January 16, 2003

Mr. William Paul Goranson
Manager, Radiation Safety,
Regulatory Compliance, and Licensing
Rio Algom Mining LLC
6305 Waterford Boulevard, Suite 400
Oklahoma City, Oklahoma 73118

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR THE RIO ALGOM LLC'S APPLICATION FOR GROUND WATER ALTERNATE CONCENTRATION LIMITS

Dear Mr. Goranson:

By letters dated February 17, 2000, and June 11, 2001, Rio Algom Mining Limited Liability Corporation (RAM) requested that the U.S. Nuclear Regulatory Commission (NRC) consider applications for alternate concentration limits for ground water at the Ambrosia Lake, New Mexico uranium mill facility. As a part of this request, RAM submitted for NRC staff review detailed applications for both the bedrock aquifers and the alluvium. The staff has completed its initial review of the applications and determined that additional information is needed to complete the detailed technical review of the plan. The staff's request for additional information (RAI) is provided in the enclosure to this letter.

Please note that your requests for alternate concentration limits will not receive a response until all of the enclosed comments have been addressed to the satisfaction of the NRC staff. Responses should be as thorough as possible in order to avoid additional requests for information and delay of the approval process. Please refer to the comment numbers when responding to specific comments.

If you have any questions regarding the staff's RAI, please contact me at (301) 415-6699 or by e-mail to JSC1@nrc.gov.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the

Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

**/RA/**

Jill S. Caverly, Project Manager
Fuel Cycle Facilities Branch
Division of Fuel Cycle Safety
and Safeguards
Office of Nuclear Material Safety
and Safeguards

Docket No.: 40-8905
License No.: SUA-1473

Enclosure: Request for Additional
Information

cc: Kevin Meyers, NMED

January 16, 2003

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cc: Kevin Meyers, NMED

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| **NAME** | J. Caverly | | B. Garrett | | G. Janosko | |
| **DATE** | 1/115/03 | | 1/16/03 | | 1/16/03 | |

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**REQUEST FOR ADDITIONAL INFORMATION**

**CORRECTIVE ACTION PROGRAM AND ALTERNATE CONCENTRATION LIMITS PETITION FOR UPPERMOST BEDROCK UNITS AMBROSIA LAKE URANIUM MILL FACILITY NEAR GRANTS, NEW MEXICO**

**AND**

**APPLICATION FOR ALTERNATE CONCENTRATION LIMITS IN THE ALLUVIAL MATERIALS AT THE QUIVIRA MILL FACILITY AMBROSIA LAKE, NEW MEXICO**

Rio Algom Mining LLC has submitted to the U.S. Nuclear Regulatory Commission (NRC) two applications for alternate concentration limits (ACLs) under NRC Materials License SUA–1473, for its Ambrosia Lake uranium mill tailings site. One application applies to contaminants in the uppermost bedrock aquifers (Quivira Mining Company, 2000), and the other to contaminants in the alluvial aquifer (Quivira Mining Company, 2001). Approval of the ACLs and the licensee's conclusion that the groundwater concentrations are as low as reasonably achievable (ALARA) would allow termination of the corrective action program to remediate groundwater contamination at the site.

Staff is reviewing the applications for compliance with the ACL regulations outlined in Criterion 5B(6) of 10 CFR Part 40, Appendix A. In performing this review, staff has identified areas in which additional information is necessary to complete the review. These requests for additional information (RAIs) are presented below as general in nature (Section A), applicable only to the bedrock aquifers application (Section B), and applicable only to the alluvial aquifer application (Section C).

## A. GENERAL

### A.1

**COMMENT:** The exposure assessments of the ACL applications for the alluvial and uppermost bedrock units do not address the cumulative effects of human exposure to hazardous constituents for which ACLs are proposed.

**BASIS:** 10 CFR Part 40, Appendix A, Criterion 5B(6) requires that cumulative effects of hazardous constituents be addressed in the consideration of ACLs. This topic is also addressed in Staff Technical Position: Alternate Concentration Limits for Title II Uranium Mills (NRC, 1996, p. 27), which was available during preparation of the applications, and the more recent draft NUREG–1620 (NRC, 2002, p. 4-31). These documents propose a limit to excess lifetime risk of fatal cancers of $1 \times 10^{-4}$ for the contaminated groundwater. In addition, these guidance documents specify that staff review ACL applications for cumulative effects. Specifically, NUREG–1620 (NRC, 2002, p. 4-31) states

Enclosure

> The cumulative effects of human exposure to hazardous constituents at the proposed alternate concentration limits, and to other constituents present in contaminated ground water, will be maintained at a level adequate to protect public health. The combined effects from both radiological and non-radiological constituents should be considered.

The exposure assessments contained in the ACL applications address the potential for health risks from human exposure by calculating a health risk-based concentration that will limit the lifetime fatal cancer risk to $1 \times 10^{-4}$ for groundwater consumption at a potential point of exposure (POE) location for each individual constituent. This calculation is performed using risk coefficients from Federal Guidance Report 13, Part 1 (EPA, 1999). Although this is an important step in the exposure assessment, it does not address the cumulative effects to human health that may be caused by the intake of all hazardous constituents at the POE. For example, if five radionuclides are present at their risk limits, the actual risk is at least $5 \times 10^{-4}$: in excess of the guideline. Federal Guidance Report 13 proposes combining risk coefficients for different radionuclides, as was done in the ACL petitions for the calculation of a risk coefficient for U-nat with the presence of Th-234 in the decay chain. Cumulative effects are addressed in 10 CFR Part 20, Appendix A, by requiring that the sum of the ratios of the concentration of radionuclides present in air to their derived air concentration be less than unity. A similar approach is appropriate in ACL applications. The health effects of all hazardous constituents present can also be addressed through the calculation of total effective dose equivalent to the average exposed individual at the POE.

**REQUIRED ACTION:** Provide additional analysis demonstrating that the cumulative effects of exposure to all hazardous constituents identified for an average individual at the POE will be maintained at a level adequate to protect public health.

**A.2**

**COMMENT:** It is not clear that gross alpha contents of groundwaters can be accounted for predominantly by the considered individual radionuclides.

**DISCUSSION:** In the bedrock aquifer application, Rio Algom requests that compliance limits for gross alpha be eliminated on the basis that they are duplicative of limits placed on the radionuclides for which limits are established. In the alluvial aquifer application, Rio Algom also argues that gross alpha content is dominated by U-nat and other considered radionuclides (nevertheless, an ACL for gross alpha is requested). In the U-238 series, alpha emitters are U-238, U-234, Th-230, Ra-226, Rn-222 and some of its short-lived daughters, and Po-210 (the U-235 series can be neglected because of its low total activity relative to U-238). The list of monitored radionuclides does not include Rn-222 and its daughters and Po-210. In addition, in groundwaters it is common for U-234 activity to exceed U-238, by factors of 5 to 10. Therefore, it cannot be assumed *a priori* that the gross alpha activity of a water sample is dominated by U-nat (for which it is assumed that U-238 and U-234 activities are equal), Th-230, and Ra-226. Thus, there is no assurance that gross alpha activities can be neglected.

**REQUIRED ACTION:** Provide a technical basis for the assertion that gross alpha activities are accounted for by considering only those radionuclides for which compliance limits have been set, so that risk calculations involving only those radionuclides are sufficiently protective.

**A.3**

**COMMENT:** It is not clear in all cases which water samples have been filtered.

**DISCUSSION:** Interpretation of contaminant contents in water samples rests partly on understanding whether the contaminants are dissolved or are present as particulates. For example, particulate content may in some cases account for elevated contaminant contents. This concern motivated a comparative study in the bedrock aquifer application of filtered and unfiltered samples. In the ACL applications and in supporting Rio Algom data files, there is no explicit information on whether a given analysis is for a filtered or unfiltered water sample.

**REQUIRED ACTION:** Provide specific information on whether groundwater samples were filtered prior to chemical and radiological analysis.

**A.4**

**COMMENT:** The risk coefficient used in both applications for Ra-226 is not consistent with the final federal guidance value.

**DISCUSSION:** The Ra-226 mortality risk coefficient for tap water ingestion is used in the bedrock aquifer application for setting the proposed health-based ACL, and in the alluvial aquifer application for comparison with the proposed ACL and monitoring data. For this parameter, the licensee used a value of $5.32 \times 10^{-9}$ $Bq^{-1}$ [197 $Ci^{-1}$], citing the 1998 interim version of the U.S. Environmental Protection Agency's (EPA) Federal Guidance Report 13 (EPA, 1998). The final version of Federal Guidance Report 13 was published prior to preparation of both applications, and uses a Ra-226 risk coefficient of $7.17 \times 10^{-9}$ $Bq^{-1}$ [265 $Ci^{-1}$] (EPA, 1999). Use of this most recent value of 1.18 Bq/L [32 pCi/L] would result in a health-based limit for Ra-226, in contrast to the value in the applications of 1.63 Bq/L [44 pCi/L]. This difference is significant enough that the licensee should use the current, more restrictive value in hazard assessments.

**REQUIRED ACTION:** Recalculate health-based limits for Ra-226 using the current guidance in Federal Guidance Report 13 (EPA, 1999).

## B. BEDROCK AQUIFERS (QUIVIRA MINING COMPANY, 2000)

**B.1**

**COMMENT:** Using the SOLUTE code (Beljin and van der Heijde, Version 2.00, 1993) transport model results to estimate attenuation factors between point of compliance (POC) and POE locations seems reasonable; however, the effect of parameter uncertainty on the calculated attenuation factor has not been evaluated.

**DISCUSSION:** In the ACL application for the bedrock aquifers, an attenuation factor is calculated for constituents of concern that exceed health-based standards at POC wells. These attenuation factors are based on mass transport calculations for U-nat transport that were made using the SOLUTE code (Beljin and van der Heijde, Version 2.00, 1993), which employs a onedimensional analytical solution for advective-dispersive solute transport. The SOLUTE model was used to fit the analytical solution to observed concentrations of chloride and U-nat in POC well 36-06KD and POE well 36-04KD. An attenuation factor of 0.16 was estimated based on the ratio of the modeled U-nat concentration peaks for the two wells (Figure 2-41 in ACL application for bedrock aquifers). This value of 0.16 represents the fraction of the peak solute concentration at the POC well that would eventually be expected to arrive downstream at the POE well. Thus, a lower number indicates a greater reduction in solute concentrations between the POC and POE locations. The reduction in solute concentrations results from the combination of reversible sorption of solutes on mineral grains and dispersive processes that tend to spread out, and thereby dilute, peak solute concentrations. While this approach is reasonable, there are important parameter uncertainties in such calculations that must be evaluated to ensure estimated attenuation factors do not produce overly optimistic expectations regarding natural attenuation of contaminants. Important parameter uncertainties in the SOLUTE model are groundwater velocity, dispersion length, retardation coefficient, and source concentration. The groundwater velocity of 55 m/yr [182 ft/yr] assumed for the model calculations is based on an assumed effective porosity of only 0.03 for the Dakota aquifer. This porosity value is uncharacteristically low for a silt or sand sedimentary formation, which could explain why a retardation coefficient of 1.4 was necessary to fit the SOLUTE model to the chloride concentration data. The assumed groundwater velocity would be proportionally slower if a higher porosity value were used.

The dispersion length value of 366 m [1,200 ft] used in the transport calculations is at the high end of the range of longitudinal dispersion lengths commonly reported in the literature (e.g., Gelhar, et al., 1992). The appropriate value for dispersion length typically tends to increase with the transport distance under consideration. In most heterogenous porous media, however, the increase in dispersion length with distance can be shown to be a function of the length scale of formation heterogeneity, and the apparent dispersion length becomes relatively scale independent beyond a certain transport distance (e.g., Dagan, 1984). Based on a survey by Gelhar, et al. (1992) of dispersion length values reported in the literature for various distance scales, an appropriate longitudinal dispersion length for the transport distance considered in the TRB formation could reasonably be expected to fall within a range of about 9–300 m [30–1,000 ft].

The uranium retardation factor is the parameter that affects both the peak arrival time and, in combination with the longitudinal dispersivity, the peak height at the POE. In the Dakota transport model, this parameter is calibrated to fit observations of uranium concentrations at POC well 36-06KD. The uranium retardation factor, which directly affects the calculated attenuation factor, is poorly constrained by the limited number of U-nat concentration measurements used in the transport model calibration. In addition, no comparison is made between the calibrated uranium retardation factor and a range of values that might be considered for this hydrologic setting.

An additional concern is that the assumption of a constant U-nat source concentration does not appear to be supported by available data. The data points chosen for calibration apparently excluded early values for waters with low pH, which had much higher uranium concentrations. Additionally, inspection of Figures 2-29 and 2-41 of the bedrock aquifer application shows that not all later data points were plotted for model-data comparison. Thus, it is not clear which data were included in the calibration or why certain data were excluded. The data that are plotted in

Figure 2-41 appear to provide little constraint on the model calibration. In addition, U-nat concentration data obtained since the application was written are not easily explained by the model calibration employed in the application (file "sua1473_gwdata.xls," provided by Rio Algom). These newer data for well 36-06KD show that, over the past 4 years, chloride is rising, pH is again dropping to values less than 4.5, and uranium is tending to higher values. This behavior is not consistent with the simple constant source concentration employed in the bedrock aquifer application, which would predict steadily decreasing chloride and uranium.

**REQUIRED ACTION:** Rio Algom should provide an uncertainty analysis for the calculations used to estimate contaminant attenuation factors. Documentation of these analyses should include the range of attenuation factors that can be estimated from a set of transport calculations that can be reasonably calibrated to match observed chloride and U-nat concentrations, considering the uncertainty in groundwater velocity, dispersion lengths, uranium retardation factor, and source concentration variability. It should be shown, based on this uncertainty analysis, that the attenuation factors used to calculate proposed health-based ACLs are reasonable and not overly optimistic. As part of this analysis, provide an explanation for the recent trends at well 36-06KD (i.e., rising chloride and U-nat, and descending pH).

**B.2**

**COMMENT:** A basis is required for the assertion that applying the uranium attenuation factor to all other contaminants is conservative because uranium is the most mobile of the group.

**DISCUSSION:** An attenuation factor based on uranium transport modeling is applied also to contaminants Pb-210, total Ra, Th-230, and Ni. The application argues this approach is conservative because uranium is more mobile than the other elements. While this may be true, no technical bases or supporting references are provided.

**REQUIRED ACTION:** Provide the technical basis for the assertion that "U-nat is the most mobile of the hazardous constituents of concern" (bedrock aquifer application, p. 2-34).

**B.3**

**COMMENT:** A basis is required for the statement that ACLs based on well 36-06KD will also be protective when applied at other POC wells.

**DISCUSSION:** The proposed ACLs for the Dakota sandstone take credit for attenuation between the POC and POE, based on transport modeling for wells 36-06KD and 36-04KD. On page 2-39, it is stated that the ACLs will also be protective at POEs down-gradient of the other POC wells (i.e., along the northernmost boundary of the proposed controlled area) because transport distances are comparable to the distance between 36-06KD and 36-04KD. From Map 1-1 of the bedrock aquifers application, it can be seen that the latter distance is approximately 1,250 m [4,100 ft]. In contrast, POC wells 30-02KD and 30-48KD are only 680 and 570 m [2,200 and 1,900 ft], respectively, south (i.e., upgradient) of the northern boundary of the proposed controlled area. These distances are only about half the distance between the modeled POC and POE wells. Therefore, it cannot be assumed that these transport pathways will be equally effective in attenuating contaminant concentrations along the transport pathway to the POE.

**REQUIRED ACTION:** Provide justification for the assumption that the proposed ACLs will be as protective at POC wells 30-02KD and 30-48KD as they are at POC well 36-06KD. Alternatively, modify the ACLs appropriately.

**B.4**

**COMMENT:** Much of the groundwater currently in the alluvial formation is expected to drain into the Tres Hermanos A (TRA) and Tres Hermanos B (TRB) bedrock units, but the application contains no discussion or analysis of fate and transport of contaminated alluvial-system drainage in the bedrock formations.

**DISCUSSION:** Numerical modeling of flow in the alluvial sediments (Quivira Mining Company, 2001) suggests that, following cessation of corrective actions, much of the water currently residing in the alluvium is expected to drain into the underlying dewatered bedrock formations. In the ACL application for the bedrock units (Quivira Mining Company, 2000), however, there is no discussion or modeling of the fate and transport of drainage from the alluvial formations into the bedrock units. Activities under the corrective action program result in diversion of substantial quantities of water into the alluvium, and some alluvial waters still contain relatively high levels of contaminants.

**REQUIRED ACTION:** Rio Algom should provide fate and transport assessments for constituents of concern entering the uppermost bedrock units as drainage from the overlying alluvial formations.

**B.5**

**COMMENT:** Some aspects of the results of the filtration test are ambiguous.

**DISCUSSION:** A filtration test on a sample from well 36-06KD, discussed on pages 2-19 and 2-20, was the basis for the decision to filter future water samples. The comparison of dissolved and total radionuclide concentrations raises questions about the reliability or interpretation of the results. For U-nat and Ra-226, the filtered water ("dissolved analysis") has higher concentrations than the unfiltered water ("total analysis"); such an outcome is unexpected. Whether this results from sample heterogeneity or analytical uncertainties is not clear.

**REQUIRED ACTION:** For the 36-06KD filtration tests, explain the deviations from the expected case that filtered concentrations would be lower than unfiltered concentrations.

**B.6**

**COMMENT:** Provide additional support for the conclusion that the rising concentrations of U-nat in TRB compliance well 31-66 will not result in exceedence of the proposed ACL.

**DISCUSSION:** Recent results from TRB POC well 31-66 (Quivira Mining Company, 2000, Figure 2-8; file "sua1473_gwdata.xls," provided by Rio Algom) suggest a trend of increasing U-nat concentration since 1993, reaching values of about 0.15 to 0.25 mg/L during the period from 2000 to 2002. The fact that the proposed ACL for the TRB is 0.25 mg/L raises the question of whether continuation of the trend will lead to exceedence of the ACL in the near future. Discussions with Rio Algom suggest that the excess uranium in this well is related to the presence of brine pits being used in the current recovery activity.

**REQUIRED ACTION:** Provide a technical basis for the attribution of elevated uranium in well 31-66 to a brine pit source, and provide a basis for the conclusion that uranium in this well will not exceed the proposed ACL in the future.

**B.7**

**COMMENT:** Data on source concentrations relevant to the nickel attenuation model for the TRB are required.

**DISCUSSION:** For the nickel ACL in the TRB, an attenuation calculation was performed to show that the value adopted on the basis of well 31-66 data—0.37 mg/L—is protective at the POE. An important parameter in the calculation is the source nickel concentration. The value used (1 mg/L) used is said to come from an "analysis of source fluids and tailings seepage…" (Quivira Mining Company, 2000, p. 2-36). This value coincides with one tabulated for tailings liquids in the alluvial aquifer application (Quivira Mining Company, 2001, Table 2.2), but the source of the data is not presented.

**REQUIRED ACTION:** Provide the data supporting tailings liquid contaminant concentrations, such as are cited for nickel in the bedrock aquifer application and such as are tabulated in the alluvial aquifer application.

## C. ALLUVIAL AQUIFER (QUIVIRA MINING COMPANY, 2001)

**C.1**

**COMMENT:** Elevated Ra-226 in well 5-08 is not consistent with models of flow in the alluvial aquifer.

**DISCUSSION:** Well 5-08, located at the alluvial POE, has higher Ra-226 activities than alluvial wells located much closer to apparent contaminant sources, including POC wells 31-61 and 32-59. This relationship is not consistent with the conceptual model of contaminant sources in the tailings impoundment. In addition, recent data (file "sua1473_gwdata.xls," provided by Rio Algom) suggest a trend of increasing Ra-226 with time, with the most recent value from March 2002 of 1.4 Bq/L [37 pCi/L] approaching the health-based limit of 1.6 Bq/L [44 pCi/L].

The discussion on page 2-12 proposes that the high Ra-226 is due to a “local source,” but does not provide supporting information.

**REQUIRED ACTION:** Provide the technical basis for attribution of elevated Ra-226 at well 5-08 to a local source that is not related to the licensee’s activities. Provide an explanation for increasing Ra-226 at the well, as well as justification that levels will not exceed the health-based limit of 44 pCi/L in the future.

**C.2**

**COMMENT:** Proposed ACLs for the alluvial aquifer are based on data from locations and times that which may be irrelevant to background at the alluvial POC.

**DISCUSSION:** Of the seven contaminants considered in the alluvial aquifer, the proposed ACLs are much higher than the calculated health-based limits for all but Th-230. Furthermore, the attenuation factor for radium implied by the geochemical model will not lower the total radium concentration below the health-based limit. The proposed ACLs are based not on health risk, but, with the exception of Th-230 and Pb-210 (which are from well 31-63 data), on a background argument. The basis for this argument is a statistical analysis of concentration data obtained for the Title I tailings disposal site located about 2.4 km [1.5 mi] northwest of the Rio Algom facility. The proposed ACLs are based on 95 percent upper tolerance limits of statistical distributions of the contaminant data, or on maximum values if statistical tests fail. However, the maximum values from the Title I facility are invariably from samples taken from on or adjacent to the tailings pile between 1982 and 1992—whereas remediation of the Title I site was not complete until 1995. The highest values for all but nickel and selenium occurred prior to the 1987 initiation of remediation activities. In addition, the use of these values as background for the Rio Algom site implicitly assumes that contaminants can be transported from the Title I facility to the Rio Algom proposed POE with no attenuation—counter to other arguments made on the basis of geochemical modeling.

The potential influence of waters derived from the Title I facility is demonstrated in the alluvial aquifer application by geochemical data, but there is insufficient evidence that the influence significantly extends to the POCs or the proposed POE (Figure 2.4). The geochemical argument is that the influence of Title I waters is reflected in an elevated ratio between total dissolved solids and chloride. The ratios in wells 31-61 (POC), 32-59 (POC), 5-03 (background), and 5-08 (proposed POE) are 11, 9, 8, and 6, respectively (according to Figure 2.4). The two possible local sources for these waters are the discharge channel and interception trenches. The ratio of total dissolved solids to chloride in waters discharged into the channel ranges from 6.0 to 8.3, with one outlier at 15.2 (file “fresh water channel.xls,” provided by Rio Algom), and the trench waters range from 7.5 to 9.9, with an outlier at 12.4 (file “TRENCHES.xls,” provided by Rio Algom). Contaminated well 31-63 and Interception Trenches 2 and 3 may also reflect the local influence of the Rio Algom tailings impoundment; the ratio in these waters ranges from 4.3 to 7.5. Thus, there is some evidence that local sources may have ratios lower than observed in the monitoring wells (ratio of 6 to 11). While there is a suggestion in these data of a small amount of influence of the higher-ratio Title I facility waters, there is not a clear-cut contrast. Therefore, evidence for the elevation of the ratio due to significant influence of the Title I site, while not countered by available data, is not compelling.

**REQUIRED ACTION:** Justify the implicit assumption that the high contaminant levels reflected in the proposed background-derived ACLs could reasonably be expected in the vicinity of the POCs and POE, resulting from the influence of the Title I facility. Alternatively, propose other ACLs.

**C.3**

**COMMENT:** The proposed ACL for Pb-210 must be demonstrated to reflect background or to be protective of health.

**DISCUSSION:** The proposed ACL for Pb-210 is based on the highest observed measurement at well 31-63, located immediately adjacent to the main Rio Algom tailings impoundment. This value {2.1 Bq/L [58 pCi/L]} was chosen over the background estimate that is based on the Title I facility data {1.3 Bq/L [36 pCi/L]} because it is higher. The calculated health-based limit for Pb-210 was 0.48 Bq/L [13 pCi/L]. Therefore, this proposed ACL is not a background value, nor is it protective of health. An attenuation argument was not explicitly proposed in favor of the ACL. While the results of the geochemical model suggest potentially large attenuation for Pb-210 (Table 2 of Appendix B), Rio Algom must provide technical justification for the proposed ACL.

**REQUIRED ACTION:** Demonstrate that the proposed ACL for Pb-210 is a background value or is protective of health. Alternatively, propose another ACL.

**C.4**

**COMMENT:** The results of the geochemical model intended to demonstrate the attenuating capacity of the alluvium are not adequately constrained.

**DISCUSSION:** A geochemical model, described in Appendix B of the alluvial aquifer application, is presented in support of the attenuation capacity of the alluvial aquifer. While the resulting attenuation factors are not directly used in establishing ACLs, they are cited in numerous locations in the alluvial aquifer application as confidence-builders. Because the proposed ACLs exceed the calculated health-based limits for all contaminants but Th-230, demonstration of protection of health is dependent on attenuation factors. (It is acknowledged that protection of health need not be demonstrated if background levels are accepted as ACLs.) The results of the geochemical model are not well-constrained, however, and do not adequately support the attenuation argument.

The model is based on sound geochemical principles and uses an acceptable code. The large attenuation factors suggested by the model are mainly functions of the change in the model from oxidizing to reducing conditions. For example, the lowering of uranium concentration by six orders of magnitude in the output compared to the starting solution (Table 2 of Appendix B) is due to control of uranium solubility by uraninite under reducing conditions. The redox change is related to the behavior of iron in the model system. However, it is not clear that the water-rock system could be consistently maintained at such conditions in the alluvial aquifer—a shallow groundwater system in which air would be expected to play a chemical role. Of the 12 alluvial wells for which redox measurements are presented in Figure 2.16, only 2 yielded negative values—and these 2 are located on the periphery of the main flow channel of the alluvium. It would be reasonable to conclude from Figure 2.16 that oxidizing conditions (positive Eh) would be maintained in the central, deepest, most voluminous portion of the aquifer. Discussion of the model results does not adequately consider the field conditions, possible open-system effects, possible kinetic effects, other model assumptions, and uncertainties attendant on the Eh measurements. The geochemical model is a useful demonstration of a potentially beneficial process in the alluvium but, without a full discussion, the model results should not be relied upon for attenuation arguments. It should also be noted that the geochemical model does not, in its present form, support radium attenuation.

**REQUIRED ACTION:** Provide a more thorough technical basis for the geochemical model, or revise the model. If the model is not better constrained or revised, provide alternative demonstrations of the alluvial attenuation capacity or abandon reliance on attenuation.

**C.5**

**COMMENT:** The notion of the alluvial “groundwater sweep” is not supported by the map of groundwater elevation contours.

**DISCUSSION:** A key principle behind the alluvium corrective action program and the assertion that alluvium contamination has been effectively remediated is the “groundwater sweep” afforded by migration of treated waters from the discharge channel back toward Interception Trench 1. However, flow in this direction is not supported by the groundwater elevation contours drawn on Figure 2.17.

**REQUIRED ACTION:** Provide the technical basis for flow as represented in the “groundwater sweep” model. If appropriate, re-draw the groundwater elevation contours on Figure 2.17.

**C.6**

**COMMENT:** If mine ventilation shafts are to be backfilled as part of the site reclamation, the effects of this action on the predicted time for dewatering of the alluvial sediments must be addressed.

**DISCUSSION:** Part of the basis put forth by Rio Algom in applying for ACLs in the alluvial groundwater is that this groundwater did not exist prior to mining and will not persist as a potential source of drinking water after corrective action activities have ceased. The transient modeling analysis used to evaluate groundwater in the alluvium following cessation of groundwater corrective action suggests that the alluvial formation could be largely dewatered after a period of about 100 years, with nearly half of the dewatering facilitated by drainage through ventilation shafts into the underlying Westwater Canyon formation. In the application for ACLs in alluvium, however, it is not clear whether the ventilation shafts are intended to be backfilled as part of the site reclamation activities.

**REQUIRED ACTION:** Indicate whether ventilation shafts that drain alluvial and bedrock aquifers are to be backfilled as part of site reclamation activities. If the ventilation shafts are to be backfilled, indicate what effects this action would have on the time required for drainage of alluvial groundwater.

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