuracy of the model

because other factors, such as variability in hydraulic conductivity, or location of redox boundaries, or variability in distance from source area to monitor point, are not included in the model.

To provide a model that is more representative of actual field conditions would require input of geochemical reaction processes. While geochemical processes such as sorption and precipitation contribute significantly to the removal of contaminants from groundwater, the parameters required to develop defensible geochemical reaction models are often difficult to obtain. Many of the processes are dependent on redox conditions that are difficult to quantify and reproduce in a model. Rather than develop a model that may be contentious and difficult to validate, COGEMA has opted to demonstrate the adequacy of restoration using a simple, overly conservative modeling approach.

Additionally, based on NUREG 1569, Section 6.13(4)(c), modeling may not even be necessary to demonstrate that the residual constituents will not pose a threat to public health and safety for the following reasons. As noted in the response to comment A-1, the only constituents/parameters that could not be restored to the secondary standard (the target restoration values), with the exception of Ra-226 and a single sample for Pb and Ba, are constituents that, with respect to EPA standards, either have no groundwater standard, or have only secondary, non-enforceable standards. Those constituents/parameters (Ca, Na, Mg, TDS, Mn, conductivity and alkalinity) do not pose a risk to public health and safety or the environment or unacceptably degrade water uses of adjacent ground water resources. This is particularly true given the class of use of the groundwater, (since every baseline well except one out of 46 exceeded the EPA MCL for radium before any mining activities occurred).