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September 18, 2003
Contract No. NRC–02–98–002
Account No. 20.01620.110

U.S. Nuclear Regulatory Commission
ATTN: Ms. Jayne M. Halvorsen
Program Management, Policy Development and
Analysis Staff, NMSS
TWFN Mail Stop 8–A23
Washington, DC 20555

Subject: Submission of Milestone 01620.110.315—Final Evaluation of Alternate Concentration Limit Application for Ambrosia Lake Site – 40-8905

Dear Ms. Halvorsen:

Attached is subject deliverable provided under Task Order 11 (Application for Alternate Concentration Limits for Uranium Mill Tailings Sites) of U.S. Nuclear Regulatory Commission (NRC) Contract No. NRC–02–98–002. To avoid confusion with the nearby Ambrosia Lake Title I facility, the report has been retitled Final Evaluation of Alternate Concentration Limit Applications, Rio Algom Mining LLC Mill Facility, Ambrosia Lake, New Mexico. An electronic copy of the document is enclosed to facilitate forwarding the comments to the licensee. An electronic copy has also been provided to the NRC Technical Monitor, J. Caverly.

While we accept the licensee's argument that groundwater contaminant concentrations are as low as is reasonably achievable, we find that the licensee has not provided sufficient bases for the proposed alternate concentration limits (ACLs) for the alluvial or bedrock aquifers. We have revised our draft evaluation report in response to interactions with NRC and the licensee.

Please contact me at 210.522.2139 or Dr. David Pickett at 210.522.5582 if you have any questions concerning this report.

Sincerely yours,

David R. Turner
Assistant Director
Systems Engineering and Integration

DRT/ls
Enclosure

cc: D. Gillen, J. Lusher, B. Meehan, J. Caverly, R. Nelson, R. von Till, W. Patrick, B. Sagar, P. Maldonado, D. Pickett, J. Winterle, Record Copy B—IQS

Letter only:
CNWRA Directors
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NMSS01

# FINAL EVALUATION OF ALTERNATE CONCENTRATION LIMIT APPLICATIONS, RIO ALGOM MINING LLC MILL FACILITY, AMBROSIA LAKE, NEW MEXICO

*Prepared for*

U.S. Nuclear Regulatory Commission
Contract NRC–02–98–002

*Prepared by*

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San Antonio, Texas

September 2003

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## ACKNOWLEDGMENTS

This report was prepared to document work performed by the Center for Nuclear Waste Regulatory Analyses (CNWRA) for the U.S. Nuclear Regulatory Commission (NRC) under Contract No. NRC–02–98–002. The activities reported here were performed on behalf of the NRC Office of Nuclear Material Safety and Safeguards, Division of Fuel Cycle Safety and Safeguards, Fuel Cycle Facilities Branch. The report is an independent product of the CNWRA and does not necessarily reflect the views or regulatory position of the NRC.

The authors thank D. Turner for technical review, and B. Sagar for programmatic review of this report. The authors also appreciate A. Woods and B. Long, and L. Selvey for editorial and secretarial support in the preparation of the document.

## QUALITY OF DATA, ANALYSES, AND CODE DEVELOPMENT

**DATA:** No CNWRA-generated original data are contained in this report.

**ANALYSES AND CODES:** EQ3NR, a component of EQ3/6 Ver. 7.2b, was used to generate results for this report. EQ3/6 is controlled under the CNWRA software procedure TOP–018. In addition, Microsoft® Excel 2002 SP–2 was used to generate plots presented in this report.

**References:**

Microsoft corporation. "Microsoft® Excel 2002." Redmond, Washington, Microsoft Corporation. 2002.

Wolery, T.J. "EQ3NR, A Computer Program for Geochemical Aqueous Speciation-Solubility Calculations: Theoretical Manual, User's Guide, and Related Documentation (Version 7.0)." UCRL–MA–11066 Pt III. Livermore, California: Lawrence Livermore National Laboratory. 1992.

# 1 INTRODUCTION

Rio Algom Mining LLC (Rio Algom) has submitted to the U.S. Nuclear Regulatory Commission (NRC) two applications for alternate concentration limits (ACLs) per NRC Materials License SUA–1473, Amendment 50, for its Ambrosia Lake uranium mill tailings site (NRC, 2002). One application applies to contaminants in the uppermost bedrock aquifers (QMC, 2000) and the other to contaminants in the alluvial aquifer (QMC, 2001). Approval of the ACLs and the licensee conclusion that the groundwater concentrations are as low as is reasonably achievable (ALARA) would allow termination of the corrective action program to remediate groundwater contamination at the site. Termination of corrective action, in combination with completion of site reclamation, would allow eventual transfer of the site to the U.S. Department of Energy (DOE) under an NRC general license under 10 CFR 40.28 for custody and long-term care. This report documents the Center for Nuclear Waste Regulatory Analyses evaluation of the ACL applications and recommendations for NRC action on them.

## 1.1 Regulatory Setting

According to Title II of the Uranium Mill Tailings Radiation Control Act of 1978, NRC has the authority to control radiological and nonradiological hazards at commercial uranium mill tailings disposal facilities. Standards for implementing that control in a way that protects public health and safety and the environment are codified in 10 CFR Part 40, Appendix A. Criterion 5, which is concerned with groundwater protection at operating mills and tailings disposal facilities, implements groundwater protection standards established by the U.S. Environmental Protection Agency (EPA) in 40 CFR Part 192. Key components of required programs at Title II sites are adherence to concentration limits for groundwater contaminants established in the site license and implementation of corrective actions if those standards are not met. However, Criterion 5B(6) of 10 CFR Part 40, Appendix A allows the establishment of a contaminant ACL that may be less restrictive than the groundwater protection standard, as long as NRC finds that the ACL "is as low as reasonably achievable, after considering practicable corrective actions, and that the constituent will not pose a substantial present or potential hazard to human health or the environment as long as the alternate concentration limit is not exceeded." Guidance for staff review of ACL applications for compliance with Criterion 5B(6) is documented in NUREG–1620 (NRC, 2003a), Section 4.3, with specific areas of review listed in Section 4.3.1. This guidance was followed in conducting the present review, with particular attention to the areas of review listed in Section 4.3.1 of the NUREG.

## 1.2 Site History and Description

Detailed site history information may be found in Quivira Mining Company (QMC) (2000, 2001). The uranium mill began operation in 1957. Three unlined evaporation ponds were put into service that year, and the main tailings disposal edifice made up of Tailings Impoundments 1 and 2 and unlined Pond 3 was first used in 1958. An additional two unlined evaporation ponds on the west side of the facility began service in 1961. Residues from the unlined ponds were transferred to Tailings Impoundments 1 and 2. Two unlined ponds began service in 1976, the same year that a bypass channel was constructed to divert mine water discharge out of the natural channel of the Arroyo del Puerto. A state-mandated remedial program initiated in 1983 led to removal from service of unlined ponds and construction of Interceptor Trench 1 on the eastern margin of Tailings Impoundment 1 and Pond 3. These actions were intended to prevent contamination of the alluvium by seepage from evaporation ponds and the tailings impoundment.

NRC groundwater protection jurisdiction began in 1986 with a monitoring program for the alluvial aquifer and three bedrock aquifers: the Tres Hermanos B Sandstone Unit (TRB), Tres Hermanos A Sandstone Unit (TRA), and the Dakota Sandstone Unit (Dakota). A corrective action plan was accepted by NRC in 1989, defining monitoring wells to be used as points of compliance (POCs) and for background definition and establishing groundwater protection standards; implementation of the corrective action program is mandated in the site license (SUA–1473; NRC, 2002). For all units, the corrective action program incorporated previously established measures such as retirement of unlined ponds and construction of interceptor trenches and the arroyo bypass channel. For the bedrock units, corrective action also includes pumping water from uranium mine shafts and ventilation holes north of the tailings facility, providing draw-down and dilution of facility-derived waters, and limiting the thickness of saturated zones within the sandstone units. For the alluvial aquifer, the corrective action program includes discharge of treated mine water (from the bedrock corrective action) into the bypass channel which, in conjunction with Interceptor Trench 1, created a groundwater sweep in the direction of the trench.

Mining and milling operations in the area have had two notable hydrologic effects: creation and maintenance of a saturated zone at the base of the alluvium and creation of a cone of groundwater depression in bedrock aquifers because of drainage in mining features and pumping. It is possible that water quality in the alluvium and the units into which the alluvium drains has been affected by area mining operations not directly related to licensee activities (see Chapter 3).

The name of the company holding the mill and tailings facility license has changed through time. Most recently, the licensee name was changed in a July 2002 amendment to SUA–1473. Thus, the ACL applications were submitted using the name QMC, but current license interactions are conducted with Rio Algom.

## 1.3 Requested Alternate Concentration Limits

In 2000 and 2001, the licensee concluded that groundwater protection standards for some contaminants in the four protected aquifers were not attainable with the corrective action program and that ACLs were needed (QMC, 2000, 2001). For the alluvial aquifer, ACLs were requested for eight constituents: molybdenum, nickel, selenium, gross alpha activity, Ra-226+228 (combined radium), Th-230, natural uranium (U-nat), and Pb-210. The requested alluvial ACLs, as revised in Rio Algom (2003), were derived from a background analysis that attempted to account for off-site contaminant sources beyond licensee control. For the TRB, ACLs were requested for nickel, combined radium, Th-230, uranium, and Pb-210. The TRB radionuclide ACLs were health risk-based (i.e., based on a calculation of cancer risk), with additional credit for attenuation in the case of uranium (revised in Rio Algom, 2003), while the nickel value was based on POC monitoring data. The TRA ACLs—for combined radium, Th-230, and Pb-210—were all health risk based. ACLs were requested for the Dakota for nickel, combined radium, Th-230, uranium, and Pb-210 based on the lower of (i) an attenuation-corrected health risk-based value and (ii) the mean plus two standard deviations of monitoring results (for combined radium, the unattenuated health risk-based concentration was used). All ACLs were asserted to be ALARA. The licensee also requested that, as the proposed ACLs had already been met, the corrective action program be terminated and site reclamation completed. In addition, the licensee defined points of exposure (POEs) for the aquifers at the long-term surveillance and institutional control boundary surrounding the facility.

This evaluation first discusses the health risk-based groundwater concentration limits that formed the basis for many of the requested ACLs, in both the bedrock and alluvial aquifer applications (Chapter 2). It then discusses and evaluates the two applications separately (Chapters 3 and 4) and concludes with a summary of findings and recommendations (Chapter 5).

# 2 HEALTH RISK-BASED LIMITS FOR CONSTITUENTS OF CONCERN

The exposure assessments contained in the ACL applications (QMC, 2000, 2001) address the potential for health risks from human exposure to radionuclides 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 POE location for each individual constituent. This concentration is calculated by the licensee using the formula

$$I\,(Bq) = R/r \qquad (2\text{-}1)$$

where R = acceptable lifetime risk of $1 \times 10^{-4}$ (for an individual constituent) and r = (EPA, 1999) risk coefficient of that constituent expressed as the probability of cancer mortality rate per unit (Bq) intake of the particular radionuclide in tap water. The health risk-based concentration ($C_{hb}$) can then be calculated using the equation:

$$C_{hb}\,(pCi/L) = [(I)(CF)]/[(y)(d)(Q)] \qquad (2\text{-}2)$$

where CF = unit conversion factor of 27 pCi/Bq, y = exposure duration of 30 years, d = exposure frequency of 350 days per year, and Q = 1.11 L/d lifetime combined average intake of tap water from a potentially contaminated source.

In response to an NRC request for additional information (NRC, 2003b), the health risk-based concentrations were recalculated by the licensee for those constituents known or suspected to cause cancer to approach the lifetime fatal cancer risk of $1 \times 10^{-5}$ so that the cumulative risk of all constituents remains less than $1 \times 10^{-4}$. Most ACLs requested by the licensee for the POC wells were based on either the health risk-based concentration or a higher concentration that would ensure the health risk-based concentrations are maintained at the POE locations because of attenuation during groundwater transport between the POC wells and the POE locations.

Limits for nonradiological contaminants molybdenum and selenium were taken from EPA (2000) concentrations based on a $1 \times 10^{-6}$ or lower lifetime cancer risk for drinking contaminated water. The limit for nickel was defined as described in Section 2.1.

## 2.1 Alluvial Aquifer

The constituents of concern in the alluvial aquifer are molybdenum, nickel, selenium, gross alpha activity, combined radium, Th-230, uranium, and Pb-210 (QMC, 2001). Although an ACL was requested for gross alpha activity, the licensee originally did not evaluate gross alpha on the basis of health risk. In response to the request for additional information (NRC, 2003b), gross alpha was evaluated as a constituent of concern using the health-based risk coefficient of Po-210 presented in EPA (1999) as a conservative approach to calculating the gross alpha health risk-based limit. Limits for the other radioactive constituents were calculated as described in the previous paragraph, and it was demonstrated that groundwater ingestion was the most likely and risk-limiting pathway. Limits for molybdenum and selenium were taken from EPA risk-based drinking water guidance (2000). For nickel (which is not considered a carcinogen), the licensee adopted a risk-based limit of 0.1 mg/L on the basis that the chronic effects of long-term nickel ingestion above 0.1 mg/L are reported to be heart and liver damage, dermatitis, and decreased body weight.

The licensee calculated health risk-based concentration limits for the constituents of concern as follows (QMC, 2001, revised in Rio Algom, 2003):

- Molybdenum 0.18 mg/L
- Nickel 0.1 mg/L
- Selenium 0.05 mg/L
- Gross alpha 8.57 pCi/L
- Ra-226+228 3.23 pCi/L
- Th-230 13.9 pCi/L
- U-nat 16.4 pCi/L (equivalent at secular equilibrium to 0.025 mg/L)
- Pb-210 1.3 pCi/L

## 2.2 Bedrock Aquifers

The bedrock ACL application (QMC, 2000) states that all hazardous constituents in the TRB, TRA, and the Dakota aquifers are below the defined groundwater protection standards with the exception of uranium, Pb-210, Th-230, combined radium, and the nickel. Radionuclide and nickel risk-based limits were calculated as for the alluvial aquifer. The licensee showed that groundwater ingestion is the pathway of most concern to dose with comparative calculations provided for other pathways.

The licensee calculated health risk-based concentration limits for the constituents of concern as follows (QMC, 2000, revised in Rio Algom, 2003):

- Nickel 0.1 mg/L
- Ra-226+228 3.2 pCi/L
- Th-230 13.9 pCi/L
- U-nat 16.4 pCi/L (equivalent at secular equilibrium to 0.025 mg/L)
- Pb-210 1.3 pCi/L

## 2.3 Evaluation

As revised in Rio Algom (2003), we find these health risk-based limits to be acceptable. The licensee has shown (QMC, 2000, 2001) that a groundwater ingestion dose pathway is the most likely and restrictive pathway. Surface water pathways do not need to be considered because the affected groundwaters do not discharge within 100 mi of the facility. The licensee has shown that risk limits based on human health also are protective of the environment. The ways in which these health risk-based limits were used in developing ACLs are discussed in Chapters 3 and 4.

# 3 ALLUVIAL AQUIFER

For groundwater in the alluvial aquifer adjacent to the facility, Rio Algom requested ACLs for eight constituents. The original set of requested limits in QMC (2001) was revised in the Rio Algom (2003) response to the request for additional information (NRC, 2003b). The revised requested ACLs (Table 3-1), like the originals, are based on proposed background values. As discussed in more detail in this section, Rio Algom argues that these ACLs are acceptable because they (i) reflect the reality that the site is surrounded by potential sources, beyond Rio Algom control, that may also contribute to alluvial aquifer contamination; (ii) are protective of human health and the environment; and (iii) are ALARA (QMC, 2001).

## 3.1 Description

The alluvial aquifer is a saturated zone formed at the base of the alluvium filling Ambrosia Lake Valley in the vicinity of the Rio Algom facility, ranging up to about 60 ft in thickness (e.g., Rio Algom, 2003, Figure 12; QMC, 2001, Figure 1.3). Aquifer water is either drained through underlying bedrock units (chiefly the TRB) or old mine shafts and vent holes, or flows to the southeast toward and along the paleochannel of Arroyo del Puerto, beyond the proposed area of control to the designated POE (QMC, 2001, Appendix C). Prior to mining operations in the area, the alluvium apparently did not contain a persistent saturated zone because naturally infiltrating water was effectively drained at the base of the alluvium. Saturated conditions originally resulted from recharge of mined water from Ambrosia Lake Valley uranium mines. The licensee maintains that current water levels in the alluvial aquifer suggest that saturated conditions are maintained by water chiefly from four sources (QMC, 2001, Figures 1.3 and 2.3; Rio Algom, 2003, Figure 12):

- Rio Algom discharge of treated mine water into the Arroyo del Puerto bypass channel, conducted in accordance with the corrective action program;
- Surface runoff that may have been affected by abandoned mine spoils and ore piles;
- Seepage from Rio Algom Tailings Impoundment 1; and
- Seepage from the Title I Ambrosia Lake Tailings Impoundment located 1.5 mi northeast of the Rio Algom impoundment.

As stated in QMC (2001, p. 2-21), however, leakage from the Arroyo del Puerto bypass channel "is the primary source of recharge to the alluvial channel." The results of the hydrologic model in QMC (2001, Appendix C) support the suggestion that water levels in the alluvial aquifer on and adjacent to the site are maintained almost entirely by recharge resulting from the Rio Algom pump-and-treat corrective action program activities. There is no evidence that the only evaporation ponds in use adjacent to the alluvium—lined Ponds 9 and 10—are sources of seepage into the alluvium. As part of the corrective action program, unlined evaporation ponds are no longer in use.

The interceptor trench constructed in 1984 along the eastern edge of Rio Algom Tailings Impoundment 1 captures the bulk of the impoundment seepage; presently, the trench is continuously pumped and the water is evaporated in lined Ponds 9 and 10.

| Table 3-1. Alluvial Aquifer Groundwater Protection Standards, Health Risk-Based Limits, and Original and Revised Requested Alternate Concentration Limits | | | | | |
|---|---|---|---|---|---|
| Contaminant | Groundwater Protection Standards* | Health Risk-Based Limit† | Original Requested ACL* | Revised Requested Alternate Concentration Limit‡ | |
| | | | | Value | Basis |
| Molybdenum (mg/L) | 0.06 | 0.18 | 83 | 3.92 | Well 0675 |
| Nickel (mg/L) | 0.06 | 0.1 | 0.14 | 0.14 | Title I site |
| Selenium (mg/L) | 0.05 | 0.05 | 3.1 | 3.1 | Title I site |
| Gross alpha (pCi/L) | Not defined | 8.57 | 16,726 | 720 | Well 32-57 |
| Ra-226+228 (combined radium) (pCi/L) | 5.0 | 3.23 | 196.1 | 196.1 | Title I site |
| Th-230 (pCi/L) | 3.1 | 13.9 | 10 | 5 | Title I site |
| U-nat (mg/L) | 0.06 | 0.025 | 11.1 | 11.1 | Title I site |
| Pb-210 (pCi/L) | 4.9 | 1.3 | 58 | 36 | Title I site |

Only includes constituents for which alternate concentration limits were requested.
*Quivira Mining Company (QMC). "Application for Alternate Concentration Limits in the Alluvial Materials at the Quivira Mill Facility, Ambrosia Lake, New Mexico." Tables 1.1 and 1.2. Grants, New Mexico: QMC. 2001.
†For molybdenum, nickel, and selenium: QMC. "Application for Alternate Concentration Limits in the Alluvial Materials at the Quivira Mill Facility Ambrosia Lake, New Mexico." Grants, New Mexico: QMC. p. 2-41. 2001; for others: Rio Algom Mining LLC (Rio Algom). "Response to 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. Ver. 1.1. Grants, New Mexico: Rio Algom. p. 1. 2003. Radium value is for Ra-226 alone; combined limit will be lower.
‡Rio Algom. "Response to 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. Ver. 1.1. Table 5. Grants, New Mexico: Rio Algom. 2003.

Because the trench was dug to bedrock, it prevents direct infiltration of impoundment seepage into the alluvium.

Infiltration from the Arroyo del Puerto bypass channel sweeps groundwater from the area of former unlined Ponds 4, 5, and 6 toward the trench and tailings impoundment.

A mineralogical report (QMC, 2001, Appendix B) shows that the alluvial material is unconsolidated and dominated by quartz and chalcedony with large amounts of limonite and calcite cement; minor constituents are gypsum and magnetite. The samples analyzed were from a single trench location, thus it is not clear how representative they are of the alluvium.

## 3.2 Hazard Assessment

The contaminants for which ACLs have been requested (Table 3-1) are those that the licensee has concluded cannot be expected to conform soon to the groundwater protection standards established in the corrective action plan (QMC, 1989; NRC, 2002). Alluvial monitoring data provided in QMC (2001, Figures 2.5 and 2.6) and Rio Algom (2002a,b) show constituent trends either decreasing slowly over the past 15 years or remaining relatively flat. There are constituents, such as Pb-210, that have varied erratically. As noted in QMC (2001) and Rio Algom (2003), groundwater radionuclide concentrations reported before July 1999 were measured on unfiltered samples. This measurement method tends to overestimate radionuclide contents and could be partly responsible for data variability; therefore, data from filtered samples from 1999 to the present should be afforded more weight in analyzing trends. In spatial distribution (QMC, 2001, Figures 2.7 to 2.15), the data indicate site-related alluvial contaminants originated from Rio Algom Tailings Impoundment 1; the site of former unlined Ponds 4, 5, and 6; and from the EPA National Pollution Discharge Elimination System (NPDES)-compliant discharge in the Arroyo del Puerto bypass channel. Rio Algom remediation and corrective actions have diminished the supply of contaminants to the alluvium through capping impoundments and closure and cleanup of unlined ponds.

There is a small number of apparent hot spots of higher contaminant concentration. The most notable hot spot is Well 5-08, located at the alluvial POE, which has higher Ra-226 activities than alluvial wells located much closer to apparent contaminant sources, including POC Wells 31-61 and 32-59. In addition, recent data (Rio Algom, 2002b) suggest a trend of increasing Ra-226 with time, with the most recent (March 2002) value for Well 5-08 of 37 pCi/L. RioAlgom (2003) argues that, because this well is adjacent to a road used for activities at the Coppin Mine, this isolated instance of contamination is possibly a result of surface contamination by uranium mine spoils material used for road fill. This hypothesis is not supported by the relatively low concentration of uranium in Well 5-08 (less than 0.01 mg/L). Rio Algom (2003) hypothesizes that uranium is low because of the relatively low oxidation potential in the water; radium is not directly redox sensitive in this type of geochemical setting. The specific chemistry of Well 5-08 does not appear to favor high radium content because it is not particularly high in complexants, such as chloride and sulfate, as compared with post-1998 waters from nearby alluvial wells with much lower Ra-226 (Rio Algom, 2002b, Wells 5-01, 5-02, 5-73, 32-59). In addition, there is no indication from alluvial wells upgradient of Well 5-08 (Rio Algom, 2002b, Wells 32-59, 5-03, 5-01, 5-02, 5-73) of passage of an Ra-226 plume of magnitude similar to the Well 5-08 concentrations. While the source of the Ra-226 in Well 5-08 is unresolved, there is no evidence that it arrived through groundwater transport from the Rio Algom facility. Ra-226 concentrations are much lower in wells upgradient from Well 5-08, and the concentration of more easily transported uranium is low.

Rio Algom (2003) recently reported that refined well sampling methods (involving presample purging) suggest lower Ra-226 in Well 5-08 of approximately 6–7 pCi/L. Thus, the level of Ra-226 contamination may have been overestimated. Also, inspection of the historical data (Rio Algom, 2002b) shows that all of the eight wells in the farthest downgradient portion of the alluvium recorded a marked increase in Ra-226 in the March 2002 sampling event—raising a concern of the quality of the 37 pCi/L measurement at Well 5-08.

A central assertion by the licensee (QMC, 2001; Rio Algom, 2003) is that the number of potential sources of alluvial contamination (Section 3.1 of this report) makes it difficult to ascribe contaminated groundwater at the POC and POE to their licensed activities. In addition to isolated cases such as the elevated Ra-226 at Well 5-08, Rio Algom (QMC, 2001) discusses the Title I Ambrosia Lake tailings impoundment 1.5 mi northeast of their facility. Reclamation and remediation at this facility has been completed, and the site is now under the stewardship of the DOE long-term surveillance and maintenance program (DOE, 2002). In granting approval of the DOE long-term surveillance and maintenance plan under general license, NRC did not require alluvial groundwater monitoring because the aquifer qualified as "limited use" according to the definition allowing supplemental standards in 40 CFR 192.11(e). NRC (1990) accepted the definition on the basis of a pump test conducted by DOE demonstrating that the alluvial aquifer at that location could not produce 150 gal of water per day for sustained continuous use. Rio Algom uses this case to support the application for ACLs at its tailings facility. For example, Rio Algom (2003) states

> If the NRC agrees that the alluvium at the DOE site is heavily contaminated from underground uranium mining and naturally occurring mineralization, and is of limited use due to low yield, then the same conditions must pertain to the alluvium at the Rio Algom site.

While Rio Algom does not use this argument as the basis for ACLs, this statement bears consideration.

The reference to heavy contamination from mining and natural mineralization applies to the bedrock aquifers, not the alluvium, because uranium deposits in the Ambrosia Lake area are located in strata below the alluvium. Also, it must be decided if conditions in the alluvial aquifer at the Title I impoundment apply to the vicinity of the Rio Algom site. Evidence supporting a close relationship between these two portions of the alluvial aquifer is inconclusive:

(i) The Rio Algom alluvial groundwater flow model for current conditions does not show water originating at the Title I facility flowing to the portion of the alluvial aquifer adjacent to the Rio Algom facility. Rather, the model shows flow being intercepted by the underlying TRB (QMC, 2001, Figure C–6).

(ii) The long-term surveillance and maintenance plan for the Title I site (DOE, 1996, p. 5-13) states that the alluvium near the Rio Algom site is "...not hydraulically connected to the alluvium/weathered Mancos Shale unit at the Ambrosia Lake [Title I] site."

(iii) The same long-term surveillance and maintenance plan report (DOE, 1996, p. 5-10) states that, in 1995, "Little or no ground water was encountered further to the south and west of the [Title I] site because the Tres Hermanos-C Sandstone units intercept the flow in the alluvium/weathered Mancos Shale unit."

These lines of evidence suggest that a direct connection between the alluvial aquifer at the two locations in terms of contaminant transport is inconclusive. Furthermore, a 40 CFR 192.11(e) "limited use" designation for the alluvial aquifer is not relevant to the use of ACLs at the Rio Algom site, because 10 CFR Part 40, Appendix A, Criterion 5B(5), allows for the use only of (i) the maximum levels defined in Table 5C of Appendix A; (ii) site-specific, NRC-approved groundwater protection standards based on background; or (iii) ACLs. For the same reason, the proposed ACLs cannot be properly termed "background" values. We therefore view the

Title I data as useful only in generally characterizing the extent of contamination in an area clearly affected by multiple sources.

The portion of the hazard assessment that identifies and evaluates potential hazards to human health and the environment is discussed in Chapter 2.

## 3.3 Exposure Assessment

Chapter 2 discussed the licensee approach to defining dose scenarios and numerical limits on groundwater contaminant concentrations that would be protective of public health and the environment. This section addresses the exposure scenarios adopted by Rio Algom as they relate to establishing ACLs. The proposed ACLs are based on estimates of "background" concentrations; the exposure assessments in QMC (2001) and Rio Algom (2003) are not explicitly for defining ACLs. Because of site complexity and the accompanying difficulty in setting appropriate ACLs, however, the exposure assessments presented by the licensee are emphasized to add confidence to the assertion that the ACLs would be protective.

### 3.3.1 "Background"

Rio Algom (QMC, 2001; Rio Algom, 2003) argues that the concept of "background" water quality is difficult to quantify in a setting with multiple contaminant source areas. The previously defined background Well, 5-03, may not be suitable because contaminants recorded there may not reflect the possible variation in contaminants arising from sources outside Rio Algom control. The ACL application therefore defined a new background. For all constituents for which ACLs were requested, except Th-230 and Pb-210 (Table 3-1), the licensee used a statistical analysis of the most contaminated portion of the alluvium not proximal to their facility, the portion below the Title I Ambrosia Lake tailings impoundment. The originally requested ACLs were the 95-percent upper tolerance limits (or maxima if statistical tests failed) for the entire set of monitor well data from the Title I site, dating back to 1980.

As discussed in Section 3.2, we reviewed this approach not as a background analysis, but rather as a means of bounding the extent of contamination in the alluvium from all sources. The central question, therefore, is whether contamination at the Title I site fairly represents the potential effects at the POE of the multiple sources in the alluvial valley. The potential influence of waters derived from the Title I facility is demonstrated in the ACL application (QMC, 2001, Figure 2.4) by geochemical data; but there is insufficient evidence that the significant influence extends to the proposed POE. 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. The two possible local sources for these waters are the discharge channel and interceptor 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 Interceptor Trenches 2 and 3 may also reflect the local influence of the Rio Algom tailings impoundment; the ratios in these waters range 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 ranging from 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 no clear-cut contrast. Therefore, evidence for the elevation of the ratio because of significant influence of the Title I site, while not countered by available data, is not compelling.

The discussion in Section 3.2 showed that (i) DOE (1996) statements about conditions at the Title I site and (ii) the Rio Algom flow model in support of the requested ACLs (QMC, 2001, Appendix C) suggest that seepage from the Title I impoundment will not significantly influence alluvial groundwater quality in the vicinity of the Rio Algom POCs. The groundwater flow model results do suggest, however, that contaminants from the Title I impoundment have as much chance of reaching the POE as do contaminants from the Rio Algom site (QMC, 2001, Appendix C, Figure C–6).

We conclude that the Title I site groundwater data, while not suitable for establishing background at the Rio Algom POCs and POE, may be considered to fairly represent contamination from the multiple sources that could have contributed to contamination in the alluvial aquifer. The suitability of these proposed ACLs for the Rio Algom site, therefore, rests on a demonstration that they are protective of human health and the environment at the POE.

### 3.3.2 Protection of Human Health and the Environment

The requested ACLs are not themselves protective of human health and the environment at the POE (Section 3.4); therefore, Rio Algom presented results of attenuation calculations using a geochemical model (QMC, 2001) and a simple groundwater transport model (Rio Algom, 2003). Monitoring data (QMC, 2001; Rio Algom, 2002b, 2003) support characterization of the alluvial aquifer as attenuating, because contaminant concentrations generally decrease away from the Rio Algom source region. Rio Algom feels, however, that the complexity of contaminant distributions and hydrologic conditions in the alluvium makes model results difficult to apply quantitatively to ACL definition. Thus, the models are intended only as support for ACLs based on "background" water quality.

A geochemical model (QMC, 2001, Appendix B) yielded very small attenuation factors that, when the requested ACLS are used as input, would lead to POE concentrations well below health risk-based limits for most constituents (the attenuation factor is defined as the ratio of the output concentration to the input concentration; thus, a low attenuation factor indicates a large amount of attenuation). The results of the geochemical model are not well constrained, however, because they are dependent almost entirely on imposition of reducing conditions, for which there is little supporting data in the alluvial aquifer (e.g., only two negative Eh measurements). The QMC (2001) 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 redox measurements. The geochemical model is a useful demonstration of a potentially beneficial process in the alluvium, but, without a full discussion and more detailed supporting data, the model results cannot be relied upon for attenuation arguments (see NRC, 2003b for a full discussion).

Subsequently, Rio Algom (2003) presented a simplified groundwater transport model, to support the attenuation capacity of the alluvium. This model, implemented with the SOLUTE code (Beljin and van der Heijde, 1993), was applied to uranium because evidence in the literature suggested uranium may be the most mobile of the contaminants for which ACLs were requested. The model yielded an attenuation factor of 0.005, which was applied to all contaminants at the requested ACL levels, and it was shown that—except for molybdenum and gross alpha—the resulting concentrations all complied with health risk-based limits (Rio Algom, 2003). The model used appropriately conservative model parameters (e.g., retardation factor of 10) adapted from Dakota sandstone simulations in the bedrock aquifer ACL application (QMC, 2000). The model was simulated for 100 years, which is a reasonable upper bound for the amount of time the alluvium will remain saturated if the corrective action program was terminated. In simulating transport from the POC to the POE, the model assumed a transport distance of 5,500 ft, which is the distance from the POE to the more distant POC Well 31-61. The model, therefore, does not apply to the Well 32-59 POC location, which is only 3,000 ft from the POE. If the model had used the distance from Well 32-59 to the POE, the amount of attenuation may have been significantly less and POE concentrations may not have complied with health-based concentration limits. In addition, with the exception of gross alpha, the comparison of attenuated concentrations with health risk-based limits did not use the revised health risk-based limits that account for cumulative effects (Rio Algom, 2003, p. 1; Chapter 2 of this report). We conclude that this model does not demonstrate compliance at the POE with health risk-based limits. Implications for the requested ACLs are discussed in the next section.

## 3.4 Corrective Action Assessment

### 3.4.1 ACLs

The originally requested ACLs were the 95-percent upper tolerance limits (or maxima if statistical tests failed) from the Title I site data for all requested contaminants except Th-230 and Pb-210, which were drawn from Rio Algom Well 31-63 data. In its response to the request for additional information, Rio Algom (2003) revised four of the requested ACLs as follows (Table 3-1):

- Molybdenum was changed to a lower value from a Title I site monitor well because the original requested ACL was not protective according to the new transport model.
- Gross alpha activity was changed to a lower value from monitor Well 32-57 positioned about midway between the two tailings facilities, because the original requested ACL was not protective according to the new transport model.
- Th-230 and Pb-210 were changed to the results of the Title I monitor well statistical analysis; they were previously taken from the "most contaminated" Rio Algom Well (31-63).

As discussed in Sections 3.2 and 3.3, we conclude that the available evidence [e.g., contaminant distributions in QMC (2001) and the groundwater flow model of QMC (2001, Appendix C)] shows that the water in the alluvial aquifer could have been affected by activities other than that of Rio Algom. A convincing technical basis for quantifying that influence, however, has been elusive. Because the alluvial sediments at the Ambrosia Lake facility were unsaturated prior to milling operations, the conventional concept of a background concentration is not applicable to the alluvial sediments. Furthermore, it is clear from the Rio Algom hydrologic model and other information in the ACL request (QMC, 2001) that the continued presence of water in the alluvial aquifer is dependent on implementation of the corrective action program. Evidence shows that if Rio Algom were to discontinue its corrective action program, the alluvium would begin to dewater by draining into mine-related features and underlying bedrock units and flowing out the southern end at the POE. We therefore have accepted the basis for the requested ACLs, but will now discuss whether they are protective.

The foremost requirement of ACLs is that they are protective of human health and the environment (NRC, 2003a, p. 4-27). Because we have not accepted the licensee's demonstration of protective ACL concentrations at the POC location (Section 3.3.2), it will be necessary for the licensee to demonstrate that natural attenuation will lower contaminant concentrations below the health risk-based limits during transport in the alluvial aquifer from POC Well 31-61 to the POE—a distance of 5,500 ft. (Note that this approach assumes Well 32-59 is not a suitable POC location; see Section 3.4.2.). We concur with the Rio Algom application of the transport model to uranium because it may be the most mobile of the contaminants (QMC, 2001; Rio Algom, 2003). Although multiple sources are present in the aquifer, it would be reasonable to assume a source exists or has existed recently near POC Well 31-61 with contaminant concentrations equivalent to the revised requested ACLs (Table 3-1). This contaminant transport model cannot be considered an accurate simulation of site conditions, but it can be used to bound the potential influence of any contaminants observed at Well 31-61.

Previous calculations by Rio Algom assumed a uranium retardation factor of 10, which, based on available literature, was clearly conservative (NRC, 2003b). More recently, the licensee communicated a desire to use a retardation factor of 100 as a conservative bound for models of both the alluvium and the bedrock aquifers. We considered whether or not this retardation factor was valid for the alluvium. The need for conservatism arises from model and data uncertainties. The transport model itself is simplified in a number of ways; for example, (i) it is uncalibrated, (ii) there are multiple potential sources, and (iii) there are wide variations in water chemistry (especially pH) that are not accounted for. Considering the wide variations in water chemistry, it is recognized increasingly that simple, $K_d$-based transport models are inadequate for accurately modeling sites, such as tailings facilities, with geochemical heterogeneities (e.g., Zhu, 2003). A major reason for this inadequacy is the strong dependence of $K_d$ on characteristics such as pH and carbonate content for many contaminants; uranium sorption is particularly sensitive to these variables (e.g., Davis, 2001). It is not practicable in the present case to apply more complex reactive transport models that could account for geochemical variation, because of time constraints and the lack of adequate geochemical characterization data. Therefore, it is especially important to use conservative assumptions and parameters when possible.

A reasonable $K_d$ corresponding to a given retardation factor can be calculated from

$$K_d = \frac{\phi}{(1-\phi)\rho}(R_d - 1) \qquad (3\text{-}1)$$

where the partition coefficient $K_d$ is in units of ml/g, $R_d$ is the retardation factor (unitless), $\phi$ is the rock porosity, and $\rho$ is the rock grain density (g/ml). The density of quartz, 2.65 g/ml, is an appropriate value for $\rho$, and a typical sand porosity is 0.25. Thus, the $K_d$ value corresponding to $R_d$ values of 100, 50, and 10 would be 12, 6, and 1.1 ml/g. To conservatively assign an $R_d$ of

100 would require confidence that the $K_d$ for uranium is well above 12 ml/g for the range of conditions along the transport pathway.

Dependence of $K_d$ for U(VI)—the dominant uranium oxidation state for atmospheric conditions—on pH, aqueous carbonate, and host surface area was reported by Pabalan, et al. (1998). Figure 3-1 shows the dependence of the U(VI) $K_d$ on pH for three different substrates in water at equilibrium with atmospheric $CO_2$. Pabalan, et al. (1998) argued that the differences between the $K_d$ values can be attributed to effective surface area differences among the solids. Therefore, the appropriate position of a curve for the alluvial aquifer on this plot can be scaled by estimating an effective surface area for alluvial materials. The alluvium has been described by the licensee as a very fine-grained sand with clay[1] (QMC, 1989), which should therefore be dominated by grains in the size range of 0.0625 to 0.125 mm but includes smaller grains. Alluvium samples reported in Appendix B of QMC (2001), however, had quartz grains ranging as large as 0.6 mm. The quartz grains used in the Pabalan, et al. (1998) experiments ranged from 0.150 to 0.250 mm, while the clinoptilolite (a zeolite mineral) grains were 0.075 to 0.150 mm. Experimental $K_d$ values for the clay mineral montmorillonite (not shown in Figure 3-1) were factors of 3 to 10 higher than clinoptilolite, reflecting the high surface area resulting from grain sizes of less than 2 μm. Considering the plausible grain-size range and mineralogy of the alluvium (i.e., <0.6 mm but dominated by grains <0.125 mm), we conclude that the alluvium may fall in the vicinity of the clinoptilolite curve on Figure 3-1. The presence of iron oxides (QMC, 2001, Appendix B) may tend to enhance $K_d$, implying that a $K_d$ curve for alluvium might lie above the clinoptilolite curve. We are limited, however, by the lack of characterization data covering a wide portion of the alluvial aquifer. In addition, iron oxides may be coated or armored by less-sorbent phases, diminishing their contribution to sorption.

Another geochemical effect on $K_d$ is illustrated in Figure 3-2. When $CO_2$ partial pressure increases, the stability of dissolved U(VI) is enhanced and $K_d$ is lowered. The $P_{CO_2} = 10^{-2}$ atm conditions in Figure 3-2, under which $K_d$ at higher pH may be reduced by as much as one order of magnitude relative to atmospheric conditions (i.e., $P_{CO_2} = 10^{-3.5}$ atm), are typical of groundwater systems. Relevant geochemical data from Rio Algom alluvial waters that would allow estimation of $P_{CO_2}$ are sparse; both alkalinity as $HCO_3^-$ and pH are reported in a limited number of cases for alluvial wells, and only during the period 1983–1989 (Rio Algom, 2002b,c). These data are plotted in Figure 3-3, which also shows the equilibrium relationships between $HCO_3^-$ and pH for $P_{CO_2} = 10^{-2}$ atm and $P_{CO_2} = 10^{-3.5}$ atm. The curves were calculated for a simple carbonate water using the code EQ3NR (Wolery, 1992); the $P_{CO_2} = 10^{-3.5}$ atm curve was checked for consistency against a similar plot in Stumm and Morgan (1981, Figure 4.3). While the quality of the data are unknown and it is possible that outliers may be disregarded, it is clear from Figure 3-3 that the majority of the alluvial groundwaters plot well above the curve representing atmospheric $P_{CO_2}$ and that $P_{CO_2}$ may have commonly exceeded $10^{-2}$ atm.

We conclude that the available geochemical evidence points to $CO_2$ partial pressures for alluvial waters ranging to values well in excess of $10^{-3.5}$ atm, suggesting the U(VI) $K_d$ curve will be lowered as observed in Figure 3-2. In other words, the $K_d$-raising effects of smaller grain size and iron oxides may be offset by the $K_d$-lowering carbonate effect. We do not have sufficient

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[1]Bostick, K. "Ground-Water Discharge Plan Analysis for Kerr-McGee Nuclear Corporation, Ambrosia Lake Uranium Mill, Quivira Mining Company." Santa Fe, New Mexico: State of New Mexico, Environmental Improvement Division. Unpublished report, 1985.

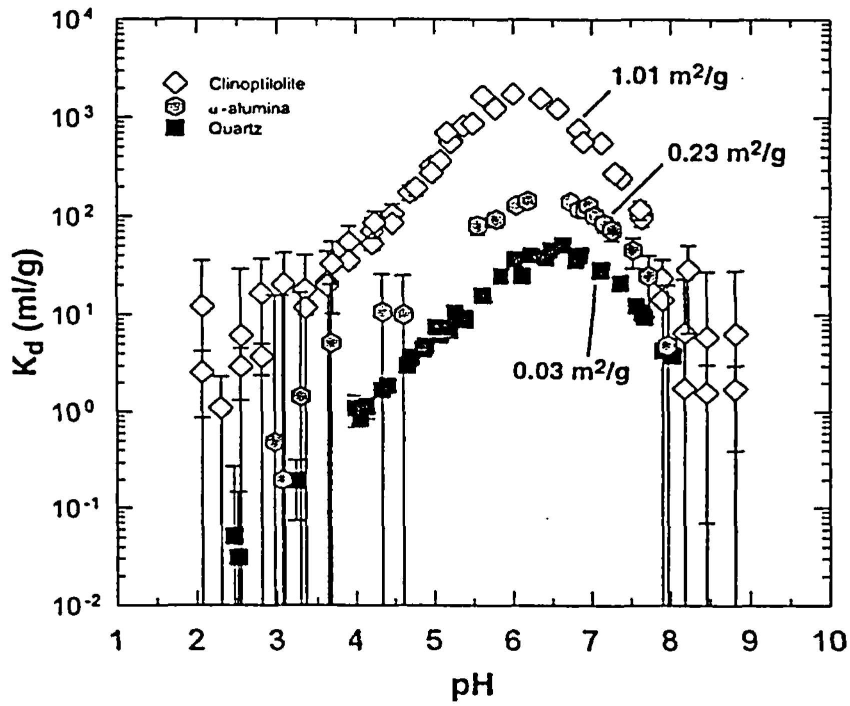


**Figure 3-1. Plot of pH Dependence of U(VI) Sorption on Clinoptilolite, α-Alumina, and Quartz, Modified after Pabalan, et al. (1998). Numbers Pointing to Each Curve Show Effective Surface Area for the Respective Solid Substrate. Error Bars Reflect 2σ Uncertainties on Uranium Measurements.**

information to quantify this effect in space and time. Thus, by reference to the clinoptilolite curve in Figure 3-1, we consider a pH range of 5 to 7.5 to provide confidence that the uranium $K_d$ will be above a value of 12 ml/g and that, thus, $R_d$ will be greater than 100.

Site water data (Rio Algom, 2002b) show that pH in alluvial wells has varied outside this range. At the low-pH end, the vast majority of measurements over the past 10 years have been above pH 5. (The five values below pH 5 from that time period were all from Well 31-63 immediately adjacent to Tailings Impoundment 1 and ranged from 4.5 to 4.8.) Measurements above pH 7.5, however, are common. Many of the monitoring wells at and on the pathway to the POE (5-01, 5-02, 5-03, 5-04, and 5-08) have in the past 10 years had pH that ranged up to as high as 10.3. On the other hand, proposed POC Wells 31-61 and 32-59 have been below pH 7.5 in the same period. Thus, it is not clear what pH range is appropriate for characterizing the transport pathway. Modeling at tailings sites has shown (Zhu, 2003) that pH heterogeneities add

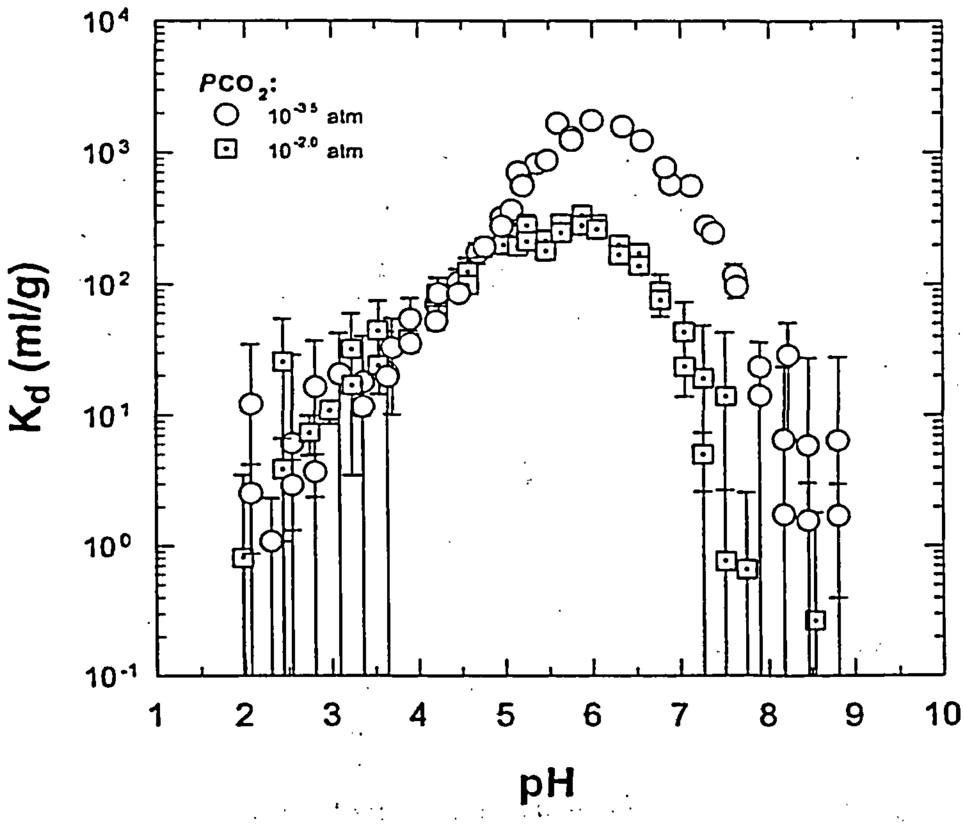


**Figure 3-2. The Effect of Increased $CO_2$ Partial Pressure in Lowering U(VI)-Clinoptilolite $K_d$ at pH Above 5, Modified after Pabalan, et al. (1998). Equilibrium with Atmosphere Corresponds to $P_{CO_2} = 10^{-3.5}$ atm. Higher Aqueous Carbonate at $P_{CO_2} = 10^{-2}$ atm Enhances the Stability of Dissolved Carbonate U(VI) Species at Higher pH, at the Expense of Sorbed Species.**

considerable uncertainty to predicting contaminant concentrations. Therefore, despite the presence of iron oxides and the relatively fine grain size of the alluvium, we do not consider an $R_d$ of 100 to provide a reasonably conservative bound on the effects of geochemical uncertainty through the entire transport pathway between POC Well 31-61 and the POE. The licensee will need to propose a defensible retardation factor lower than 100 and demonstrate that applying that $R_d$ to the transport distance from POC Well 31-61 to the POE, during a period of time conservatively chosen to reflect how long the alluvium may remain saturated, will yield contaminant concentrations below the health risk-based limits.

Of the eight constituents for which ACLs were requested, molybdenum is the only one that may typically be more mobile than uranium for oxidizing conditions. The licensee should demonstrate that the $K_d$ value corresponding to the adopted $R_d$ is reasonable for molybdenum in

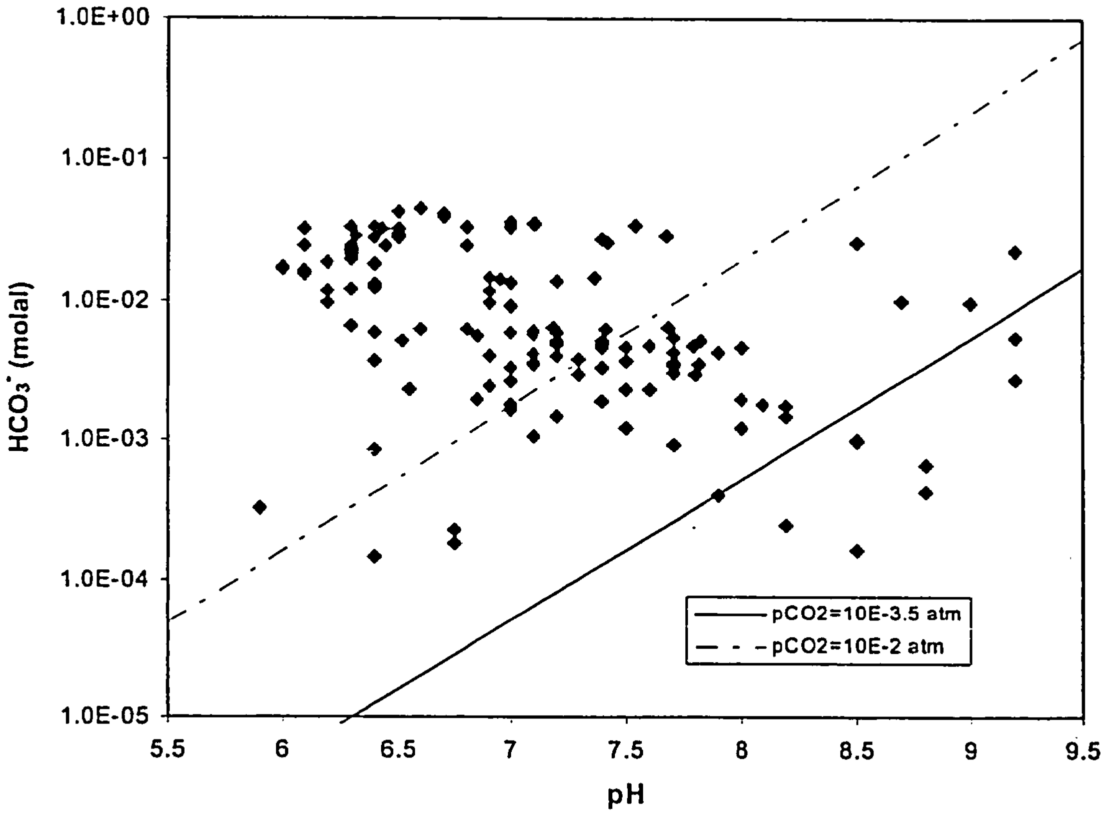


**Figure 3-3. Plot of Reported Alluvial Groundwater Bicarbonate and pH Data (Rio Algom, 2002b,c) from 1983–1989, Along With Equilibrium Curves Calculated Using EQ3NR for Two $CO_2$ Gas Partial Pressures**

light of literature data [e.g., sand soil values in Sheppard and Thibault (199)] and evidence from spatial distributions at the site (e.g., QMC, 2001, Figure 2.9)

Any transport model employed in ACL development would admittedly be simplified (e.g., there could be no calibration to site conditions), and may not account for anomalies such as the high Ra-226 at Well 5-08. Nevertheless, a model could be developed that is sufficiently bounding that, absent a major effort to distinguish the various potential sources at the site and thus better define a background water quality, compliance with health risk-based limits could be reasonably assured. Again, it should be noted that the ACL scenario assumes that Rio Algom will cease recharging the alluvium and that, within 100 years, the aquifer will be dry enough that flow will not take place between the POCs and POE.

In devising a new transport model for demonstrating protection, rationale should be provided for any changes to transport model parameters (e.g., retardation coefficient for uranium) from those used in the previous model or suggested in this report In addition, the licensee should ensure that its modeled attenuation factor is not overly dependent on a model period of 100 years. In other words, sensitivity of the attenuation factor to the model period should be assessed.

### 3.4.2 Corrective Action Program

As described in QMC (1989, 2001), the corrective action program for the alluvial aquifer at the Rio Algom site consists of three main components: (i) diversion of surface water around evaporation ponds in the bypass channel, (ii) discontinued use of unlined ponds and removal of pond waters, and (iii) construction of Interceptor Trench 1 along the eastern margin of Tailings Impoundment 1. The bypass channel and trench together have resulted in a reverse hydraulic gradient that directs channel waters—derived from treatment of mine waters under the bedrock aquifer corrective action program—to the west, "sweeping" alluvial contaminants to the trench. Currently, trench waters are collected and evaporated in lined ponds, though a portion undoubtedly drains into the TRB at the bottom of the trench. Historical monitoring data (QMC, 2001) show that this program has resulted, in general, in the gradual decrease of contaminant concentrations in the alluvial aquifer. Furthermore, with some exceptions such as Ra-226 in Well 5-08, monitor wells show that the declining trends have been leveling off during the past 5–15 years (QMC, 2001; Figures 2.5 and 2.6; Rio Algom, 2002b). Therefore, evidence *suggests that continued implementation of the corrective action program will not directly lead to* lower contaminant levels in the alluvial aquifer. In fact, QMC (2001) modeling shows that, in the absence of the corrective action program, the alluvium would go dry within 65–100 years and cease acting as a potential groundwater source. In addition, reclamation activities, such as construction of a low permeability barrier on Tailings Impoundments 1 and 2 and cleanup and retirement of all unlined ponds, assure that Rio Algom facilities will not indefinitely continue to act as contaminant sources (e.g., seepage from the tailings impoundment will cease within 100 years).

QMC (2001) argues that the present contaminant levels are ALARA. The two alternatives to continuing the corrective action program analyzed are (i) completion of site reclamation and cessation of mine water discharge (the base case) and (ii) enhanced dewatering of Tailings Impoundments 1 and 2 by way of wells drilled into the impoundments. QMC (2001) shows, using reasonable assumptions, that enhanced impoundment dewatering would yield relatively few benefits and would cost an estimated $1.7 million per person-rem averted—far in excess of the value of $2,000 per person-rem in the NRC draft regulatory guide DG–4006 (NRC, 1998). Continuation of the current program for 100 years (the time estimated for complete dewatering of the tailings impoundments) is the most expensive option, costing an estimated $59 million per person-rem averted. The alternatives lead to relatively low reductions in contaminants compared to the basecase (QMC, 2001, Table 3.2), and there is reasonable assurance that, in all cases, attenuation in the alluvium will reduce contaminant concentrations to safe levels.

Rio Algom proposes (QMC, 2001, Section 4.1) to discontinue the current corrective action program, continue site reclamation, and monitor POC Wells 31-61 and 32-59 and POE Wells 5-04 and 5-08. We conclude that continuation of the corrective action program will not result in a significant improvement in protection of human health and the environment. Cessation of the corrective action program will allow the alluvial aquifer to return to an unsaturated state so that it will eventually cease to be a potential source of groundwater. As discussed earlier in this chapter, however, we find the requested ACLs currently have insufficient bases because they have not been shown to be protective.

Because reclamation includes filling in interceptor trenches, seepage from the tailings impoundments would no longer be intercepted and would act once again as a potential contaminant source for the alluvial aquifer. However, (i) impoundment seepage will diminish because of impoundment infiltration barriers, (ii) groundwater modeling (QMC, 2001) suggests that this seepage will drain dominantly into the underlying TRB bedrock unit, and (iii) any ACLs found acceptable to NRC will nevertheless be protective for the alluvial groundwater that does travel to the POE.

Because of the complexity of the site, we propose that Rio Algom should be required to continue monitoring the alluvial aquifer for an additional period after site reclamation is completed. We accept the Rio Algom request to eliminate MW–24 as a POC well because it is located downgradient from the POE location. In addition, we accept elimination of Well 5-03 as a background location, because it is located on the pathway from the POCs to the POE and may bear some imprint of facility-derived contamination. We also propose eliminating Well 32-59 as a POC location. 10 CFR Part 40, Appendix A, Criterion 5B(1), states that the "point of compliance must be selected to provide prompt indication of ground-water contamination on the hydraulically downgradient edge of the disposal area." Well 32-59 is not located appropriately for a POC well, because it is at least 2,200 ft from potential sources (e.g., Rio Algom, 2003, Figure 12). In contrast, Well 31-61 is approximately 230 ft from Interceptor Trench 1. POC Well 31-61 should continue to be monitored for compliance and POE Wells 5-04 and 5-08 should continue to be monitored for assurance that concentrations are at protective levels (i.e., a factor of 0.25 times the recommended ACLs of Table 3-2). At Well 5-08, Ra-226 and gross alpha (which Ra-226 contributes to) should not be required to be held to protective limits because we have concluded that Ra-226 contamination at this well is unlikely to be related to the licensee activities. The licensee should provide an adequate technical basis for any other specific, potentially hazardous contaminant levels that arise from sources beyond its control.

NUREG–1620 (NRC, 2003a, p. 4-36) states "some locations between the point of compliance and the points of exposure should be included [in monitoring] to assure the identified aquifer attenuation mechanisms are reducing the hazardous constituent concentrations to the predicted levels." We, therefore, propose that Rio Algom continue to monitor Wells 32-59, 5-01, 5-02, and 5-73, which together span the alluvial transport pathway between POC Well 31-61 and POE Wells 5-04 and 5-08 (Rio Algom, 2003, Figure 12). In the three of these wells nearest the POE (5-01, 5-02, and 5-73), the only evidence for contamination is the occurrence of uranium concentrations of approximately 0.2 mg/L in Well 5-73; because 5-73 is shallow and lies near the arroyo channel, we speculate this well may be affected by solid mill materials washed down the arroyo during past site activities or runoff from other sources. Nevertheless, it is close enough (1,800 ft) to the POE that groundwater contamination is a concern.

## 3.5 Summary

For the alluvial aquifer at the Rio Algom site, we recommend

(i) Available information is sufficient to reasonably conclude that continuation of the corrective action program will not lead to further reductions in contaminant concentrations.

(ii) The requested ACLs should be denied because they have not been demonstrated to be protective of human health and the environment. The licensee should demonstrate protection using, if necessary, an attenuation argument based on a defensible retardation factor or submit a new set of ACLs that are protective. The licensee should clarify that its ACLs are not to be construed as true "background" concentrations.

(iii) Wells 32-59 and MW–24 should no longer be classified as POCs.

(iv) If compliance with the groundwater protection standards and new ACLs is demonstrated, monitoring at POC Well 31-61 should continue until site reclamation is completed and for an additional period proposed by the licensee. The additional period should be long enough that continued compliance is assured. Monitoring should be conducted in accordance with current license conditions for constituents measured, reporting, and frequency.

(v) The proposed POE should be accepted, and monitoring at POE Wells 5-04 and 5-08 should continue for the same period so adherence to protective limits (i.e., the higher of existing groundwater protection standards and calculated health risk-based limits) is maintained, with the exception of Ra-226 and gross alpha at Well 5-08.

(vi) Monitoring at POC–POE intermediate Wells 32-59, 5-01, 5-02, and 5-73, intermediate to the POC and POE, should continue for the same period so that the attenuating action of the alluvial aquifer may be verified.

# 4 BEDROCK AQUIFERS

For groundwater in the bedrock aquifers at the site, Rio Algom requested ACLs for five constituents (QMC, 2000). One ACL value (uranium in the TRB) was modified in the Rio Algom (2003) response to the request for additional information (NRC, 2003b). As discussed in more detail in this chapter, Rio Algom argues that these ACLs are acceptable because they are protective of human health and the environment and because current levels are ALARA.

## 4.1 Description

The uppermost bedrock aquifer units affected by uranium mining and milling activities at the Rio Algom facility include the Tres Hermanos Sandstone and the Dakota Sandstone units. In the vicinity of the Rio Algom site, the Tres Hermanos Sandstone is present as a series of three relatively permeable sand units interbedded within the Mancos Shale. From bottom to top, these three layers are referred to as the TRA, TRB, and Tres Hermanos C Sandstone Unit (TRC). The Dakota is a single sand layer that underlies the Mancos Shale. At the licensed site, these four hydrogeologic layers either outcrop at the surface or subcrop beneath the alluvial sediments at the site and dip downward in a north-northeasterly direction. The groundwater flow in these hydrogeologic layers is generally north-northeast, down dip toward a regional depression in groundwater hydraulic heads that can be attributed to dewatering related to mining activities (QMC, 2000).

Affected groundwater in the TRA, TRB, and Dakota generally flows downdip to the north and northeast beyond the POE boundary to where it is intercepted by numerous vent holes and shafts associated with the underground mines and by vertical fractures induced by collapse of mine stopes. The majority of affected water is expected to drain into the mine shafts and vents, which lead to the ore body in the deeper Westwater formation. Groundwater in the ore body and mine works within the Westwater formation is not included in the groundwater corrective action program (QMC, 1989; NRC, 2002).

## 4.2 Hazard Assessment

The TRA crops out and subcrops (i.e., directly underlies alluvium) in the general vicinity of unlined Ponds 7 and 8 (QMC, 2000, Map 1-1, Drawing 2-3). Most seepage from Ponds 7 and 8 that may have migrated into the TRA has been minimized by the dewatering trench located between Pond 7 and Tailings Impoundment 2. Concentrations of several monitored constituents have exceeded groundwater protection standards for the TRA in the past. In recent years, however, only gross alpha and combined radium have consistently exceeded groundwater protection standards (QMC, 2000, Figures 2-10 through 2-18).

The TRB subcrops beneath most of Tailings Impoundments 1 and 2 (QMC, 2000, Drawings 2-1 and 2-2). On cessation of the groundwater corrective action plan, drainage of residual fluids from Tailings Impoundments 1 and 2 would migrate into the TRB formation (QMC, 2001, Appendix C). The TRB also receives recharge from drainage of saturated alluvium in the vicinity of Ponds 3, 4, 5, 6, 9, and 10. The current source of water in the saturated alluvium is treated process water discharged to the Arroyo del Puerto bypass channel. On cessation of the groundwater corrective action plan, discharge into Arroyo del Puerto would cease. Groundwater modeling (QMC, 2001, Appendix C) suggests that alluvium overlying the TRB west of Arroyo del Puerto would drain completely in less than 65–100 years and, therefore, would not be a long-term source of in-flow to the TRB. In the TRB, concentrations of nickel, Pb-210, combined radium, Th-230, uranium, and gross alpha have consistently been above groundwater protection standards at one or more POC wells, despite the ongoing groundwater corrective action (QMC, 2000, Figures 2-1 through 2-9).

In downhole investigations to determine the flow of water from each of the bedrock units to 30 ventilation holes and shafts, no measurable fluids were observed in the TRC. Two monitoring wells completed in the TRC were also dry. Thus, the TRC does not appear to be affected by tailings seepage from the Rio Algom Ambrosia Lake facility and is not included in the corrective action program.

The Dakota crops out and subcrops in the general vicinity of Pond 8. Seepage from Pond 8 and the adjacent Pond 7 appears to have migrated into the Dakota. This contaminant source was eliminated in 1983 when Ponds 7 and 8 were taken out of service and pond residues were subsequently removed. Concentrations of nickel, Pb-210, combined radium, Th-230, uranium, and gross alpha, however, continue to exceed groundwater protection standards at one or more POC wells (QMC, 2000, Figures 2-19 through 2-32).

ACLs have been requested by Rio Algom for constituents of concern in the TRA, TRB, and Dakota (Table 4-1) that do not conform to the groundwater protection standards in the corrective action plan.

## 4.3 Exposure Assessment

Chapter 2 discussed the licensee approach to defining dose scenarios and groundwater contaminant concentration limits that would be protective of human health and the environment. Many of the requested ACLs, however, are greater than the health risk-based limits. Rio Algom justified the use of these higher concentration limits using solute transport calculations to demonstrate that sufficient attenuation would occur between POC and POE locations that health risk-based concentration limits would be met at the POE (QMC, 2000, Section 2.3.2). Rio Algom (2003) also provided a parameter uncertainty analysis for the solute transport calculations to demonstrate that the calculated attenuation factors are reasonably conservative for estimating solute attenuation between the POC and POE locations in the TRB and Dakota.

The use of attenuation factors is a reasonable approach, but the requested ACLs obtained using this method are not acceptable for the following reason. In its response to the NRC (2003b) request for additional information, Rio Algom (2003) revised its estimates for health risk-based concentrations for Pb-210, combined radium, Th-230, and natural uranium, but Rio Algom did not use the attenuation factor approach to recalculate ACLs that would meet the revised health risk-based limits.

Table 4-2 shows what the estimated protective POC concentration limits should be in Dakota POC Well 36–06KD using the revised health risk-based limits and the attenuation factor of 0.16 developed by the licensee. The Rio Algom requested ACLs (Table 4-1) for combined radium and Th-230 in the Dakota were based on the old health risk-based limit. The protective concentrations for combined radium and Th-230 listed in Table 4-2 would be more appropriate values for ACLs in the Dakota unit.

| Table 4-1. Groundwater Protection Standards, Health Risk-Based Limits, and Requested Alternate Concentration Limits for Uppermost Bedrock Aquifer Units | | | |
|---|---|---|---|
| Contaminant | Original Groundwater Protection Standards* | Health Risk-Based Limit† | Requested Alternate Concentration Limit* |
| **Tres Hermanos A Sandstone Unit** | | | |
| Ra-226+228 (combined radium) (pCi/L) | 5.0 | 3.23 | 41 |
| Th-230 (pCi/L) | 4.3 | 13.9 | 139 |
| Pb-210 (pCi/L) | 4.1 | 1.3 | 13 |
| **Tres Hermanos B Sandstone Unit** | | | |
| Nickel (mg/L) | 0.06 | 0.1 | 0.37 |
| Ra-226+228 (pCi/L) | 7.4 | 3.23 | 41 |
| Th-230 (pCi/L) | 2.2 | 13.9 | 139 |
| U-nat (mg/L) | 0.02 | 0.025 | 1.56 |
| Pb-210 (pCi/L) | 0.9 | 1.3 | 13 |
| **Dakota Sandstone Unit** | | | |
| Nickel (mg/L) | 0.03 | 0.1 | 0.12 |
| Ra-226+228 (pCi/L) | 5.0 | 3.23 | 41 |
| Th-230 (pCi/L) | 2.3 | 13.9 | 869 |
| U-nat (mg/L) | 0.02 | 0.025 | 0.81 |
| Pb-210 (pCi/L) | 1.9 | 1.3 | 57 |

Only includes constituents for which ACLs were requested.
*Quivira Mining Company (QMC). "Corrective Action Program and Alternate Concentration Limits Petition for Uppermost Bedrock Units, Ambrosia Lake Uranium Mill Facility Near Grants, New Mexico." Table 1-1. Grants, New Mexico: QMC. 2000; except Rio Algom Mining LLC (Rio Algom). "Response to 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." Ver. 1.1. Oklahoma City, Oklahoma: Rio Algom. p. 16. 2003 for Tres Hermanos B Sandstone Unit requested alternate concentration limit for U-nat.
†QMC. "Corrective Action Program and Alternate Concentration Limits Petition... ." Table 2-8 for nickel; Rio Algom. "Response to Request for Additional Information—Corrective Action Program... . p. 1, for others. Radium value is for Ra-226 alone; combined limit will be lower.

| Table 4-2. Estimates of Protective Concentrations Based on Revised Health Risk-Based Limits for Dakota Point of Compliance Well 36–06KD | | | |
|---|---|---|---|
| Contaminant | Health Risk-Based Limit* | Attenuation Factor† | Protective Concentration‡ |
| Nickel (mg/L) | 0.1 | 0.16 | 0.63 |
| Ra-226+228 (combined radium) (pCi/L) | 3.23 | 0.16 | 20 |
| Th-230 (pCi/L) | 13.9 | 0.16 | 87 |
| U-nat (uranium natural) (mg/L) | 0.025 | 0.16 | 0.15 |
| Pb-210 (pCi/L) | 1.3 | 0.16 | 8.1 |

*Quivira Mining Company (QMC). "Corrective Action Program and Alternate Concentration Limits Petition for Uppermost Bedrock Units, Ambrosia Lake Uranium Mill Facility Near Grants, New Mexico." Table 2-8. Grants, New Mexico: QMC. 2000, for nickel; Rio Algom Mining LLC (Rio Algom). "Response to 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." Ver. 1.1. Oklahoma City, Oklahoma: Rio Algom. p. 1. 2003, for others. Radium value is for Ra-226 alone; combined limit will be lower.
†QMC. "Corrective Action Program and Alternate Concentration Limits Petition...." Section 2.3.2.1.
‡Health risk-based limit divided by attenuation factor

Rio Algom also used an attenuation factor of 0.16 for TRB POC Well 31-66 to demonstrate health risk-based limits for nickel and natural uranium in the TRB could be met at the POE. Since the health risk-based limit for nickel was not changed by Rio Algom (2003), that requested ACL remains acceptable. The requested ACL for natural uranium in the TRB, however, was based on the previous health risk-based concentration limit of 0.25 mg/L, which has been revised by Rio Algom (2003) to a value of 0.025 mg/L. Although Rio Algom (2003) also revised the requested ACL for natural uranium to a higher value, the revised value remained based on the previous health risk-based concentration limit. Accordingly, the ACL for natural uranium at POC wells in the TRB should be revised to a value that is protective based on the revised health risk-based concentration limit of 0.025 mg/L for natural uranium. The value of 0.15 mg/L listed in Table 4-2 would meet this objective, using the Rio Algom attenuation factor of 0.16. Alternatively, Rio Algom should provide additional justification for any greater ACL for natural uranium.

The requested concentration limits for Pb-210, uranium, and nickel in the Dakota were obtained using a different approach that did not employ the health risk-based limits or attenuation factors. For these constituents, ACLs were based on the mean concentration plus two standard deviations calculated from a statistical evaluation of groundwater monitoring results from POC Well 36–06KD. Typically, such an analysis would be performed to establish an upper bound value for a range of background concentrations. An argument cannot be made that POC Well 36–06KD is representative of background concentrations, however, because it is immediately downgradient from the former contamination source in Ponds 7 and 8 and has consistently had higher concentrations of Pb-210, uranium, and nickel than any of the other POC wells in the Dakota.

In its application for ACLs (QMC, 2000), Rio Algom demonstrated that the requested concentration limits for Pb-210, uranium, and nickel in the Dakota were less than the protective concentration at Well 36–06KD, which was calculated using an attenuation factor of 0.16. However, because the heath risk-based concentration estimates have been revised by Rio Algom (2003) for Pb-210 and natural uranium, the requested ACLs for those constituents are no longer lower than the calculated protective limit. Accordingly, the ACLs for Pb-210 and natural uranium at Dakota POC Well 36–06KD should be revised to values equal to or lower than the protective concentrations listed in Table 4-2. Alternatively, Rio Algom should provide justification for any greater ACLs for Pb-210 or natural uranium in the Dakota.

The requested ACLs for Pb-210, Th-230, and combined radium in both the TRA and TRB were all set equal to the original health risk-based values (QMC, 2000, table 2-15). Because these three values have been revised by Rio Algom (2003), the requested ACLs for the TRA should be revised also. The revised heath risk-based values listed in Table 4-1 would be acceptable.

## 4.4 Corrective Action Assessment

### 4.4.1 ACLs

As discussed in Section 4.3, many of the requested ACLs for the uppermost bedrock units are not acceptable because they have not been recalculated to be consistent with the revised health risk-based concentration limits provided by Rio Algom (2003). Rio Algom should propose a new set of ACLs and provide the supporting rationale to justify that those concentration limits will be protective, based on the revised health risk-based limits.

Recently, Rio Algom communicated a desire to use a retardation factor of 100 as a conservative bound for attenuation models of the bedrock aquifers. Previously, in the original ACL application for the bedrock aquifers, Rio Algom used a retardation factor of 10, a justifiably conservative value, to estimate an attenuation factor of 0.16. Using the same modeling approach, a retardation factor of 100 would result in an attenuation factor of 0.016—one-tenth the original attenuation factor, which exactly compensates for the factor-of-10 decrease in the health risk-based limits and thereby leaves Rio Algom with the same ACLs as originally proposed. We have considered whether the suggested tenfold increase in the retardation factor is reasonable and, if not, what a reasonably conservative retardation factor would be. The need for conservatism arises from model and data uncertainties. This discussion follows directly from the corresponding discussion for alluvium in Section 3.4.1.

As explained in Section 3.4.1, the use of a simplified, one-dimensional transport model that assumes a geologically and geochemically homogenous aquifer necessitates the adoption of conservative assumptions to yield model results that provide a reasonable bounding or worst-case assessment rather than an estimate of what is actually expected to occur. Accordingly, we concur with Rio Algom applying the transport model to uranium because it is likely to be the most mobile of the contaminants. The proposed use of a retardation factor of 100, however, has not been shown to be a reasonably conservative estimate of the ability of the bedrock aquifers to attenuate concentrations of contaminants in groundwater.

Retardation factors are estimated based on the solute-to-soil partitioning coefficient, or $K_d$. The underlying $K_d$ value for a retardation factor can be obtained from Eq. (3-1). We surmise that porosity and grain density for the bedrock aquifers are generally similar in magnitude to those of the alluvial aquifer (i.e., 0.25 and 2.65 g/ml, respectively). Thus, to conservatively assign an $R_d$ of 100 for the bedrock aquifers would require confidence that the $K_d$ value for uranium is well above 12 ml/g for the range of conditions along the transport pathway.

As discussed in detail in Section 3.4.1, $K_d$ values for uranium are strongly dependent on the pH of groundwater and the grain size distribution of the transport medium. The sandstone that comprises the bedrock aquifers is described by the licensee as a fine-grained sand (QMC, 2000), which, similar to the alluvial sediments, should be dominated by grains in the range 0.0625–0.125 mm. Also, similar to the alluvial transport pathway, the pH of groundwater in the bedrock aquifers is observed to be spatially and temporally variable (Rio Algom, 2002b). For example, the pH in Dakota POC Well 36-06, near the original contaminant source, has generally remained in the range 3.0–4.2, a condition unfavorable for uranium sorption. Moving downgradient from Well 36–06, however, groundwater pH generally increased to values greater than 5 and less than 9, with occasional temporal variations outside this range.

As previously discussed for the alluvial transport pathway, and as evident from Figure 3-1, a pH range of 5 to 7.5 would generally provide confidence that the uranium $K_d$ will be above a value of 12 ml/g and, hence, that $R_d$ will be greater than 100. Because the range of pH in groundwater at the Rio Algom site falls outside this range with local and temporal variations (Rio Algom, 2002b), and in the absence of a more detailed geochemical analysis (including, for example, aqueous carbon species data and iron oxide content) to bound uranium sorption at the site, a retardation factor less than 100 would be necessary to provide confidence that calculated attenuation factors are reasonably bounding.

### 4.4.2 Corrective Action Program

The approved groundwater corrective action program involves continuation of mine water pumping from the Westwater Canyon hydrogeologic unit so that any groundwater in the TRA, TRB, and Dakota downgradient of the tailings impoundments and ponds will be intercepted by the mine shaft, ventilation holes, and subsidence fractures that drain into the mine. The pumped water is treated at the mill facility and discharged pursuant to the NPDES permit for mine water discharge. A dewatering trench was also installed between evaporation Pond 7 and Tailings Impoundment 2 to intercept seepage from Tailings Impoundment 2 and Pond 7. This dewatering trench is pumped, and flow is routed to the seepage intercept trench southeast of Tailings Impoundment 1.

In its application for ACLs, Rio Algom states that continuation of mine water pumping is not necessary to intercept groundwater from the TRA, TRB, and Dakota by the mine shafts and vents. Regional groundwater modeling studies suggest it will take hundreds of years for the dewatered formations in the mined region to recover enough for resaturation to occur at POE locations in the TRA and TRB. Although mine water pumping has not dewatered the Dakota at the POE location, removal of tailings fluids and byproduct material from Ponds 7 and 8 has eliminated the contaminant source, and groundwater in the Dakota would be protected at the POE if approved ACLs are met at POC wells.

Regulations in 10 CFR Part 40, Appendix A, Criterion 5B(6) require a demonstration that contaminant concentrations are ALARA before ACLs can be applied. Monitoring well data show that concentrations of constituents associated with mill operations generally have declined in the uppermost bedrock units as a result of source mitigation and groundwater corrective action (e.g., QMC, 2000, Figures 2-1 through 2-32, Section 3.2). In approximately the past decade, however, contaminant concentrations, while variable, have stabilized, and no appreciable reductions in contaminant concentrations are occurring in the uppermost bedrock units, despite ongoing groundwater corrective action. An evaluation of possible alternative corrective actions indicates that alternative actions are either unfeasible or would likely achieve only minimal reductions in contaminant concentrations at a cost that would not be justified by the results (QMC, 2000, Sections 3.3 and 3.4). Available information and analyses, therefore, support a conclusion that constituent concentrations for which Rio Algom is seeking ACLs in the uppermost bedrock aquifers are ALARA. However, Criterion 5B(6) is clear that an ALARA demonstration alone is not sufficient for acceptance of ACLs; constituents must also "... not pose a substantial present or potential hazard to human health or the environment ...."

If acceptable ACLs for hazardous constituents can be established, and if those standards are met at designated POC wells, the ongoing groundwater corrective action in the uppermost bedrock units would be terminated, and compliance monitoring would continue to ensure protection of health and the environment.

Rio Algom has proposed four POC wells for the Dakota formation. POC Well 36-06KD is located just north of Pond 7, close to the original source of contamination, and is the POC location used by Rio Algom in transport calculations to demonstrate the proposed ACLs are protective. Dakota POC Wells 30–48KD, 30–02KD, and 32–45KD are all located more than 5,500 ft farther from the source than POC Well 36-06, but are much closer to potential POE locations beyond the long-term control boundary. NRC (2003b) previously commented that a concentration limit that is protective at the location of Well 36-06 may not be protective at the other POC wells. Rio Algom (2003) responded that the other POC wells are much farther from the source and, thus, may not be appropriate as POC wells. We concur that Wells 30-48KD, 30–02KD, and 32–45KD are not suitably located and do not need to be categorized as POC wells. Any approved ACLs for the Dakota should be applicable only to POC Well 36-06. Dakota Wells 30–48KD, 30–02KD, and 32–45KD should continue to be monitored as trend wells, however—especially considering that groundwater protection standards for several constituents have been exceeded previously in Dakota Well 30–48KD.

Four POC wells also have been proposed for the TRB. Wells 36-02, 31-66, and 31-67 are appropriately located for ensuring groundwater protection at POE locations. Well 36-01, however, is too far from potential sources and too close to the POE location to serve as a useful POC location. We, therefore, suggest Well 36-01 should not be used as a POC well for the TRB, but Rio Algom should continue monitoring Well 36-01 as a means of identifying any trends in constituents approaching the POE boundary.

TRB monitor Well 31-02, which is not currently an established POC well, is suitably located to monitor potential contamination in the TRB that may originate from Tailings Impoundment 1 and should be considered as a POC well. Natural uranium concentrations in Well 31-02 currently exceed both the groundwater protection standards and the requested ACL for natural uranium in the TRB. Rio Algom (QMC, 2000, Section 2.3.2.2) speculates that elevated natural uranium concentrations in Well 31-02 are a result of seepage from a nearby freshwater pond, but no supporting evidence is provided. In fact, the map of the TRB subcrop area (QMC, 2000, Drawing 2-1) indicates TRB is isolated from the freshwater pond by the overlying Mancos Shale in this area. Rio Algom will need to demonstrate that high uranium concentrations in Well 31-02 will not pose a threat to health or the environment at the POE. Rio Algom also should consider designating Well 31-02 as a POC well.

Well 31-01 is the only POC well established for the TRA. This well is appropriately located for ensuring groundwater protection at POE locations for the TRA. Because the TRA is largely dewatered in other areas of the mill facility, this sole POC location is sufficient. Rio Algom should consider whether to use other TRA locations as trend wells.

## 4.5 Summary

(i) Available information is sufficient to conclude reasonably that continuation of the groundwater corrective action program in the uppermost bedrock aquifers will not lead to further reductions in contaminant concentrations.

(ii) The requested ACLs, except for nickel in the TRB and Dakota bedrock, should be denied because they are not demonstrated to be protective of human health and the environment. The licensee should either demonstrate protection using, if necessary, an attenuation argument based on a defensible retardation, or submit a new set of ACLs that are protective.

(iii) The licensee should submit a revised set of ACLs that complies with 10 CFR Part 40, Appendix A, Criterion 5, using the revised health risk-based limits.

(iv) Dakota Wells 30–02KD, 30–48KD, and 32–45KD, and TRB Well 36-01 do not need to be classified as POC wells, but monitoring for contaminant trends should continue at these locations as long as POC and POE monitoring continues.

(v) The licensee needs to demonstrate that high uranium concentrations in TRB Well 31-02 will not pose a threat to health or the environment at the POE and should also consider designating Well 31-02 as a POC well.

(vi) Proposed POE monitoring locations are acceptable.

(vii) If compliance with the groundwater protection standards and new ACLs is demonstrated, all prescribed groundwater monitoring should continue until site reclamation is completed and for an additional period to be proposed by the licensee. The additional period should be long enough that continued compliance is assured. Monitoring should be conducted in accordance with current license conditions for constituents measured, reporting, and frequency.